

OPERATION MANUAL

TH2638/A

Precision Capacitance Meter

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Announcement

The description of the manual may not cover all contents of the instrument, and our company is subject to change and to improve the performance, function, inner structure, appearance, accessory and package of the instrument without notice. If there is puzzle caused by inconsistency of manual and instrument, then you can contact with our company by the address on the cover.

Chapter 1 Out of Box Audit

When you receive the instrument, some inspections are necessary, and the condition must be understood and available before installing the instrument.

1.1 To Inspect the package

Inspect the shipping container for damage after unpacking it. It is not recommended to power on the instrument in the case of a damaged container.

If the contents in the container do not conform to the packing list, notify us or your dealer.

1.2 Power connection

- 1) Power-supplying voltage range: 100-120Vac or 198~242Vac.
- 2) Power-supplying frequency range: 47~63Hz.
- 3) Power-supplying power range: not less than 200VA.
- 4) Power supplying input phase line L, zero line N, ground lead E should be as same as the power plug of the instrument.
- 5) After careful design, the instrument can reduce the clutter jamming caused by AC power terminal input; however, it should be used under the environment with low-noise. Please install power filter if being unavoidable.

Warning: In order to prevent user and instrument from being hurt by leakage, it is necessary for user to guarantee the ground line of supply power being reliably grounded.

1.3 Fuse

The instrument has installed fuse, so operators should use the installed fuse of our company.

Warning: Be sure that the location of fuse is consistent with power-supplying voltage range before charging.

1.4 Environment

- 1) Please do not operate the instrument in the place that is vibrative, dusty, under direct sunlight or where there is corrosive air.
- 2) The normal working temperature is 0℃~40℃, relative humidity ≤75%, so the instrument should be used under above condition to guarantee the accuracy.
- 3) There is heat abstractor on the rear panel to avoid the inner temperature rising. In order to

keep good airiness, please don't obstruct the left and right airiness holes to make the instrument maintain the accuracy.

- 4) Although the instrument has been specially designed for reducing the noise caused by ac power, a place with low noise is still recommended. If this cannot be arranged, please make sure to use power filter for the instrument.
- 5) Please store the instrument in the place where temperature is between 5°C and 40°C, humidity is less than 85%RH. If the instrument will not be put in use for a time, please have it properly packed with its original box or a similar box for storing.
- 6) The instrument, especially the test cable should be far from strong electro-magnetic field, to avoid the jamming on measurement.

1.5 Use of Test Fixture

Please use the accessory test fixture or cable, **the test fixture made by user or from other company may cause the incorrect measurement result**. The test fixture or cable should be kept clean, as well as the pin of DUT, thus to guarantee the good connection between DUT and fixture.

Connect the fixture or cable to four test terminals Hcur, Hpot, Lcur, Lpot on the front panel. As for the DUT with shielding shell, connect shielding layer or ground “ $\perp$ ”.

Note: When test fixture or cable has not being installed, the instrument will display an unstable test result.

1.6 Warm-up

- 1) To guarantee the accurate measurement, the warm-up time is no less than 15min.
- 2) Please not turn on or off instrument frequently, in order to avoid the inner data fluster.

1.7 Other features

- 1) Power: consumption power $\leq$ 150VA.
- 2) Dimension (W*H*D): 369mm*108mm*408mm;
- 3) Weight: About 5 kg.

Chapter 2 Introduction

In this chapter, the basic operation procedures and names & functions of the front panel, rear panel as well as screen display of TH2638 are described.

Product Introduction

TH2638 is a capacitance meter for ceramic capacitor production tests. It can be used for evaluating ceramic capacitance at frequencies 100Hz, 120Hz, 1kHz, 10 kHz, 40 kHz, 100 kHz, 1 MHz and test signal levels (0.1 V to 1 V).

TH2638 offers C-D measurement with a basic accuracy of $\pm 0.07\%$ (C), ± 0.0005 (D) at all frequencies with seven-digit resolution (the dissipation factor resolution is 1 ppm) in every range.

With its built-in comparator, TH2638 can output comparison/decision results for sorting components into a maximum of ten bins. Furthermore, by using the handler interface and scanner interface, TH2638 can be easily combined with a component handler, a scanner, and a system controller to fully automate component testing, sorting and quality-control data processing.

The GPIB/LAN/USB interfaces are standard on the TH2638 (no GPIB and Scanner interface in TH2638A) and enable automatic testing.

2.1 Introduction to front panel

Figure 2-1 shows the front panel of TH2638.

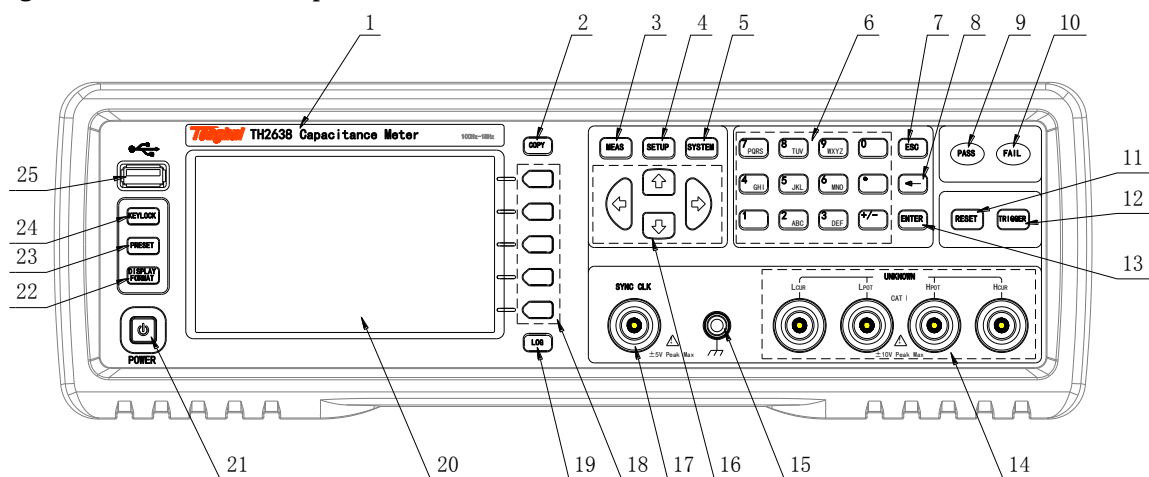


Figure 2-1 Front panel

-
- 1) Brand and model
Brand and model.
 - 2) [COPY]
Press this key to save the screen shot of test result to USB disk.
 - 3) [MEAS]
Press this key to enter into the measurement result display page.
 - 4) [SETUP]
Press this key to set the measurement conditions, limit values of correction, list setup, file setup and contact check function.
 - 5) [SYSTEM]
Set the system. Set the GPIB/LAN interface. Default setting and system reset.
 - 6) Numerical keys
These keys are used to input data to the instrument. The key consists of numerical keys [0] to [9], decimal point [.] and [+/-] key. Entered values are displayed on the input line (second line from the bottom of the LCD screen), and pressing the softkey terminates numeric input. The plus/minus key deletes the last character of the input value.
 - 7) [ESC]
ESCAPE key.
 - 8) [←]
BACKSPACE key. Press this key to delete the last number input.
 - 9) PASS indicator
PASS LED indicator shows the test result has passed.
 - 10) FAIL indicator
FAIL LED indicator shows the test result has failed.
 - 11) [RESET]
Press this key to stop scanning only in transformer automatic scanning. No operation will be executed on other pages.
 - 12) [TRIGGER]
When the trigger mode is set to MAN mode, press this key to trigger the instrument.
 - 13) [ENTER]
Stop data inputting, confirm and save the data displayed in the input line (the bottom line on the LCD).

14) UNKNOWN terminals

These are the UNKNOWN terminals used to connect a four-terminal pair test fixture or test leads for measuring the device under test (DUT).

NOTE: When using a four-terminal pair test fixture or test leads with a stopper, remove the stopper or the bumper of TH2638.

Caution: please do not apply DC voltage or current to the UNKNOWN terminals. Applying DC voltage or current may lead to device failure. Connect the measurement sample (DUT) to the test port (or the test fixture, cables, etc. connected to the test port) after the Capacitance meter has been completely discharged.

The maximum load the UNKNOWN terminals can withstand is 10 kgf (rated value).

15) Ground terminal

It is connected to the chassis of TH2638 and used to protect or shield ground connection.

16) Cursor keys

Cursor keys are used to move the field select cursor from field to field on a displayed page. When the cursor is moved to a certain field, the field will change to an inverse video image of the original field. The cursor can only be moved from field to field.

17) Synchronous clock

The internal clock signal is outputted.

18) Soft keys

Five soft keys are used to select measurement condition and parameter function. The corresponding function of each soft key has been displayed in the left.

19) [LOG]

Press this key to save the test data automatically after inserting the U-disk in MEAS interface and save the system setup in [SYSTEM].

20) LCD

800*480 colorful TFT LCD displays measurement results and conditions.

NOTE: there are missing pixels or constantly lit pixels occasionally, but this is not a malfunction and does not affect the performance of your product.

21) POWER

Power switch.

22) Display format

Press this key to switch the window or full screen display method of measurement results.

23) Reset

This key is used to return the Capacitance meter to the initial setup state. There are three methods for initialization.

24) [KEYLOCK]

Press [KEYLOCK], it will be lighted, which means the function of current panel is locked. Press it again, it will be off, which means discharging the lock status. If the password function is ON, it means correct password is necessary when discharging the key-lock, or the key cannot be unlocked.

When the instrument is controlled by RS232, [KEYLOCK] will be lighted. Press [KEYLOCK] again, it will be off, which means returning to the local discharging lock status.

25) Front USB HOST interface

Connect U flash disk so as to save or load the file.

NOTE: do not unplug the USB disk while in the process of storage.

2.2 Introduction to rear panel

Figure 2-2 shows the rear panel of TH2638.

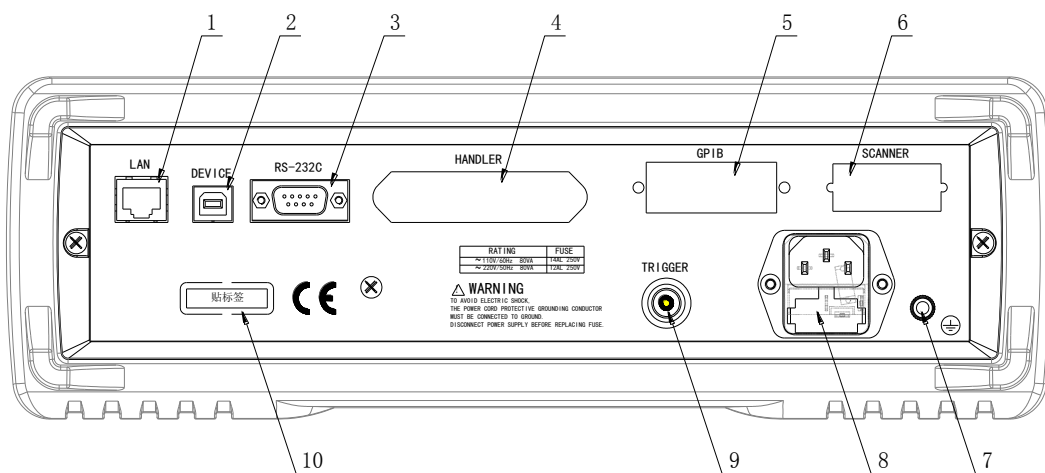


Figure 2-2 Rear panel

1) LAN interface

The port can connect the TH2638 to a LAN (Local Area Network). Connecting this instrument to a LAN enables you to control this instrument by using SICTL-LAN or telnet, or from an external PC via a Web server.

2) USB(USBTMC, USB CDC) DEVICE interface

The tester can communicate with PC through the USB DEVICE interface.

3) RS232C interface

Series communication interface can realize the communication with PC.

4) HANDLER interface

This interface is for data exchange with an automatic machine (handler) used on a production line.

-
- 5) GPIB interface
General Purpose Interface Bus (GPIB). The connection of an external controller and other devices through this connector allows you to configure an automatic measurement system.
 - 6) Scanner interface
The interface to connect a scanner can perform up to 256 sets of multi-channel corrections and measurements.
 - 7) Ground terminal
The ground terminal is connected with instrument casing, being available for protecting or shielding ground connection.
 - 8) Power socket (to LINE)
Input AC power.
NOTE: To connect the device to a power source (outlet), use the supplied three-prong power cable with a ground conductor
The plug attached to the power cable (on the power outlet side or device side of the cable) serves as the disconnecting device (device that cuts off the power supply). When the power supply must be cut off to avoid such danger as electric shock, pull out the power cable plug (on the power outlet side or device side of the cable).
 - 9) External trigger input connector
The BNC connector to input the positive/negative TTL pulse can trigger the TH2638 with external trigger signals. (The trigger mode must be set to EXT).
 - 10) Nameplate
Information about production date, instrument number and manufacturer etc..

2.3 FAN

The cooling fan is used for controlling the temperature inside TH2638. This fan extracts heated air from inside the Capacitance meter.

2.4 Introduction to display zone

This section describes the names and functions of parts on the LCD screen.

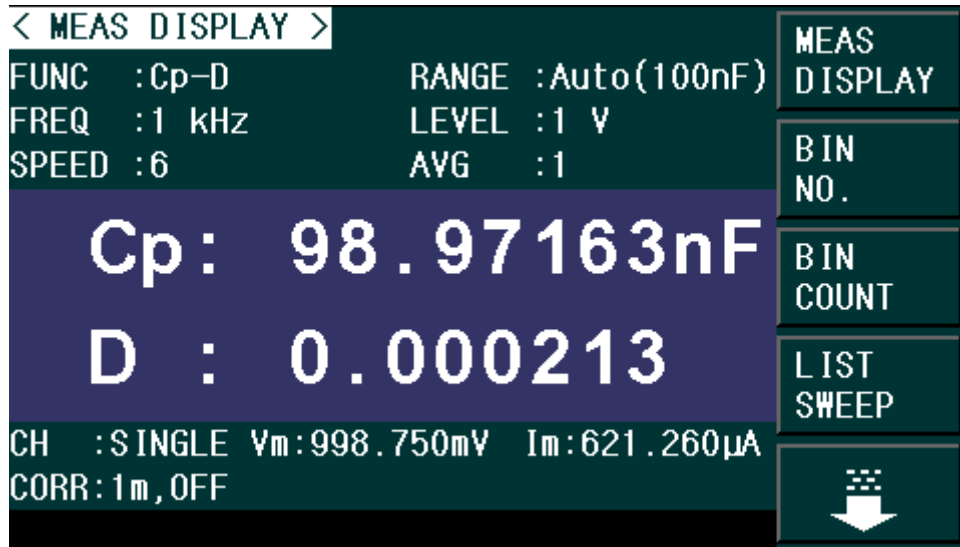


Figure 2-3 display zones

- 1) Display page name
Indicate the name of the currently displayed page.
- 2) Soft keys
The zone is used to display the function definition of soft key.
A displayed to the right of a softkey indicates that pressing ↓ will display the softkey label one level lower. Pressing the ← key when the lower level softkey label is displayed will display the softkey label one level higher.
- 3) Test condition display zone
In this zone, test condition is displayed.
- 4) Test result display zone
In this zone, test result information is displayed.
- 5) System message display zone
In this zone, the system message, warning, and an error message will be displayed.
- 6) Status display zone
When the front panel key is locked, “LOCK” is displayed in this area. When sending SCPI commands from an external controller, “RMT” is displayed and the front panel keys are locked. When TH2638 accesses the USB memory, “USB” is displayed in this area.

2.5 Basic Operation

Basic operation of TH2638 is as follows:

- Use [MEAS] keys and soft keys to select the desired page.
- Use cursor keys ([←][→] [↑] [↓]) to move the cursor to the desired zone. When the cursor moves to a specified zone, the zone will become reverse expression.
- The soft key functions corresponding to the current zone of the cursor will be displayed in the soft key zone. Users can select and use the desired key. Numeric keys, [←] and [ENTER] are used to input data.

When a numeric key is pressed down, the usable unit soft key will be displayed in the soft key zone. You can press [ENTER] to end data inputting.

The unit changes according to the field selected.

Chapter 3 Basic Measurement Procedure

This chapter describes the procedure to measure a capacitor with the test fixture by using TH2638.

3.1 Connecting test fixture

Generally, it is difficult to connect the DUT (capacitor) directly to the TH2638. Therefore, a test fixture is generally used to connect the DUT to the TH2638. Choose the suitable test fixture for DUT.

NOTE: To avoid failure, do not apply DC voltage or current to the UNKNOWN terminal. Special care must be taken for capacitors because they may be charged. Fully discharge before connecting them to the UNKNOWN terminal (or the test fixture).

3.2 Setting up basic measurement conditions

This section describes how to set up basic measurement conditions for capacitor measurement.

Initializing the Instrument

Step 1: Press [Preset] key.

Step 2: Use the softkeys to select one of the following four default states:

Default state	Initialize the instrument
CLEAR SETTING	When you select this state, all basic parameters configured through the front panel and SCPI commands are cleared. (You get the same result by issuing the :SYST:PRES command).
CLEAR SET&CORR	When you select this state, calibration data listed in the initial setting list are all cleared. (You can get the same result by issuing the *RST command).
LAN RESET	When you select this state, the LAN setting is returned to the factory default state.
FACTORY DEFAULT	When you select this state, it reverts to factory default settings with all user-configurable data cleared.

NOTE: It takes a few seconds for the initialization to complete.

Setting up measurement parameters

Set up the primary parameter and secondary parameter you want to measure. TH2638 provides you the following parameter combinations.

Primary parameter	Secondary parameter
Cp	D, Q, G, Rp
Cs	D, Q, Rs, Rs – Ls

Each parameter is described below.

Cp: Capacitance value measured by parallel equivalent circuit model

Cs: Capacitance value measured by series equivalent circuit model

D: Dissipation factor

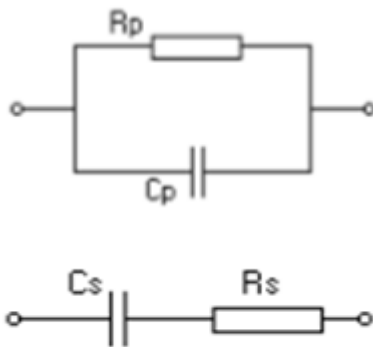
Q: Quality factor (inverse of D)

G: Equivalent parallel conductance measured by parallel equivalent circuit model

Rp: Equivalent parallel resistance measured by parallel equivalent circuit model

Rs: Equivalent series resistance measured by series equivalent circuit model

Rs – Ls: Equivalent series resistance and equivalent series capacitance measured by series equivalent circuit model



The procedure to set up the measurement parameters is described below.

Step 1: Press the [MEAS] key.

Step 2: Move the cursor key to the FUNC zone (as shown in Figure 3-1).

Step 3: Press the Cp or Cs softkey to select the primary parameter.

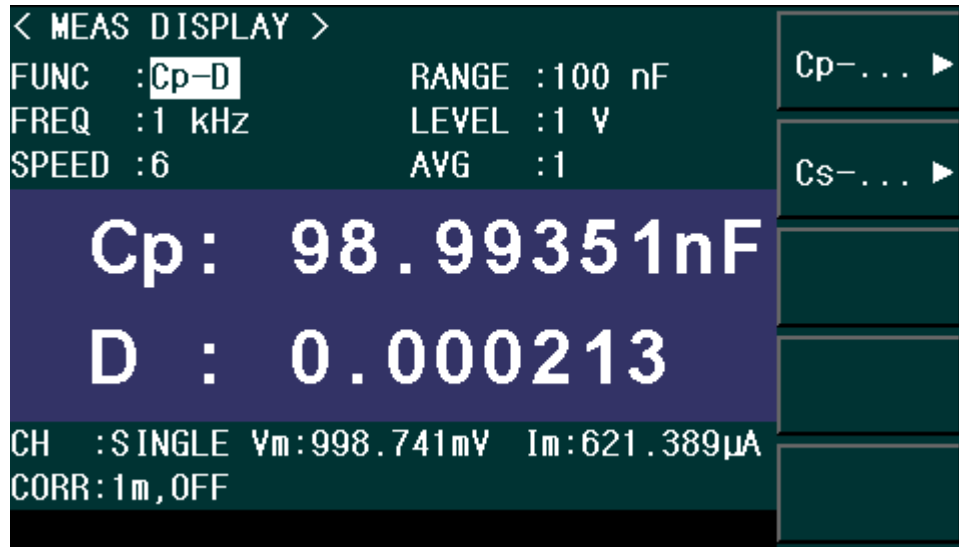


Figure 3-1 Primary parameter selection menu screen

Step 4: Press the softkey to select the secondary parameter (as shown in Figure 3-2)



Figure 3-2 Secondary parameter selection menu screen

Setting up measurement signal frequency

Set up the frequency of the signal applied to the DUT (capacitor) during measurement.

Step 1: Press [MEAS] key.

Step 2: Move the cursor key to FREQ zone.

Step 3: Use the softkeys or entry keys to enter the frequency. When data is entered with the numeric entry keys, the softkeys change to unit labels (Hz, kHz, MHz).

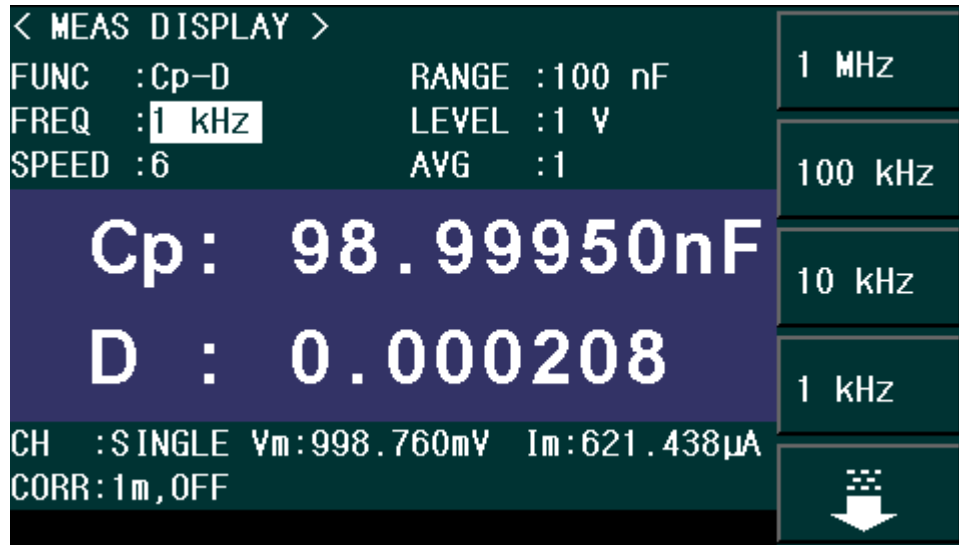


Figure 3-3 Measurement signal frequency selection menu screen

Setting up measurement signal level

Set up the voltage level of the signal applied to the DUT (capacitor) during measurement.

Step 1: Press [MEAS] key.

Step 2: Move the cursor key to the **LEVEL** zone.

Step 3: Use the softkeys or entry keys to enter the test signal level. When data is entered with the entry keys, the softkeys change to units labels (mV, V).

Softkey	Description
INCR++	Increments the level in steps of 100 mV, 500 mV, 1 V.
INCR+	Increases the level with a resolution of 10 mV.
DECR-	Decreases the level with a resolution of 10 mV.
DECR--	Decrements the level in steps of 1 V, 500 mV, 100 mV.

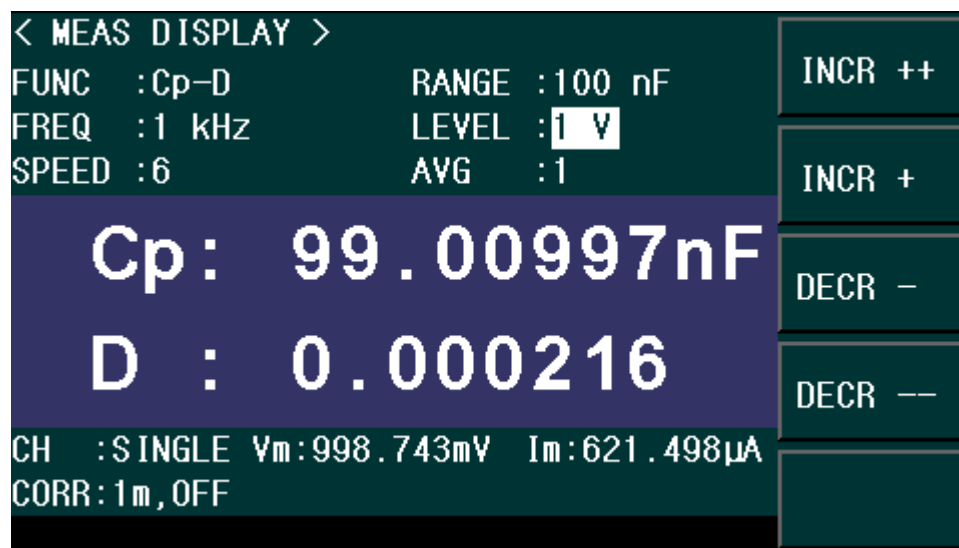


Figure 3-4 Measurement signal level selection menu screen

Setting up cable length

Select the length of the measurement cable from 0 m, 1 m, or 2 m, depending on the test set lead you use.

- 0 m when you do not use the test lead (in other words, when you connect the test fixture directly to the UNKNOWN terminal).
- 1m / 2m when you use the test lead to connect the test terminal.
- 1A when you use Agilent's 1m test cable

The procedure used to set up the length of the measurement cable is described below.

Step 1: Press [SETUP] key.

Step 2: Press the **CORRECTION** softkey.

Step 3: Move the cursor keys to the CABLE zone.

Step 4: Use the following softkeys:

Softkeys	Description
0m	Sets the cable length to 0 meter.
1m	Sets the cable length to 1 meter.
2m	Sets the cable length to 2 meter.

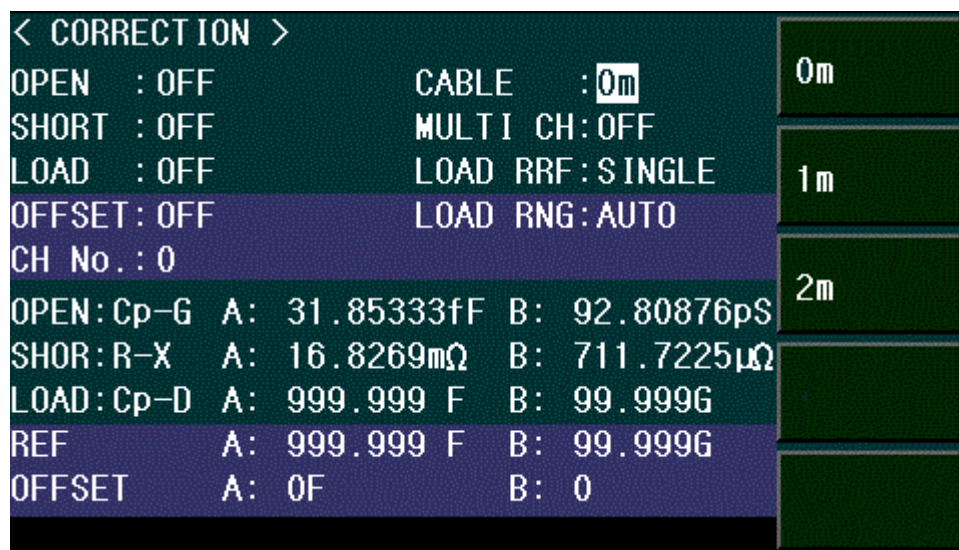


Figure 3-5 Cable length selection menu screen

3.3 Executing measurement to compensate errors

You can compensate for errors in the measurement caused by disturbances such as stray admittance and residual impedance of the test fixture and cable.

Corrections should be performed before actually connecting the DUT to the test fixture.

Measuring data for OPEN correction

The OPEN correction is provided to remove stray admittance parallel to the DUT.

Steps for OPEN correction is described as below:

Step 1: Press the [SETUP] key.

Step 2: Press the CORRECTION softkey. The CORRECTION display page as shown in Figure 3-6 appears.

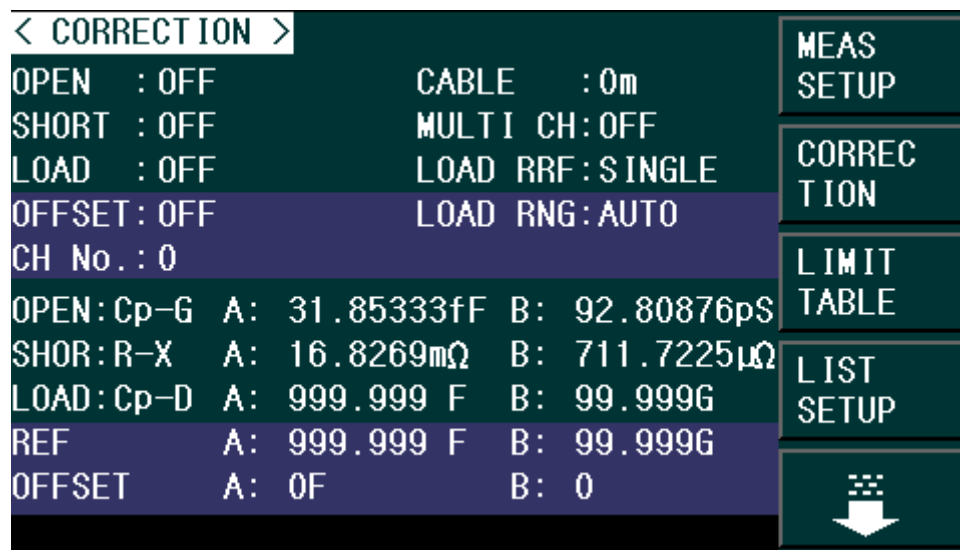


Figure 3-6 Correction Screen

Step 3: Use the cursor keys to select the OPEN field.

Step 4: Connect the UNKNOWN terminal and the test fixture with no DUT connected.

Step 5: Press the MEAS OPEN softkey. The data for the OPEN correction is then measured. During the measurement, an “OPEN measurement in progress” message is shown on the display.

When the measurement has finished, the “OPEN measurement in progress” message disappears.

During the measurement, the ABORT softkey is shown. Use this key when you want to abort open correction.

Step 6: When measurement of the data for OPEN correction is successfully completed, the OPEN correction turns to ON (as shown in Figure 3-7).

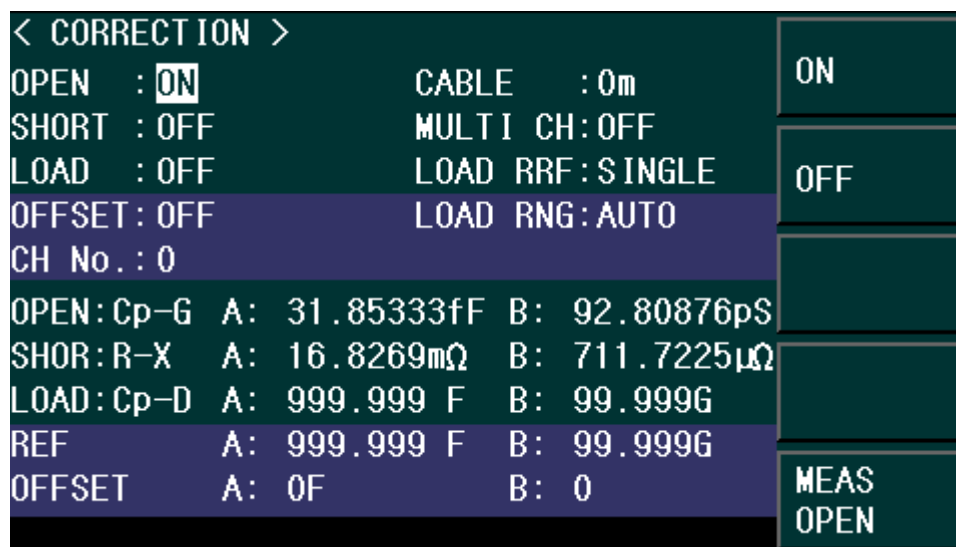


Figure 3-7 Screen upon completion of measuring data for OPEN correction

Description of Softkeys

To enable/disable or otherwise control the behavior of open correction, use the following softkeys:

Softkey	Description
ON	Enables open correction.
OFF	Disables open correction.
MEAS OPEN	Starts open correction.

If open admittance $|Y_o| (= \sqrt{G^2 + B^2})$ is greater than 20 μS (an unsuitable level for the data used in OPEN correction), the warning message “**OVERLOAD!**” appears on the below of the screen.

NOTE: Even if this warning message appears, the data for OPEN correction is still used. However, you should recheck the connection between the test fixture and the UNKNOWN terminal and confirm that the OPEN correction procedure was done correctly.

Checking data for OPEN correction

You can check the measured open admittance value (data for the OPEN correction). The procedure is given below.

- Step 1: Press the [SETUP] key.
- Step 2: Press the CORRECTION softkey.
- Step 3: Move the cursor keys to the OPEN G-B zone.
- Step 4: Use the softkeys to select the desired display.

< CORRECTION >			G-B
OPEN : ON	CABLE : 0m		
SHORT : OFF	MULTI CH: OFF		Cp-G
LOAD : OFF	LOAD RRF: SINGLE		
OFFSET: OFF	LOAD RNG: AUTO		
CH No.: 0			
OPEN: G-B	A: 92.80876pS	B: 200.1403pS	
SHOR: R-X	A: 16.8269m Ω	B: 711.7225 $\mu\Omega$	
LOAD: Cp-D	A: 999.999 F	B: 99.999G	
REF	A: 999.999 F	B: 99.999G	
OFFSET	A: 0F	B: 0	

Figure 3-8 OPEN Correction Data

Measuring data for SHORT correction

The SHORT correction removes residual impedance in series with the DUT. Steps for SHORT correction is described below.

- Step 1: Press the [SETUP] key.

Step 2: Press the CORRECTION softkey. The CORRECTION display page as shown in Figure 3-9 appears.

Step 3: Move the cursor to the SHORT zone.

Step 4: Connect the UNKNOWN terminal and the test fixture and short-circuit the high and low test terminals

Step 5: Press the MEAS SHORT softkey. The data for the SHORT correction is then measured.

During the measurement, a “SHORT measurement in progress” message is shown on the display.

When the measurement has finished, the “SHORT measurement in progress” message disappears.

During the measurement, the ABORT softkey is shown. Use this key when you want to abort short correction.

NOTE: The data for SHORT correction is stored as data for all the measurement frequencies.

Step 6: When measurement of the data for SHORT correction is successfully completed, the SHORT correction turns to ON (as shown in Figure 3-9).

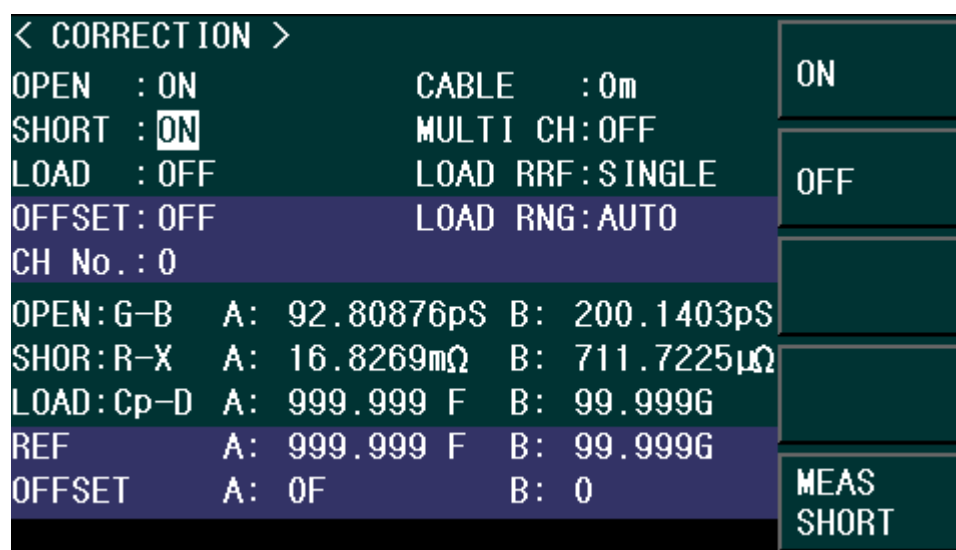


Figure 3-9 Screen upon completion of measuring data for SHORT correction

Description of Softkeys

To enable/disable or otherwise control the behavior of short correction, use the following softkeys:

Softkey	Description
ON	Enables short correction.
OFF	Disables short correction.
MEAS SHORT	Starts short correction.

If the short impedance $|Z_s|$ ($=R_2 + X_2$) is greater than 20 μS (an unsuitable level for the data used in SHORT correction), the warning message “OVERLOAD!” appears on the below of the

screen.

NOTE: Even if this warning message appears, the data for SHORT correction is still used. However, you should recheck the connection between the test fixture and the UNKNOWN terminal and confirm that the SHORT correction procedure was done correctly.

Checking data for SHORT correction

You can check the measured short impedance value (data for the SHORT correction). The procedure is given below.

- Step 1: Press the [SETUP] key.
- Step 2: Press the CORRECTION softkey.
- Step 3: Move the cursor keys to the SHORT R-X zone.
- Step 4: Use the softkeys to select the desired display.

< CORRECTION >			R-X
OPEN : ON	CABLE : 0m		
SHORT : ON	MULTI CH: OFF		
LOAD : OFF	LOAD RRF: SINGLE		Ls-Rs
OFFSET: OFF	LOAD RNG: AUTO		
CH No.: 0			
OPEN: G-B	A: 92.80876pS	B: 200.1403pS	
SHOR: R-X	A: 16.8269mΩ	B: 711.7225μΩ	
LOAD: Cp-D	A: 999.999 F	B: 99.999G	
REF	A: 999.999 F	B: 99.999G	
OFFSET	A: 0F	B: 0	

Figure 3-10 SHORT Correction Data

3.4 Connecting the DUT (capacitor)

Mount a capacitor on the test fixture. The measurement result for the parameter selected in “Setting up measurement parameters” is displayed. Figure 3-11 shows an example when the primary parameter is Cp and the secondary parameter is D.

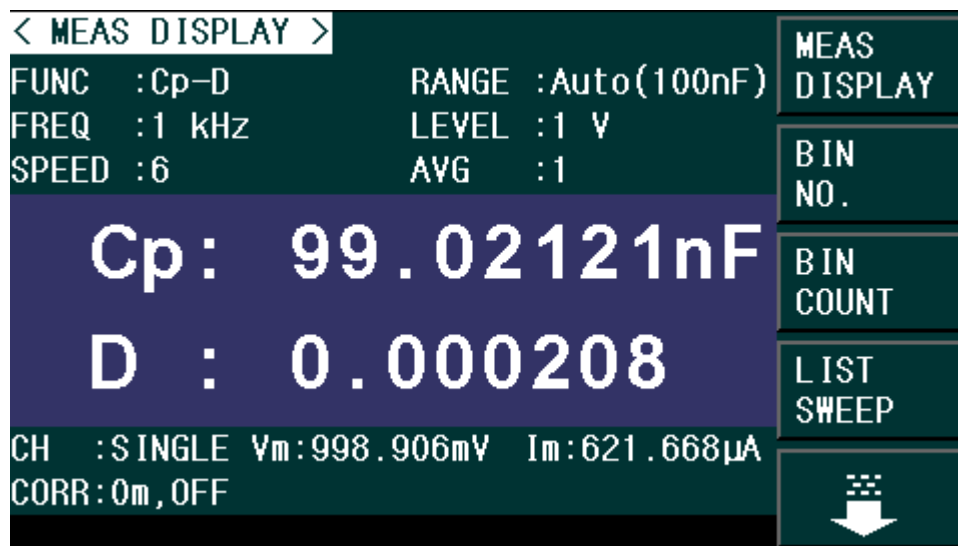


Figure 3-11 Measurement result display screen

Chapter 4 Configuration of Measurement Conditions and Display

This chapter provides information on initializing the instrument, setting up the measurement conditions & display. Also, storage and load of the setting status and measurement conditions is described.

4.1 Selecting a measurement parameter

TH2638 provides you the following parameter combinations. You can select a measurement parameter along with figure 4-1.

Primary parameter	Secondary parameter
Cp	D, Q, G, Rp
Cs	D, Q, Rs, Rs-Ls

Each parameter is described below.

Cp: Capacitance value measured by parallel equivalent circuit model

Cs: Capacitance value measured by series equivalent circuit model

D: Dissipation factor

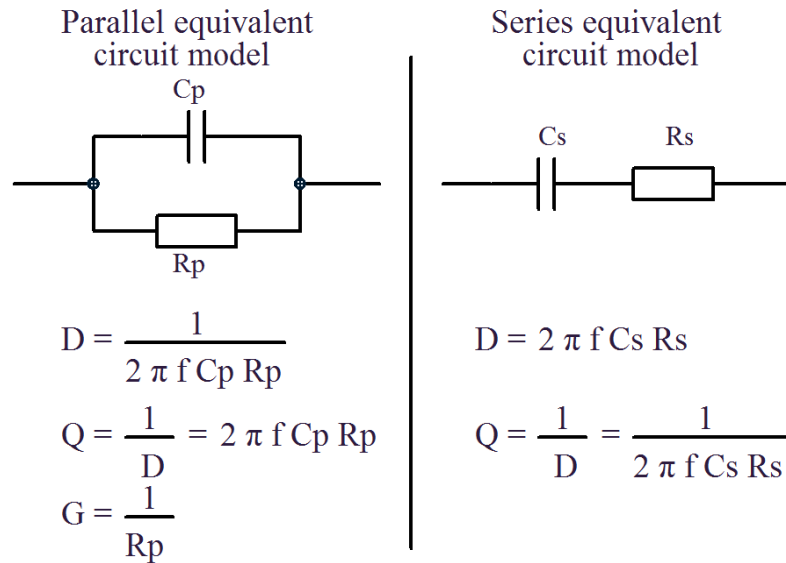
Q: Quality factor (inverse of D)

G: Equivalent parallel conductance measured by parallel equivalent circuit model

Rp: Equivalent parallel resistance measured by parallel equivalent circuit model

Rs: Equivalent series resistance measured by series equivalent circuit model

Rs – Ls: Equivalent series resistance and equivalent series capacitance measured by series equivalent circuit model



f: Measurement signal frequency(100Hz/120Hz/1kHz/10kHz/100kHz/1MHz)

Figure 4-1 Relation between equivalent circuit model and measured parameters
For detailed configuration steps, please refer to "Configuring Measurement Parameters".

4.2 Configuration of measurement signal (frequency and level)

4.2.1 Setting frequency

The frequency can be set as 100Hz, 120Hz, 1kHz, 10kHz, 40kHz, 100kHz, 1MHz.

Note:

TH2638:100Hz, 120Hz, 1kHz, 10kHz, 100kHz, 1MHz;

TH2638A : 100Hz, 120Hz, 1kHz, 10kHz, 40kHz, 100kHz.

4.2.2 Setting level

The level can be set as 0.1V~1V with 10mV as the step.

4.2.3 Setting signal level compensation (SLC) function

Function instruction:

If the impedance of the DUT is small, the internal resistance of the signal source and the impedance on the test cable will cause the voltage applied across the two terminal of the DUT to be lower than the set voltage of the signal source. The signal level compensation is characterized by adjusting the voltage across the DUT to the same voltage as the set signal level. With this feature, it is possible to keep the voltage of the measured signal level on the DUT as a constant.

Setting up signal level compensation:

Step 1: Press [SETUP] key.

Step 2: Move the cursor key to LEVEL zone.

Step 3: Set the signal level compensation function as ON/OFF.

Level error of signal level compensation function

NOTE: When the DUT is large capacitance value and high loss D, even if the signal level compensation function turns on, the signal level will decrease.

NOTE: the default setting is ON. When the capacitance is increasing, the output current of signal source is increasing and the limit value is 1Arms. When exceeding the limit value, OVLD will be displayed on the screen.

Perform signal level check

A level error occurs when the signal level exceeds 10% of the set value. If the signal level drops by more than 10% of the set value, the following error will occur:

- When the signal level compensation and contact check are turned on at the same time, a contact check error will occur.
- When the signal level compensation is turned on and the contact check is turned off, ALC error will be displayed and automatically jump to the voltage setting value before compensation.

4.3 Selecting measurement range

Setting the measurement range as AUTO

There are two modes for selection, as shown below:

Mode	Instruction	Advantage	Disadvantage
AUTO	Set the best impedance range.	No need to select the impedance range.	Need to change the time of measurement range.
HOLD	Set the fixed impedance.	No need to change the time of measurement range.	Need to select the suitable impedance range according to the DUT.

Selecting the desired impedance range (HOLD)

As shown in the table, different measurement ranges are selected according to the frequency of the measurement signal. Therefore, if the set current measurement range and the set frequency conflict, the range will automatically jump to the current frequency to enter the range.

FREQ (Hz)	TH2638 Range	TH2638A Range
100/120	10nF, 22nF, 47nF, 100nF, 220nF, 470nF, 1uF, 2.2uF, 4.7uF, 10uF, 22uF, 47uF, 100uF, 220uF, 470uF, 1mF	
1k	100pF, 220pF, 470pF, 1nF, 2.2nF, 4.7nF, 10nF, 22nF, 47nF, 100nF, 220nF, 470nF, 1uF, 2.2uF, 4.7uF, 10uF, 22uF, 47uF, 100uF	
10k	100pF, 220pF, 470pF, 1nF, 2.2nF, 4.7nF, 10nF, 22nF, 47nF, 100nF, 220nF, 470nF, 1uF, 2.2uF, 4.7uF, 10uF	
40k	No this test frequency	22pF, 47pF, 100pF, 220pF, 470pF, 1nF, 2.2nF, 4.7nF, 10nF, 22nF, 47nF, 100nF, 220nF, 470nF, 1uF, 2.2uF
100k	10pF, 22pF, 47pF, 100pF, 220pF, 470pF, 1nF, 2.2nF, 4.7nF, 10nF, 22nF, 47nF, 100nF, 220nF, 470nF, 1uF	
1M	1pF, 2.2pF, 4.7pF, 10pF, 22pF, 47pF, 100pF, 220pF, 470pF, 1nF	No this test frequency

Setting up the range mode:

Step 1: Press [SETUP] key.

Step 2: Move the cursor key to RANGE zone.

Step 3: Use function keys or numeric key to select the desired range.

Function keys	Instruction
AUTO	Set the RANGE as AUTO
HOLD	Set the RANGE as HOLD
INCR +	Increase the range in HOLD mode
DECR -	Decrease the range in HOLD mode

4.4 Selecting measurement speed

TH2638 has 5-speed in measurement speed, including 1, 2, 4, 6 and 8. Among which, speed 1 is the fastest, but low accuracy; speed 8 is the slowest, but high accuracy.

Note: Refer to Appendix A for the correspondence between speed and accuracy and the corresponding measurement time for speed.

Setting up the measurement speed:

Step 1: Press [SETUP] key.

Step 2: Move the cursor key to SPEED zone.

Step 3: Use function keys or numeric key to select the desired speed.

4.5 Configure three-parameter measurement (Cs-Rs-Ls)

Function Description

For DC-link film capacitors used in new energy vehicles and other fields, it is necessary to simultaneously measure their equivalent series capacitance (Cs), equivalent series resistance (ESR) and equivalent series inductance (ESL). The general measurement can only be obtained. The first two parameters and the three-parameter measurement (Cs-Rs-Ls) of the TH2638A capacitance meter can meet the results of three parameters at the same time. The characteristics

of this measurement are obtained according to the processing of the measurement plus algorithm.

In order to reduce the impact of errors such as measurement methods or measurement conditions, Tonghui can provide customized fixtures to ensure the accuracy of its measurements.

Note: Only the TH2638A has a three-parameter measurement mode function.

Configuration steps:

Step 1: Press the [SETUP] key.

Step 2: Use the cursor keys to select the function area.

Step 3: Use the Select Cs-... function key.

Step 4: Select the Cs-... function key.

Step 5: Select the Cs-Rs - Ls function key.

Step 6: Use the cursor keys to select the frequency area.

Step 7: Use the numeric keys or function keys to make your selection.

Step 8: Use the cursor keys to select the range area.

Step 9: Use the function keys to select the auto range.

Step 10: Use the cursor keys to select the range area.

Step 11: Use the function keys to select the auto range.

Step 12: Use the cursor keys to select the baseband area.

Step 13: Use the numeric keys or function keys to make your selection.

Note:

1. The range must be selected as AUTO; otherwise it cannot be measured;
2. The base frequency setting is smaller than the current measurement frequency. The default value is 1kHz.

4.6 Selecting the cable length

Select the length of the measurement cable from 0 m, 1 m, or 2 m, depending on the test set lead you use.

0m: The user must interconnect the UNKNOWN terminal with the external contacts of the leads Hcur, Hpot, Lpot, and Lcur.

1m: The user must interconnect the wire ends of the 1m test leads with the external contacts of the leads Hcur, Hpot, Lpo and Lcur.

2m: The user must interconnect the wire ends of the 2m test leads with the external contacts of the leads Hcur, Hpot, Lpot and Lcu.

Note: When the power is turned off, the backup function cable length information is saved in the internal FLASH memory.

4.7 Configuration of average factor

Function description:

This function can help you to acquire variable average value when in continuous measurement.

It can be set between 1~256.

Setting up the measurement speed:

Step 1: Press [SETUP] key.

Step 2: Move the cursor key to AVG zone.

Step 3: Use function keys or numeric key to input the desired average factor. If the averaging factor is entered using the Enter key, the function key mark will change to the unit mark (x1).

Function keys	Instruction
INCR++	Increase the average factor by 10 steps.
INCR+	Increase the average factor by 1 step.
DECR -	Reduce the average factor by 1 step.
DECR - -	Reduce the average factor by 10 steps.

4.8 Configuration of trigger delay time

Function description:

You can set a trigger delay time from the start of measurement to trigger detection. The time can be set between 0-1s with 100 us as the step.

Setting up the measurement speed:

Step 1: Press [SETUP] key.

Step 2: Move the cursor key to DELAY zone.

Step 3: Use function keys or numeric key to input the desired delay time.

4.9 Synchronous clock source function

Function description:

You can set a trigger delay time from the start of measurement to trigger detection. The time can be set between 0-1s with 100 us as the step.

Setting up the measurement speed:

Step 1: Press [SETUP] key.

Step 2: Move the cursor key to SYN SR zone.

Step 3: Use function keys or numeric key to set the SYN SR as ON/OFF.

Step 4: Move the cursor key to SR DLY zone.

Step 5: Use function keys or numeric key to input the desired SR DLY time.

NOTE: the SR DLY time is valid only when the SYN SR is set as ON. When SYN SR and trigger delay are both set as ON, the SYN SR enjoys the prioritization of execution.

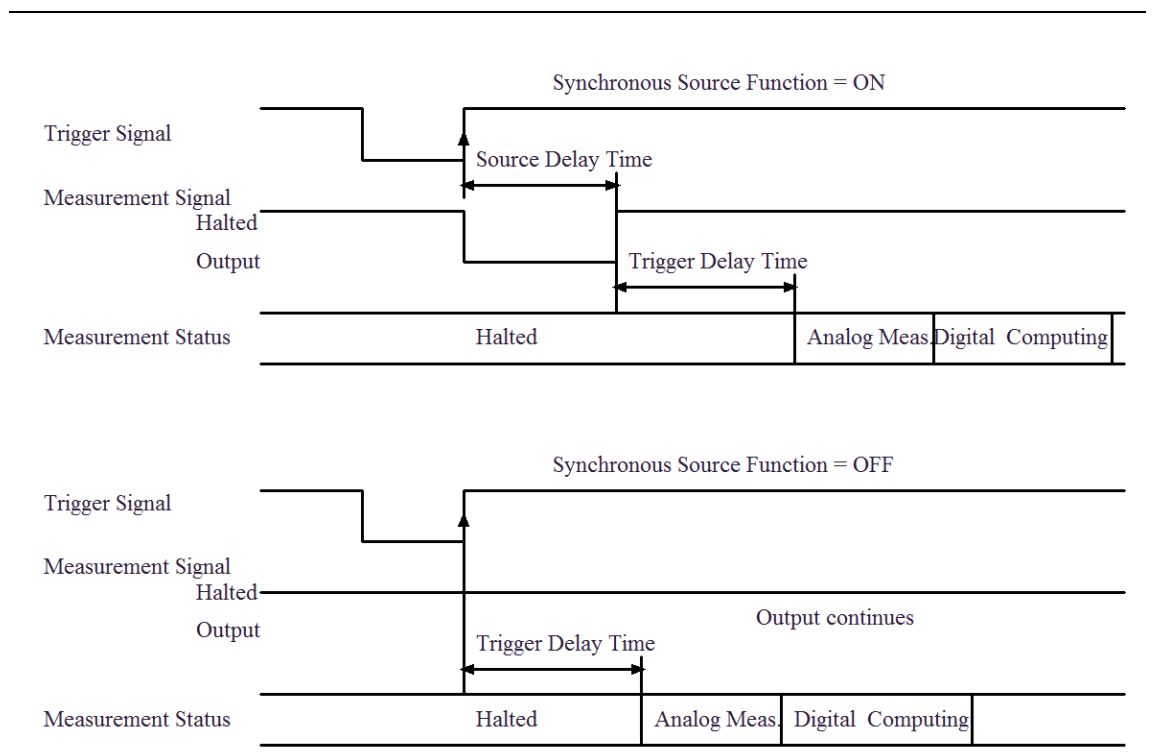


Figure 4-2 Measurement signal output timing sequence

4.10 Configuration of frequency shift

Function description:

When using two or more than two TH2638 instruments, you can set the frequency shift 0%, +1%, -1%, +2%, -2% to avoid the signal interference between measuring instruments.

Setting up the measurement speed:

- Step 1: Press [SETUP] key.
- Step 2: Move the cursor key to FR SHT zone.
- Step 3: Use function keys to select the frequency shift.

NOTE: when using this function, short and open clearing operation should be re-executed.

4.11 Configuration of display

4.11.1 ON/OFF of display

DISPLAY ON/OFF can be set through MEAS key. If the display is set as DISPLAY BLANK, the measurement results could not be displayed on the screen.

Setting up the display:

- Step 1: Press [MEAS] key.
- Step 2: Press ↓ function key.
- Step 3: Press DISPLAY BLANK function key.

4.11.2 Using fixed display

There are two display modes to display the measurement results.

Function key	Instruction
D.P. AUTO (default)	The measurement result is displayed according to different measured value each time and the decimal point is not fixed.
D.P. FIX	The measurement result is displayed according to settings and the decimal point is fixed.

Setting up the display:

Step 1: Press [MEAS] key.

Step 2: Move the cursor to measurement result zone.

Step 3: Use the following function key:

Function key	Instruction
D.P. AUTO (default)	Automatically display the corresponding digits and units.
D.P. FIX	Display the measurement result with fixed decimal point. At this time, ▲ is displayed at the fixed decimal point.
D.P. POS INCR+	Move the decimal point to left and the supplementary unit changes correspondingly.
D.P. POS DECL-	Move the decimal point to right and the supplementary unit changes correspondingly.

4.11.3 Deviation test mode

Function instruction

The deviation test function can make the deviation value (instead of real test value) be directly displayed on the screen. The deviation value is equivalent to the real test value subtracting the pre-set reference value. This function brings great convenience to observe variations of component parameters with temperature, frequency, bias. Bias test function can be used for primary or secondary parameter or primary and secondary parameters meanwhile. The instrument provides two deviation test modes as below:

■ Δ ABS (Absolute Deviation mode)

The deviation currently displayed is the difference between the test value of the DUT and the preset reference value. The formula of calculating Δ ABS is as below:

$$\Delta\text{ABS} = X - Y$$

Where, X is the test value of DUT

Y is the preset reference value.

■ $\Delta\%$ (Percentage deviation mode)

The deviation currently displayed is the percentage of the difference between the test value of DUT and the preset reference value divided by the reference value. Its calculating formula is as below:

$$\Delta\%=(X-Y)/Y*100[\%]$$

Where, X is the test value of DUT.

Y is the preset reference value.

Operation steps for setting deviation test function

Step 1: Press [SETUP] key.

Step 2: Move the cursor to the **REF A** zone.

Step 3: Use function key and enter key to input the reference value.

Function key	Instruction
MEASURE	If using specific component as reference component, connect it with the DUT and press MEASURE key. Once the DUT is measured, the measured value will be displayed in REFA and REFB, that is, reference value.

Step 4: Move the cursor to the **DEV A** zone.

Step 5: Press the suitable function key to select the deviation mode for primary parameter.

Function key	Instruction
ABS	Display the difference between the test value of the DUT and the preset reference value.
%	Display the difference between the test value of the DUT and the preset reference value divided by the reference value.
OFF	Turn off the deviation measurement.

Step 6: Move the cursor to the **DEV B** zone.

Step 7: Press the suitable function key to select the deviation mode for secondary parameter.

4.12 Configuration of list sweep function

The list sweep feature of the TH2638 can perform automatic sweep measurement by sweeping the frequency, voltage or current through a maximum 10 sweep points and their test results will be compared with their limits.

4.12.1 Sweep modes

The list sweep feature supports two sweep modes: sequential (SEQ) and step (STEP). In sequential mode, once the TH2638 has been triggered, it performs sweep measurement throughout all the defined sweep points. In step mode, the TH2638 performs one sweep point each time it is triggered.

NOTE: When the trigger mode is set to INT, sweep test modes of SEQ and STEP will not be controlled by [TRIGGER]. When the trigger mode is set to MAN, [TRIGGER] can be used to trigger the list sweep test.

Operation steps for setting the list sweep mode:

- Step 1: Press [SETUP] key.
- Step 2: Press LIST SETUP key.
- Step 3: Move the cursor to the **MODE** zone
- Step 4: Select the desired mode:
 - Press **SEQ** to set the sweep mode as sequential sweep test mode.
 - Press **STEP** to set the sweep mode as single step sweep test mode.

4.12.2 Sweep parameter

The sweep parameter used in list sweep measurement can be measurement frequency, signal level or current. Use the sweep point field to specify the list sweep measurement parameter.

Operation steps for setting the list sweep parameters:

- Step 1: Press [SETUP] key.
- Step 2: Press LIST SETUP key.
- Step 3: Move the cursor to the **FREQ** zone.
- Step 4: Configure the limit sweep parameter by pressing the appropriate softkey:
 - Press **FREQ** to set frequency as the sweep parameter.
 - Press **LEVEL** to set level as the sweep parameter.

4.12.3 Sweep Points and Limit Mode

The list sweep measurement feature supports up to 10 sweep points as well as measurement limit values. Figure 4-3 shows the fields you can use to configure the sweep points, limit parameters, and upper and lower limit values.



Figure 4-3 List sweep setup interface

Operation steps for setting the sweep points:

- Step 1: Press [SETUP] key.
- Step 2: Press LIST SETUP key.
- Step 3: Move the cursor to the FREQ zone.
- Step 4: Using the cursor keys to select one of the sweep point fields (1 through 10) and use DELETE LINE key to clear the current limit values of sweep points.
- Step 5: Enter the sweep point value using the entry keys. When you enter the value, the softkey labels change to unit labels (Hz, kHz, MHz, mV, V, uA, mA, A).
- Step 6: Using the cursor keys to select the LMT field.
- Step 7: Configure the limit parameter by pressing the appropriate softkey:
- | | |
|--------------|--|
| LIMIT DATA A | Uses the measurement function's primary parameter as the limit parameter. |
| LIMIT DATA B | Uses the measurement function's secondary parameter as the limit parameter |
| OFF | Turns OFF the sweep point limit function. |
- Step 8: Using the cursor keys to select the LOW field.
- Step 9: Enter the lower limit value.
- Step 10: Using the cursor keys to select the HIGH field.
- Step 11: Enter the upper limit value.
- Step 12: Repeat Step 4 to Step 11.

4.13 Configuration of contact check

The contact check feature of the TH2638 can check the contact fault between the connector of TH2638 and DUT.

When the contact fault is detected, **N.C.** will be displayed on the screen. The measuring result obtained from the GPIB/LAN/USB interface is a fixed value (9.9E37). The /LOWC_OR_NC signal in HANDLER interface is LOW.

NOTE: the contact check feature is only valid when in 100Hz, 120Hz and 1kHz. The function is not working when the RANGE is set as AUTO.

Operation steps for setting the contact check:

- Step 1: Press [SETUP] key.
- Step 2: Press ↓ key.
- Step 3: Press CONTACT CHECK key.
- Step 4: Using the cursor keys to select CONT CHK.
- Step 5: Using the following softkey:
- | | |
|-----|---------------------------------------|
| ON | Turns ON the contact check function. |
| OFF | Turns OFF the contact check function. |
- Step 6: Using the cursor keys to select CC TH1. It is a parameter proportional to the contact resistance of Hp or Hc.
- Step 7: The recommended set value is 0.1.
- Step 8: Using the cursor keys to select CC TH2. It is a parameter proportional to the contact resistance of Lp or Lc.

Range		CC TH1	CC TH2
100Hz/120Hz	1kHz		
10nF	100pF – 1nF	0.1 ^{*1}	0.08
22nF – 100nF	2.2nF – 10nF		0.08
220nF – 1uF	22nF – 100nF		0.08
2.2uF – 10uF	220nF – 1uF		0.1
22uF – 100uF	2.2uF – 10uF		0.151
220uF – 1mF	22uF – 100uF		NA

^{*1}: Default value

Step 9: Using the function keys or input keys to input the value according to the above table. When the data input is entered, the function key is changed to the unit's label (m, X1).

Function key	Instruction
INCR++	The successive increments are 0, 10m, 20m, 50m, 100m, 200m, 500m, 1.
INCR+	Increase by 10 steps
DECR-	Decrease by 10 steps
DECR--	The successive decrements are 1,500m, 200m, 100m, 50m, 20m, 10m, 0.

4.14 Configuration of limit table beep

The BEEP function can be set to work in different condition, see as follows:

BEEP	Working condition	
OFF	Turn off the beep function.	
FAIL	Beep is output when executing wrong key operation, turning up fault, alarm or other information.	When the comparator sorting result is OUT_OF_BIN, AUX_BIN, OVLD or not connected.
PASS		When the comparator sorting result is one of BIN1 through BIN9.

Operation steps for setting the beep:

- Step 1: Press [SETUP] key.
- Step 2: Press LIMIT TABLE function key.
- Step 3: Using the cursor keys to select BEEP zone.
- Step 4: Using the function keys to set the beep function as ON/OFF.

4.15 BEEPER

The sounding function is activated when one or more of the following conditions occur:

- An error message or warning message appears.
- The instrument completes the open/short correction.

-
- The instrument completes the open/short/load correction at the frequency point specified by the user.
 - When the DUT exceeds the limit value, or the DUT is sorted in the comparator, the status is OUT_OF_BIN, AUX_BIN, OVLD or no connection.
 - When the device under test is within the limit value, or the device under test in the comparator is sorted to any state between BIN1 and BIN9.
 - The user activates or deactivates the key lock button (the alarm will be activated regardless of whether the alarm function is enabled or not).
 - When starting TH2638.
 - The user can change the tone of the alarm through the front panel.

Note: The volume control is not supported.

Operation steps for setting the beeper function:

- Step 1: Press [SYSTEM] key.
- Step 2: Press SYSTEM SETUP function key.
- Step 3: Using the cursor keys to select BEEPER zone.
- Step 4: Using the function keys to set the beep function as ON/OFF.

4.16 BEEPER TONE

There are four tones for user selection.

Operation steps for setting the beeper function:

- Step 1: Press [SYSTEM] key.
- Step 2: Press SYSTEM SETUP function key.
- Step 3: Using the cursor keys to select BEEPER TONE zone.
- Step 4: Using the function keys to select the desired beeper tone.

Function key	Instruction
HIGH LONG	Select high and long beep.
HIGH SHORT	Select high and short beep.
LOW LONG	Select low and long beep.
TWO SHORT	Select two low and short beeps.

4.17 LANGUAGE

There are two languages for user selection: **English and Chinese.**

Operation steps for setting the language:

- Step 1: Press [SYSTEM] key.
- Step 2: Press SYSTEM SETUP function key.
- Step 3: Using the cursor keys to select LANGUAGE zone.
- Step 4: Using the function keys to select the desired language.

4.18 PASS WORD

This zone is used to display the password-protection mode.

Operation steps for setting the password

- Step 1: Press [SYSTEM] key.
Step 2: Press SYSTEM SETUP function key.
Step 3: Using the cursor keys to select PASS WORD zone.
Step 4: Using the function keys to select the desired pass word.

Function key	Instruction
OFF	Turn off the password protection mode.
LOCK SYSTEM	Turn on the password protection function including file protection and starting up password.
LOCK FILE	This soft key is used to protect user's file.
MODIFY	This soft key is used to modify the password. The operation steps are as follows:

- 1) Press **MODIFY** to input the current password (the default password is 2638) and press to enter key.
- 2) After inputting, the prompt information will appear on the screen to prompt you to input the new password.
- 3) Input the new password and press enter key, the prompt information will appear on the screen to prompt you to input the new password again till the modification finishes.

4.19 TALK ONLY

The Talk only function is used to control the instrument to send each measurement result to bus through its interface of RS232C, GPIB, LAN, USBTMC or USB CDC. When the talk only function is ON, the instrument cannot be controlled by PC.

Operation steps for setting the talk only function

- Step 1: Press [SYSTEM] key.
Step 2: Press SYSTEM SETUP function key.
Step 3: Using the cursor keys to select TALK ONLY zone.
Step 4: Using the function keys to set the TALK ONLY as ON/OFF.

4.20 BAUD RATE

Baud rate is used select the baud rate of the RS232C interface. The available baud rate of this instrument is from 9.600k to 115.200k.

Operation steps for setting the baud rate

- Step 1: Press [SYSTEM] key.
Step 2: Press SYSTEM SETUP function key.
Step 3: Using the cursor keys to select BAUD RATE zone.
Step 4: Using the function keys to increase or decrease the baud rate.

4.21 TIME

There is internal clock in TH2638.

Operation steps for setting the time

- Step 1: Press [SYSTEM] key.
- Step 2: Press SYSTEM SETUP function key.
- Step 3: Using the cursor keys to select DATE/TIME zone.
- Step 4: Using the input keys to input the date and time.

4.22 GPIB ADDR

This zone is used to control and display the current GPIB address.

Operation steps for setting the GPIB address:

- Step 1: Press [SYSTEM] key.
- Step 2: Press SYSTEM SETUP function key.
- Step 3: Using the cursor keys to select GPIB ADDR zone.
- Step 4: Using the function keys or input keys to input the value between 0-30.

4.23 LAN SETUP

When using LAN to communicate, the IP address must be set and LAN cable must be connected.

The AUTO IP can be set as ON/OFF to obtain the IP address automatically or manually.

Once obtaining the IP address automatically, users can check the IP address, subnet mask and gateway.

- IP ADDR
- SUBNET MASK
- GATEWAY

Operation steps for setting the IP ADDR automatically:

- Step 1: Press [SYSTEM] key.
- Step 2: Press LAN SETUP function key.
- Step 3: Using the cursor keys to select AUTO IP zone.
- Step 4: Press ON function key to obtain the IP address automatically.

Operation steps for setting the IP ADDR manually:

- Step 1: Press [SYSTEM] key.
- Step 2: Press LAN SETUP function key.
- Step 3: Using the cursor keys to select AUTO IP zone.
- Step 4: Press OFF function key to obtain the IP address manually.
- Step 5: Input the IP ADDR, SUBNET MASK and GATEWAY.

Check the network connections:

You can check the current network conditions in LAN Status zone. The status can be one of the following:

Status	Instruction
Working properly	LAN is well-connected
Working improperly	LAN is not well-connected
Recognizing	LAN connection is initializing

4.24 File Manage

TH2638 can save the user-set parameter to the nonvolatile memory in the form of file, so when use the same setting next time user can load a corresponding file to obtain the parameter set and used last time. By doing so, it can save the time of setting parameter and improve the production efficiency.

Operation steps for entering into the file manage page, shown as below:

Step 1: Press [MEAS] key.

Step 2: Press ↓ function key.

Step 3: Press the FILE MANAGE function key.

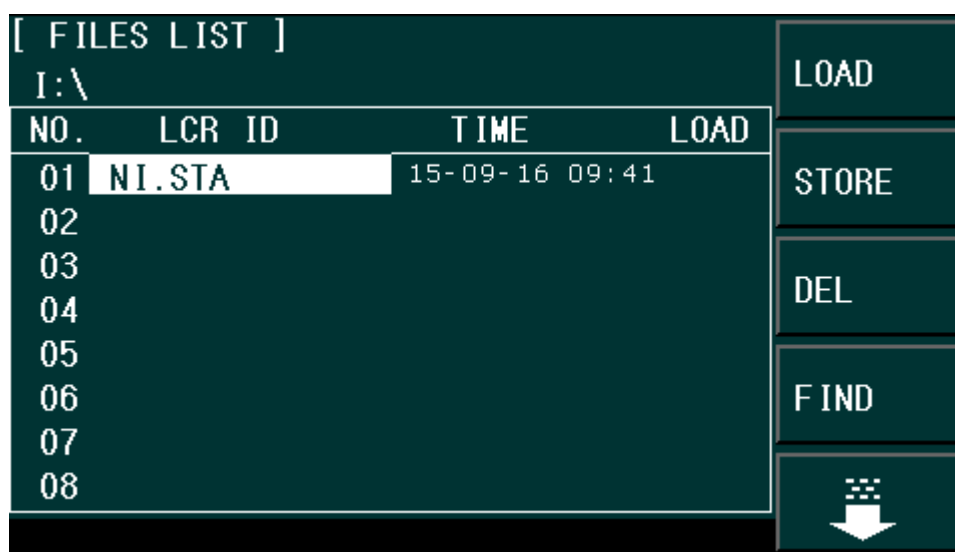


Figure 4-4 File Manage interface

4.24.1 Setup file for single-group component

40 groups of different single groups of component set file (*.STA file) can be saved in the instrument, but external storage U-disk can display/operate 500 groups of different single groups of component set file (note: U-disk is an optional accessory).

Use **FILE MANAGE** function on the following File menus, the following data will be saved or loaded in the form of file, which are called *.STA file.

■ **Control and setting parameter on <MEASURE SETUP> page**

□ FUNC

-
- ☐ FREQ
 - ☐ LEVEL
 - ☐ RANGE
 - ☐ SPEED
 - ☐ AVG
 - ☐ TRIG
 - ☐ SYN SR
 - ☐ SR DLY
 - ☐ ALC
 - ☐ DELAY
 - ☐ FR SHT
 - ☐ LCRJ
 - ☐ Rsou
 - ☐ Vm
 - ☐ Im
 - ☐ ISO
 - ☐ DEV A
 - ☐ DEV B
 - ☐ REF A
 - ☐ REF B
 - **Control and set parameters on <BIN COUNT DISP> page**
 - ☐ BIN COUNT (ON/OFF)
 - **Control and set parameter on <LIMIT TABLE SETUP> page**
 - ☐ PARA (swap parameter)
 - ☐ NOM (reference value)
 - ☐ MODE (%-TOL/ABS-TOL/SEQ-MODE)
 - ☐ AUX (ON/OFF)
 - ☐ COMP (ON/OFF)
 - ☐ High and low limits of each bin
 - **Control and set parameters on <LIST SWEEP SETUP> page**
 - ☐ List Sweep Mode (SEQ/STEP)
 - ☐ List Sweep Parameter (Frequency/Level)
 - ☐ Test points of all sweep parameters
 - ☐ High and low limits of all test points, including limit parameters (LIMIT-DATA A/LIMIT-DATA B)
 - **Page format currently displayed**

4.24.2 U-disk manage performance

As described above, TH2638 has a standard configuration of USB HOST interface, so the external U-disk can be used as the memory media. In this condition, it breaks the memory limit of 40 groups of *.LCR files. Meanwhile those files can be copied to IBM PC or compatible desk-top computer, laptop with USB interface to reach the infinite extension.

TH2638 supports the USB memory devices as below:

-
- Meet the USB 1.0/1.1 standard
 - Capacity: 32MB/256MB/2GB/4GB
 - File format: FAT16, FAT32 (Format the USB memory on Microsoft Windows operation system)

4.24.3 Operation steps for file management

A. Search an existed file

- Step 1: Press [MEAS] key.
- Step 2: Press ↓ function key.
- Step 3: Press the FILE MANAGE function key.
- Step 4: Use the ↑ and ↓ key to view one by one and use the [←] and [→] to view one page by one page.
- Step 5: Press the soft key **FIND**. Input the file character and then press the [ENTER] to search the target file.
Input the page number and press the [ENTER] to search the file.

B. Save the following control and setting parameters to a file by the following steps

- Step 1: Press [SETUP] key.
- Step 2: Press ↓ function key.
- Step 3: Press the FILE MANAGE function key.
- Step 4: Use the cursor key to select LCR ID blank zone.
- Step 5: Press **STORE** and press **Yes**.
- Step 6: Use numeric keys to input the desired file name and press [ENTER].

C. Load the control and setting parameters from a file by the following steps

- Step 1: Press [MEAS] key.
- Step 2: Press ↓ function key.
- Step 3: Press the FILE MANAGE function key.
- Step 4: Use the cursor key to select the file needed to be loaded.
- Step 5: Press LOAD function key.
- Step 6: Press **Yes** to load the currently selected file.
- Step 7: Press **No** to cancel the current load operation and return step 4.
- Step 8: After loading, TH2638 will return the current display page.

D. Copy a file to an U disk by the following steps

- Step 1: Press [MEAS] key.
- Step 2: Press ↓ function key.
- Step 3: Press the FILE MANAGE function key.
- Step 4: Move the cursor the file to be copied and press [ENTER] to confirm.
- Step 5: When copying multiple files, repeat step 4-5.
- Step 6: After selecting the file, press ↓ key.
- Step 7: Press **COPY to E:** to copy the file the instrument.

NOTE: While copying the file, the progress bar will present the progress of the file copy.

When the progress bar is disappeared, the operation of the file copy is finished.

NOTE: Please make sure that your U-disk meets the standard that described in this chapter and no write-read protection.

4.24.4 Saving measurement results into USB memory

You can save measurement results obtained by the TH2638 into USB memory as .CSV files. You can later load your saved files into an application program running on a PC.

There are two modes for saving measurement results into the USB storage.

- **Continuous measurement mode**

Namely, the measurement results are saved into the memory buffer. After it, all the data will be saved into the USB disk;

- **Consecutive storage mode**

Namely, the measurement result will be saved into the USB storage after one measurement.

Measurement result format

Measurement Screen	Comparator	Result Format
One point	OFF	<Data A>,<Data B>,<Status>
One point	ON	<Data A>,<Data B>,<Status>,<BIN No.>
List	ON/OFF	<Data A>,<Data B>,<Status>,<IN/OUT>

The Data A and Data B fields of a measurement result file differ depending on whether the “effective digits” setting is on or off (controlled by the :FORMat:ASCii:LONG command).

Data A

Outputs the measurement data for the primary parameter.

The Data A field uses the following two different fixed-length ASCII formats:

When the “effective digits” setting is OFF: SN.NNNNNESNN
(:FORM:ASC:LONG OFF) (S:+/-, N:0 to 9, E: exponent character)

When the “effective digits” setting is ON: SN.NNNNNNNNNNESNN
(:FORM:ASC:LONG ON) (S:+/-, N:0 to 9, E: exponent character)

Data B

Outputs the measurement data for the secondary parameter.

The Data B field uses the following two different fixed-length ASCII formats:

When the “effective digits” setting is OFF: SN.NNNNNESNN
(:FORM:ASC:LONG OFF) (S:+/-, N:0 to 9, E: exponent character)

When the “effective digits” setting is ON: SN.NNNNNNNNNNESNN
(:FORM:ASC:LONG ON) (S:+/-, N:0 to 9, E: exponent character)

Status

Represents the measurement result status by using one of the following status values:

0	Measurement successfully completed.
+1	Overload.
+2	Defective goods or not connected

The Status field uses the following two-character fixed-length ASCII format: SN(S: +/- , N: 0~2)

NOTE: If the value is 1, the measurement data is 9.9E37; if the value is 0 or 2, the actual measurement data is output.

NOTE: The data buffer memory contains a measurement result with no data (as represented by the status value of -1), but it is excluded when the data is saved into USB memory.

Bin No. (IN/OUT)

Represents the bin sorting results as well as IN/OUT evaluation results in list sweep measurement, as shown below:

0	OUT_OF_BINS
+1 to +9	BIN 1 through BIN 9
+10	AUX_BIN
-1	LOW
0	IN
+1	HIGH

The <BIN No.> data output format is either 2- or 3-character fixed-length ASCII format: SN or SNN (S:+/-, N:0 to 2)

Example of measurement result output

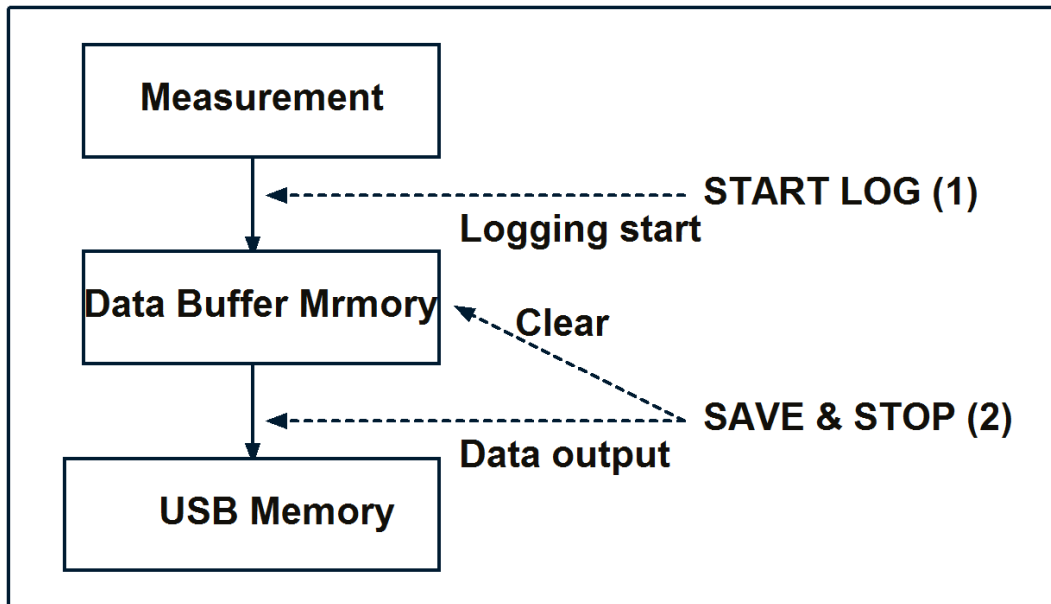
```
+1.059517689E-24,+1.954963777E+00,+0,+0
+9.706803904E-25,+2.095857894E-01,+0,+0
+2.172725184E-24,+2.072965495E-01,+0,+0
+3.660460872E-25,+7.172688291E+00,+0,+0
+1.135428381E-24,+6.490636201E-01,+0,+0
+1.384790632E-24,+2.193020669E+00,+0,+0
+3.829879310E-26,+2.788435221E+01,+0,+0
```

Save measurement results into USB memory (continuous measurement mode):

- Step 1. Plug a USB memory stick into the front USB port.
- Step 2. Press [LOG] function key.
- Step 3. Press the START LOG softkey and then press the following softkeys to enter the measurement results into the data buffer memory.
- Step 4. Start measurement. The data buffer memory is filled with up to 1000 sets of measurement results.
- Step 5. Press the SAVE & STOP softkey to save results into the USB

memory.

Step 6. When the data has been saved into the USB memory, a “Storing data completed: TH2638XXX.csv” message appears in the system message area.

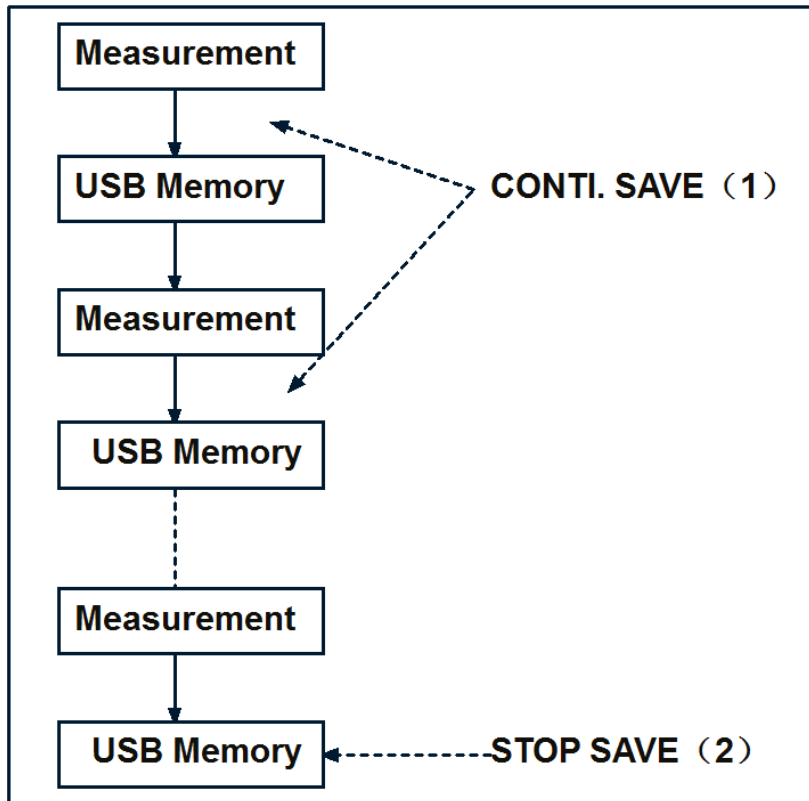


NOTE: Measurement result files are automatically assigned file names TH2638001.csv through ~TH2638999.csv and you cannot change the file names.

If the total size of the measurement result data exceeds the capacity of the data buffer memory, a “Data Buffer Overflow” error message is displayed. If this happens, press the SAVE & STOP softkey.

How to save the measurement result of List Sweep Measurement to USB memory (Consecutive storage mode):

- Step 1. Plug a USB memory stick into the front USB port.
- Step 2. Press [LOG] function key.
- Step 3. Press the START LOG softkey and start measurement.
- Step 4. The measurement result is saved to the USB storage after one measurement each time.
- Step 5. Press the SAVE & STOP softkey to save results into the USB memory.



NOTE: If the capacity of the USB memory device is large enough, the total amount of measurement data will not overflow.

4.24.5 Saving a Screenshot into USB Memory

The user can save the screenshot of the TH2638 display as a GIF file to the USB memory. The user can then download the saved file to a PC and open to browse.

TH2638 provides a quick screen capture function; users only need to press the [COPY] function button on the front panel to complete the screen capture operation.

Chapter 5 Correction

This chapter describes the operation method for different types of correction in TH2638.

5.1 Introduction of correction functions

TH2638 provides four types of correction functions: OPEN correction, SHORT correction, LOAD correction and compensation correction.

5.1.1 OPEN/SHORT/LOAD/compensation correction

The following table provides four types of correction functions: OPEN correction, SHORT correction, LOAD correction and OFFSET correction. The following table gives a brief description of each correction function:

Type of correction	Description
OPEN correction	Corrects errors caused by parallel stray admittance of the test fixture. This correction is based on the results of admittance measurement in the OPEN state which is performed in advance. OPEN correction can be performed at any frequency and the correction data remains valid for all measurement frequencies.
SHORT correction	Corrects errors caused by series residual impedance of the test fixture. This correction is based on the results of impedance measurement in the SHORT state which is performed in advance. SHORT correction can be performed at any frequency (120Hz/1 kHz/1MHz) and the correction data remains valid for all measurement frequencies.
LOAD correction	Corrects complex errors related to amplitude/phase errors, the scanner, and other factors caused by the cable and test fixture. This correction is based on the results of impedance measurement of the standard having a known value which is performed in advance. LOAD correction is frequency dependent and the correction data remains valid only for the measurement frequency at which the LOAD correction is applied. If the frequency is changed, the LOAD correction needs to be performed again.
OFFSET correction	Corrects errors between the actual measured value and the ideal value that the user desires. This is done by subtracting any value that the user enters from the measured result (for example, difference between a known standard value and its measured value, or instrument-by-instrument differences in the measured values of the same DUT).

5.1.2 Cable correction

Cable correction avoids measurement error due to the differences of each cable when you use a cable length of 1 m or 2 m in 1 MHz.

Measurement error due to an individual cable is proportional to the square of the test frequency. Accordingly, the difference of each test cables may not be ignored at high frequencies, such as 1 MHz. When the TH2638 is shipped from the factory, it contains typical correction data for both 1m and 2m cables. Cable correction can compensate the error for your own cable.

5.2 Turning ON/OFF correction function

You can turn ON/OFF each correction function separately.

5.2.1 Turning on OPEN correction

Use one of the following two ways to set the OPEN correction to ON:

Measuring data for OPEN correction

Execute measurement of the data for the OPEN correction. When the measurement is finished successfully, the OPEN correction is automatically set to ON.

Setting up ON/OFF directly

- Step 1. Press [SETUP] key.
- Step 2. Press CORRECTION softkey.
- Step 3. Use the cursor keys to select the OPEN field.
- Step 4. Press the ON softkey to turn ON the OPEN correction function.

NOTE: If you change the setup of the cable length or frequency shift (1 MHz) with the OPEN correction ON, the warning message “Need corr meas” appears and the OPEN correction is automatically set to OFF. Along with OPEN correction, SHORT and LOAD correction is set to OFF as well. You must again execute correction to ensure accurate measurement.

NOTE: When the measurement result becomes OVLD, “OVERLOAD” error is displayed and OPEN correction data is not updated.

5.2.2 Turning on SHORT correction

Use one of the following two ways to set the SHORT correction to ON:

Measuring data for SHORT correction

Execute measurement of the data for the SHORT correction. When the measurement is finished successfully, the SHORT correction is automatically set to ON.

Setting up ON/OFF directly

- Step 1. Press [SETUP] key.
- Step 2. Press CORRECTION softkey.
- Step 3. Use the cursor keys to select the SHORT field.
- Step 4. Press the ON softkey to turn ON the SHORT correction function.

NOTE: If you change the setup of the cable length or frequency shift (1 MHz) with the SHORT correction ON, the warning message “Need corr meas” appears and the SHORT correction is automatically set to OFF. Along with OPEN correction, SHORT and LOAD correction is set to OFF as well. You must again execute correction to ensure accurate measurement.

NOTE: When the measurement result becomes OVLD, “OVERLOAD” error is displayed and SHORT correction data is not updated.

5.2.3 Turning on LOAD correction

Use one of the following two ways to set the LOAD correction to ON:

Measuring data for LOAD correction

Execute measurement of the data for the LOAD correction. When the measurement is finished successfully, the LOAD correction is automatically set to ON.

Setting up ON/OFF directly

- Step 1. Press [SETUP] key.
- Step 2. Press CORRECTION softkey.
- Step 3. Use the cursor keys to select the LOAD field.
- Step 4. Press the ON softkey to turn ON the LOAD correction function.

NOTE: If you change the setup of the cable length or frequency shift (1 MHz) with the LOAD correction ON, the warning message “Need corr meas” appears and the LOAD correction is automatically set to OFF. Along with OPEN correction, SHORT and LOAD correction is set to OFF as well. You must again execute correction to ensure accurate measurement.

NOTE: When the measurement result becomes OVLD, “OVERLOAD” error is displayed and LOAD correction data is not updated.

5.2.4 Turning ON OFFSET correction

Use the following way to set the LOAD correction to ON:

- Step 1. Press [SETUP] key.
- Step 2. Press CORRECTION softkey.
- Step 3. Use the cursor keys to select the OFFSET field.
- Step 4. Press the ON softkey to turn ON the OFFSET correction function.

NOTE: If you change the setup of the measurement parameter with the OFFSET correction ON,

the OFFSET correction is automatically set to OFF.

You cannot separately set the ON and OFF states as the primary parameter and secondary parameter. You can set up separate ON/OFF states by setting the correction value of either parameter to 0.

5.3 Obtaining correction Data

5.3.1 Obtaining data for OPEN correction

The normal measurement operation data and the OPEN correction data are separated.

For Open correction, each frequency will be measured and each data frequency is saved. Therefore, even if the measurement frequency is changed there is no need to reset the correction.

Measurement conditions:

Measurement range mode: auto range mode

Measurement speed: 8

For other settings, such as averaging and trigger delay, the measurement conditions set up at execution are used for measurement.

5.3.2 Obtaining data for SHORT correction

The normal measurement operation data and the SHORT correction data are separated.

For SHORT correction, each frequency will be measured and each data frequency is saved. Therefore, even if the measurement frequency is changed there is no need to reset the correction.

Measurement conditions:

Measurement range mode: auto range mode

Measurement speed: 8

Output impedance of measurement signal source: 10 Ω

For other settings, such as averaging and trigger delay, the measurement conditions set up at execution are used for measurement.

5.3.3 Obtaining data for LOAD correction

Preparing the standard for LOAD correction

To measure the data for the LOAD correction, you must first prepare a device as the standard used for this measurement. You can use any device that has a stable known value as the standard. Also, the type of standard and the type of DUT can be different. For example, even if you measure a capacitor, you can use a resistor as the standard.

When using an existing standard:

Any device that has an accurate value (guaranteed as the specification) can be used as the standard.

When using a general Capacitance component as the standard:

If you cannot prepare an existing standard, value a general purpose device (capacitor, resistor, and so on) by using a Capacitance meter and use it as the standard. Notes on selecting a device to use as the standard are given below:

When you measure DUTs with a fixed impedance value, use a device with an impedance value close to the fixed value. On the other hand, when you measure DUTs of several different values, use a device whose impedance can be valued accurately within a range of approximately 100 to 1 k Ω .

Use a stable device that is not sensitive to factors of the measuring environment such as temperature and magnetic field.

You must value the standard as accurately as possible. The valuing procedure is described below:

Step 1: Connect the direct coupled test fixture to a Capacitance meter and execute OPEN/SHORT correction.

Step 2: Set the measurement frequency of the Capacitance meter to the frequency actually used when measuring the data for the LOAD correction.

Step 3: Set up the Capacitance meter under measurement conditions that allow high-accuracy valuing (measurement) (for example, setting up the measurement speed to 8 or increasing the averaging count).

Step 4: Connect a device you use as the standard to the direct coupled test fixture and perform the measurement. Use the obtained measured value as the standard for the LOAD correction.

Defining standard for LOAD correction (setting up LOAD reference value)

Before measuring the data for the LOAD correction, you must define the value of the standard used in LOAD correction. You can define the standard for the LOAD correction by using one the following parameter combinations.

Primary parameter	Secondary parameter
C _p	D , Q , G , R _p
C _s	D , Q , R _s

Defining parameters when using a resistance standard

When using a resistance standard (a standard that has been valued in the R-X format) as the standard for LOAD correction, you must convert it to the Cs-Rs format because the TH2638 does not allow you to enter a value directly in the R-X format as the definition value. The conversion expression is given below:

$$R_s = R$$

$$C_s = -\frac{1}{2\pi fX}$$

Where, f is the measurement frequency.

Definition procedure

The procedure to define the standard value for the LOAD correction is described below.

- Step 1: Press [SETUP] key.
- Step 2: Press CORRECTION softkey.
- Step 3: Use the cursor keys to select the LOAD Cp-D field.
- Step 4: Press the appropriate softkey (Cp-.../Cs-...) to select the primary parameter.
- Step 5: Press the appropriate softkey to select the secondary parameter.
- Step 6: Use the cursor keys to select REF A/B field.
- Step 7: Use the entry keys to enter the reference value for load.

Measurement conditions:

The data for the LOAD correction is measured under the following measurement conditions.

Measurement range mode: auto or fixed range mode

Measurement time mode: 8

For other settings, such as averaging and trigger delay, the measurement conditions set up at execution are used for measurement.

Measurement procedure

- Step 1: Connect the standard for the LOAD correction to the test fixture.
- Step 2: Press [SETUP].
- Step 3: Press CORRECTION softkey to display the correction page.
- Step 4: Use the cursor keys to select the LOAD field.
- Step 5: Press the MEAS LOAD softkey. The data for the LOAD correction is then measured. During the measurement, an “LOAD measurement in progress” message is shown on the display. When the measurement has finished, the “LOAD measurement in progress” message disappears.
- During the measurement, the ABORT softkey is shown. Use this key when you want to abort load correction.
- Step 6: When measurement of the data for LOAD correction is successfully completed, the LOAD correction turns to ON.

If the difference between the measured value and definition value of the standard for the LOAD correction exceeds 10%, the warning message “Out of limit” appears.

NOTE: Even if this warning message appears, data for the LOAD correction is still used. However, it is recommended to confirm that whether the connection between the test fixture and the UNKNOWN terminal as well as the measurement procedure is correct.

If a measurement failure occurs while measuring the data for correction, the error message “Correction Meas Aborted” appears.

NOTE: If this error occurs, the data used for correction remain without change before the measurement.

- Step 7: Use the cursor keys to select LOAD RNG field.
- Step 8: Use the following softkeys:
 - AUTO Turns ON the auto-ranging function when load correction is

executed.

- **FIX** Turns OFF the auto-ranging function.

When the load range is set at FIX, the selected measurement range is used at the LOAD measurement.

5.3.4 Selecting Single/Multiple Correction Mode

Functional Description

TH2638 can store up to 256 sets of OPEN/SHORT/LOAD correction data. In addition, it can store one set of the standard's reference value data at a specified frequency point. In multiple correction mode, you can switch among up to 256 data sets to carry out correction.

NOTE: The correction features default to single correction mode.

In multiple correction mode, the channel number for which correction data is selected.

Setting procedure

Step 1: Press [SETUP].

Step 2: Press CORRECTION function key.

Step 3: Use the cursor keys to select the MULTI CH field.

Step 4: Use function key to select it as ON or OFF.

Step 5: Use the cursor keys to select the CH No. field.

Step 6: Use the numeric key to input the channel number or using the function keys.

Step 7: Use the cursor keys to select the LOAD REF field.

Step 8: Using the following softkey:

- **SINGLE** Defines a single LOAD correction standard value commonly applied to all channels.
- **MULTI** Defines a LOAD correction standard value for each channel.

5.3.5 Setting data for offset correction

You can define a certain value and set it up as the data for OFFSET correction.

When the OFFSET correction is ON, taking the measured value before correction as Meas and the data for the OFFSET correction as Offset, the measured value is corrected as $\text{Meas} - \text{Offset}$. Therefore, to correct the measurement result to your desired value, set up the difference between the desired value and the measurement result as the data for the OFFSET correction. For example, to correct the current measured value of the primary parameter of 1.012 nF to the measured value of 1.000 nF, set up the data for the OFFSET correction for the primary parameter to 12 pF.

Setting procedure

Step 1: Press [SETUP].

Step 2: Press CORRECTION function key.

Step 3: Use the cursor keys to select the OFFSET field.

Step 4: Use function key to select it as ON or OFF.

Step 5: Use the cursor keys to select the OFFSET A or B field.

Step 6: Use the numeric key to input the desired correction value for primary/secondary

parameter.

The entered values are set up as the data for the OFFSET correction for the measurement frequency at the time of data entry.

5.4 Checking displaying/Setting up correction Data

5.4.1 Checking displaying/setting up data for OPEN correction

Displaying data/Selecting parameter format for OPEN correction

- Step 1: Press [SETUP] key.
- Step 2: Press CORRECTION function key.
- Step 3: Use the cursor keys to select the OPEN G-B field.
- Step 4: Select G-B or Cp-G which you required.
- Step 5: Use the right cursor keys to select A field.
- Step 6: Input your desired value for the primary parameter for OPEN.
- Step 7: Use the right cursor keys to select B field.
- Step 8: Input your desired value for the secondary parameter for OPEN.

5.4.2 Checking displaying/setting up data for SHORT correction

Displaying data/Selecting parameter format for SHORT correction

- Step 1: Press [SETUP] key.
- Step 2: Press CORRECTION function key.
- Step 3: Use the cursor keys to select the SHORT R-X field.
- Step 4: Select R-X or Ls-Rs which you required.
- Step 5: Use the right cursor keys to select A field.
- Step 6: Input your desired value for the primary parameter for SHORT.
- Step 7: Use the right cursor keys to select B field.
- Step 8: Input your desired value for the secondary parameter for SHORT.

5.4.3 Checking displaying/setting up data for LOAD correction

The parameter format of LOAD correction data depends on the parameter format of the standard value for the LOAD correction and cannot be selected independently.

Setting up data for LOAD correction

- Step 1: Press [SETUP] key.
- Step 2: Press CORRECTION function key.
- Step 3: Use the cursor keys to select the LOAD Cp-D field.
- Step 4: Select Cp... or Cs... which you required.
- Step 5: Use the right cursor keys to select A field.
- Step 6: Input your desired value for the primary parameter for LOAD.
- Step 7: Use the right cursor keys to select B field.

Step 8: Input your desired value for the secondary parameter for LOAD.

5.5 Avoiding mistakes related to work in obtaining correction data

To avoid simple work-related mistakes in measuring the data for OPEN/SHORT/LOAD correction (for example, setting up the OPEN state and SHORT state inversely), it is important to confirm that the measured data is correct.

Using warning messages

If the measured data is out of the valid range shown in below table when measuring the data for OPEN/SHORT/LOAD correction, the warning message “OVERLOAD” appears, which allows you to detect an error of the measured data.

NOTE: The valid ranges are fixed and cannot be changed. Even after the warning message is displayed, the correction data is still be used.

Type of correction	Valid range
OPEN correction	$ Y < 20 \mu\text{S}$
SHORT correction	$ Z < 20 \Omega$
LOAD correction	$ Z_{\text{ref}} \times 0.9 < Z < Z_{\text{ref}} \times 1.1$

In the table, Y is the measured admittance value, Z is the measured impedance value, and Zref is the definition value of the standard for the LOAD correction.

Chapter 6 Executing Measurement

6.1 Starting (triggering) Measurement

The method used to start (trigger) measurement varies depending on the setup of the trigger mode, as shown in the following table:

Trigger mode	Instruction
Internal trigger (INT)	The internal trigger is used to generate a trigger.
Manual trigger (MAN)	Pressing the [Trigger] key on the front panel generates a trigger.
External trigger (EXT)	Inputting an external trigger signal through the Ext Trig terminal, handler interface, or scanner interface to generate a trigger.
BUS trigger (BUS)	The instrument performs one cycle of measurement each time it receives a trigger command sent via GPIB/LAN/USB.

NOTE: the instrument ignores any trigger that is input during the measurement cycle. Be sure to trigger the instrument when it is not in a measurement cycle.

6.1.1 Setting the trigger mode

- Step 1: Press [SETUP] key.
Step 2: Use the cursor keys to select the TRIG field.
Step 3: Press the corresponding function key to select the required trigger mode.

6.1.2 Perform successive measurements automatically

Select the internal trigger mode, in this mode, measurements are automatically repeated, triggered by the internal trigger signal.

6.1.3 Specifying measurement time

Generating a trigger manually

- Step 1: Select manual trigger mode.
Step 2: Press [MEAS] key.
Step 3: Press [Trigger] key to make a single measurement.

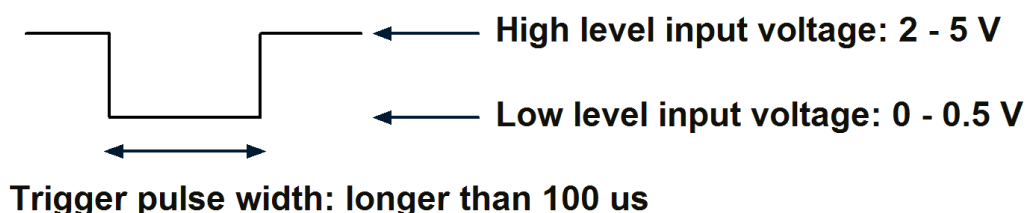
Generating a trigger with an external signal

Step 1: Select external trigger mode.

Step 2: Press [MEAS] key.

Step 3: Input a trigger signal (TTL pulse signal) from the Ext Trig terminal on the rear panel or input EXT_TRIG through the handler/scanner interface to perform a single measurement.

The trigger signal input from the Ext Trig terminal on the rear panel must meet the following requirements (input voltage and pulse width).



Step 4: To repeat measurement, repeat Step 3.

Selecting polarity for BNC external trigger

Step 1: Press [SYSTEM] key.

Step 2: Use the cursor keys to select EXT TRIG POL field.

Step 3: Use the following softkeys:

- POS Specifies positive edge trigger
- NEG Specifies negative edge trigger

NOTE: Setting the trigger polarity for BNC external trigger on the rear panel does not affect the trigger signal on handler/scanner interface.

6.1.4 Inputting the trigger signal

Any trigger signal will not be recognized until measurement with the previous input trigger is finished (the $\text{\AA OM}$ signal turns to LOW)

If a trigger signal is input twice (double trigger), only the first one is valid.

6.2 Tips for more accurate measurement

You can use the following techniques to increase the measurement accuracy.

6.2.1 Setting the measurement time to 8

Set the measurement time to 8, which provides better measurement accuracy.

6.2.2 Selecting an appropriate measurement range

When in fixed range mode, select the measurement range so that measurement is performed

within the recommended range.

6.2.3 Using correction function

The OPEN correction eliminates the error due to the parallel stray admittance of the measurement cable and test fixture.

The SHORT correction eliminates the error due to the series residual impedance of the measurement cable and test fixture.

The LOAD correction eliminates the complex error due to the amplitude/phase error of the measurement cable and test fixture, scanner, and so on.

6.2.4 Improving measurement stability

In a high-noise measurement environment, you can obtain more reliable measurement results by performing averaging.

6.2.5 Using a four-terminal pair in measurement

You can use four-terminal pair measurement to eliminate measurement errors.

6.2.6 Using frequency shift

When two or more TH2638 are used in a single system, you can shift the 1 MHz measurement frequency (by +1%, -1%, 0%, -2%, or +2%) to avoid interference between the measurement signals. If the specified value is out of allowable setup range, the maximum value or minimum value is set.

6.3 Tips for higher measurement speed

You can use the following techniques to increase the measurement time.

6.3.1 Set the measurement time to 1

Set the measurement time to 1, which provides a shorter measurement time.

6.3.2 Setting measurement range mode to the fixed range

If you set the measurement range mode to the auto range, the measurement time is lengthened because a ranging time is required. Therefore, setting a fixed range can improve the measurement speed.

6.3.3 Turning OFF display

Turning OFF display can shorten the measurement computation time (EOM).

6.3.4 Decreasing the average time

If you use the averaging function, set the averaging time to as small a value as possible.

6.3.5 Setting the trigger delay time to 0

If you do not use the trigger delay function, set the trigger delay time to 0.

6.3.6 Reducing the waiting time for analog measurement

TH2638 has the capability to reduce the waiting time for analog measurement. The waiting time is included in the analog measurement time. This is a system default measurement delay time. When waiting time is reduced, the measurement accuracy is not guaranteed.

6.3.7 Turning off the status register update

When the status register is OFF, the measurement computation time can be reduced to 0.7ms (the measurement computation time is 1ms when status register is ON).

Chapter 7 Limit setup (comparator function)

This chapter describes how to use the function that performs sorting based on the measured results (comparator function).

Introduction of Comparator Function

The comparator function of TH2638 lets you set up to 9 limit ranges for the primary parameter (BIN1 to BIN9) and 1 limit range for the secondary parameter and sort the DUTs into up to 11 categories: BIN1 to BIN9, OUT_OF_BINS or AUX_BIN. If you need only simple pass/fail judgment and do not need BIN sorting, use the comparator function while setting up only 1 limit range for the primary parameter (BIN1) (and, if necessary, 1 limit range for the secondary parameter) to judge whether the measured result of the DUT falls into the specified limit range.

You can specify the upper and lower limit values for the primary parameter with not only absolute values but also relative values (deviation) from the reference value (nominal value).

The sorting judgment result of the comparator function is displayed on the screen and also output from the handler interface. In addition, you can read out the sorting judgment result from an external controller by using the SCPI command together with the measured value.

You can use the BIN count function to count the number of DUTs sorted into each BIN, display the counts on the screen, and read them out with the SCPI command.

7.1 Turning ON/OFF Comparator Function

The ON/OFF state of the comparator function also controls the ON/OFF state of the output of the handler interface signal.

Setup steps:

1. Press SETUP key.
2. Press LIMIT TABLE function key.
3. Use the cursor key to select COMP field.
4. Press ON/OFF to turn on or off the comparator function.

7.2 Setting up sorting judgment conditions

7.2.1 Clearing (resetting) limit ranges

Clearing the limit ranges returns the settings of the following items to the factory-default preset values.

- ON/OFF, lower limit value, and upper limit value of all limit ranges (BIN1 to BIN9 and secondary parameter limit range)
- Limit range designation method

- Reference value for the tolerance mode

Setup steps:

1. Press SETUP key.
2. Press LIMIT TABLE function key.
3. Use the cursor key to select BIN field.
4. Press CLEAR TABLE to clear the limit ranges.

7.2.2 Selecting a limit range designation method

Two methods can be used to designate the limit ranges for the primary parameter (BIN1 to BIN9). One is to designate the limit boundary value using an absolute value (absolute mode) and the other is to designate it using a relative value (deviation) from the reference value (nominal value) (tolerance mode). The tolerance mode is further divided into a method to designate the deviation using an absolute value (absolute tolerance mode) and a method to designate the deviation using the percentage of the reference value (percent tolerance mode).

NOTE: Only the absolute mode can be used to designate the secondary parameter limit range.

Function key	Mode	
OFF	Absolute	
ΔAB	Tolerance mode	Absolute tolerance mode
$\Delta\%$		Percent tolerance mode

Setting the limit range designation method and reference value

1. Press SETUP key.
2. Press LIMIT TABLE function key.
3. Use the cursor key to select MODE field.
4. Use the following function key:

Function key	Function
OFF	Switches the comparator into absolute mode.
ΔABS	Switches the comparator into tolerance mode based on absolute value.
$\Delta\%$	Switches the comparator into tolerance mode based on deviation percentages.

5. Use the cursor keys to select NOM field and then set the reference value for absolute tolerance mode or percent tolerance mode.
6. Enter the limit value using the numeric keys. If you use the entry keys to enter the value, the softkey labels change to unit labels (p, n, u, m, x1).

Relationship between the limit range designation method and the setup value

The limit ranges are shown in Figure 7-1 and Figure 7-2 respectively. The compare setup values and limit designation methods are shown in Table 7-1 and Table 7-2 respectively.

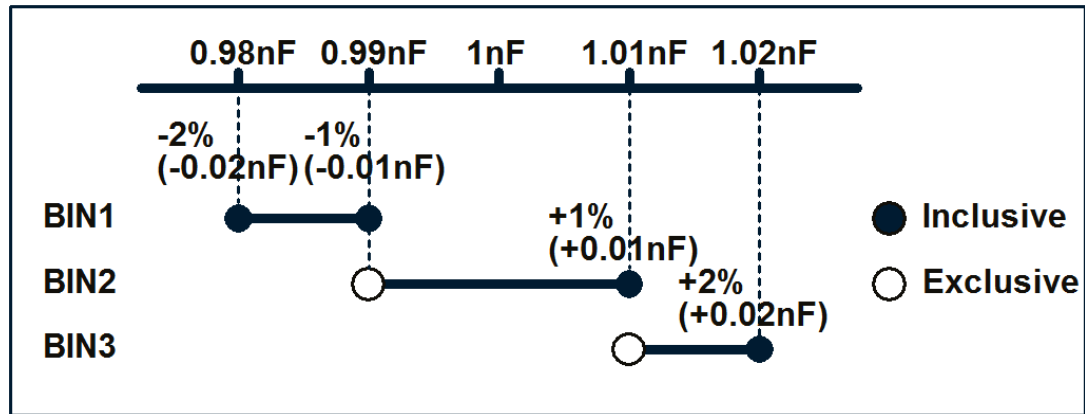


Figure 7-1 Example of limit range settings

	Absolute mode		Tolerance mode (reference value: 1 nF)			
			Absolute		Percent	
	Lower limit value	Upper limit value	Lower limit value	Upper limit value	Lower limit value	Upper limit value
BIN1	0.98nF	0.99nF	-0.02nF	-0.01nF	-2%	-1%
BIN2	0.99nF	1.01nF	-0.01nF	+0.01nF	-1%	+1%
BIN3	1.01nF	1.02nF	+0.01nF	+0.02nF	+1%	+2%

Table 7-1 Lower and upper limit values of limit ranges

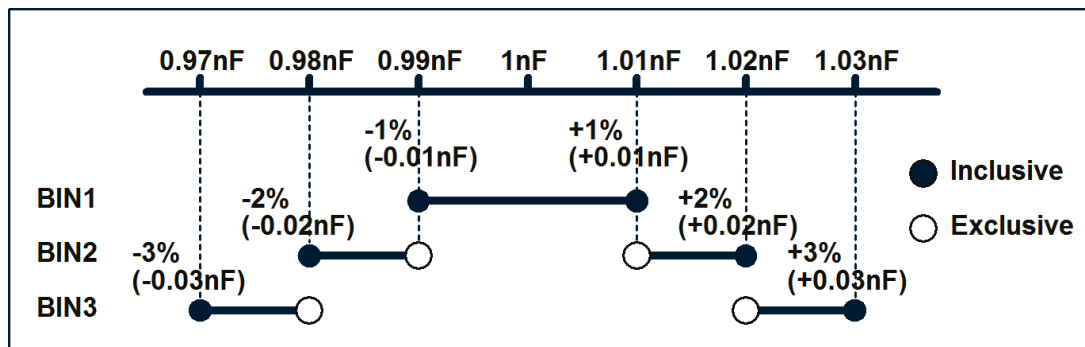


Figure 7-2 Example of limit range settings

	Absolute mode		Tolerance mode (reference value: 1 nF)			
			Absolute		Percent	
	Lower limit value	Upper limit value	Lower limit value	Upper limit value	Lower limit value	Upper limit value
BIN1	0.99nF	1.01nF	-0.01nF	+0.01nF	-1%	+1%
BIN2	0.98nF	1.02nF	-0.02nF	+0.02nF	-2%	+2%
BIN3	0.97nF	1.03nF	-0.03nF	+0.03nF	-3%	+3%

Table 7-2 Lower and upper limit values of limit ranges

7.2.3 Setting up limit ranges

Attention on setup

- If the upper limit value is set to a value equal to or less than the lower limit value, this limit range will not be used. This operation is equivalent to setting the limit range to OFF.
- If BINs overlap, the resulting measurement is sorted into the BIN of the smallest number (refer to Figure 7-5, “Sorting judgment flow”). Therefore, you need to set up the limit ranges starting from the narrowest to the widest as shown in Figure 7-2.
- For the tolerance mode, the reference value is not required to be within the limit range (between the lower limit value and upper limit value).
- Gaps between the limit ranges are allowed. Therefore, you can set up the limit ranges as shown in Figure 7-3.

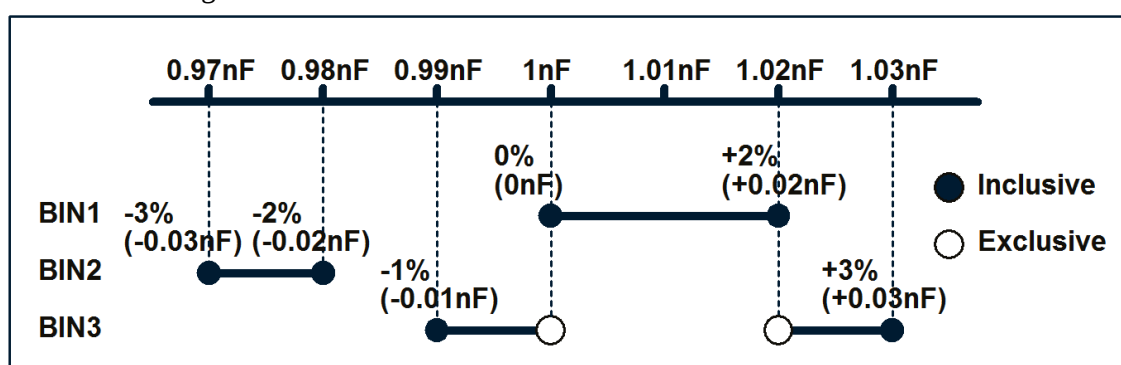


Figure 7-3 Example of gap between limit ranges

	Absolute mode		Tolerance mode (reference value: 1 nF)			
			Absolute		Percent	
	Lower limit value	Upper limit value	Lower limit value	Upper limit value	Lower limit value	Upper limit value
BIN1	1nF	1.02nF	0nF	+0.02nF	0%	+2%
BIN2	0.97nF	0.98nF	-0.03nF	-0.02nF	-3%	-2%
BIN3	0.99nF	1.03nF	-0.01nF	+0.03nF	-1%	+3%

Table 7-3 Lower and upper limit values of limit ranges

NOTE: When the low limit value is greater than the upper limit, a warning message “Improper high/low limits” is displayed.

Setting steps for BIN1~BIN9 (ON/OFF and lower and upper limit values)

1. Press SETUP key.
2. Press LIMIT TABLE function key.
3. Use the cursor key to select BIN1 field.
4. Press ON/OFF/CLEAR LINE function key.
5. Repeat Step 3 to Step 4 using the cursor keys until you have turned ON the other bins.

6. Use the cursor key to select BIN1 LOW field.
7. Enter the limit value using the numeric keys. When you enter the value, the softkey labels change to unit labels (p, n, u, m, k, M, x1).
 - You can enter the lower limit value and then the higher limit value is automatically changed to LOW*1.
 - You can enter the higher limit value and then the lower limit value is automatically changed to HIGH* (-1).
 - You can clear all the limit values and sets the status to OFF for your selected bin by pressing the CLEAR LINE softkey.
8. Use the cursor keys to select the BIN 1 HIGH field.
9. Enter the limit value using the numeric keys. When you enter the value, the softkey labels change to unit labels (p, n, u, m, k, M, x1).
10. Repeat Step 6 to Step 9 until you have entered the lower and upper limit values for other bins.

Procedure to set up secondary parameter limit range (ON/OFF and lower and upper limit values)

1. Press SETUP key.

Primary parameter sorting result	AUX BIN	Sorting result
----------------------------------	---------	----------------

2. Press LIMIT TABLE function key.
3. Use the cursor key to select BIN2nd field.
4. Press ON/OFF/CLEAR LINE function key.
5. Use the cursor key to select 2nd LOW field.
6. Enter the limit value using the numeric keys. When you enter the value, the softkey labels change to unit labels (p, n, u, m, k, M, x1).
 - You can enter the lower limit value and then the higher limit value is automatically changed to LOW*1.
 - You can enter the higher limit value and then the lower limit value is automatically changed to HIGH* (-1).
 - You can clear all the limit values and sets the status to OFF for your selected bin by pressing the CLEAR LINE softkey.
7. Use the cursor keys to select the BIN 1 HIGH field.
8. Enter the limit value using the numeric keys. When you enter the value, the softkey labels change to unit labels (p, n, u, m, k, M, x1).

7.2.4 Setting up AUX function

If the secondary parameter limit range is ON, the sorting result varies according to the ON/OFF state of the AUX function (Table 7-4).

BIN1 to BIN9	OFF	OUT_OF_BINS
	ON	AUX_BIN
Not sorted to any BINs	No relation	OUT_OF_BINS

Table 7-4 Sorting result

Setup procedure

1. Press SETUP key.
2. Press LIMIT TABLE function key.
3. Use the cursor key to select AUX field.
4. Use the function key to select ON/OFF state of the AUX function.

7.3 Judgment of Low Measured Results

TH2638 has a function to detect extremely low measured primary parameter values (Cp or Cs) that are equal to or less than the preset boundary value (Low C). This is called the Low C reject function.

NOTE: When the comparator function is ON, normal sorting judgment will be performed even if Low C is detected. However, the sorting judgment result displayed on the screen is LOWC and, on the handler interface, the /LOWC_OR_NC signal becomes active (low level) in addition to the sorting judgment result.

7.3.1 Turning ON/OFF Low C reject function

Setting procedure

1. Press SETUP key.
2. Use the cursor key to select LOW C field.
3. Use the function key to select ON/OFF.

7.3.2 Setting up limit of Low C reject function

Set the percentage of the measurement range (full scale) as the limit of the Low C reject function. The applicable measurement range varies depending on the setting of the measurement range mode:

For the auto range mode

The minimum measurement range is applicable regardless of whether the measurement is actually performed. Specifically, the following is the minimum range under different frequencies:

- When measurement frequency is 100Hz/120 Hz: 10E-9F (10 nF) range
- When measurement frequency is 1 kHz: 100E-12F (100 pF) range

- When measurement frequency is 10kHz: 100E-12F (100 pF) range
- When measurement frequency is 100 kHz: 10E-12F (100 pF) range
- When measurement frequency is 1 MHz: 1E-12F (1 pF) range

For the fixed range mode

The measurement range currently selected is the range in which the measurement is actually performed.

For example, if you make a measurement with the 1 μ F range fixed and set the limit to 1%, Low C is detected when the measured primary parameter value (C_s or C_p) is equal to or less than 10 nF.

Setting procedure

1. Press SETUP key.
2. Use the cursor key to select LOW C field.
3. Use the numeric keys or function keys to enter the limit value. When you enter the value, the function key unit label changes to (%).

7.4 Reading out Sorting Judgment Result

The sorting judgment is obtained through the comparator function according to the flow shown in Figure 7-5.

Figure 7-4 shows the relationship between the screen display and the sorting result.

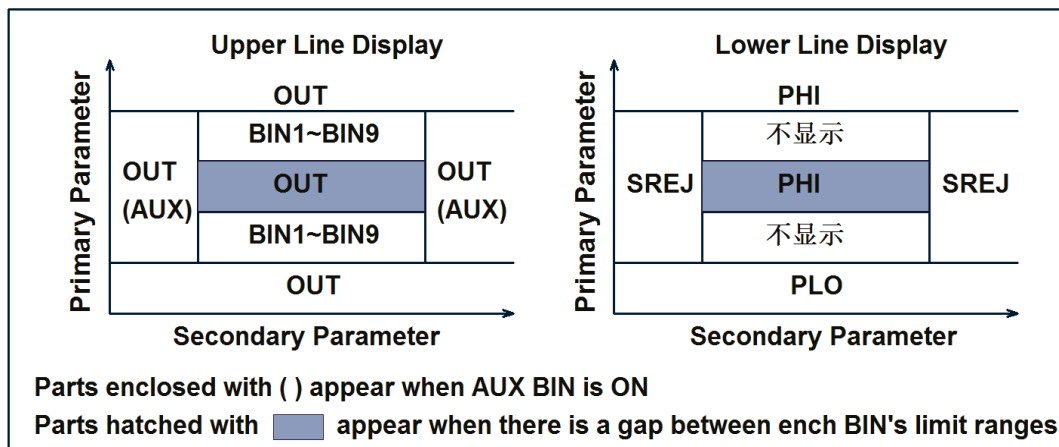


Figure 7-4 Relationship between display output and comparator sorting result

NOTE: If an overload is detected, the sorting judgment cannot be performed and therefore ---- is displayed in the upper row. If Low C reject is detected, normal sorting judgment is performed but LOWC is displayed in the upper row instead of the sorting judgment result (OUT, AUX, or BIN1 to BIN9).

NOTE: The sorting judgment result can be read out through the SCPI command.

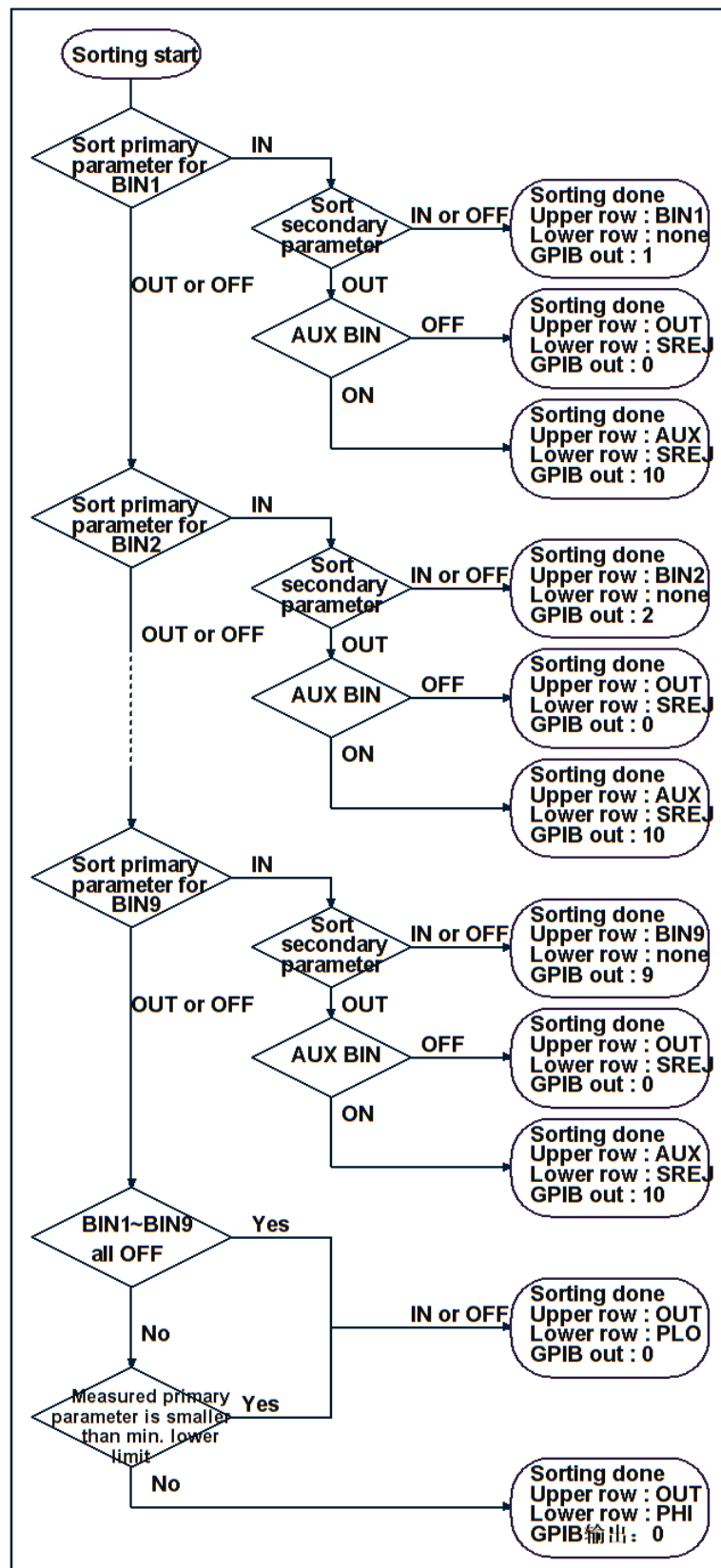


Figure 7-5 Sorting judgment flow

7.5 Reading out sorting count of each BIN (BIN count function)

You can count the number of DUTs sorted into each BIN by turning ON the BIN count function. The maximum value of the count is 999999. The count will remain at 999999 if this value is exceeded (it does not return to 0).

When the MULTI correction function is ON, channel-by-channel count is performed separately. You can read out the result by using the SCPI command.

NOTE: You can read all the BIN count values using the following command: `CALCulate1:COMParator:COUNT:DATA?` For more information, refer to the command chapter.

NOTE: The overload count value can be read only through the SCPI command and cannot be displayed on the screen.

Setting procedure

The BIN count value is displayed in the BIN COUNT DISPLAY page.

1. Press MEAS key.
2. Press BIN COUNT key.
3. Use the cursor key to select COUNT zone.
4. Use the following function key:

Function key	Instruction
COUNT ON	Turns on the count function.
COUNT OFF	Turns off the count function.
RESET COUNT	Resets the count function.

NOTE: Clearing the BIN count values initializes all of the count values to 0.

NOTE: When the MULTI correction function is ON, the BIN count value for each channel can be checked only through SCPI command and cannot be displayed on the screen.

NOTE: When the MULTI correction function is set as ON, the overload count value of each channel can be read by using the following SCPI command: `CALCulate1:COMParator:COUNT:MULTi:OVLD?`. For more information, refer to the command chapter.

7.6 Making a beep for sorting judgment result

You can set the conditions for making a beep sound based on the sorting judgment result:

- Makes a beep when the sorting judgment result is OUT_OF_BINS, AUX_BIN or OVLD and LOWC_OR_NC.
- Makes a beep when the sorting judgment result is BIN1 to BIN9.

You can also disable the beep sound.

Chapter 8 HANDLER Interface

The handler interface of TH2638 can output the measurement end signal, the sorting result of the comparator function, and other data from the TH2638, as well as input an external trigger signal or a key lock signal to the TH2638. This chapter also gives information required to configure an auto-sorting system that combines the TH2638 and a handler in using the handler interface and the comparator function.

8.1 Output of Comparator Sorting Result

When the comparator function is ON, the comparator sorting result is output through the handler interface. Figure 8-1 and Table 8-1 show the relationship between the comparator sorting result and the output signals of the handler interface.

NOTE: When the comparator function is OFF, no signals are output, except for /INDEX, /EOM, and /ALARM. /INDEX and /EOM stay LOW. When the comparator is ON, /ALARM signal will be output when an error occurs.

When the trigger mode is set to the external trigger (EXT), regardless of the ON/OFF state of the comparator function, EXT_TRIG signal is active. When /KEY_LOCK is LOW, regardless of the ON/OFF state of the comparator function, the key lock state remains unchanged.

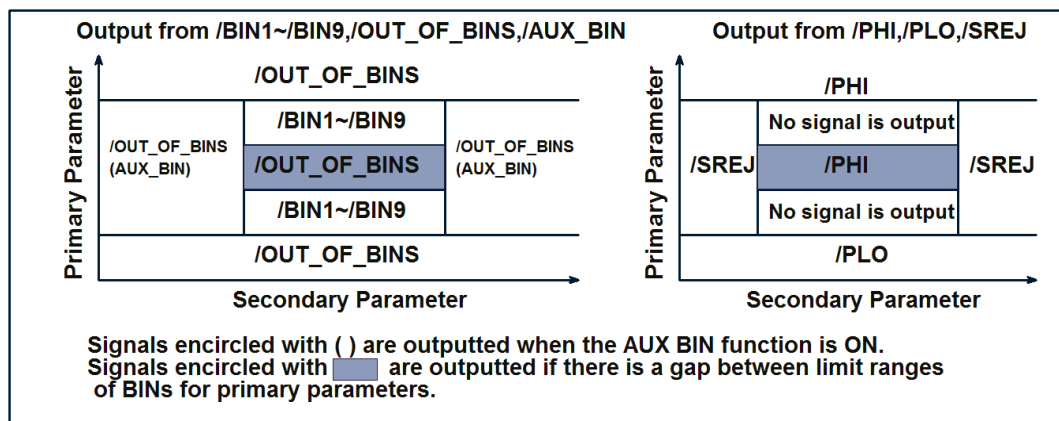


Figure 8-1 Output of comparator sorting result to the HANDLER interface

Measurement status	Judgment result				Handler interface signals that become active	GPIB output		
	Primary parameter		Secondary parameter			Measurement status	Measured value	BIN sorting result
No error	IN	B	IN		/BIN1	0	Measured value	1
		B			/BIN2			2
		B			/BIN3			3
		B			/BIN4			4
		B			/BIN5			5
		B			/BIN6			6
		B			/BIN7			7
		B			/BIN8			8
		B			/BIN9			9
	One of BIN1 To BIN9	OUT	AUX BIN: OFF	/OUT_OF_BINS /SREJ	0			
			AUX BIN: ON	/AUX_BIN /SREJ	10			
	OUT	Less than the	N/A		/OUT_OF_BINS /PLO			
Oth er than		/OUT_OF_BINS /PHI						
Overload	Cannot be sorted.				/OVLD	1	9.9E37	11
Low C					/LOWC_OR_NC	2	Measured value	1-10
No Contact	Cannot be sorted				/LOWC_OR_NC	2	9.9E37	11

Table 8-1 Relationship between comparator sorting result and output signals of the handler interface

8.2 Input/Output signal pin assignment

Figure 8-2 shows the input/output signal pin assignment of the handler interface connector. Table 8-2 gives a description of the input/output signals.

NOTE: A slash (/) symbol preceding signal names indicates that this signal is negative logic (active low).

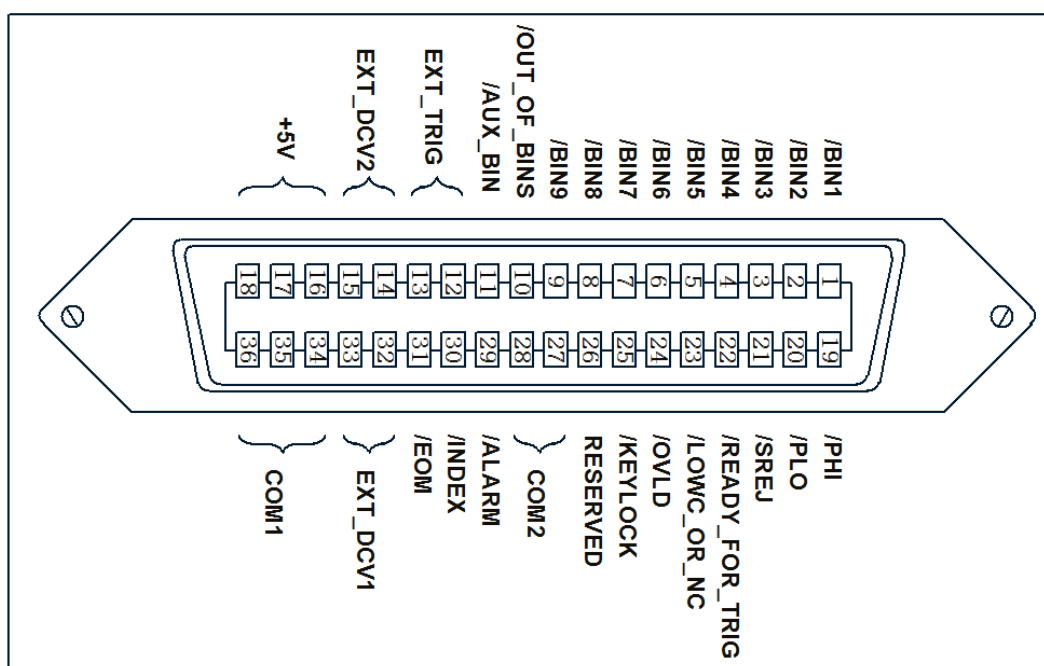


Figure 8-2 Pin assignment of the handler interface connector

Pin number	Signal name	Input/output	Description
1	/BIN1	Output	Sorting judgment signals. A BIN signal of the sorting result (one of pin numbers 1 - 11) becomes LOW. These signals are based on the open-collector output.
2	/BIN2		
3	/BIN3		
4	/BIN4		
5	/BIN5		
6	/BIN6		
7	/BIN7		
8	/BIN8		
9	/BIN9		
10	OUT_OF_BINS		
11	/AUX_BIN		
12,13	EXT_TRIG	Input	External trigger signal. These signals are used in the external trigger mode. It will be triggered when the pulse reaches the rising edge. When this pin is not be used, connect the pin to GND.

14,15	EXT_DCV2	Input	External DC voltage. This supplies the voltage to the input signals (EXT_TRIG and /KEYLOCK) and the operation output signals (/ALARM, /INDEX, /EOM, and /READY_FOR_TRIG). The input voltage range is between +5V and +24V.
16,17,18	+5V	Output	Internal DC voltage.
19	/PHI		Primary-parameter-upper-limit-exceeded signal. When the upper limit of BIN1 - BIN9 is exceeded, this signal becomes LOW.
20	/PLO		Primary-parameter-lower-limit-not-reached signal. When the lower limit of BIN1 - BIN9 is not reached, this signal becomes LOW.
21	/SREJ		Secondary-parameter-out-of-limit signal. If the secondary parameter is out of the limit, this signal becomes LOW.
22	/READY_FOR_TRIG		Trigger-acceptable signal. When a trigger-signal-acceptable state is established, this signal becomes LOW. When the trigger mode is internal trigger, this signal cannot be output.
23	/LOWC_OR_NC		Low-C-reject-detection and contact detection signal. For Low-C-Reject, if the measured Cp or Cs result is equal to or less than the preset boundary value (percentage of the measurement range), this pin value becomes LOW. If the measurement value becomes very less i.e 9.99E37, Pin 23 becomes LOW.
24	/OVLD		Measurement failure signal. This signal is low when the analog measurement mechanism is unable to perform measurements (due to overload).
25	/KEY_LOCK	Input	“Key lock” signal. When this signal is input, the front panel buttons of the TH2638 are all disabled.
26	RESERVED	---	Unused
27,28	EXT_DCV1	Input	External direct voltage. This pin function is not used by TH2638.

29	/ALARM	Output	An error signal was detected. This signal is displayed when an instantaneous power failure is detected. This signal is also displayed when the HANDLER interface board is reset.
30	/INDEX		Analog measurement end signal. This signal is displayed when the analog measurement ends. This means that once HANDLER receives the signal, the next DUT can be connected to the UNKNOWN terminal. However, measurement data is not supplied before the /EOM signal is output.
31	/EOM		"Measurement cycle end" signal. When this signal is output, measurement data and classification results are provided.
32,33	COM2	---	Common signal of external DC current EXT_DCV2.
34,35,36	COM1		Common signal of external DC current EXT_DCV1.

Table 8-2 Description of the handler interface input/output signals

8.3 Timing diagram

Figure 8-3 shows the TH2638's ineffective signal output during the unpredictable time period and after the end of the analog measurement. For detailed measurement time, please refer to Table 8-3.

Table 8-3.

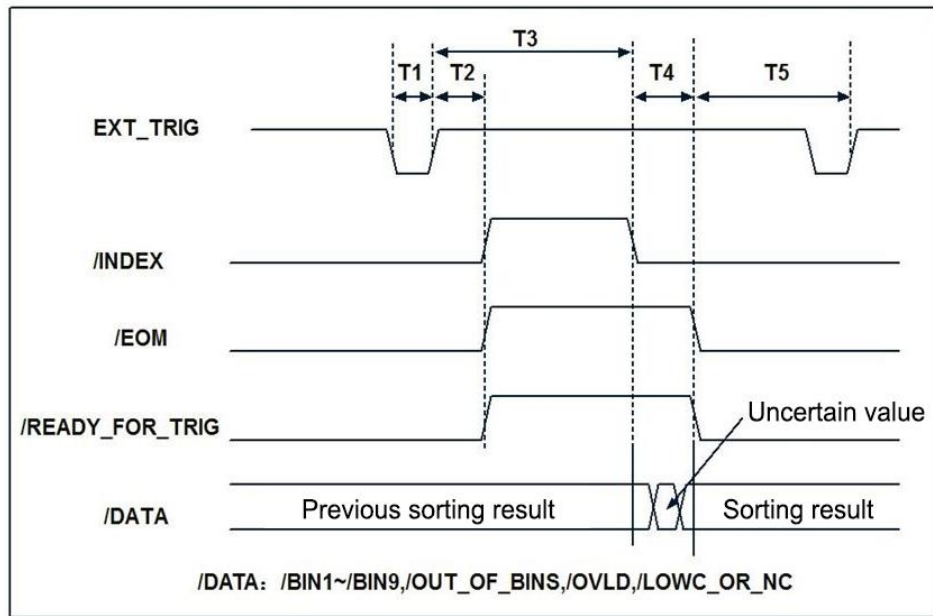


Table 8-3 HANDLER Interface Timing Diagram

			Measure Time	Mini.	Typical Value
T1	Trigger pulse width		N/A	1us	---
T2	/READY_FOR_TRIG,/INDEX,/EOM Trigger response time		N/A	---	40us
T3+T4	Measurement Time	T3 Analog measurement time	1(100Hz)	---	10.0ms
			1(120Hz)	---	10.0ms
			1(1kHz)	---	2.2ms
			1(10kHz/40kHz)	---	2.3ms
			1(100kHz)	---	1.6ms
			1(1MHz)	---	1.3ms
		T4 Measuring calculation time	N/A	---	0.75ms
T5	Trigger Wait Time		N/A	0us	---

Figure 8-3 Time of Timing Diagram

8.4 List Scan signal line

When the HANDLER interface is used with the list scan comparator, the following signal definitions are used.

The signal definitions used when using the processor interface in the list scan comparator:

- Test result output signal

The signals /BIN1~/BIN9 and AUX_BIN represent the IN/OUT test results at scan points 1~10, respectively.

/OUT_OF_BINS indicates that the DUT is qualified/failed.

These signals are output at the end of the scan cycle

- Control output signal

The output timing of the /INDEX (analog measurement end) and /EOM (measurement cycle end) signals differs depending on the scan mode of the list scan (the characteristics of these signals are different when the comparator is used).

1. **SEQ scan mode**

Output /INDEX when the last analog measurement of the scan cycle is completed. Output /EOM when all comparator test results become available after the scan cycle are over.

2. **STEP scan mode**

Output /INDEX after the end of the analog measurement step in each step of the scan cycle. Output /EOM when all measurements in each step of the scan cycle (including the measurement time) are completed.

Table 8-4, Figure 8-4, and Figure 8-2 show the connector pin layout and comparator signal description for the list scan comparator.

Pin#	SignalName	Signal Direction	Explanation
1	/BIN1	Output	A fault occurred at scan point 1 (out of limit)
2	/BIN2		A fault occurred at scan point 2 (out of limit)
3	/BIN3		A fault occurred at scan point 3 (out of limit)
4	/BIN4		A fault occurred at scan point 4 (out of limit)
5	/BIN5		A fault occurred at scan point 5 (out of limit)
6	/BIN6		A fault occurred at scan point 6 (out of limit)
7	/BIN7		A fault occurred at scan point 7 (out of limit)
8	/BIN8		A fault occurred at scan point 8 (out of limit)
9	/BIN9		A fault occurred at scan point 9 (out of limit)
10	/OUT_OF_BINS		Output the signal when the DUT fails at any scanning point within one scan cycle
11	/AUX_BIN		A fault occurred at scan point 10(out of limit)
19-21	N.U.	---	Unused (Always off when high level)
30	/INDEX	Output	SEQ scan mode: Output this signal when the last analog measurement of the scan cycle is completed. This means that once the processor receives the signal, the next DUT can be connected to the UNKNOWN terminal. However, the measurement data is not provided before the /EOM signal is output. STEP scan mode: Output this signal at the end of the analog measurement at each scan point of the scan cycle. This means that once the processor receives the signal, the instrument can proceed to the next scan point. However, measurement data is not provided before the EOM signal is output.
31	/EOM		SEQ scan mode: output this signal at the end of the scan cycle. Therefore, the measurement data and the classification result are provided when the signal is output. STEP scan mode: This signal is output when the measurement at each scan point ends (including the

			comparator test time) and the corresponding measurement data is provided. The comparator test result is provided after the /EOM signal of the last scan point is output.
12-18 22-29 32-36			Its function is the same as the comparator

Table 8-4 List scan comparator pin distribution map

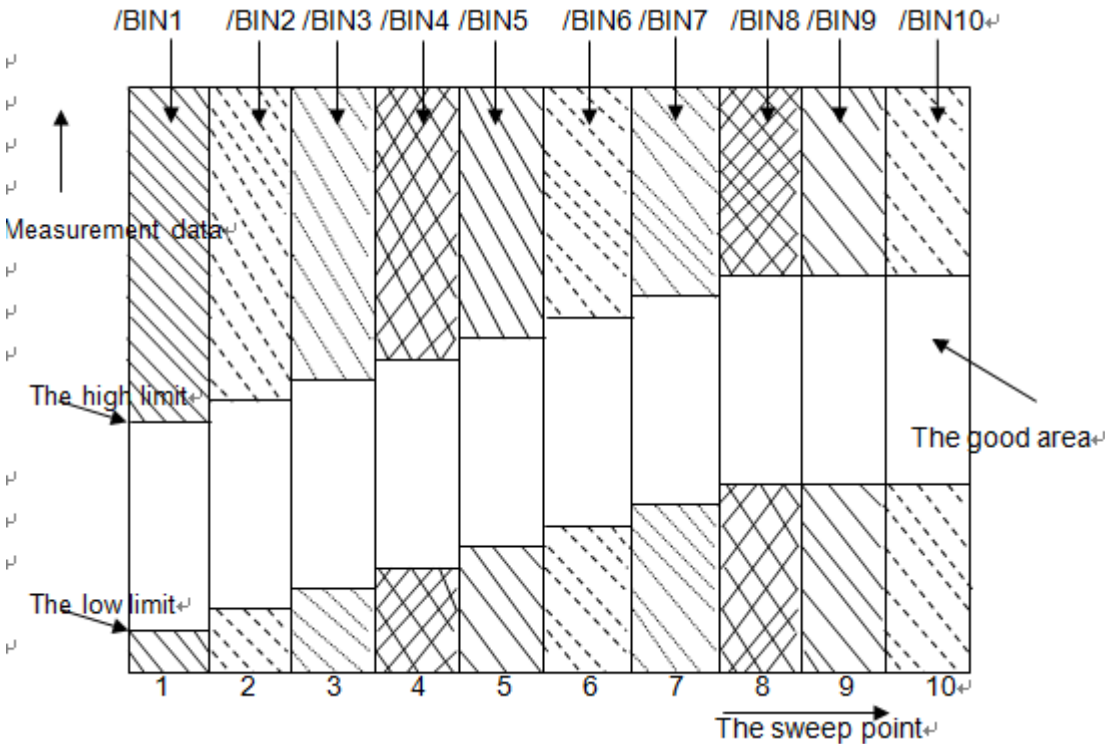


Figure 8-4 List sweep comparator signal area

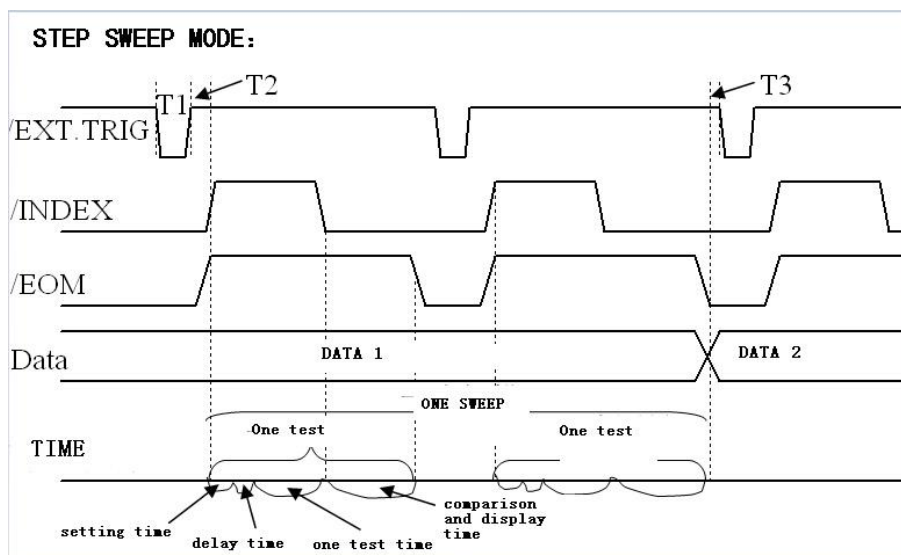
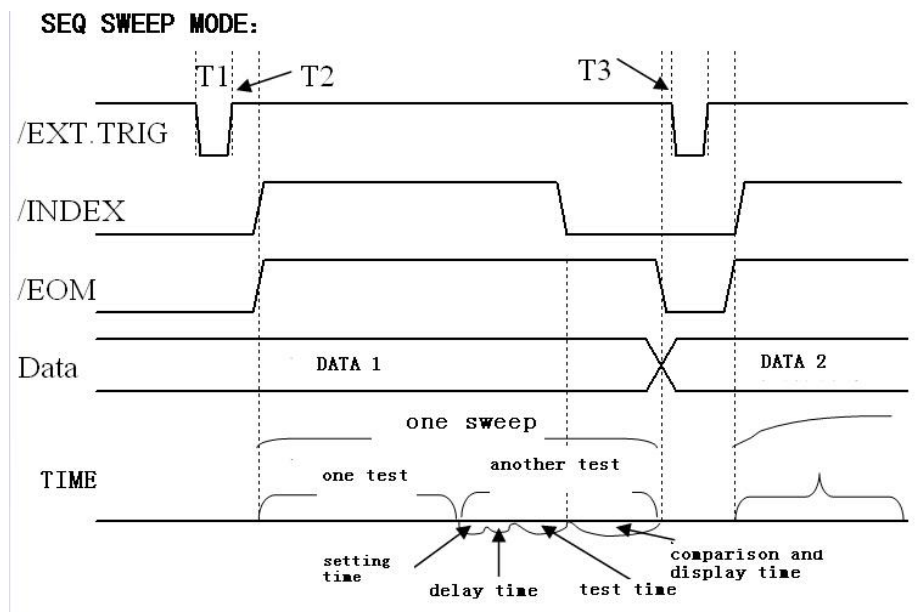


Figure 8-5 List scan comparator timing diagram

	Time	Mini.	Typical
T1	Trigger pulse width	1us	---
T2	/INDEX and /EOM response times for measurement time	0s	40us
T3	Trigger wait time after output/EOM	0s	---

Table 8-5 Time in list scan comparator timing diagram

8.5 Electrical Characteristics

8.5.1 Output Signal

The output signal is isolated by an open collector optocoupler. Users can refer to Table 8-6 to use various DC voltages as external pull-up resistors for the TH2638.

Pull-up voltage (V)	Resistance Value (Ω)	recommended resistance value (Ω)
5	1.7k(5V/3mA)	1.78k
9	3.0k(9V/3mA)	3.16k
12	4.0k(12V/3mA)	4.22k
15	5.0k(15V/3mA)	5.11k
24	8.0k(24V/3mA)	8.25k

Table 8-6 recommended pull-up resistor value

The output signals are divided into two categories: test result output signals and control output signals. The user sets different input voltages for them. Table 8-7 shows the electrical characteristics of the output signal. Figure 8-6 and Figure 8-7 show the circuit connections for the test result output signal and the control output signal.

Output Signal	Output Voltage (V)		Max.Current (mA)
	Low Level	High Level	
Test result output signal: /BIN1~/BIN9,/AUX_BIN,OUT_OF_BINS,/PHI, /PLO,/SREJ,/OVLD,/LOWC_OR_NC	0~0.5	+5V~+24V	6
Control output signal: /INDEX,/EOM,/READY_FOR_TRIG,/ALARM	0~0.5	+5V~+24V	6

Table 8-7 Electrical characteristics of the HANDLER interface output signal

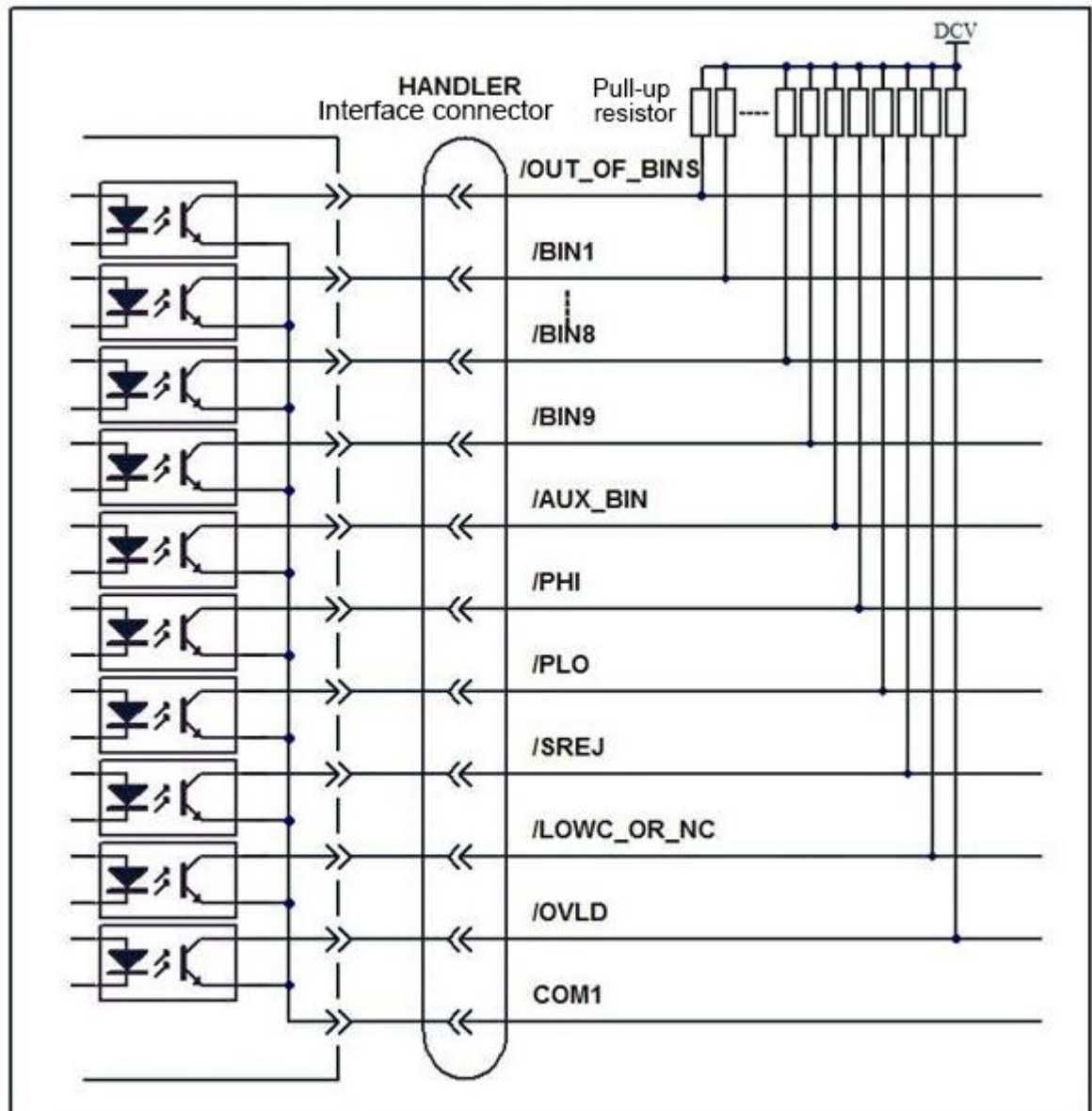


Figure 8-6 Test result output signal circuit block diagram

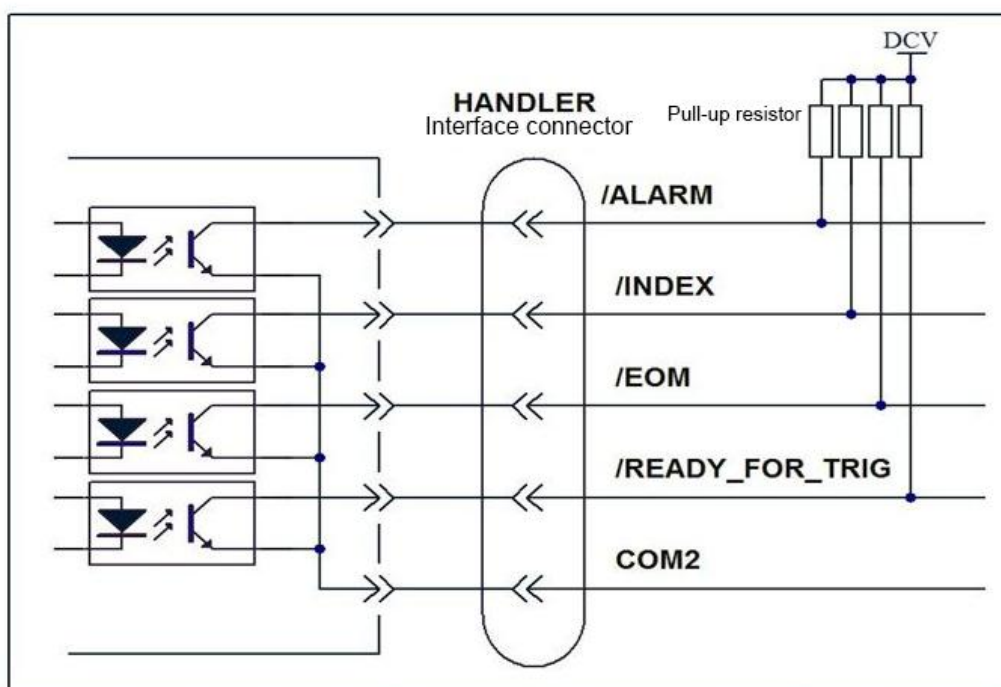


Figure 8-7 Control output signal circuit block diagram

8.5.2 Input Signal

Each input signal is connected to the cathode of the optocoupler LED. The anode of the optocoupler LED is connected to a voltage source. The electrical characteristics of the input signal are shown in Table 8-8, and the circuit connections are shown in Figure 8-8. The current flowing through the LED depends on the voltage source supplied and the internal resistance connected in series to the optocoupler.

Input Signal	Input Voltage (V)		Mini. Input Current (mA)			
			Power Source: DCV2			
	Low Level	High Level	5V	12V	15V	24V
EXT_TRIG	0~1	DCV2	11.0	11.7	12.1	12.9
/KWY_LOC K			2.2	6.0	7.7	12.7

Table 8-8 Electrical characteristics of the HANDLER interface input signal

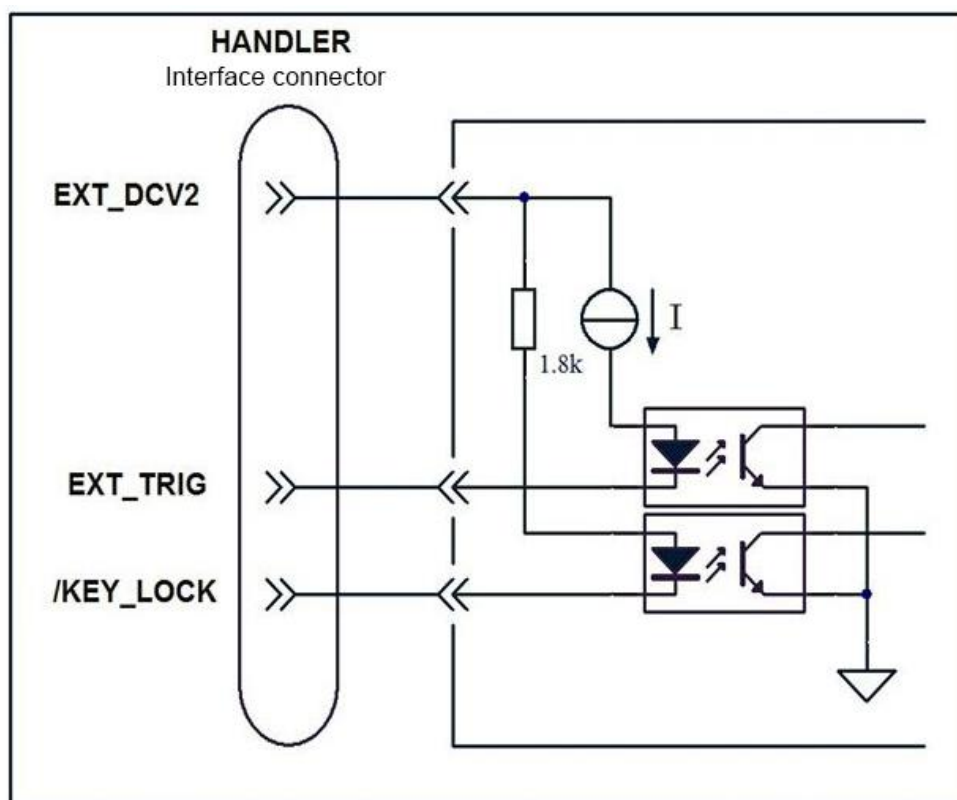


Figure 8-8 HANDLER interface input signal connection

Note: The string I on the EXT_TRIG signal line in the figure is a circuit with an approximate constant current source, the output current I is calculated as:

$$I \approx 12(mA)$$

Chapter 9 SCAN Interface

The user can scan the measured input/output timing control signals through the scan interface or select to correct each scan channel. This chapter describes the configuration using the scan interface and multi-channel calibration.

9.1 Use Multi-Channel Correction

TH2638 provides the ability to allow users to pre-measure before measurement or to recall calibration data from up to 256 calibration data sets. This function performs open/short/load correction for each channel scanned, avoiding errors caused by different measurement paths. This feature therefore provides a highly reliable measurement.

9.1.1 Turn multi-channel correction on/off

When the user turns on the multi-channel correction function, the correction data of each channel is measured by the square in the “Measurement Multiple Correction Data”, and the correction data is used to compensate the error.

Note: The on/off status of the multi-channel correction function is controlled by the on/off status of the scan interface. When the multi-channel correction function is turned off, the input channel number (/CH0~/CH7, /CH_VALID) of the scan interface is ignored, and the /INDEX and /EOM signals are low. When the trigger mode is set to the external trigger mode (EXT), the external trigger function is valid regardless of whether the multi-path correction function is turned on.

Steps for turning the multi-channel correction function ON/OFF

Step 1: Press the [SETUP] key.

Step 2: Press the User Correction function key.

Step 3: Use the cursor keys to select a multi-channel area.

Step 4: Use the function keys to turn this feature on/off.

9.1.2 Select one channel

Use the front panel to select a channel

Step 1: Press the [SETUP] key.

Step 2: Press the User Correction function key.

Step 3: Use the cursor keys to select the channel number area.

Step 4: Use the numeric input keys to enter, or the function key to input.

Fuction Key	Explanation
++	Increase the channel number in steps of 10
+	Increase the channel number in steps of 1

-
- Decrease the channel number in steps of 1
 - Decrease the channel number in steps of 10

Select channel through scan interface

The channel is selected by using the /CH0~/CH7 and /CH_VALID signal lines of the scan interface. The signal line of /CH0~/CH7 is represented by the binary of high level (0) and low level (1) to indicate the channel number. /CH7 signal line is the most significant bit, /CH0 is the least significant bit. For example, if the /CH7 signal is low and the other signal lines /CH0~/CH6 are all high, it means that the channel number is selected as 128; if the /CH0~/CH1 signal line is low, the other signal lines /CH2~/CH7 are all High, select channel number 3.

The /CH_VALID signal line enables or disables the setting of the /CH0~/CH7 signal lines. If the /CH_VALID signal line is low, a channel that sets the trigger setting signal to set TH2638 is generated by specifying the channel number from the /CH0~/CH7 signal lines.

Can be set by the following steps:

Step 1: Set the /CH_VALID signal line to high.

Step 2: Set a channel number through the /CH0~/CH7 signal lines.

Step 3: Set the /CH_VALID signal line to low.

Step 4: Generate a trigger.

Note: The mode of channel selection determines the timing of the execution.

When a channel is selected via the front panel or SCPI command, the selection is performed immediately. When using the /CH0~/CH7 and /CH_VALID signal lines of the scan interface, the channel number selection will be executed only when a trigger is generated.

9.1.3 Measuring multiple calibration data

Figure 9-1 shows the basic flow of measuring the open/short/load correction data for the Multiplex function

Note: The user cannot initialize the calibration data for the multi-channel correction function. Even if the reset signal is turned off or the power is turned off, the measurement multiplexed correction data is corrected and the data is still valid.

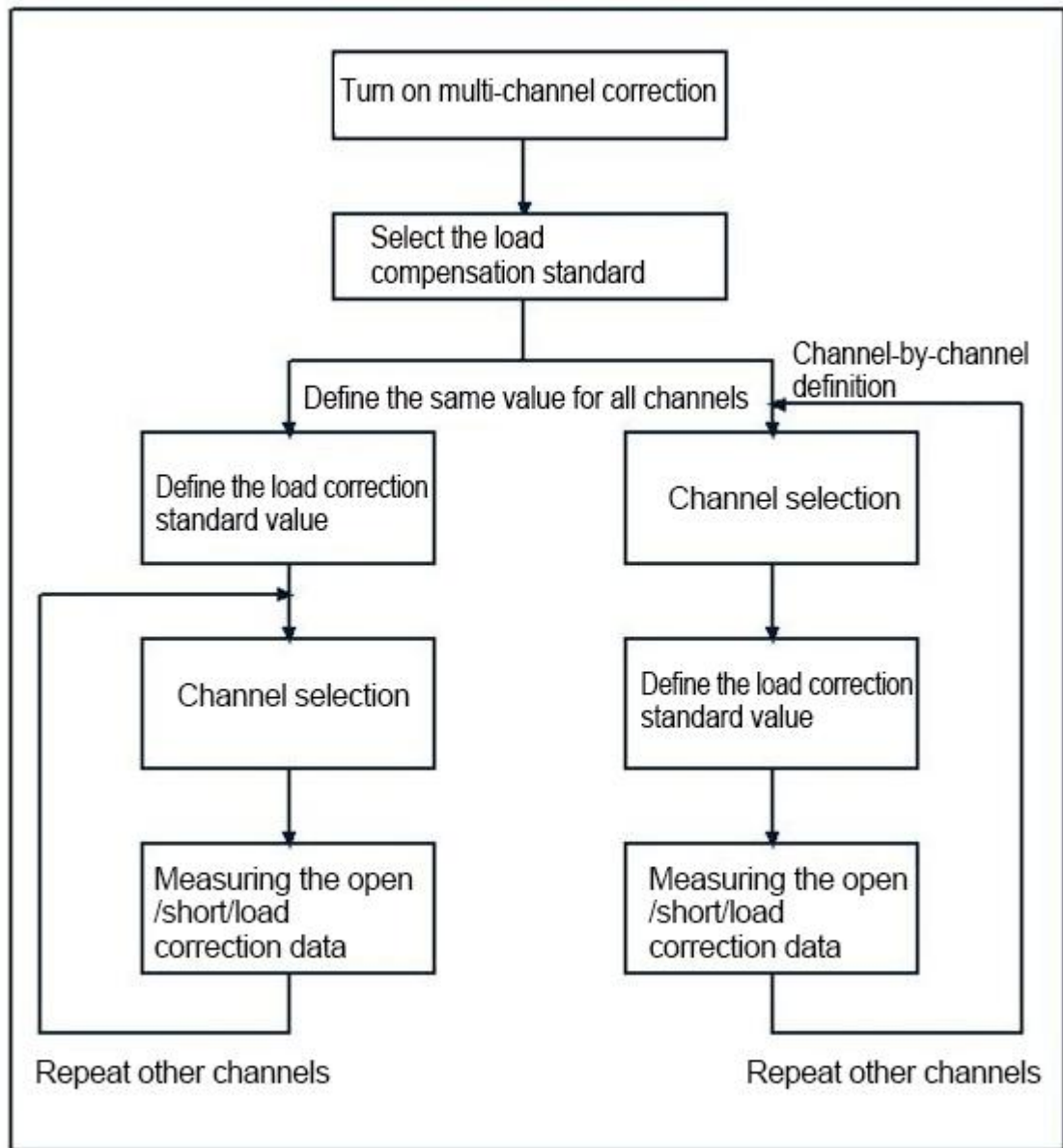


Figure 9-1 Multi-channel correction function test flow

Select the method defined by the load correction standard

The user can choose how to define the load correction standard value (LOAD correction reference value): either define a value for each channel or define the same value for all channels. If the user selects a channel-by-channel definition, the reference value entered by the user is the reference value for that channel. If the user selects all channels to define the same value, the value is stored as the reference value for all channels selected when setting the value.

The setup steps are as follows:

Step 1: Press the [SETUP] key.

Step 2: Press the user to correct the function key

Step 3: Use the cursor keys to select the load reference area.

Step 4: Use the function keys to select the single or multiple you want.

Measure open/short/load correction data

The process of measuring the open/short/load correction data is the same as the usual correction

data, except that it is necessary to select a channel number to be corrected before the measurement. When the user measures the open/short/and multi-correction function load correction data, the measured value is stored as the correction data of the current measurement channel.

Check open/short/load correction data

The procedure for checking the open/short/load correction data is the same as the usual calibration, except that you need to select a channel number you want to view before checking.

9.2 Input/output pin assignment

Figure 9-2 shows the scan interface I/O pin assignments. Table 9-1 shows the definition of the input/output pins.

Note: A signal with a forward slash (/) in front of the signal line indicates that the signal is negative logic (active low).

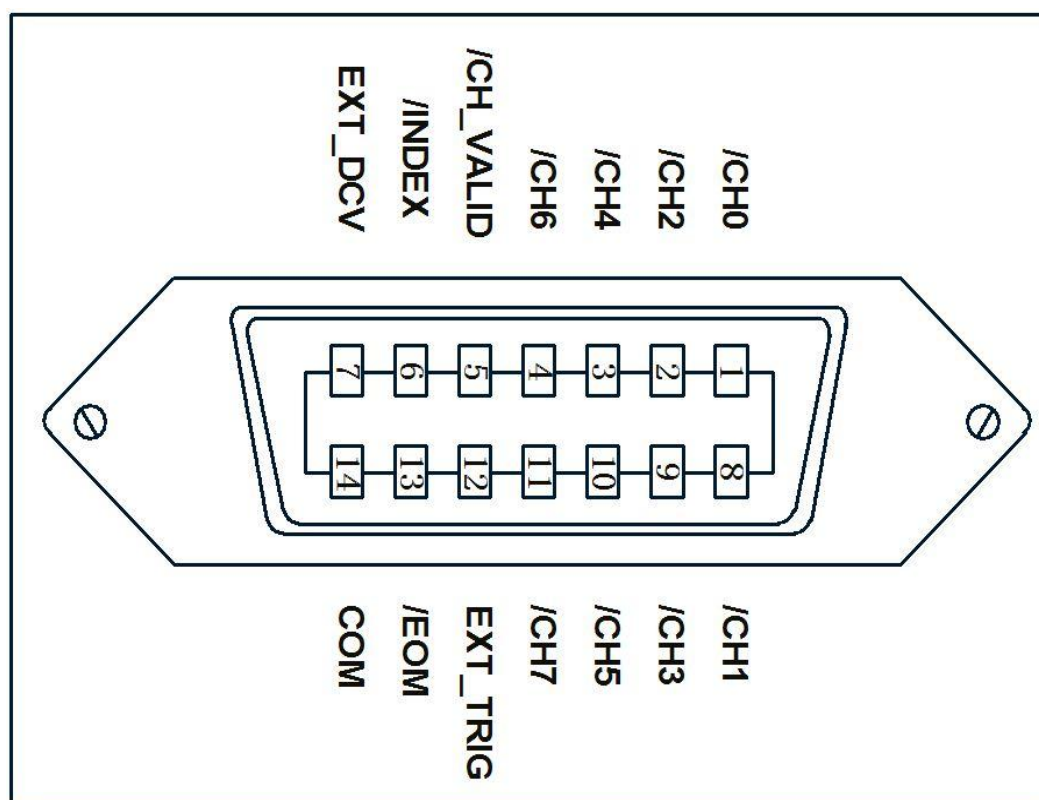


Figure 9-2 Scan interface connector pin assignment

Pin#	Pin Name	Signal Direction	Explanation
1	/CH0	Input	Channel selection signal (8-bit binary input). Select the correction data corresponding to the scanner channel. The most significant bit is /CH7 and the least significant bit is /CH0.
2	/CH2		
3	/CH4		
4	/CH6		
5	/CH_VALID		Channel valid signal. This signal is low to generate a trigger that makes the channel set by the channel select signal active.
6	/INDEX	Output	The analog measurement ends. Since this type of signal is asserted at the end of the analog measurement, the channel can be switched to the next one. However, measurement data is not available until the EOM is identified.
7	EXT_DCV	Input	External DC voltage
8	/CH1		Channel selection signal (8 bits, binary input). Select the correction data corresponding to the scanner channel. The most significant bit is /CH7 and the least significant bit is /CH0.
9	/CH3		
10	/CH5		
11	/CH7		
12	EXT_TRIG		External trigger signal. These signals are used in the external trigger mode. Trigger when the pulse reaches the rising edge. When this pin is not used, this pin should be connected to GND.
13	/EOM	Output	The measurement is over. Since this type of signal is asserted at the end of a series of measurements, the TH2638 goes to the next measurement. When such signals are identified, the measurement data and the comparison results are valid.
14	COM	---	Common signal of external DC current EXT_DCV.

Table 9-1 Scan interface input / output pin definition instructions

9.3 Timing Diagram

Figure 9-3 shows the measurement timing diagram of the scan interface. T1~T5 in the figure are the various times in the measurement cycle, as shown in the following table:

		Mini.	Typical
T1	Trigger pulse width	1us	---
T2	/INDEX and /EOM trigger response time	---	60us
T3	Channel number input hold time	---	0us
T4	Channel number input setting time	---	0us
T5	Trigger wait time	---	0us

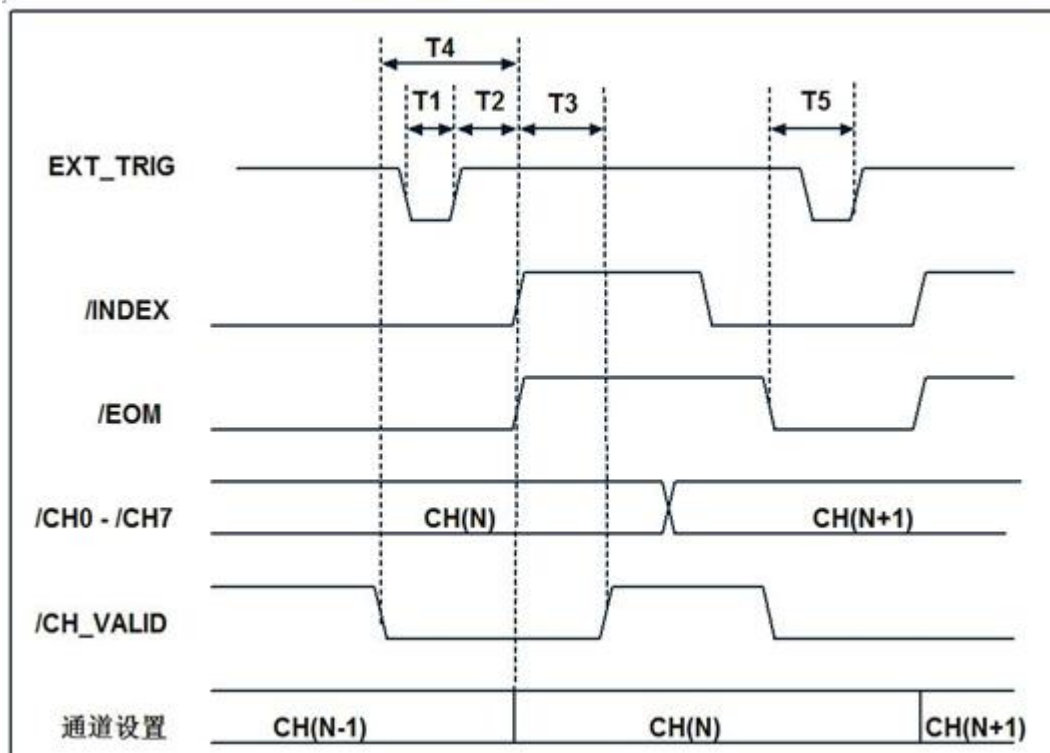


Figure 9-3 Scan interface timing diagram

CH (N): Measurement of the N th channel

CH (N-1): Measurement of the (N-1) th channel

CH (N+1): Measurement of the (N+1) th channel

9.4 Electrical characteristics

9.4.1 Output signal

The output signals (/ INDEX and / EOM) are connected to the optocoupler isolated collector open output. The output of each voltage can be obtained by connecting a pull-up resistor (see Table 9-2) to the TH2638's scan interface.

Pull-upVoltage (V)	ResistanceValue (Ω)	Recommended resistance value (Ω)
5	1.7k(5V/3mA)	1.78k
9	3.0k(9V/3mA)	3.16k
12	4.0k(12V/3mA)	4.22k
15	5.0k(15V/3mA)	5.11k
24	8.0k(24V/3mA)	8.25k

Table 9-2 recommended pull-up resistance value

The electrical characteristics of the output signals are given in Table 9-3.

Figure 9-4 shows the circuit connection diagram for the output signal.

Output Signal	Output Voltage (V)		Maximum current (mA)
	Low Level	High Level	
/INDEX,/EOM	0-0.5	EXT_DCV* ¹	6

*1.EXT_DCV range: +5V~+15V

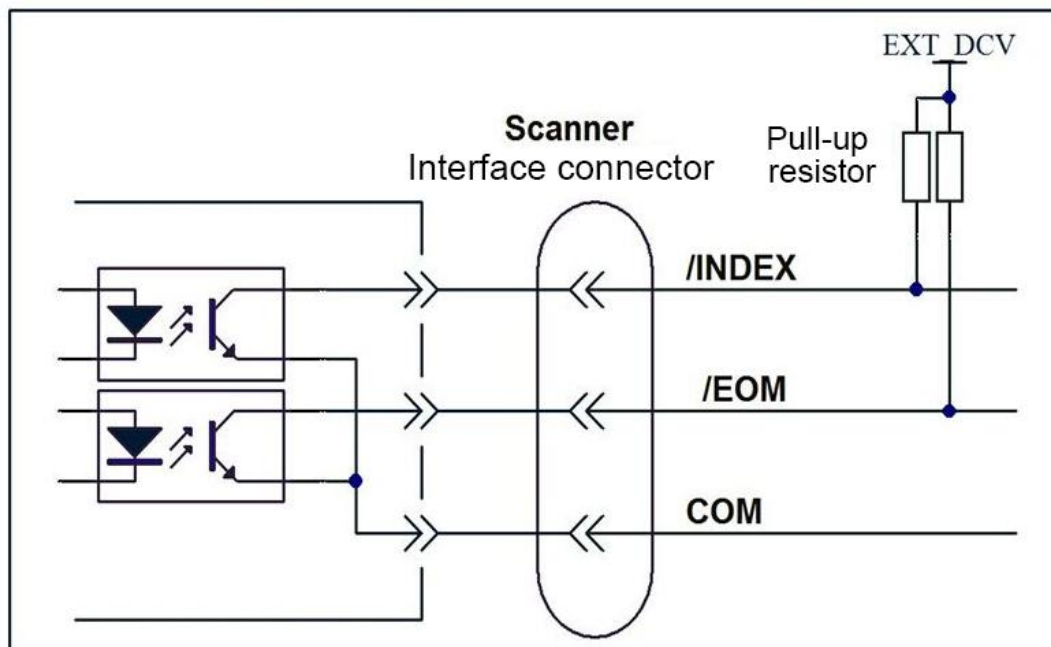


Figure 9-4 Scan interface output signal circuit connection diagram

9.4.2 Input signal

Each input signal is connected to the cathode side of the LED of the optocoupler. The anode side of the LED is connected to the voltage of the drive source. Table 9-4 shows the electrical characteristics of the input signal. Figure 9-5 shows the circuit connections for the input signal. The setting of the drive source voltage determines the current flowing through the LED.

Input Signal	Input Voltage (V)		Minimum input current (mA) (Typical)		
			power source: EXT_DCV		
	Low Level	High Level	5V	9V	15V
/CH0~/CH7, /CH_VALID	0~1	EXT_DCV	4.7	9.5	16.8
EXT_TRIG			1.7	3.4	6.1

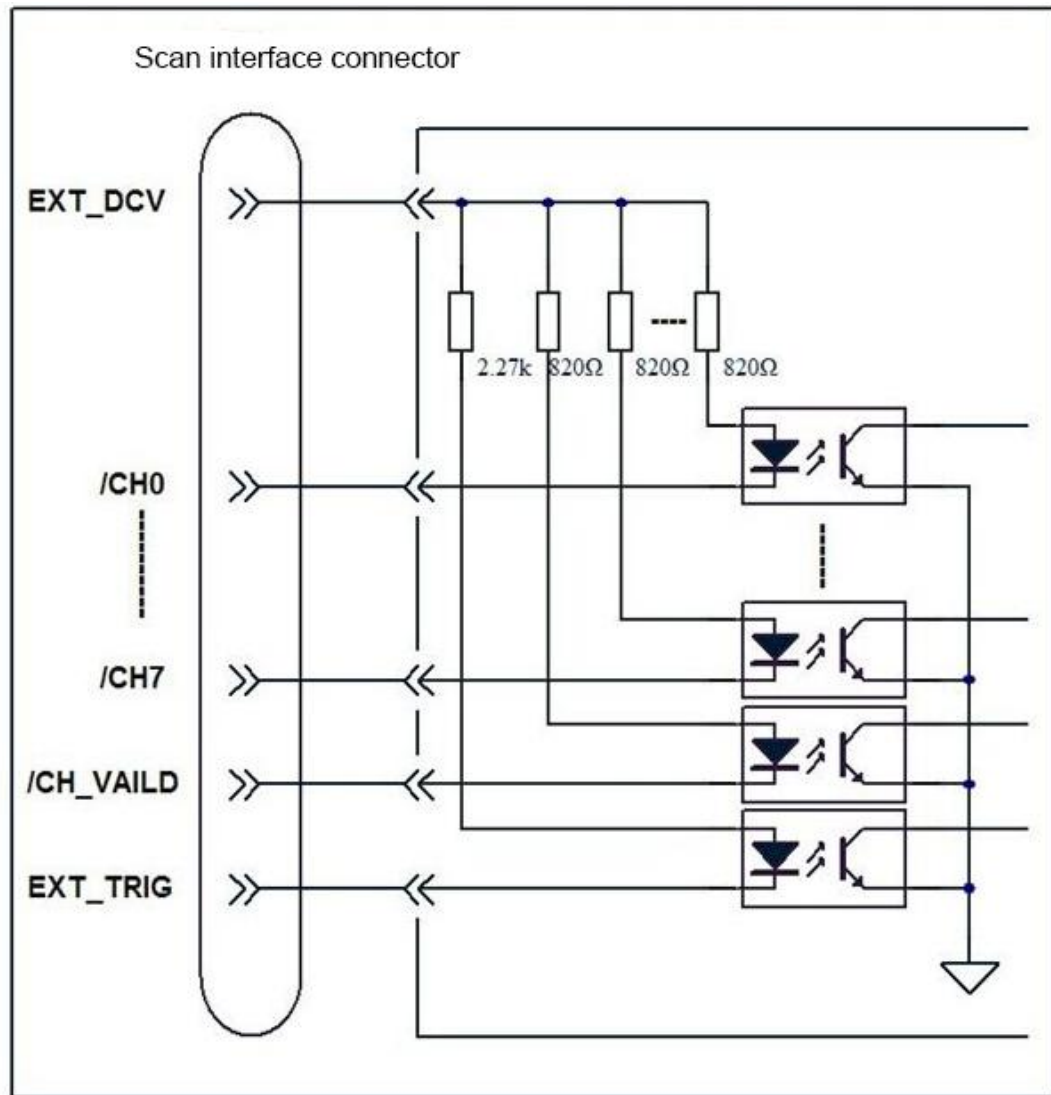


Figure 9-5 Scan interface input signal connection diagram

Appendix A Technical Parameters

General parameters

Model		TH2638	TH2638A
Test signal parameter		Cp-D, Cp-Q, Cp-Rp, Cp-G, Cs-D, Cs-Q, Cs-Rs, Cs-Rs-Ls	
Test Signal			
Frequency	Allowable frequency	100Hz,120Hz, 1kHz,10kHz,100kHz,1MHz, 1MHz ±1%, 1MHz ±2%	100Hz,120Hz, 1kHz, 10kHz, 40kHz,100kHz
	Accuracy	±0.02%	
Level	Range	0.1V-1V	
	Resolution	0.01V	
	Accuracy	±5%	
Output method		Continuous or Synchronous	
Signal source delay	Range	0-1s	
	Resolution	0.1ms	
Output impedance	100 Hz	SLC OFF (≥ 220μF range)	1.5 Ω
	120Hz	SLC ON (≥ 220μF range)	0.3 Ω
		10 nF - 100μF range	10 Ω
	1kHz	SLC OFF (≥ 22μF range)	1.5 Ω
		SLC ON (≥ 22μF range)	0.5 Ω
		220 nF - 10μF range	0.3 Ω
		100 pF - 100 nF range	10 Ω
	10kHz	10 Ω	
	40kHz	-----	10 Ω

	100kHz	10 Ω	
	1MHz 1MHz $\pm 1\%$ 1MHz $\pm 2\%$	10 Ω	-----
Test Speed		5 speeds: 1, 2, 4, 6, 8	
Fastest measurement speed	100/120Hz	11ms	
	1k/10k Hz	3.3ms	
	40 kHz	-----	3ms
	100kHz	2.5ms	
	1MHz	2.3ms	-----
Test range mode		Automatic, Keep	
Test signal frequency range	100Hz 120Hz	10 nF, 22 nF, 47 nF, 100 nF, 220 nF, 470 nF, 1 μ F, 2.2 μ F, 4.7 μ F, 10 μ F, 22 μ F, 47 μ F, 100 μ F, 220 μ F, 470 μ F, 1 mF	
	1k Hz	100 pF, 220 pF, 470 pF, 1 nF, 2.2 nF, 4.7 nF, 10 nF, 22 nF, 47nF , 100 nF, 220 nF, 470 nF, 1 μ F, 2.2 μ F, 4.7 μ F, 10 μ F, 22 μ F , 47 μ F , 100 μ F	
	10k Hz	100 pF, 220 pF, 470 pF, 1 nF, 2.2 nF, 4.7 nF, 10 nF, 22 nF, 47nF, 100 nF, 220 nF, 470 nF, 1 μ F, 2.2 μ F, 4.7 μ F, 10 μ F	
	40k Hz	-----	22 pF, 47 pF, 100 pF, 220 pF, 470pF , 1 nF, 2.2 nF, 4.7 nF, 10 nF, 22 nF, 47 nF, 100 nF, 220 nF, 470nF , 1 μ F, 2.2 μ F
	100k Hz	10 pF , 22 pF , 47 pF , 100 pF , 220 pF, 470 pF, 1 nF, 2.2 nF, 4.7 nF, 10 nF, 22 nF, 47 nF, 100 nF, 220 nF, 470 nF, 1 μ F	
	1MHz 1MHz $\pm 1\%$ 1MHz $\pm 2\%$	1 pF , 2.2 pF , 4.7 pF, 10 pF, 22 pF, 47 pF, 100 pF, 220 pF, 470 pF, 1 nF	-----
Average number of times		1 – 256	

Trigger Mode		Internal, Manual, External, Bus	Internal, Manual, External (except Scanner), Bus (except GPIB)
Trigger Delay Time	Range	0 – 1s	
	Resolution	0.1ms	
Measuring display range			
Parameters	Cs , Cp	±1.000000 aF to 999.9999 EF	
	D	±0.000001 to 9.999999	
	Q	±0.01 to 99999.99	
	Rs, Rp	±1.000000 aΩ to 999.9999 EΩ	
	G	±1.000000 aS to 999.9999 ES	
	Δ%	±0.0001 % to 999.9999 %	
Display Method		Floating/fixed decimal point display, ΔABS, Δ%	
List Sweep		10-point list sweep, can scan frequency and voltage	
Comparator Function		11bins, BIN1~BIN9, OUT_OF_BIN, AUX_BIN	
Interface		RS232C , LAN , USB CDC , HANDLER , GPIB , Scanner	RS232C , LAN , USB CDC , HANDLER
Internal Storage		40 instrument settings files	
External USB Storage		GIF image 500 instrument settings files Test data is directly stored to USB memory Screen shot file saved directly to USB memory	
General technical parameters			
Input voltage source	Voltage	90VAC – 264VAC	
	Frequency	47Hz - 63Hz	
	Power consumption	Max.150VA	
Operating environment	temperature	0 °C - 45 °C	
	humidity	15% - 85% RH (≤40°C, No condensation)	
	altitude	0 – 2000m	
Storage environment	temperature	-20 °C - 70 °C	
	humidity	0 - 90% RH (≤65 °C, No condensation)	
	altitude	0 – 4572m	

Attached Table A-1 General technical parameters

Effective measurement range

Range capacitance	Recommended measurement range	Effective measurement range
10nF	0F—15nF	0F—15nF
22nF	15nF—33nF	0F—33nF
47nF	33nF—68nF	0F—68nF
100nF	68nF—150nF	0F—150nF
220nF	150nF—330nF	0F—330nF
470nF	330nF—680nF	0F—680nF
1uF	680nF—1.5uF	0F—1.5uF
2.2uF	1.5uF—3.3uF	0F—3.3uF
4.7uF	3.3uF—6.8uF	0F—6.8uF
10uF	6.8uF—15uF	0F—15uF
22uF	15uF—33uF	0F—33uF
47uF	33uF—68uF	0F—68uF
100uF	68uF—150uF	0F—150uF
220uF	150uF—330uF	0F—330uF
470uF	330uF—680uF	0F—680uF
1mF	680uF—2mF	>0F

Attached Table A-2 Measuring capacitance range when the measurement frequency is 100/120 Hz

Range capacitance	Recommended measurement range	Effective measurement range
100pF	0F—150pF	0F—150pF
220pF	150pF—330pF	0F—330pF
470pF	330pF—680pF	0F—680pF
1nF	680pF—1.5nF	0F—1.5nF
2.2nF	1.5nF—3.3nF	0F—3.3nF
4.7nF	3.3nF—6.8nF	0F—6.8nF
10nF	6.8nF—15nF	0F—15nF
22nF	15nF—33nF	0F—33nF
47nF	33nF—68nF	0F—68nF
100nF	68nF—150nF	0F—150nF
220nF	150nF—330nF	0F—330nF
470nF	330nF—680nF	0F—680nF
1uF	680nF—1.5uF	0F—1.5uF
2.2uF	1.5uF—3.3uF	0F—3.3uF
4.7uF	3.3uF—6.8uF	0F—6.8uF
10uF	6.8uF—15uF	0F—15uF
22uF	15uF—33uF	0F—33uF
47uF	33uF—68uF	0F—68uF
100uF	68uF—200uF	>0F

Attached Table A-3 Measuring capacitance range when the measurement frequency is 1kHz

Range capacitance	Recommended measurement range	Effective measurement range
100pF	0F—150pF	0F—150pF
220pF	150pF—330pF	0F—330pF
470pF	330pF—680pF	0F—680pF
1nF	680pF—1.5nF	0F—1.5nF
2.2nF	1.5nF—3.3nF	0F—3.3nF
4.7nF	3.3nF—6.8nF	0F—6.8nF
10nF	6.8nF—15nF	0F—15nF
22nF	15nF—33nF	0F—33nF
47nF	33nF—68nF	0F—68nF
100nF	68nF—150nF	0F—150nF
220nF	150nF—330nF	0F—330nF
470nF	330nF—680nF	0F—680nF
1uF	680nF—1.5uF	0F—1.5uF
2.2uF	1.5uF—3.3uF	0F—3.3uF
4.7uF	3.3uF—6.8uF	0F—6.8uF
10uF	6.8uF—15uF	>0F

Attached Table A-4 Measuring capacitance range when the measurement frequency is 10kHz

Range capacitance	Recommended measurement range	Effective measurement range
22pF	0F—33pF	0F—33pF
47pF	33pF—68pF	0F—68pF
100pF	68pF—150pF	0F—150pF
220pF	150pF—330pF	0F—330pF
470pF	330pF—680pF	0F—680pF
1nF	680pF—1.5nF	0F—1.5nF
2.2nF	1.5nF—3.3nF	0F—3.3nF
4.7nF	3.3nF—6.8nF	0F—6.8nF
10nF	6.8nF—15nF	0F—15nF
22nF	15nF—33nF	0F—33nF
47nF	33nF—68nF	0F—68nF
100nF	68nF—150nF	0F—150nF
220nF	150nF—330nF	0F—330nF
470nF	330nF—680nF	0F—680nF
1uF	680nF—1.5uF	0F—1.5uF
2.2uF	1.5uF—3.3uF	0F—3.3uF
4.7uF	1.5uF—3.3uF	0F—6.8uF
10uF	1.5uF—3.3uF	>0F

Attached Table A-5 Measuring capacitance range when the measurement frequency is 40kHz

Range capacitance	Recommended measurement range	Effective measurement range
10pF	0F—15pF	0F—15pF
22pF	15pF—33pF	0F—33pF
47pF	33pF—68pF	0F—68pF
100pF	68pF—150pF	0F—150pF
220pF	150pF—330pF	0F—330pF
470pF	330pF—680pF	0F—680pF
1nF	680pF—1.5nF	0F—1.5nF
2.2nF	1.5nF—3.3nF	0F—3.3nF
4.7nF	3.3nF—6.8nF	0F—6.8nF
10nF	6.8nF—15nF	0F—15nF
22nF	15nF—33nF	0F—33nF
47nF	33nF—68nF	0F—68nF
100nF	68nF—150nF	0F—150nF
220nF	150nF—330nF	0F—330nF
470nF	330nF—680nF	0F—680nF
1uF	680nF—1.5uF	>0F

Attached Table A-6 Measuring capacitance range when the measurement frequency is 100kHz

Range capacitance	Recommended measurement range	Effective measurement range
1pF	0F—1.5pF	0F—1.5pF
2.2pF	1.5pF—3.3pF	0F—3.3pF
4.7pF	3.3pF—6.8pF	0F—6.8pF
10pF	6.8pF—15pF	0F—15pF
22pF	15pF—33pF	0F—33pF
47pF	33pF—68pF	0F—68pF
100pF	68pF—150pF	0F—150pF
220pF	150pF—330pF	0F—330pF
470pF	330pF—680pF	0F—680pF
1nF	680pF—1.5nF	0F—1.5nF

Attached Table A-7 Measuring capacitance range when the measurement frequency is 1MHz,
1MHz $\pm$ 1%, 1MHz $\pm$ 2%

Precision index

In order to ensure the measurement accuracy, the following conditions must be met:

- Warm-up time: 30 minutes or more
- Ambient temperature: $23\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$
- Perform open circuit correction
- Perform 1MHz cable correction
- Measuring cable length: 0m, 1m, 2m
- D (loss factor) ≤ 0.5

When $D \leq 0.1$, refer to the attached table A-10 to A-21 for the measurement accuracy of the parameters C_p , C_s and D .

When $D \leq 0.1$, refer to attached table A-9 for the measurement accuracy formulas of parameters G , R_s , Q and R_p .

When $0.1 < D \leq 0.5$, first refer to the attached table A-8 for the measurement accuracy of all parameters, and then calculated according to $D \leq 0.1$.

Parameter	Coefficient
C_p , C_s , G , R_s	$1+D^2$
D	$1+D$

Attached Table A-8 Loss factor

Note: If the user needs to measure the sub-parameters other than D , the value of D should be calculated first, and then the corresponding calculation is performed.

Parameter	Formula
G_e (Accuracy of G)	$G_e = (C_e/100) \times 2 \times \pi \times f \times C_x$
R_{s_e} (Accuracy of R_s)	$R_{s_e} = (C_e/100) \times 2 \times \pi \times f \times C_x$
Q_e (Accuracy of Q)	$Q_e = \frac{\pm Q_x^2 \times D_e}{1 \mp Q_x \times D_e}$
R_{p_e} (Accuracy of R_p)	$R_{p_e} = \frac{\pm R_{p_x}^2 \times G_e}{1 \mp R_{p_x} \times G_e}$

Attached Table A-9 Measurement accuracy formulas for G , R_s , Q and R_p

Which:

f : measurement frequency (Hz)

C_x : measured value of C_p or C_s (F)

C_e : accuracy of C_p or C_s (%)

Q_x : measured value of Q

R_{p_x} : measured value of R_p (Ω)

D_e : accuracy of D (%)

C _p , C _s (%)					
Test speed	1	2	4	6	8
10nF	0.055+0. 030xK	0.055+0. 022xK	0.055+0. 018xK	0.055+0. 016xK	0.055+0. 015xK
22nF					
47nF					
100nF					
220nF					
470nF					
1uF					
2.2uF					
4.7uF					
10uF					
22uF					
47uF					
100uF					
220uF	0.4+0.06 0xK	0.4+0.04 4xK	0.4+0.03 6xK	0.4+0.03 2xK	0.4+0.03 0xK
470uF					
1mF					

Attached Table A-10 Measurement accuracy of CP, CS (measurement frequency: 100Hz/120Hz)

D					
Test speed	1	2	4	6	8
10nF	0.00035 +0.0003 0xK	0.00035 +0.0002 2xK	0.00035 +0.0001 8xK	0.00035 +0.0001 6xK	0.00035 +0.0001 5xK
22nF					
47nF					
100nF					
220nF					
470nF					
1uF					
2.2uF					
4.7uF					
10uF					
22uF					
47uF					
100uF					
220uF	0.004+0. 00060x K	0.004+0. 00044x K	0.004+0. 00036xK	0.004+0. 00032x K	0.004+0. 00030xK
470uF					
1mF					

Attached Table A-11 Measurement accuracy of D (measurement frequency: 100 Hz / 120 Hz)

C _p , C _s (%)					
Test speed	1	2	4	6	8
100pF	0.055+0. 070xK	0.055+0. 047xK	0.055+0. 036xK	0.055+0. 033xK	0.055+0. 030xK
220pF	0.055+0. 045xK	0.055+0. 032xK	0.055+0. 025xK	0.055+0. 022xK	0.055+0. 020xK
470pF	0.055+0. 030xK	0.055+0. 022xK	0.055+0. 018xK	0.055+0. 016xK	0.055+0. 015xK
1nF					
2.2nF					
4.7nF					
10nF					
22nF					
47nF					
100nF					
220nF					
470nF					
1uF					
2.2uF					
4.7uF					
10uF					
22uF	0.4+0.06 0xK	0.4+0.04 4xK	0.4+0.03 6xK	0.4+0.03 2xK	0.4+0.03 0xK
47uF					
100uF					

Attached Table A-12 Measurement accuracy of C_p, C_s (measurement frequency: 1kHz)

D					
Test speed	1	2	4	6	8
100pF	0.00035 +0.0007 0xK	0.00035 +0.0004 7xK	0.00035 +0.0003 6xK	0.00035 +0.0003 3xK	0.00035 +0.0003 0xK
220pF	0.00035 +0.0004 5xK	0.00035 +0.0003 2xK	0.00035 +0.0002 5xK	0.00035 +0.0002 2xK	0.00035 +0.0002 0xK
470pF	0.00035 +0.0003 0xK	0.00035 +0.0002 2xK	0.00035 +0.0001 8xK	0.00035 +0.0001 6xK	0.00035 +0.0001 5xK
1nF					
2.2nF					
4.7nF					
10nF					
22nF					
47nF					
100nF					
220nF					
470nF					
1uF					
2.2uF					
4.7uF					
10uF					
22uF	0.004+0. 00060x K	0.004+0. 00044x K	0.004+0. 00036xK	0.004+0. 00032x K	0.004+0. 00030xK
47uF					
100uF					

Attached Table A-13 Measurement accuracy of D (measurement frequency: 1kHz)

C _p , C _s (%)					
Test speed	1	2	4	6	8
100pF	0.055+0. 070xK	0.055+0. 047xK	0.055+0. 036xK	0.055+0. 033xK	0.055+0. 030xK
220pF	0.055+0. 045xK	0.055+0. 032xK	0.055+0. 025xK	0.055+0. 022xK	0.055+0. 020xK
470pF	0.055+0. 030xK	0.055+0. 022xK	0.055+0. 018xK	0.055+0. 016xK	0.055+0. 015xK
1nF					
2.2nF					
4.7nF					
10nF					
22nF					
47nF					
100nF					
220nF					
470nF					
1uF					
2.2uF	0.4+0.06 0xK	0.4+0.04 4xK	0.4+0.03 6xK	0.4+0.03 2xK	0.4+0.03 0xK
4.7uF					
10uF					

Attached Table A-14 Measurement accuracy of C_p, C_s (measurement frequency: 10kHz)

D					
Test speed	1	2	4	6	8
100pF	0.00035 +0.0007 0xK	0.00035 +0.0004 7xK	0.00035 +0.0003 6xK	0.00035 +0.0003 3xK	0.00035 +0.0003 0xK
220pF	0.00035 +0.0004 5xK	0.00035 +0.0003 2xK	0.00035 +0.0002 5xK	0.00035 +0.0002 2xK	0.00035 +0.0002 0xK
470pF	0.00035 +0.0003 0xK	0.00035 +0.0002 2xK	0.00035 +0.0001 8xK	0.00035 +0.0001 6xK	0.00035 +0.0001 5xK
1nF					
2.2nF					
4.7nF					
10nF					
22nF					
47nF					
100nF					
220nF					
470nF					
1uF					
2.2uF	0.004+0. 00060x K	0.004+0. 00044x K	0.004+0. 00036xK	0.004+0. 00032x K	0.004+0. 00030xK
4.7uF					
10uF					

Attached Table A-15 Measurement accuracy of D (measurement frequency: 10kHz)

C _p , C _s (%)					
Test speed	1	2	4	6	8
22pF	0.055+0. 070xK	0.055+0. 047xK	0.055+0. 036xK	0.055+0. 033xK	0.055+0. 030xK
47pF	0.055+0. 045xK	0.055+0. 032xK	0.055+0. 025xK	0.055+0. 022xK	0.055+0. 020xK
100pF	0.055+0. 030xK	0.055+0. 022xK	0.055+0. 018xK	0.055+0. 016xK	0.055+0. 015xK
220pF					
470pF					
1nF					
2.2nF					
4.7nF					
10nF					
22nF					
47nF					
100nF					
220nF					
470nF	0.4+0.06 0xK	0.4+0.04 4xK	0.4+0.03 6xK	0.4+0.03 2xK	0.4+0.03 0xK
1uF					
2.2uF					

Attached Table A-16 Measurement accuracy of C_p, C_s (measurement frequency: 40kHz)

D					
Test speed	1	2	4	6	8
22pF	0.00035 +0.0007 0xK	0.00035 +0.0004 7xK	0.00035 +0.0003 6xK	0.00035 +0.0003 3xK	0.00035 +0.0003 0xK
47pF	0.00035 +0.0004 5xK	0.00035 +0.0003 2xK	0.00035 +0.0002 5xK	0.00035 +0.0002 2xK	0.00035 +0.0002 0xK
100pF	0.00035 +0.0003 0xK	0.00035 +0.0002 2xK	0.00035 +0.0001 8xK	0.00035 +0.0001 6xK	0.00035 +0.0001 5xK
220pF					
470pF					
1nF					
2.2nF					
4.7nF					
10nF					
22nF					
47nF					
100nF					
220nF					
470nF	0.004+0. 00060x K	0.004+0. 00044x K	0.004+0. 00036xK	0.004+0. 00032x K	0.004+0. 00030xK
1uF					
2.2uF					

Attached Table A-17 Measurement accuracy of D (measurement frequency: 40kHz)

C _p , C _s (%)					
Test speed	1	2	4	6	8
10pF	0.055+0. 070xK	0.055+0. 047xK	0.055+0. 036xK	0.055+0. 033xK	0.055+0. 030xK
22pF	0.055+0. 045xK	0.055+0. 032xK	0.055+0. 025xK	0.055+0. 022xK	0.055+0. 020xK
47pF	0.055+0. 030xK	0.055+0. 022xK	0.055+0. 018xK	0.055+0. 016xK	0.055+0. 015xK
100pF					
220pF					
470pF					
1nF					
2.2nF					
4.7nF					
10nF					
22nF					
47nF					
100nF					
220nF	0.4+0.06 0xK	0.4+0.04 4xK	0.4+0.03 6xK	0.4+0.03 2xK	0.4+0.03 0xK
470nF					
1uF					

Attached Table A-18 Measurement accuracy of C_p, C_s (measurement frequency: 100kHz)

D					
Test speed	1	2	4	6	8
10pF	0.00035 +0.0007 0xK	0.00035 +0.0004 7xK	0.00035 +0.0003 6xK	0.00035 +0.0003 3xK	0.00035 +0.0003 0xK
22pF	0.00035 +0.0004 5xK	0.00035 +0.0003 2xK	0.00035 +0.0002 5xK	0.00035 +0.0002 2xK	0.00035 +0.0002 0xK
47pF	0.00035 +0.0003 0xK	0.00035 +0.0002 2xK	0.00035 +0.0001 8xK	0.00035 +0.0001 6xK	0.00035 +0.0001 5xK
100pF					
220pF					
470pF					
1nF					
2.2nF					
4.7nF					
10nF					
22nF					
47nF					
100nF					
220nF	0.004+0. 00060x K	0.004+0. 00044x K	0.004+0. 00036xK	0.004+0. 00032x K	0.004+0. 00030xK
470nF					
1uF					

Attached Table A-19 Measurement accuracy of D (measurement frequency: 100kHz)

C _p , C _s (%)					
Test speed	1	2	4	6	8
1pF	0.055+0. 070xK	0.055+0. 047xK	0.055+0. 036xK	0.055+0. 033xK	0.055+0. 030xK
2.2pF	0.055+0. 045xK	0.055+0. 032xK	0.055+0. 025xK	0.055+0. 022xK	0.055+0. 020xK
4.7pF	0.055+0. 030xK	0.055+0. 022xK	0.055+0. 018xK	0.055+0. 016xK	0.055+0. 015xK
10pF					
22pF					
47pF					
100pF					
220pF					
470pF					
1nF					

Attached Table A-20 Measurement accuracy of C_p, C_s (measurement frequency: 1MHz, 1MHz±1%, 1MHz±2%)

D					
Test speed	1	2	4	6	8
1pF	0.00035 +0.0007 0xK	0.00035 +0.0004 7xK	0.00035 +0.0003 6xK	0.00035 +0.0003 3xK	0.00035 +0.0003 0xK
2.2pF	0.00035 +0.0004 5xK	0.00035 +0.0003 2xK	0.00035 +0.0002 5xK	0.00035 +0.0002 2xK	0.00035 +0.0002 0xK
4.7pF	0.00035 +0.0003 0xK	0.00035 +0.0002 2xK	0.00035 +0.0001 8xK	0.00035 +0.0001 6xK	0.00035 +0.0001 5xK
10pF					
22pF					
47pF					
100pF					
220pF					
470pF					
1nF					

Attached Table A-21 Measurement accuracy of D (measurement frequency: 1MHz, 1MHz±1%, 1MHz±2%)

Note:

When $C_X \leq C_r$, $K = (1/V_S) \times (C_r/C_X)$

When $1.25 \times C_r > C_X > C_r$, $K = (1/V_S)$

When $C_X \geq 1.25 \times C_r$, $K = (1/V_S) \times (C_x/C_r)$

Which:

- C_x Capacitance measurement value of C_p or C_s
- C_r Measurement range
- V_s Level of the DUT both ends (V)

Measurement speed and measurement time

Frequency	Measurement speed				
	1	2	4	6	8
100Hz	11.1ms	21.1ms	41.1ms	61.1ms	81.1ms
120Hz	9.3ms	17.8ms	34.4ms	51.1ms	67.9ms
1kHz	3.2ms	5.2ms	9.2ms	13.2ms	17.2ms
10kHz	3.3ms	5.3ms	9.3ms	13.3ms	17.3ms
100kHz	2.5ms	3.8ms	6.3ms	8.9ms	11.4ms
1MHz	2.3ms	3.3ms	5.3ms	7.3ms	9.3ms

Attached Table A-22 Measurement speed and measurement time

Note: The measurement time is the time from the start of the trigger to the end of the EOM.