6500 Piezo/Crystal Resonance Search Mode

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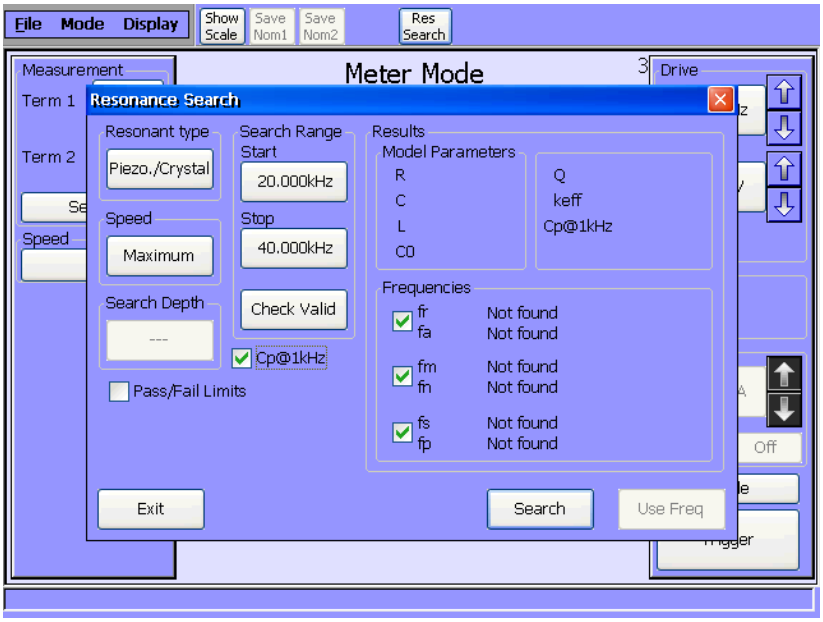
1. INTRODUCTION

The Resonance Search function has been updated to allow the critical parameters of a PIEZ0/CRYSTAL type DUT to be determined quickly, without having to perform a full sweep of the DUT characteristics. The method employs a combination of fast measurements and mathematical modelling. This document describes this additional feature only. The Series/Parallel functions are described in the User Manual.

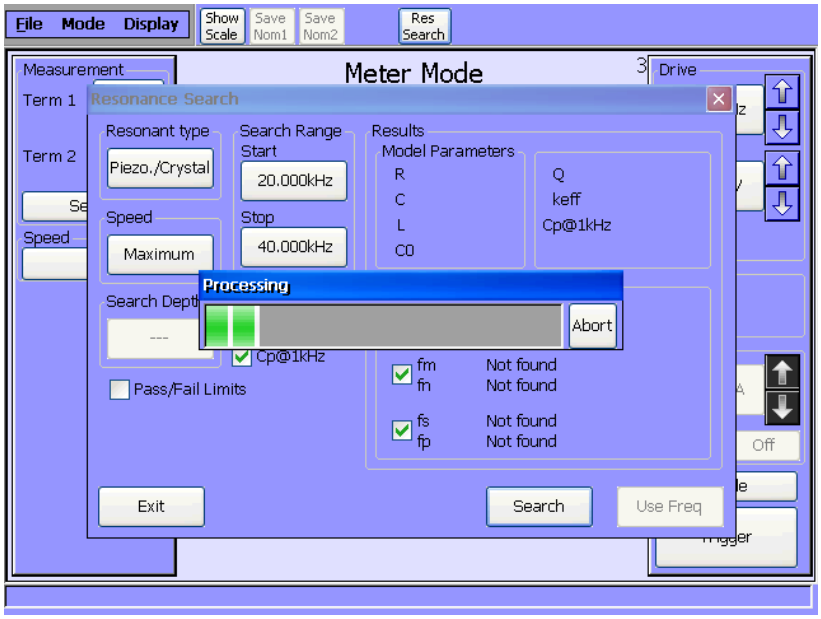
2. DESCRIPTION

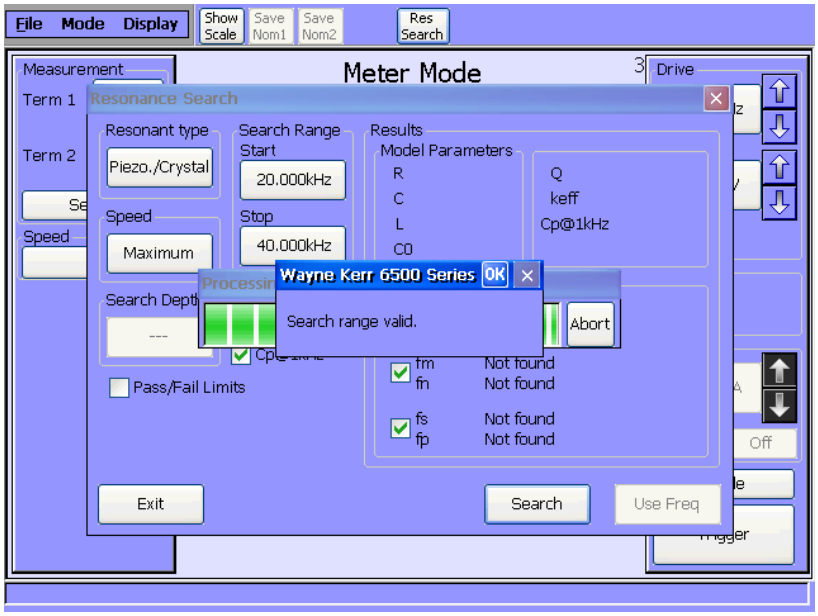
The Resonance Search function is enabled using the 'Res Search' button in Meter Mode. Use the 'Resonant Type' button to select Piezo/Crystal.



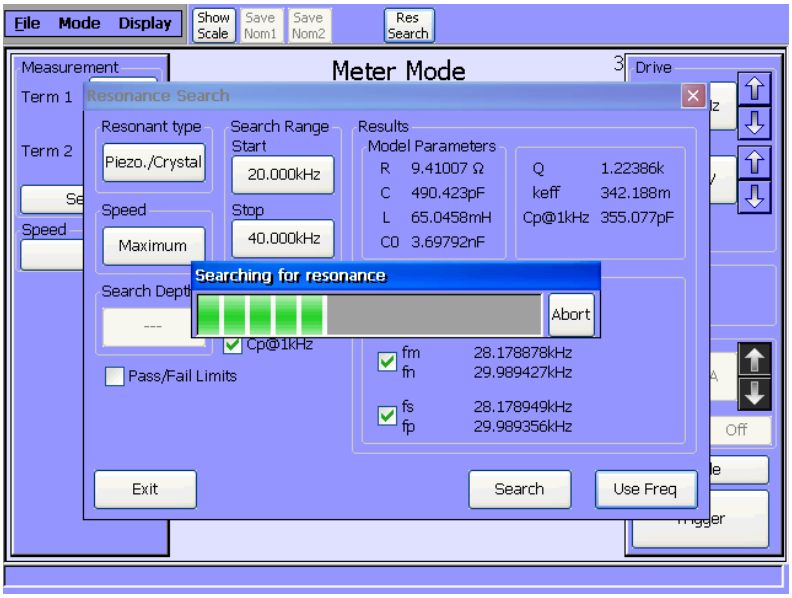
This function has been optimised to allow the resonance frequencies of similar devices to be located quickly and accurately within a frequency range specified by the user. The frequency range is set using the 'Start' and 'Stop' buttons.

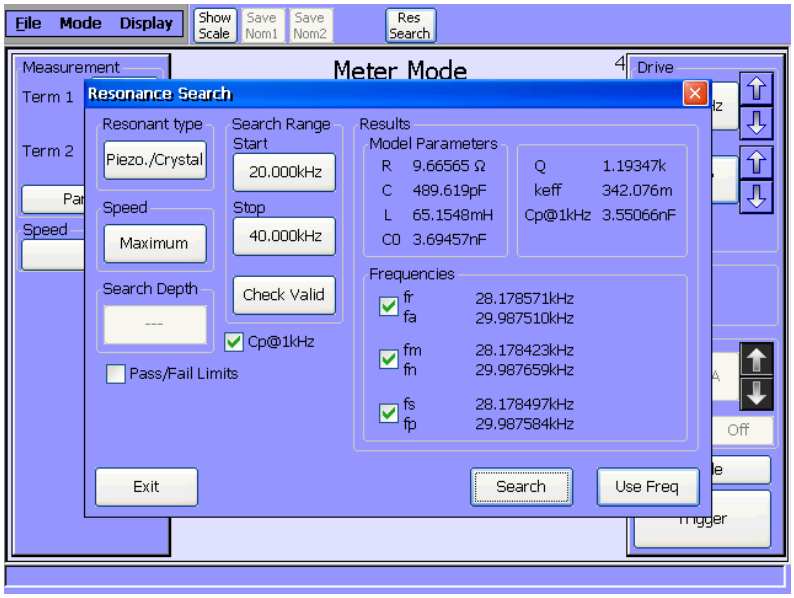
Initially a typical DUT is connected to the instrument and the 'Check Valid' function is executed. This function checks that there is a valid pair of resonance frequencies within the frequency range specified, and chooses an optimum set of measurement conditions to enable rapid location of these frequencies.





Once the ‘Check Valid’ function has been executed successfully, this device and further similar devices can be measured simply by using the ‘Search’ button.

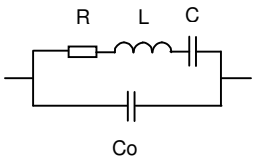




The following parameters can be displayed on the completion of a successful search:

Parameter	Description	Definition
fr	Series resonance frequency at zero phase	
fa	Parallel resonance frequency at zero phase	
fm	Frequency at Z min	
fn	Frequency at Zmax	
fs	Frequency at Gmax	
fp	Frequency at Rmax	
R	Series R in 4-term model	
L	Series L in 4-term model	
C	Series C in 4-term model	

Co	Parallel C in 4-term model	
Q	Mechanical Q	$\frac{2\times\pi\times f_s\times L}{R}$
Keff	Effective coupling factor	$\sqrt{\frac{\left(f_p^2-f_s^2\right)}{f_p^2}}$
Cp @ 1kHz	Capacitance at 1kHz	Actual measurement



4 term model

Note: To save the settings use the 'File', 'Save', 'QuickSave' function.

3. EXAMPLE PROCEDURE

DUT Description: Piezo device with 'fr' at approx. 28kHz and 'fa' at approx. 30kHz.

1) Select Piezo/Crystal in the 'Resonant Type' field
2) Enter the 'Start' frequency. This should be lower than 'fr'. In this case 20kHz is used.
3) Enter the 'Stop' frequency. This should be higher than 'fr. If there is a second resonance near to the main resonance it is advised to set the 'Stop' frequency below the next known resonance. In this case 40kHz is used.
4) Select the required results using the check boxes.
5) Press 'Check Valid'. Wait for it to complete and check that a valid resonance has been found.
6) Press 'Search' to execute the fast search.
7) Place a similar DUT into the fixture and press 'Search' to test next DUT.

4. NOTES ON OPERATION

1) This function uses fast measurements and mathematical modelling (using a 4-term model) in order to measure/calculate the results. As some devices are not a perfect fit to this model there may be small differences between the calculated frequencies and the actual frequencies. After the initial device has been tested the user should satisfy themselves that any differences noted are within acceptable limits.
2) At present this function has an upper frequency limit of 10MHz

5. GPIB COMMANDS

These GPIB commands allow Resonance Search to be controlled remotely. The Resonance Search dialog does not need to be open for the GPIB commands to work.

RESONANCE MODE

:METER:RESOnance:StarT <real>

Set the start frequency for the search.

Parameters:

The required frequency in Hertz..

Example:

```
:METER:RESO:ST 1k
```

Would set the search to start at 1kHz.

Response:

None.

:METER:RESOnance:StarT?

Returns the start frequency of the search.

Parameters:

None.

Response:

Returns the start frequency in engineering format.

Example: `+.10000000E+05`

For a start frequency of 10kHz.

:METER:RESOnance:StoP <real>

Set the stop frequency for the search.

Parameters:

The required frequency in Hertz. Example:

```
:METER:RESO:SP 1k
```

Would set the search to stop at 1kHz.

Response:

None.

:METER:RESOnance:StoP?

Returns the stop frequency of the search.

Parameters:

None.

Response:

Returns the stop frequency in engineering format.

Example: `+.10000000E+05`

For a stop frequency of 10kHz.

RESONANCE MODE

:METER:RESOnance:EQU-CCT <disc>

Select the equivalent circuit type for resonance search.

Parameters:

The following parameters are valid:

`SER` Series resonance.

`PAR` Parallel resonance.

`XTAL` Dual resonance device eg. piezo-electric or crystal

Example:

`:METER:RESO:EQU-CCT SER`

will select the series resonance search.

Response:

None.

:METER:RESOnance:EQU-CCT?

Returns the currently selected equivalent circuit.

Parameters:

None.

Response:

Returns the equivalent circuit state according to this table:

`0` Series.

`1` Parallel.

`2` Xtal.

Example: `1`

indicates the parallel resonance search circuit is selected.

RESONANCE MODE

:METER:RESOnance:TRIG

Begin a resonance search.

Parameters:

None.

Response:

Returns 7 values all separated by commas.

The values returned for the 3 different modes are indicated below:

Series Mode

Fo, 0, 0, C, L, R, Q, Pass/Fail

Parallel Mode

Fo, 0, 0, C, L, R , Q, Pass/Fail

Crystal/Piezo Mode

Fr, Fa, C0, C1, L, R , Q, Pass/Fail

Note: Pass = 1, Fail = 0 and Disabled = -1.

Example (Crystal/Piezo Mode): `:METER:RESO:TRIG`

returns

+.77534195E+06, +.77535195E+06, +.47321000E-05, +.47321000E-12, +.89043000E-08, +.19562000E-02, +.221748E+02, -1

indicating resonant frequencies of fr = 775.342kHz and fa = 775.352kHz with equivalent circuit values of C0 = 4.7321µF, C1 = 4.7321pF, L = 8.904nH, R = 1.956mΩ , a Q value of 22.175 and Pass/Fail disabled

RESONANCE MODE

:METER:RESOnance:TRAINing

Execute the 'Check Valid' function.

Parameters:

None.

Response:

Returns the result of the 'Check Valid' function:

5 Series resonance not found. Decrease Start frequency.

4 No resonances found. Decrease Start frequency and increase Stop frequency (Start and Stop frequencies are between the resonance frequencies).

3 Parallel resonance not found. Increase Stop frequency

2 No resonances found. Decrease Start frequency and/or increase Stop frequency.(Start and Stop frequencies are both above or both below the 2 resonance frequencies)

1 Search range valid

0 Unknown state

Example: `4`

:METER:RESOnance:FM-FN?

Returns the frequencies at Zmin and Zmax (fm and fn).

Parameters:

None.

Response:

Returns 2 values separated by a comma.

Example: `:METER:RESO:FM-FN?` returns

+.77534195E+06, +.77535195E+06

indicating resonant frequencies of fm = 775.342kHz and fn = 775.352kHz

RESONANCE MODE

:METER:RESOnance:FS-FP?

Returns the frequencies at Gmax and Rmax (fs and fp).

Parameters:

None.

Response:

Returns 2 values separated by a comma.

Example: `:METER:RESO:FS-FP?` returns

+.77534195E+06, +.77535195E+06

indicating resonant frequencies of fs = 775.342kHz and fp = 775.352kHz

:METER:RESOnance:CP-1K?

Returns the Cp reading at 1kHz (enabled/disabled using the **:METER:RESO:ENABLE-CP** function)

Parameters:

None.

Response:

Returns the Cp reading at 1kHz in engineering format.

Example1: `:METER:RESO:CP-1K?` returns

`+.10000000E-11`

for a C0 of 1pF.

Example2: `:METER:RESO:CP-1K?` returns

`+0.0000000E+000`

if the function is not enabled.

RESONANCE MODE

:METER:RESOnance:KEFF?

Returns the Keff result

Parameters:

None.

Response:

Returns the Keff result in engineering format.

Example: `:METER:RESO:KEFF?` returns

`+.10000000E-3`

for a Keff of 0.0001.

:METER:RESOnance:ENABLE-CP

Enables an additional Cp reading to be made at 1kHz

Parameters:

0 Disable

1 Enable

Example:

`:METER:RESO:ENABLE-CP 1`

will enable this measurement

Response:

None.

:METER:RESOnance:ENABLE-CP?

Returns the status of the 'ENABLE-CP' function.

Parameters:

None.

Response:

0 Disabled

1 Enabled

Example: `0`

RESONANCE MODE

:METER:RESOnance:DEPTH

Set resonance search depth. Applies to Series and Parallel searches only.

Parameters:

The following parameters are valid:

`0 to 16`

Example:

`:METER:RESO:DEPTH 2`

The instrument will conduct a binary search to a depth of two iterations then use the final pair of frequencies found to calculate resonance.

Response:

None.

:METER:RESOnance:DEPTH?

Returns the resonance search depth.

Parameters:

None.

Response:

The search depth.

Example: `0`

Indicates that resonance is calculated using the entered frequency limits. No resonance search is carried out prior to calculation.

:METER:RESOnance:SPEED

Select the required measurement speed for the pair of test frequencies used to calculate resonance.

Parameters:

`MAX`	Maximum speed.
`FAST`	Fast speed.
`MED`	Medium speed.
`SLOW`	Slow speed.
`<Integer>`	Custom

Example:

`:METER:RESO:SPEED SLOW`

will select slow speed for the resonance measurements.

Response:

None.

:METER:RESOnance:SPEED?

Returns the current measurement speed for the pair of frequencies used to calculate resonance.

Parameters:

None.

Response:

Returns the test speed as an integer according to the table:

`-4`	Maximum
`-3`	Fast
`-2`	Medium
`-1`	Slow
`1-256`	Custom

Example: `-3`

indicates that Fast measurements are selected.

:METER:RESOnance: LO-LIM <real>

Set the low limit.

Parameters:

The required frequency in Hertz.

Example:

```
:METER:RESO:LO-LIM 1k
```

Would set the low limit to 1kHz.

Response:

None.

:METER:RESOnance: LO-LIM?

Returns the low limit value.

Parameters:

None.

Response:

Returns the low limit frequency in engineering format.

Example: `+.10000000E+05`

For a low limit frequency of 10kHz.

:METER:RESOnance: HI-LIM <real>

Set the high limit.

Parameters:

The required frequency in Hertz

Example:

```
:METER:RESO:HI-LIM 2k
```

Would set the high limit to 2kHz.

Response:

None.

:METER:RESOnance: : HI-LIM?

Returns the high limit value.

Parameters:

None.

Response:

Returns the high limit frequency in engineering format.

Example: `+.10000000E+05`

For a high limit frequency of 10kHz.

:METER:RESOnance:ENABLE-HILO

Enables the Hi/Lo test limits

Parameters:

0 Disable

1 Enable

Example:

```
:METER:RESO:ENABLE-HILO 1
```

will enable the test limit

Response:

None.

:METER:RESOnance:ENABLE-HILO?

Returns the status of the 'ENABLE-HILO' function.

Parameters:

None.

Response:

0 Disabled

1 Enabled

Example: `0`