

# Agilent High Accuracy and Fast RF Inductor Testing

Application Note 369-10

## Agilent 4285A Precision LCR Meters



Agilent Technologies

## Introduction

RF inductors are employed in electronic equipment such as VCRs and intermediate frequency (IF) circuits for AM/FM radios, mobile radios, pagers and code-less telephone, which require RF inductors to be smaller, lower cost, and have higher reliability. This application note describes solutions offered by the Agilent 4285A precision LCR meter for realizing these requirements. Information for accurate and fast RF inductor testing, and for practical simple test systems are discussed.

## Problems and the solutions offered by the Agilent 4285A

### 1. Measurement accuracy and measurement speed

Stable inductance (L) and quality factor (Q) low inductance measurements are difficult to make, because measuring low inductance values means measuring low impedance, values. If a higher measurement frequency (MHz) is issued to increase the measured impedance, the LCR meter's measurement accuracy is worse, so accurate measurement data cannot be obtained.

The 4285A can perform reliable and fast measurements with 0.5% inductance measurement accuracy even in the MHz frequency range, and with a 30 ms measurement speed. Formerly LCR meters could not measure accurately enough for testing high Q inductors, and Q meters required long measurement time and high operator skill. Table 1 lists the 4285A's key specifications.

### 2. Measurement condition setup

There are many types of RF inductors, so the measurement frequency range for an inductor is selected from across a frequency range spanning kHz through MHz, depending on the inductance value to be measured and the application in which it will be used. The 4285A covers a measurement frequency range of from 75 kHz to 30 MHz, including frequencies defined in the MIL C-15305D standard (79.6 kHz, 252 kHz, 796 kHz, ..25.5 MHz)

A constant current test signal gives the best inductance measurement results, because inductive devices are current mode devices and L and Q values depend on current levels rather than voltage levels. Q meters do not offer current test signals, and former LCR meters used voltage test signals, not current test signals.

The 4285A offers both voltage and current test signal level selections. Furthermore, its auto level control (ALC) function allows constant test signal level measurements.

Table 1. 4285A key specifications

|                             |                      | Agilent 4285A (standard)  |
|-----------------------------|----------------------|---|
| Measurement method          |                      | Auto balancing bridge   |
| Measurement frequency       |                      | 75 kHz to 30 MHz with 100 Hz resolution   |
| Basic accuracy (typical)    | 10 mH<br>@100 kHz    | L: $\pm 0.18\%$<br>Q: $\pm 5\%$ @Q=30   |
|                             | 1 $\mu$ H<br>@10 MHz | L: $\pm 0.5\%$<br>Q: $\pm 10\%$ @Q=30   |
| Measurement speed (typical) |                      | 30 ms/65 ms/ 200 ms   |
| Test signal level           |                      | V: 5 mVrms ~ 2 Vrms<br>(10 mVrms ~ 1 Vrms in constant mode)<br>I: 200 $\mu$ Arms ~ 20 mArms<br>(100 $\mu$ Arms ~ 20 mArms in constant mode)<br>V/I monitors are available |

## Example of an accurate and fast measurement system

### 3. Functions for a test system

Formerly an LCR meters' cable extension capability was limited to an upper measurement frequency limit of approximately 15 MHz, and they could not fully compensate for errors due to extension cables and test fixtures. So, the LCR meter performance was limited when used in a measurement test system. The 4285A can use 1 m or 2 m test leads over its full frequency range, and its open/short/load correction function can compensate for measurement errors due to extension leads. You can obtain accurate measurement values by performing error correction at the actual measurement frequencies (for example the frequencies defined in MIL standards).

An internal comparator and an optional automatic handler interface are available for setting up RF inductor test systems.

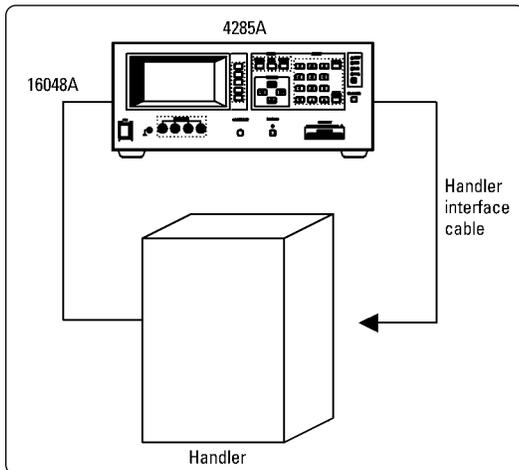


Figure 1 . Example of an accurate and fast L-Q measurement system

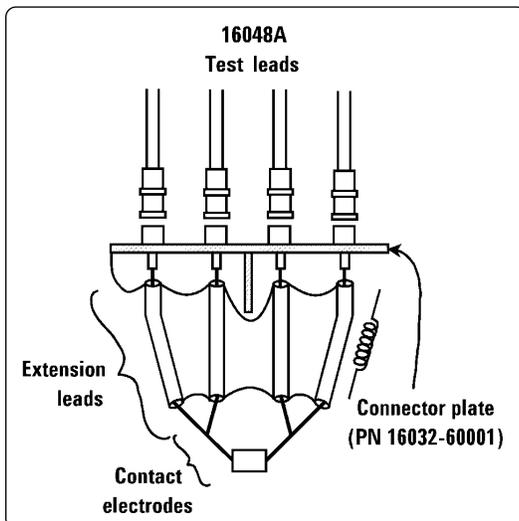


Figure 2 . Contact electrodes

This paragraph describes an example of L-Q measurement and sorting system for RF inductor production line applications, and gives some techniques for designing such systems.

Figure 1 shows a simplified model of an RF inductor test system. In this system, the 4285A measures L and Q and performs BIN sorting using its internal comparator. Equipment used in this system is as follows (refer to 'Appendix A. Ordering Information' for details).

- 4285A precision LCR meter with option 201 handler interface
- 16048A test leads (1 m, BNC connectors )
- Handler interface cable (Amphenol 36 pin connectors (male))
- Automatic component handler (compatible with 4285A option 201)

The following are technical hints for designing a test system, and for maximizing the 4285A's performance.

#### 1. Cable connections

Use Agilent test leads to extend the measurement terminals of the 4285A to the handler's contact electrodes.

You can select 1 m or 2 m test leads, however, 1 m test leads are recommended to minimize the error caused by the addition of extension cables.

#### 2. Extension leads and contact electrodes

- The 16048A test leads will extend the signal path from the 4285A measurement terminals to the end of cables while maintaining a Four-Terminal Pair configuration.

Use connector plate (Agilent PN 16032-60001, furnished with the 16048A) to change the terminal configuration and extend the leads to the contact electrodes as shown in figure 2.

Extension leads and contact electrodes which are not a Four-Terminal Pair configuration cause measurement errors, because of residual impedance and noise. Thus, pay close attention to the following items. Especially when performing low inductance measurements, the following must be closely considered, because for low impedance measurements, measurement repeatability depends on contact electrode stability rather than the 4285A's inductance measurement repeatability.

- To shield against noise, the outer conductors of the extension leads must be connected to each other at a point as near as possible to the test device.
- To reduce residual impedance, the extension leads must be as short as possible.

For stable residual impedance, the layout, positioning, and length of the extension leads and contact electrodes must not be changed, and careful consideration must be given to eliminating mechanical vibration.

### 3. Error correction

The Agilent 4285A's powerful error correction function can be used to compensate for the residual impedance of extension leads and contact electrodes to give more accurate impedance (L and Q) measurement values.

First, set the cable length function to 1 m to correct for the error caused by 1 m test leads (A in figure 3).

Open/short/load correction should be performed at the actual measurement frequencies. Up to seven correction frequencies can be set (B in figure 3), so the six frequency points specified in MIL C-15305D can be covered.

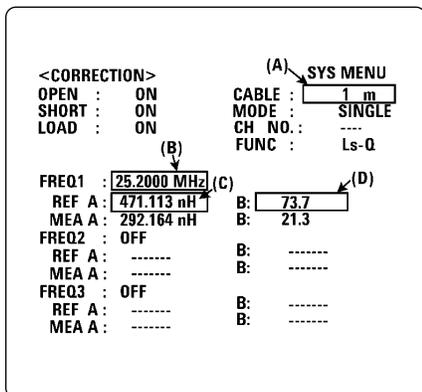


Figure 3. Correction function setup

As shown in figure 4, leave the contact electrodes open, then perform an open correction measurement to compensate for the stray admittance of extension leads and the contact electrodes.

The short correction function compensates for the residual impedance of extension leads and contact electrodes, and is very important for L and Q measurements. Short the electrodes to each other as directly as possible, then perform a short correction measurement. If you want to base your measurement on a working standard as a reference, then we recommend performing a load correction measurement in addition to an open/short correction measurement. The load correction function compensates for measurement errors of a test device by using load correction coefficients obtained from the measured values and the reference values of a working standard (load). Input the reference values of the working standard such as; L and Q values (C and D in figure 3). Connect the working standard to the contact electrodes, then perform the load correction measurement.

When using the 4285A, the reference values of the working standard can be obtained at the actual test frequency and signal level. Measure the working standard using the 4285A with a test fixture (such as the, 16047E or 16034G) setup under actual measurement conditions, and input these values as the reference values.

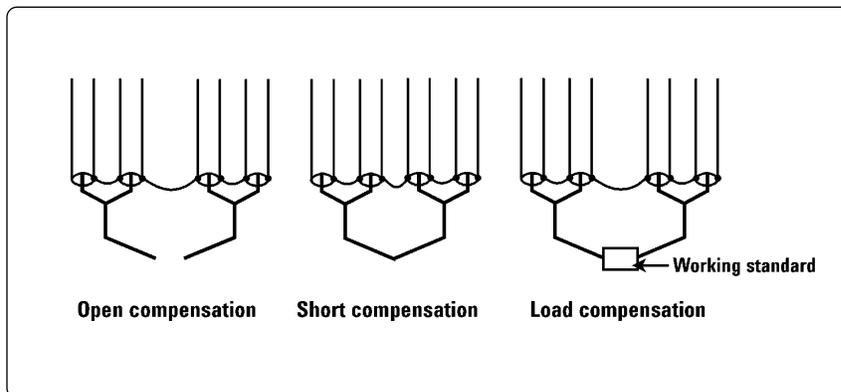


Figure 4. Performing correction measurements

#### 4. Measurement conditions and comparator setup

The measurement conditions, including frequency and signal level, should be set to appropriate values.

Figure 5 shows a comparator setup to sort test devices into BIN 1 through BIN 9 by L value and into IN/OUT by Q value.

#### 5. Interface timing design

The 4285A option 201 handler interface has the capability for adjusting the control signal timing between the 4285A and a handler. The interface is triggered by an (/EXT\_TRIG) signal from a handler, and outputs an end of analog measurement signal (/INDEX), an end of digital computation and comparison signal (/EOM), and BIN sort data (/BIN 1 through/BIN 9). Each output and input is isolated using an optocoupler, and the outputs are open collector.

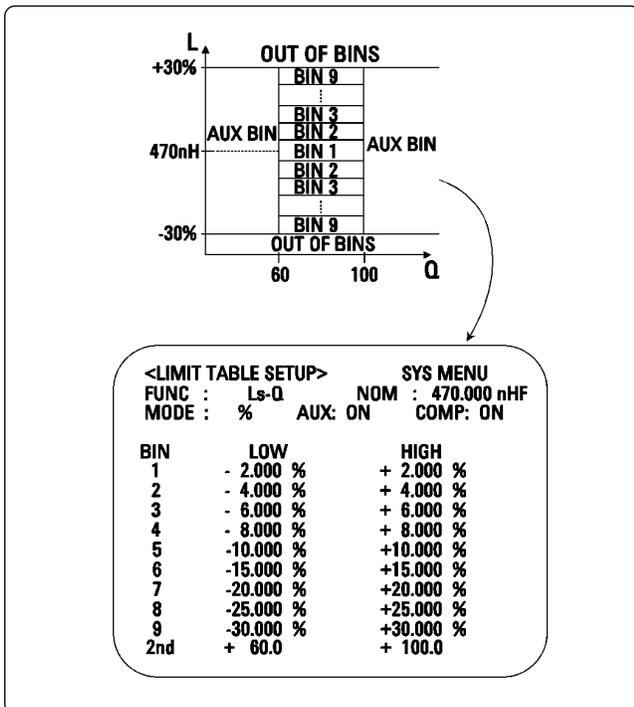


Figure 5 : Comparator setup

Figure 6 shows a sample timing chart for an interface. The total testing time for a device is as follows.

Measurement Time (30 ms @SHORT INTEG TIME) - Calculation/Comparison time + Device change/Sort Time. If necessary, a delay time (1 ms - 60 s) can be inserted before the measurement time (Tm1 in figure 6) to allow for a mechanical contact check within the handler.

#### 6. Memory card

Setup data including measurement conditions and comparator limit values can be stored in a memory card. Using this function, all setup data can be recalled with just a few key strokes, this is especially useful on the production line.

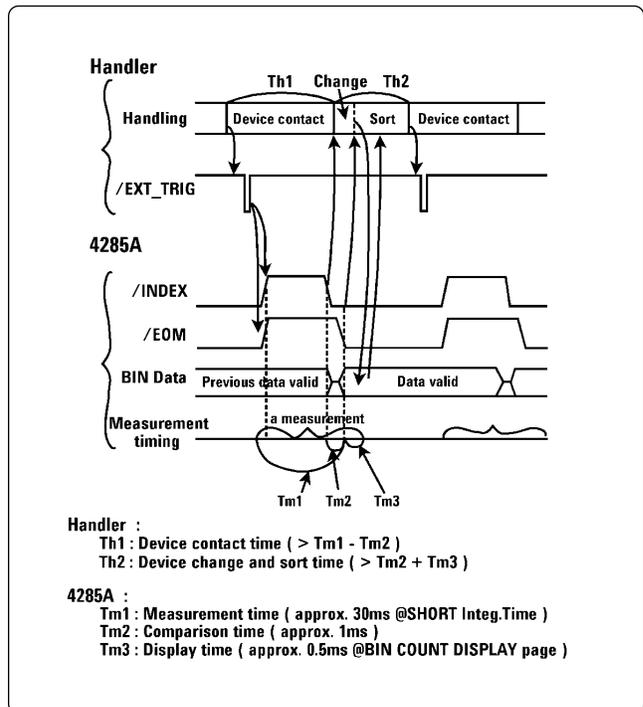


Figure 6 : Sample interface timing chart

## 7. Execution of measurement and sorting

During measurement and sorting, the BIN COUNT DISPLAY page shown in figure 7 displays the device count for each BIN. The display time ( $T_{m3}$  in figure 6) of the BIN COUNT DISPLAY page, is approximately 0.5 ms, shorter than for the other pages.

| <BIN COUNT DISPLAY> |          |             | SYS MENU |
|---------------------|----------|-------------|----------|
| FUNC :              | LOW[ % ] | HIGH[ % ]   | ▶ COUNT  |
| 1 -                 | 2.000    | + 2.000     | 49       |
| 2 -                 | 4.000    | + 4.000     | 23       |
| 3 -                 | 6.000    | + 6.000     | 12       |
| 4 -                 | 8.000    | + 8.000     | 9        |
| 5 -                 | 10.000   | + 10.000    | 6        |
| 6 -                 | 15.000   | + 15.000    | 0        |
| 7 -                 | 20.000   | + 20.000    | 0        |
| 8 -                 | 25.000   | + 25.000    | 0        |
| 9 -                 | 30.000   | + 30.000    | 0        |
| 2nd +               | 60.0     | + 100.0 [ ] |          |
| REJ CNT             | AUX: 2   | OUT: 7      |          |

Figure 7 : Sorting result

## Conclusion

This application note explains how the Agilent 4285A with its high accuracy/speed, can be employed to create a high quality and low cost RF inductor test system.

Furthermore, data acquisition and statistical analysis are available for quality control of RF inductors by adding an GPIB controller to the system, If you need dc current bias characteristics of inductors, it can be obtained by using the Agilent 42841A bias current source with the Agilent 4285A (up to 10 A bias). The 4285A can contribute to producing higher quality and lower cost inductors with its high performance measurement capabilities.

## Appendix A. ordering information

### Accurate and fast L-Q measurement system (figure 1)

- Agilent 4285A precision LCR meter  
Select one option among the following.
  - Option 201 handler interface  
Interface to output signals or measurement end and comparator data.
- Test leads  
Select one among the following.
  - Agilent 16048A (Total length is Approx. 95cm, BNC connectors)
  - Agilent 16048D (Total length is Approx. 189cm, BNC connectors)
- Agilent PN 04278-61650 handler interface cable (Amphenol 36 pin connectors (m))  
Approx. 1 m cable to connect between the 4285A and a handler. If necessary to extend a cable, make the following parts.
  - Cable (36 lines)
  - Amphenol 36 pin connector (m) (57FE-30360-20N(D8))
  - Amphenol 36 pin connector (f) (Agilent PN 1252-2022)

**By internet, phone, or fax, get assistance with all your test and measurement needs**

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