

# Keysight Technologies Effective Transformer/ LF Coil Testing

## Application Note





## Introduction

Transformers and LF coils are used in power supplies, digital networks (for example, ADSL) and various communication instruments to step up (or down) an AC voltage or for impedance conversion or filtering purposes. Though production of transformers is increasing year after year, there are problems that QA test efficiency and production test throughput cannot be easily improved because several different measurement instruments and setups need to be used for testing various transformer parameters. This application note introduces the cost-effective solutions to the transformer parameter measurements by using the Keysight Technologies, Inc. 4263B LCR Meter.

## Current Problems on Transformer/LF Coil Evaluation

The primary parameters that need to be known for transformer/LF coils are self-inductance, DC resistance, turns ratio and inter-winding capacitance. Conventional low-cost LCR meters have the following shortcomings when used for transformer/LF coil evaluation.

1. DC resistance of primary and secondary windings cannot be measured with LCR meters. (The DC resistance measurement requires using a separate test instrument such as a multimeter.)
2. The turns ratio, a key transformer parameter, cannot be measured with LCR meters.
3. The transformer parameters cannot be measured at 100 kHz because many low-cost LCR meters do not cover high frequencies up to 100 kHz.
4. The test signal level is automatically selected according to the measurement range, the test signal level cannot be user-defined for a specified level.
5. Total test throughput on production lines cannot be maximized because of slow measurement speed.
6. The connections of a transformer to the instrument (test fixture) must be changed to measure parameters for the primary and secondary windings. The required connection changes make it difficult to enhance the measurement efficiency.

## Keysight 4263B LCR Meter Solution

### 1. DC resistance measurement capability

The Keysight 4263B with option 001 (N/M/DCR measurement capability) can sequentially measure self-inductance and dc resistance ( $R_{dc}$ ) by alternately applying AC signal and DC signal to the DUT, as shown in Figure 1. DC resistance measurement function covers a wide range from 1 m $\Omega$  to 100 M $\Omega$  and enables a low resistance of transformer winding to be measured with a 0.01 m $\Omega$  minimum resolution. The N/M/DCR measurement function dispenses with a separate multimeter and additional measurement step, thus improving test efficiency.

### 2. Turns ratio and mutual inductance measurement capabilities

The Keysight 4263B with option 001 also adds turns ratio and mutual inductance measurement capabilities. A turns ratio (N) measurement value of 0.9000 to 200.00 can be obtained from a voltage ratio measurement for the primary and secondary. In the N measurement mode, an internal voltmeter and a selector switch (a unique function of the 4263B) are configured as shown in Figure 2. Mutual inductance (M) of 1  $\mu$ H to 100 H can be measured by connecting a transformer as shown in Figure 3. Mutual inductance value is obtained from the ratio measurement of the primary current and secondary voltage according to the equation ( $V_2 = j\omega MI_1$ ) shown in the figure. The direction (in-phase or an opposing phase connection) of windings can also be known from the plus/minus sign of mutual inductance measurement value. The combination of M and N measurements is suitable for the transformer parameter test based on general pulse transformer specifications.

### 3. Wide frequency range

The Keysight 4263B covers 5 test frequencies of 100 Hz, 120 Hz, 1 kHz, 10 kHz, and 100 kHz, which are the most popular to evaluate transformers and LCR components in low frequency region. Thus, the 4263B can perform 1 kHz transformer parameter tests in compliance with IEC 1007 and JIS C 6435 standards. Moreover, when evaluating transformers used in switch-mode power supplies, leakage inductance and inter-winding capacitance can be measured at 100 kHz, which is close to actual operating frequency of the transformer.

### 4. Flexible test signal level and level monitor

The variable test signal level (20 mV to 1V rms in 5 mV rms steps) and signal level monitor function allow you to test transformers at a specified test signal voltage or current and to evaluate the transformer parameters under the defined test signal conditions. Thereby, consistent measurement data can be obtained even when the characteristics of the transformer exhibit a test signal level dependency.

## 5. High-speed measurements

The 4263B can perform high-speed measurements to enhance test throughput. In the short integration time mode, measurement time is 25 ms even at the lowest test frequency of 100 Hz. Additionally, the 4263B has the following features which enhance measurement efficiency, reliability and ease of system integration:

- Built-in High/In/Low comparator
- Handler interface
- GPIB interface
- Fast contact check function ( $\leq 5$  ms)
- Trigger delay function (variable from 0 to 9.999 seconds)
- Non-volatile memory to save/recall up to ten measurement setups

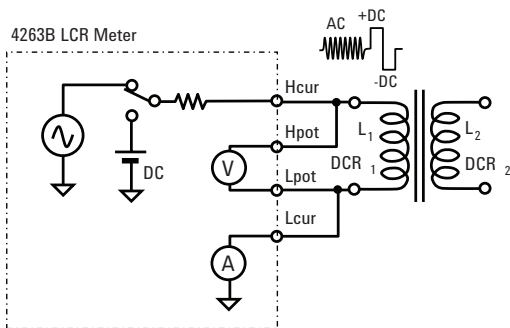


Figure 1. L – DCR measurement

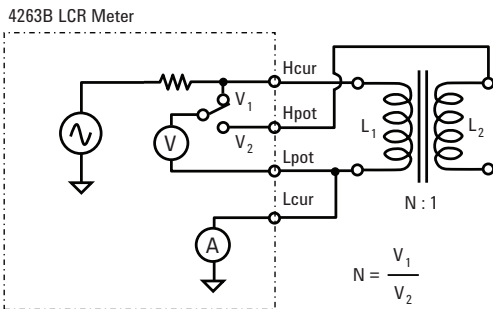


Figure 2. Turns ratio (N) measurement

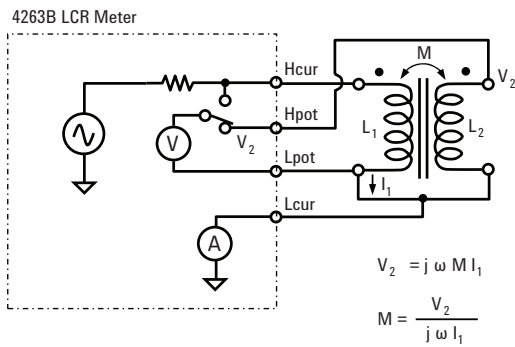


Figure 3. Mutual inductance (M) measurement

## 6. Keysight 16060A transformer test fixture

The 16060A transformer test fixture further enhances the transformer measurement efficiency. The 16060A enables the inductance and DC resistance of secondary winding to be measured without changing the connections between the transformer and the test fixture's terminals. By manually operating a selector switch on the 16060A, you can quickly switch the connections to the secondary from the primary or revert back. Circuit diagram shown in Figure 4 indicates how the 16060A works to facilitate transformer measurements. Figure 5 shows an example of transformer measurement setup using the 16060A and the 4263B equipped with option 001.

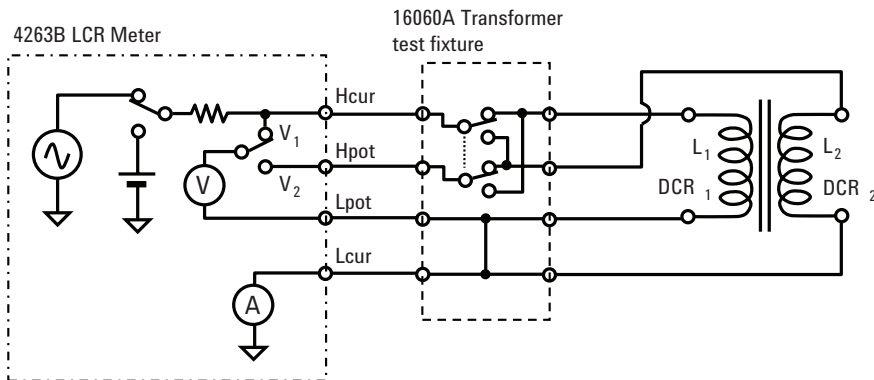


Figure 4. 16060A Transformer test fixture schematic diagram

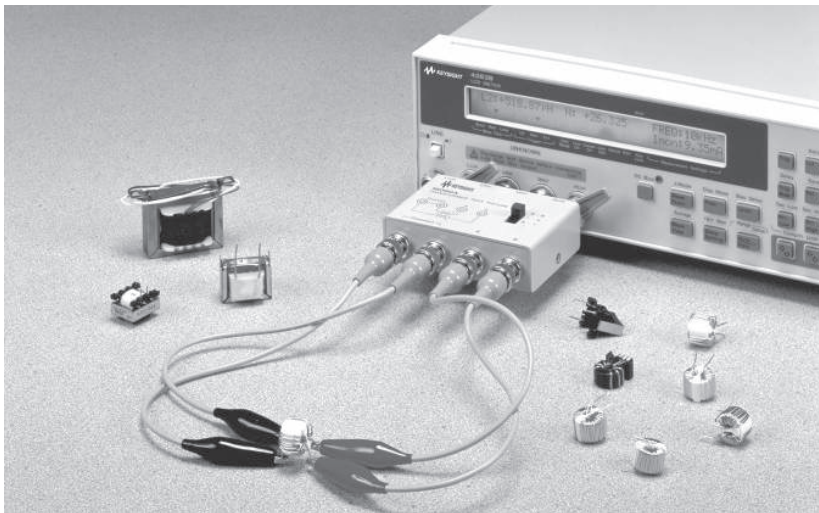


Figure 5. Transformer measurement using the 16060A

## Conclusion

The Keysight 4263B LCR meter realizes the wide frequency range, and flexible test signals with high measurement speed. In addition, when equipped with Option 001 the 4263B offers a one box measurement solution for dc resistance, turns ratio, and mutual inductance. So now an effective measurement solution is available for your transformer/LF coil evaluation needs.

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