Keysight Technologies
Effective Multi-tap Transformer Measurement using a Scanner and the 4263B LCR Meter

Application Note
Introduction

With the progress of recent electronics equipment and digital networks, production amounts are increasing of the transformers which contribute to equipment miniaturization, low power dissipation and higher quality. Therefore, improvement of select estimate efficiency is required at the production line or incoming inspection. Noticed recently, improvement of estimation efficiency is required for pulse transformers which are used in LAN or ISDN digital networks, and for multi.-tap transformers with three or more pole taps, such as switching power transformers. This application note shows an effective multi-tap transformer measurement using a scanner and the 4263B LCR meter.
The 4263B LCR meter is a low price instrument which measures the fundamental parameters of LCR components with speeds as fast as 25ms, at frequencies of 100, 120, 1k, 10k and 100kHz. In addition, with option 001, the 4263B measures turns ratio (N), mutual inductance (M) and dc resistance (DCR) which are required for transformer measurement. Figure 1 shows a 4263B simple block diagram for L, M, and DCR measurement.

For example, in the inductance-turns ratio (L-N) measurement, an ac voltage is applied at the Hcur terminal. Self-inductance value (L1) is calculated from the measured values of V1 and I1. Turns ratio (N) is automatically obtained from the ratio of measured values V1 and V2 (discriminating the polarity simultaneously).

In the dc resistance (of L-DCR) measurement, the applied voltage at the Hcur terminal is dc. Dc resistance value (DCR1) is calculated from the measured values V1 and I1.

There are, however, the following limitations when using the measurement connection.

- Only primary self-inductance and dc resistance of the transformer can be measured. For the secondary values, the transformer connections must be changed.
- Turns ratio must be 0.9 or more (In the case of less than 0.9, the measurement is not performed due to saturation of internal circuitry).

The Keysight Technologies, Inc. 16060A transformer test fixture can be used to overcome these limitations. By changing the external switch of this fixture, connections to the transformer are changed and thus both primary and secondary parameters and turns ratio can easily be measured. Figure 2 shows the simple block diagram of the 16060A.
Multi-Tap Transformer Measurement Using a Scanner

Multi-tap transformers having two or more poles can be measured with the 4263B and a scanner.

(A) System configuration

Figure 3 shows the system configuration for measuring a multi-tap transformer that has 4 taps.

The 3488A switch/control unit with a 4 x 4 matrix switch module (Opt. 013) is used. Option 013 offers highly flexible switching, and any combination of 4 input channels may be connected to any combination of 4 output channels. Thus option 013 is suitable for testing the multi-tap transformer. Figure 4 shows the hardware configuration of the 4 x 4 matrix switch module.

(B) System construction recommendations

When constructing the system, the following points must be considered to assure the measurements are as precise as can be. (See figure 5)

1. Make measurement cables as short as possible. The parasitic inductance and resistance of measurement cables make a large contribution to measurement error. For recommendable length, conductive wire inductance value must be 1/10 or less than the measured inductance value (similarly conductive wire resistance).

2. Configure into a shielded 2 terminal configuration, to prevent the influence of external noise or stray capacitance.

3. Connect the low terminals close to the transformer. In the 4263B transformer measurement, the primary and secondary inductors’ low terminals of the transformer must be connected together. When using a scanner, these connections should be close to the transformer under test. If connecting at a far point from the transformer (for example, input point of scanner module), low side wire resistance would contribute to increase measurement error.
(C) Measurement procedure

All measurements of the multi-tap transformer, self-inductance, dc resistance, and turns ratio, can be measured with only one connection by using the sample program shown at the end of this note (for HP 9000 Series 300 Controller). Figure 6 show the flow chart of the sample program.

Figure 6. Flow chart of sample program
This program executes the open and short corrections and displays each measured value of each tap of the transformer. If turns ratio measurement cannot be made due to the condition that turns ratio must be 0.9 or greater, the scanner will be automatically changed and the measurements re-done. This program can be modified to match other systems or conditions.

The following steps outline the program procedure:

**Step 1.** Run the program. The following message is displayed on the controller’s display.

```
Selection (1) Measurement (2) Correction ?
Type number and press RETURN key
```

At this point, select the measurement directly, or first the measurement of correction data. To execute the measurement, type 1 and press RETURN key on the controller (Go to step 4). To measure the correction data, type 2 and press RETURN key on the controller.

**Step 2.** If the measurement of correction data in step 1 was selected, the following message is displayed on the controller’s display. The open correction data of each channel of the scanner (CH.0-CH.3) is now measured.

```
CH.0 Open measurement
Open test terminals of CH.0
Start open meas. (2) Skip CH.0 open meas?
Type number and press RETURN key
```

To measure the open correction data, set all channels to the open condition as shown in figure 7. Then, type 1 and press RETURN key on the controller. Open correction data of channel number 0 (CH.0) is acquired. Continue to acquire data for channels 1 - 3.

![Figure 7: OPEN Condition](image)
Step 3. After the open correction measurements are completed, the following messages is displayed on the controller's display. The short correction data of each channel of the scanner (CH.0 - CH.3) is now measured.

CH.0 Short measurement
Short test terminals of CH.0
Start short meas. (2) Skip CH.0 short meas.?

Type number and press RETURN key

To measure the short correction data, set all channels to short condition as shown in figure 8. Then, type 1 and press the RETURN key on the controller. Short correction data of channel number 0 (CH.0) is acquired. Continue to acquire data for channels 1 - 3.

Step 4. After the open/short correction data is acquired, the following message (same as in step 1) is displayed on the controller’s display.

Selection (1) Measurement (2) Correction?
Type number and press RETURN key

To execute the measurement, connect the multi-tap transformer under test to the scanner as shown in figure 9. Type 1 and press the RETURN key on the controller.

Self-inductance, dc resistance and turns ratio are measured by scanning each tap of the multi-tap transformer.

| N1: | L[H]: 6.00928E-6 DCR [OHM]: .0134568726173 N: 1 |
| N2: | L[H]: 2.392557E-5 DCR [OHM]: .0171348134407 N: 2.1304 |
| N4: | L[H]: 0.0038334126 DCR [OHM]: .0250939715609 N: 8.0188 |

Do you want to continue to measure (1) yes (2) no

Step 5. If you want to repeat the measurement, type 1 and press RETURN key on the controller. Or to end the program, type 2 and press RETURN key on the controller.

(D) Additional measurement error
The system configuration shown in figure 3, slightly increases measurement errors, in comparison with measured values using the 16060A transformer test fixture. These errors (supplemental characteristics) are the following using frequency: 1 kHz, signal level: 1 Vrms, measurement time: Medium.

Self-inductance: refer to figure 10
Dc resistance: refer to figure 11
Turns ratio: 0.02 % or less
Conclusion

By combining the 4263B (with Option 001) with a scanner, the required parameters of a multi-tap transformer can be measured with only one connection. Using this method improves efficiency at the production line or incoming inspection.
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