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Design Ideas: ***July 6, 1995***

Measure inductance with dc superimposed

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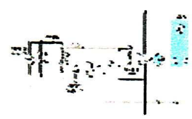


In some applications, magnetic components are difficult to characterize when steady-state current is flowing. Bridges having the necessary dc capability are expensive. If you don't need extreme precision (for example, 2% or better), other measurement methods exist. The method in Fig 1 is universally applicable over a range of inductances and frequencies. The basis for the inductance measurement is to determine the ac impedance at the frequency (f), ideally the inductor's working frequency of interest. In Fig 1, the ac voltages across the inductor and the reference resistor R_R are V_{LAC} and V_{RAC}, respectively, and the circulating alternating current is I_{AC}.

You need the following two components for proper operation: 1. The dc isolation transformer with a gap that prevents saturation at the maximum rated dc. In this example, for 25A current, use an EI-configured core of 0.014-in. grain-oriented silicon steel. The primary winding uses 160 turns of AWG 30 double-covered magnet wire. The secondary winding consists of 32 turns of AWG 14 magnet wire wound in two steps: 16 turns, followed by the primary winding, followed by the final 16 turns. 2. The reference resistor, which must have four terminals (two for forcing current, two for sensing voltage) if its value is lower than 3ê. It also must have negligible inductance and skin effect at the frequency of interest. One way to make a resistor with such characteristics is to connect several (maybe five to 10) metal-film resistors in parallel.

To keep errors low, ensure that $3V_{RAC}$ is less than V_{LAC}. Check oscilloscope photos to be sure the waveforms are reasonably sinusoidal, denoting that the flux density is below the saturation level. You can also measure the dc I_{DC} by using the same DVM or the oscilloscope in dc mode. To determine the impedance, Z_L, use the following equations:

$$Z_L = \frac{V_{LAC}}{I_{LAC}} = \frac{V_{LAC} \times R_R}{V_{RAC}} \Rightarrow \frac{V_{LAC}}{I_{LAC}} = \frac{V_{LAC} R_R}{V_{RAC}}$$

$$L = \frac{Z_L}{2\pi f} = \frac{V_{LAC} \times R_R}{2\pi f V_{RAC}} \Rightarrow \frac{Z_L}{2\pi f} = \frac{V_{LAC} R_R}{2\pi f V_{RAC}}$$

The error in V_{LAC} from V_{RAC} is negligible because these two quantities are 90ø out of phase. Measure both V_{LAC} and V_{RAC} the same way--by using the oscilloscope's p-p value, the DVM's average value, or the DVM's rms value. The power supply should have 3 to 5% maximum ripple and a constant-current setting for ease of making repeated measurements. The zener diodes across the primary winding protect the frequency generator against spikes that occur when you instantaneously apply or cut off the dc.

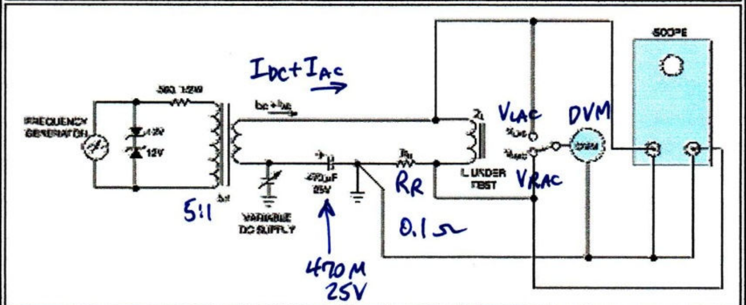
An example uses a 50-µH inductor operating at 100 kHz, with a 100-mê reference resistor, R_R. Measurements yield V_{RDC}=1V (10A), V_{LAC}=1.2V, and V_{RAC}=38 mV.

$$L=\frac{V_{LAC}R_R}{2\pi f\,V_{RAC}}=\frac{1.2V\times 0.100\Omega}{6.28\times 100{,}000\ Hz\times 0.038V}=5.03\ \mu H$$

(DI ##1729)

$$L=\frac{V_{LAC}\,R_R}{2\pi f\,V_{RAC}}$$

Figure 1



Using this circuit, you can measure inductance with any amount of direct current superimposed.

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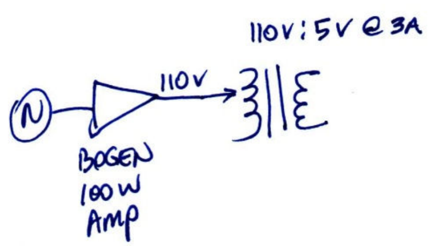

INSURE:
VLAC > 3 × VRAC