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TRANSFORMERS

How to measure primary inductance in output transformers

A common question about our tube output transformers and chokes is: "Why is the primary inductance I measure with my LCR meter much lower than the value in the datasheet?"

Primary magnetizing inductance is a complex and dynamic parameter, making it difficult to measure consistently across different methods. We measure the primary inductance value at 50 Hz, with the primary windings in series, and at the transformer's normal working voltage. Our method is to excite the primary winding using a variac (adjustable voltage output transformer) connected to the mains, then measure the voltage and current. Because the inductive reactance is much higher than the winding resistance, a good approximation is $X_L=V/I$, and $L=X_L/(2\pi f)$.

Note: This method can be hazardous with risk of electrical shock. It should only be performed by those with appropriate knowledge and equipment.

Are there other ways to measure? Let's use our LL1663/PP transformer as an example and compare the results from different measurement alternatives:

1.1) Use a LCR meter (Tenma 72-10465) Lp mode on primary

1.2) same as 1.1 but on secondary and multiply by turns ratio N squared

2.1) Signal generator as stimuli and measure voltage and current on primary

2.2) same as 2.1 but on secondary and multiply by turns ratio N squared

3) Signal generator and a 47kOhm series resistor as stimuli and measure phase difference between resistor and transformer voltage.

4) Variac, direct voltage and current measurement

Alt.	U (Vrms)	I (mArms)	Frequency (Hz)	Phase (degr.)	Inductance(H)	Formula
1.1	0.6	-	100	-	36.8	LCR result
1.2	0.6	-	100	-	102.8	N^2*LCR result
2.1	10	0.27	50	-	118	L=V/(2*pi*f*I)
2.2	7.9	88	50	-	167	L= N^2*V/(2*pi*f*I)
3	90	-	50	42.1	135	47k*tan(φ)
4	230	4.36	50	-	168	L=V/(2*pi*f*I)

The table shows a clear correlation between the stimulus voltage applied to the primary winding and the measured inductance. This is because the core permeability is nonlinear: at low magnetic fields (such as when using an LCR meter), the core operates far from its normal working point, resulting in a lower measured inductance. There is also a frequency dependency—most handheld LCR meters use 100 or 120 Hz as their lowest setting. All the measurements above are valid, but they are performed at different magnetic flux work points. In our opinion the voltage/current measurement using a variac best represents the transformer's behaviour in an actual application.

However, as shown in table alternative 2.2, it is possible to obtain a comparable result by applying a low-power source to the secondary winding and scaling by the turns ratio squared (N^2). For example, with a 24:1 turns ratio, a modest voltage on the secondary produces a high primary voltage, bringing the core closer to its normal operating point. This method is advantageous because signal generators are more commonly available than variacs in most home labs, and it is electrically safe since the signal generator is power-limited and often isolated from mains voltage. This method works with output transformers but not with chokes, because it require a low voltage secondary winding.