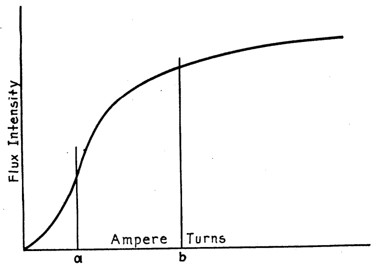
Old power supply chokes typically don't come with a rating plate stating their inductance and DC current rating. Manufacturers like Rola were an exception, with labelling such as 14H at 60mA measured at 10V 100Hz, with 560Ω DC resistance for the choke type 14/60.

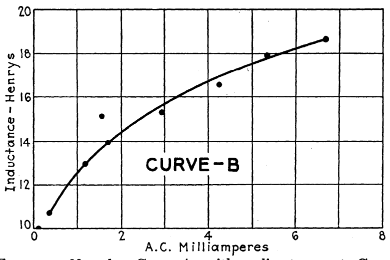
Within a valve amplifier, the high voltage (HT) DC supply with "choke input" filter applies a very large 100Hz AC voltage across the choke which is much greater than 10V, and contains substantial higher harmonic levels (one end of the choke cycles from 0V to the peak of the AC supply, and the other end of the choke is pinned to the HT DC voltage). Whereas a smoothing choke application, where the choke is connected between two capacitors, experiences a much lower AC voltage (likely to be less than 10V at 100Hz, with relatively low harmonic levels).

ROLA 14/60 choke

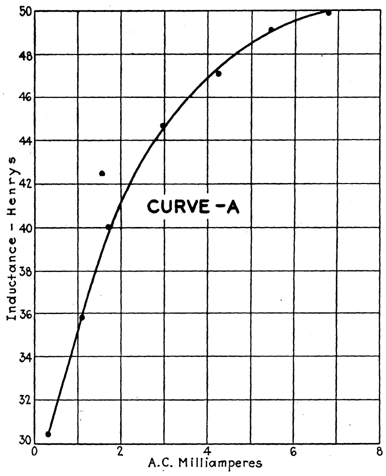
The inductance of an iron-cored choke can vary significantly with applied AC voltage (ie. ac current), and with the level of DC current passing through the choke. Results below, from [1], show those characteristics. So it is important to compare choke ratings only when similar operating conditions are being applied, and to be aware that the choke inductance value by itself is only half the story for power supply use.

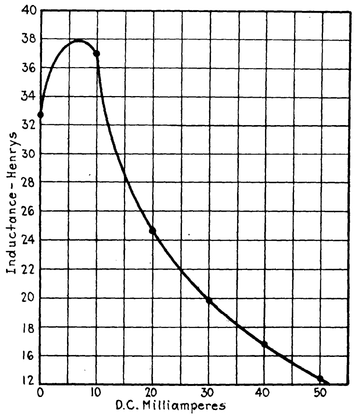


Typical Magnetization Curve of Transformer Iron.



Frequency 60 cycles. Curve *A*—with no direct current. Curve *B*—with 50 milliamperes of direct current flowing.





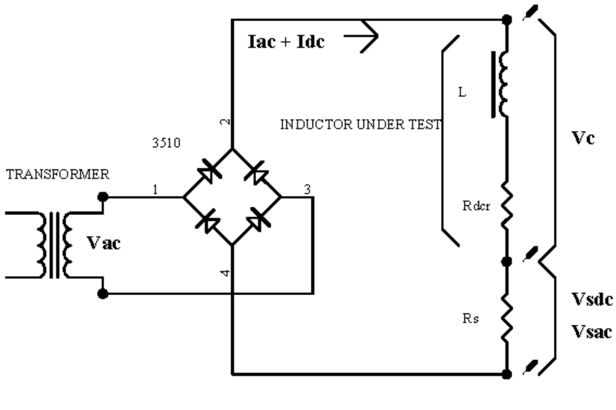
Frequency 60 cycles
5 milliamperes of alternating current.

Choke inductance measurements [1] showing variation with AC & DC current.

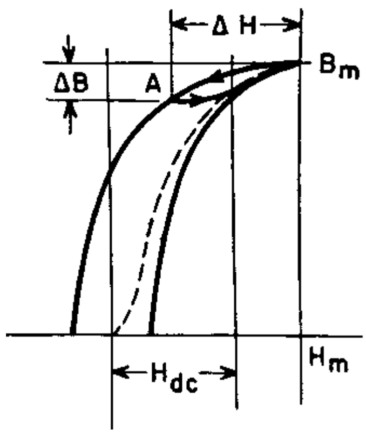
Simple measurement scheme

Choke inductance can be measured using a relatively simple method that passes DC plus AC current through the choke. The test circuit uses the choke to load the rectified output of a transformer power supply. A low value sense resistor Rs is used to make Idc and Iac current measurements. The choke is shown as an inductance L and a DC resistance Rdcr. The total DC resistance of the loading circuit is Rdcr + Rs.

By using different AC supply voltage levels, Vac (rms), the level of DC current can be varied. The AC waveform applied to the choke is a rectified sinewave with a DC level of 0.9*Vac, and so a DC current of about Idc = 0.9*Vac/(Rdcr + Rs) flows through the choke.



The AC voltage across the choke has a level of $Vc=1.27*Vac/(n^2-1)$, where n=2,4,6.. (ie. the even harmonics of the mains frequency) [2]. The harmonic levels drop off rapidly, so simply using just the n=2 (ie. 100Hz) harmonic frequency indicates that the applied AC voltage on the choke is approximately Vc = 0.42*Vac. The AC current can be approximated by Iac = Vac/(1500*L), where L is in Henry - this approximation assumes the choke reactance (2.π.f.L) is much larger than Rdcr, and only 2^{nd} harmonic current is significant. If we assume Rdcr>>Rs, then the previous equations can be rejigged to show that DC current is larger than the AC current by the ratio of about Idc/Iac = 1350*L/Rdcr, which is 38 times for the Rola choke example.



So this simple test method measures the small signal (incremental) inductance of the choke, where a relatively large DC current is passing in comparison to the AC current, and is similar to a smoothing choke application. With respect to what the choke core experiences for this application, the graph on the right shows the choke core magnetised with the DC magnetising force Hdc, and a smaller AC magnetisation level ΔH is superimposed which causes a cyclical magnetisation loop to be followed between A and Bm.

This measurement scheme is not inherently accurate, due to affects like rectifier diode drop, mains voltage waveform distortion, and the influence of higher order rectification harmonics, but in practise gives sufficiently good inductance precision, especially given that choke inductance can vary so much with operating conditions.

When the mains is turned off or the supply disconnected in some manner, and twice during each mains cycle, the DC current in the test circuit commutates through the diode bridge, which acts as a free-wheeling diode (similar in action to the protection/suppression diode typically placed across a DC relay coil).

Test Method

Use a true-rms meter to measure Vsac across sense resistor Rs (to derive Iac=Vsac/Rs), and to measure Vc across the choke. Choke impedance Z is then Z= Vc / Iac. For most types of choke, the choke inductance can be approximated by the impedance, such that choke inductance L = Z/(2.π.f), as $|Z| = \sqrt{((2.\pi.f.L)^2+Rdcr^2)}$ and $(2.\pi.f.L)^2 >> Rdcr^2$. A calculation spreadsheet is available [4], and accounts for the effect of Rdcr on the choke inductance calculation.

Measure the DC Voltage Vsdc across sense resistor Rs. DC current through choke is then Idc=Vsdc/Rs.

Using a small value for Rs (ie. 10Ω) will require a meter with at least 1-10mV resolution. This will normally require a high quality voltmeter to be used, as the likes of a Fluke 115 handheld won't do (although it has a 600mV AC-DC range, this can over-range due to the DC level exceeding 600mV even though the AC level being measured is low, and so 6VAC range is only available). Raising Rs value to say 100Ω will help with poorer resolution meters, and shouldn't really affect accuracy or be significant compared to Rdcr for many chokes. Check your meter performance specification as part of preparing to take measurements.

A tapped transformer can be used to change the Vac level, to change the DC current through the inductor, and hence check the drop off of inductance as DC current increases. I test using 12V, 20V, 32V and 52VAC secondaries through a bridge diode, and get sufficient sense voltage levels with Rs=10Ω although I am using a lab grade Keithley 197 DMM. A couple of multi-tapped 0-24VAC transformers would be quite practical. The test circuit requires the transformer secondaries to have sufficient current rating to suit the DC current being applied to the choke (eg. a 1A secondary rating would suit many chokes used in valve amps).

Choke Performance

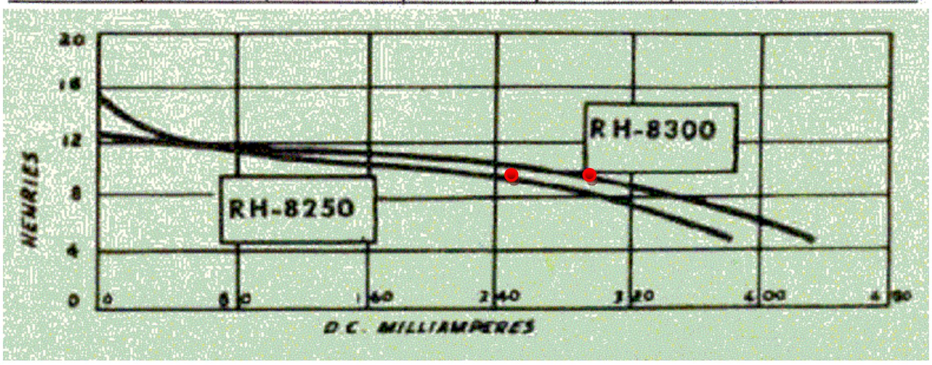
The example 14H Rola choke was measured using the described test method. The nominal transformer voltage Vac used for four measurement points is given in the following table. Rdcr was measured at 535Ω, and SRF at 6kHz (C≈50pF). The test results agree well with the 14H at 60mA DC part rating.

Vac	12 V	20 V	32 V	52 V
Idc	17 mA	30 mA	50 mA	82 mA

Iac	0.6 mA	0.9 mA	1.4 mA	2.7 mA
Vc	5.85 V	9.17 V	14.1 V	23.1 V
L	15.5 H	16.2 H	16.1 H	13.6 H

The measured drop in inductance with DC current, along with the DC resistance of the choke, can provide a good estimate of the manufacturer's DC current rating for the part. The following product curves of inductance are from Chicago Transformer chokes at 10V 60 Hz excitation [3]. The power loss at rated max DC current is about 5.5W for each choke (note that these are large chokes). The much smaller example Rola choke has a max power loss of only 2W at rated 60mA DC.

Catalog No.	Inductance Henries	Max. D-C Current, Ma.	D-C Resistance in Ohms	Insulation Test Volts RMS	Case Size	Wt. Lbs.
RH-8250	8	250	90	2500	22	10½
RH-8300	8	300	60	3500	22	12½



Uncommon iron-cored chokes for valve amp power supplies

The typical flouro ballast choke is compact, double insulated, and appears fine to sit at 600VDC or more and be used for a choke-input filter. A 240VAC 18W choke is very common, measures about 1.5-2H, and would be suitable for up to 300mA DC (power dissipation up to 5W). A 240VAC 9W choke would be even better.

An ATCO EC18/20 240VAC 50Hz choke gave measurement levels of Rdcr=54Ω, SRF=10kHz (150pF shunt):

Vac	12 V	20 V	32 V	52 V
Idc	147 mA	260 mA	420 mA	517 mA
L	1.88 H	1.69 H	1.45 H	1.26 H

Some Wurlitzer organs included a large number of note inductors (iron-cored with variable gap setting), of which a few provide up to 4H inductance and are suitable for up to 30mA DC (eg. suitable for screen and preamp filtering).

A Wurlitzer 500407 inductor from a 4100B organ (minimum gap) gave measurement levels of Rdcr=266Ω:

Vac	12 V	20 V	32 V
Idc	30 mA	50 mA	90 mA
L	4.1 H	2.3 H	0.9 H

Ripple trap assessment

The test circuit can be used to measure the changing AC current harmonics passing through a choke with a parallel capacitor (and series dampening resistance), sometimes referred to as a ripple trap (a technique used in power supplies to attenuate the dominant 2f ripple component). Displaying the ripple current (voltage across sense resistor) on a spectrum analyser shows the increasing attenuation of the 2f harmonic as the parallel capacitance value is increased towards LC resonance, but also shows a corresponding increase in the magnitude of higher ripple frequencies being passed through. The filter capacitor following the choke bypasses the ripple currents, with the net result of a lower rms ripple voltage across that capacitor. Given the likelihood of choke inductance being higher than its rated value when DC current is below the rated level, and given the increase in higher order harmonics with increasing capacitance, it is recommended that a lower capacitor value is used than what would be expected to tune the rated inductance at 2f – perhaps at least 20% lower. The dampening resistance in series with the capacitor is typically twice the choke DCR.

Output Transformer Primary Inductance

The test circuit can be used to measure the half primary, and P-P primary winding inductances of output transformers with an unbalanced DC current level. The measured inductances will be significantly below the zero DC current inductance level, and will reduce with higher DC current level. Hi-fi quality OT's will measure the same primary inductance, whereas PA OT's will show different inductances.

Inductance measurement at zero DC current can be achieved by connecting a DC current source with high AC impedance to pass DC current through one half-primary, so that the DC current from the test circuit is nulled in the other half winding. The DC current source could be eg. a 12V battery in series with a 2W 500Ω pot and a choke.

[1] 'The Measurement of Choke Coil Inductance', C.A.Wright & F.T.Bowditch, 1927. www.dalmura.com.au/projects/THE MEASUREMENT OF CHOKE COIL INDUCTANCE.pdf

[2] Fourier Analysis, Lucas Illing, 2008

http://www.reed.edu/physics/courses/Physics331.f08/pdf/Fourier.pdf

[3] Chicago, Transformers and filter reactors, CT8-58.

[4] http://www.dalmura.com.au/projects/OT%20calcs.xls