GENERAL RADIO COMPANY
engineering department

TECHNICAL PUBLICATION B-12 AUGUST, 1959

DETERMINATION OF RESONANCE FREQUENCIES OF GENERAL RADIO TYPE 1482 STANDARD INDUCTORS

by

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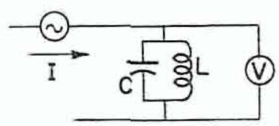
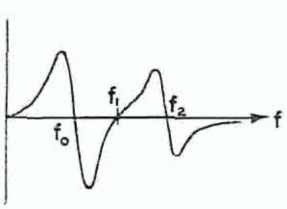
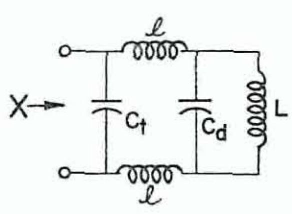
The General Radio Type 1482 Standard Inductors have, as do all such inductors, some capacitance in parallel with the inductance. The magnitude of this capacitance is indicated in the GR Catalog by a tabulation of the frequencies of resonance of the winding inductance with this shunt capacitance in each inductor. The resonance is presumed to be a "free" resonance, that is, with neither the inductance nor the capacitance modified by elements external to the inductor, such as the connections made to the terminals. The frequency of this resonance could, in theory, be determined by driving the inductor with a constant current of variable frequency and adjusting the frequency until the voltage across the inductor, measured with a voltmeter of infinite input impedance, was maximum.



At maximum impedance and, hence, maximum voltage, $f_o^2 = 1/4\pi^2\ LC$.

Life is, of course, not quite so simple. In the first place, the inductor is not a simple parallel-resonant circuit but has multiple resonances, as shown in the figure below, corresponding to an equivalent circuit of the form also shown below.





These multiple resonances arise, essentially, from the fact that the symmetry of distributed capacitance of the toroidal coil is disturbed at the ends, the largest and most effective C being that across the ends of the coil. The lowest frequency of resonance, f_o, is that determined by the terminal capacitance, C_t, and the effective inductance of the other circuit elements. It is this first resonance, f_o, that is to be determined.

The basic method of determining the resonance frequency is that described above. The constant-current generator is approximated by connecting a high impedance in series with a constant-voltage generator of variable frequency. The voltmeter of infinite input impedance is also approximated by adding a very high impedance in series with a high-impedance VTVM. The frequency is then varied for maximum voltmeter deflection, and the lowest frequency giving a maximum is the desired f_o.

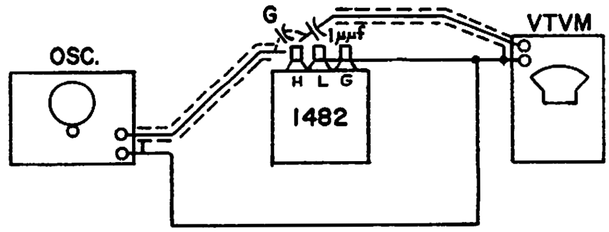
In more practical terms, the measurement can be made in the following manner: For the generator, use a variable-frequency oscillator with a high output voltage (10-50 volts). The Type 1330-A Bridge Oscillator is suitable for all our inductors except the 10-henry 1482-T, but for the larger inductors with resonances below 20 kc per second, the adjustment of frequency is easier with the Type 1304-B Beat-Frequency Audio Generator. The accuracy of frequency measurement can, of course, be improved by comparing the oscillator frequency with a frequency standard (such as the Type 1213-C).

Couple the generator to the inductor through a very small capacitance (less than 1 μμf). This can be just an air gap of about 1/4" between the end of the lead from the high generator terminal and the high terminal of the inductor. This lead should be shielded from the generator up to the inductor with just a small section of the high lead exposed at the end next to the inductor terminal. For this purpose, a Type 274-NCO Patch Cord can be used; at the inductor end, the ground side of the plug is inserted into the inductor ground terminal, but the high side of the plug is outside the terminal and about 1/4" away from it.

A similar loose (and high-impedance) coupling is to be used between the vacuum-tube voltmeter and the inductor. Connect a miniature ceramic capacitor (about 1 μμf) to the high terminal of the voltmeter probe or to the end of a shielded cable from the voltmeter. The capacitor lead is to be brought only as near to the high inductor terminal as is required to give a usable deflection on the meter at resonance. In the few cases where the capacitor might have to be connected to the inductor terminal for adequate deflection, the capacitance connected across the inductor is still limited to the 1 μμf or so of the small capacitor.

To keep the capacitance added to the inductor as low as possible, it is desirable to use a voltmeter of high sensitivity. The Type 1800-B with 0.5 volt full scale is used by the GR Laboratory, but meters with higher sensitivity are to be recommended.

Some care should be taken to keep the direct coupling between the generator lead and the voltmeter probe as small as possible. The effect of such coupling will be to give a "zero" deflection of the meter which will obscure or diminish the resonance peak. It is the purpose of the shielding on the generator and voltmeter leads to reduce the direct capacitance, C_3. This capacitance can also be reduced by the positioning of the two leads on opposite sides of the inductor terminal so that the terminals help to shield the voltmeter from the generator lead.



With these precautions and with adequate calibration of the oscillator frequency, the measurement of the resonance frequency, f_o, should be accurate to better than ±1%. The values tabulated in the catalog are average values for the Type 1482 Standard Inductors. The calibration certificate supplied with each Type 1482, however, gives the frequency measured for that inductor. The precision of measurement and other useful information are to be found in the table below. The most common error is the measurement of the second resonance peak instead of the first, particularly in the large inductances where the second resonance has the higher maximum voltage. The resonances to be avoided are also indicated in the table.

RESONANCE FREQUENCIES OF TYPE 1482 INDUCTORS

Type 1482 Inductor	L	Catalog f_o	$C = 1/\omega_o^2 L$	Range		Avoid Peaks Above	Measure To
				Min	Max		
		kc	μμf	kc	kc	kc	kc
B	100 μh	3500	21	3300	4400	4950	20
C	200	2150	27	1900	2400	2850	20
D	500	1180	36	1000	1300	1500	10
E	1 mh	700	52	610	780	920	5
F	2	620	33	570	680	850	5
G	5	370	37	340	420	510	2
H	10	240	44	230	280	345	2
J	20	170	44	150	200	225	1
K	50	92	60	82	100	125	1
L	100	61	68	52	66	80	0.5
M	200	38	88	35	44	53	0.2
N	500	27	69	24	31	36	0.2
P	1 h	15.3	108	12.8	18.8	20*	0.05
Q	2	10.2	122	9.0	11.0	13.5*	0.05
R	5	6.2	132	5.8	7.0	8.7*	0.05
T	10	4.3	137	3.5	5.1	5.1*	0.05

*Strong false peak. WATCH OUT!

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WEST CONCORD, MASSACHUSETTS

Printed in U.S.A.