UPC No. 91
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2/22/79

Recommendation to Replace existing Inductance Bridges for ED Dipole L and Q Measurements.

I have made some L and Q measurements on ED dipoles in the Magnet Factory with Bill Mumper (works for Jim Humbert) using both the HP4260 bridge and the GR1650B bridge. Both instruments read correctly on an inductance standard made to represent a typical ED dipole at 1kHz (L ~ 26 mHy, Q = 2.0).

the GR bridge read L = 24.0 mHy, Q = 2.25 (no ground) and L = 24.4 mHy, Q = 2.25 (grounded collars). By contrast, the HP instrument read L = 26.0 mHy, Q = 5.0 (grounded collars). When the collars were not grounded, a very poor and unreliable reading resulted. The signal level and the grounding problem in the HP 4260 is not compatible with an industrial environment, and I recommend its replacement.

the signal level in the GR 1650B bridge is roughly 8X higher than the HP instrument (1 v RMS vs 120 mv rms) and therefore less sensitive to industrial noise. the 0.4 mHy rise seen in the GR bridge readings when the collars are grounded was predicted (see my earlier note on Interpretation of L+Q Meas). As the GR bridge is battery operated it does not suffer from ground loop problems. Cost of GR bridges is about $1100 ea.

the GR bridge suffers from the same problem most others do - accuracy.

The calibrations are at 2% intervals (L) and 10% intervals (Q). Interpolation is required to get a better reading. The resistor - DVM method (see attached note) seems to have an inherent accuracy of 0.5% to 1% in L and 1%-2% in Q for an industrial environment.

Clearly, the existing bridges need to be replaced. We need to discuss whether we should go the route of another commercial bridge, or the resistor- DVM route. I prefer the latter for several reasons but recognize certain disadvantages. We need to discuss this.

Shafer
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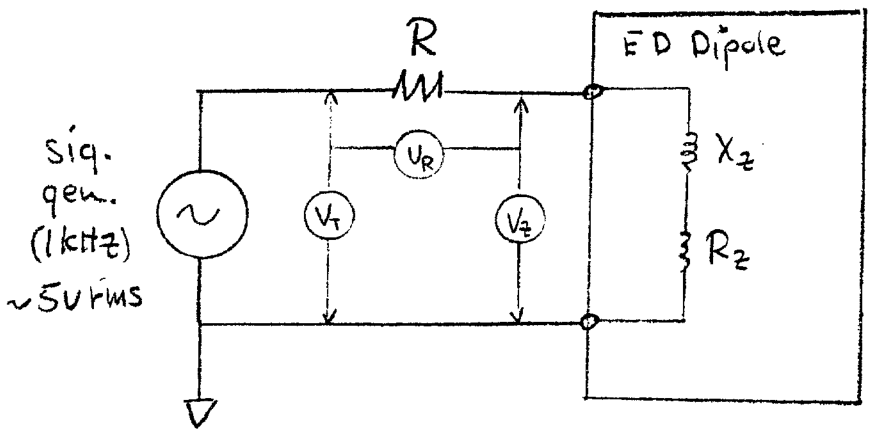
Proposal for Simple Reliable L and Q Measuring Circuit for ED Dipoles

the present inductance bridges available and in use suffer from the following problems:

1. Small signal level, making instrument sensitive to stray pickup.
2. Both terminals are floating, hence (severely) affected by grounding
3. Complex circuit, hence easy to "loose" calibration

I therefore propose that for any serious production line QC measurements that the following circuit be used:



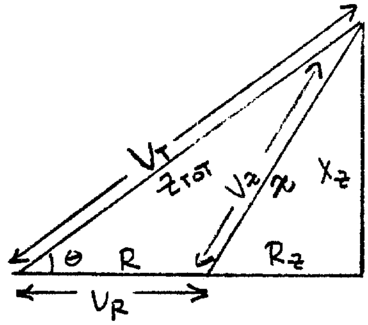
R is a precision resistor in the 100 Ω to 200 Ω range (non inductive)
the 3 following voltages are measured (absolute voltages, no phase relationships):

V_T = total voltage across R + dipole

V_R = voltage across R

V_Z = voltage across dipole

A vector diagram of the voltages is:



$$\cos\theta = \frac{V_T^2 + V_R^2 - V_Z^2}{2 V_R V_T}$$

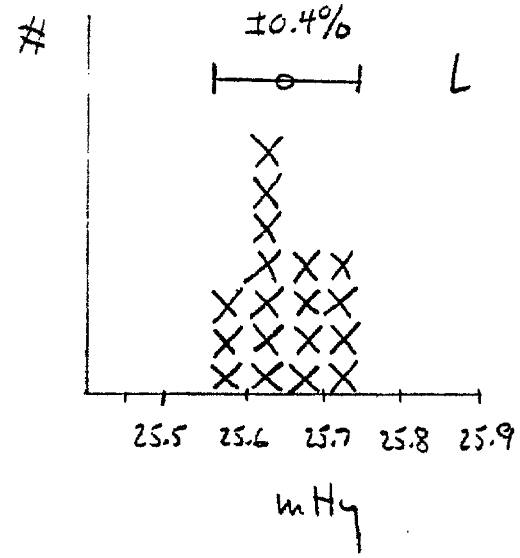
$$X_Z = Z_{TOT} \sin\theta = \frac{R V_T}{V_R}\left[1 - \cos^2\theta\right]^{1/2}$$

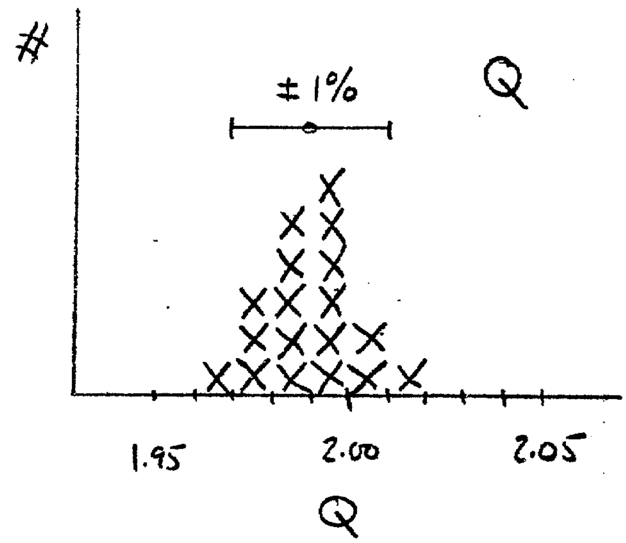
$$L_Z = \frac{X_Z}{\omega} \times 1000 = \frac{1000\, R V_T}{2\pi f V_R}\left[1 - \cos^2\theta\right]^{1/2} \text{ mHy.}$$

$$R_Z = Z_{TOT} \cos\theta - R = \frac{R V_T}{V_R} \cos\theta - R$$

$$Q = \frac{X_Z}{R_Z}$$

Typical precision of method can be seen from the following 18 measurements on a calibration standard provided to Jim Humbert on 2/20/79. the series resistor was varied from 100 to 200 Ω during measurement, and V_Z was varied from 35mV to 120mV. (f = 1 kHz).





So the precision is about ± 0.5% on L and ±1% on Q

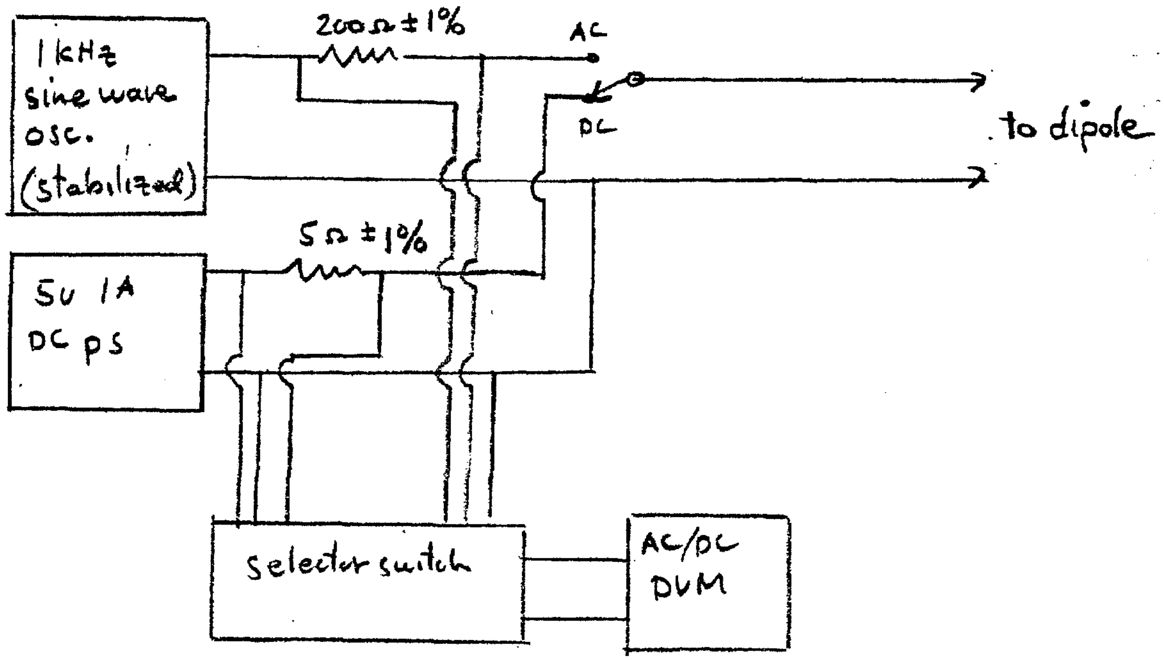
Advantages of measuring technique

1. Inherently more accurate than bridge. Depends only on linearity of voltmeter, and stability of resistor. Inductance bridges are more elaborate, and have inherently poorer accuracy (typically ~ ± 5%).
2. No knobs to adjust. Just 3 voltages to measure (or 2 voltage ratios)
3. One side of circuit may be grounded (not true of bridges)
4. Amplitude may be adjusted to overcome any inherent noise in industrial environment.

Disadvantages

1. Requires use of algorithm to find L and Q
2. Requires fabrication of ckts (probably 2 or 3)

Actual proposed ckt (includes ckt for measuring DC resistance)



One option is to include precision rectifier ckt (active ckt) in selector switch so operator is not required to change DVM from AC to DC readings. Sine wave oscillator will probably require a hand-wound gapped core (I can supply materials). It needs to drive about 5 volts into a 200 Ω load (25ma rms) so can be done with op amp ckt.

If such ckts are built, they should be built either by an Accel Support Group or by Research Services Dept (Research Div).