SIMPLIFIED COIL DESIGN (Part I)

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PROBLEM - HOW TO WIND COILS accurately for specific amateur radio applications.

Solutions:

1. Calculating the coil inductance and dimensions from the formula

$$L_O = \frac{2.54 \times 0.03948 \left(\frac{2}{d} \right)^2 n^2 K}{1}$$

—too complicated ; forget it.

2. Estimating inductance with reactance charts, plus a coil nomograph. Usually after winding, finished coil must be pruned to the correct inductance value to compensate for inaccuracies.
3. Simplified graphs which can be prepared with equipment found in most amateur radio stations.

Solution 3 takes the "try" out of "cut and try" coil winding. The materials needed are:

1. Log graph paper (K & E No. 359 – 110, log 2 x 2 cycles, or equivalent);
2. calibrated receiver;
3. two-terminal oscillator (see Fig. 1 for a Franklin oscillator circuit); and
4. at least two calibrated fixed capacitors in the range of 20 and 150 pF.

Access to a "Q" meter will permit all of the measurements to be made with no additional equipment; or, a calibrated grid-dip oscillator will take the place of the calibrated receiver and two-terminal oscillator.

Suppose a coil 1 inch in diameter and 1.5 inches long, having 30 turns, is available; and our standard capacitors are C_{S1} = 19 pF, and C_{S2} = 160 pF.

Connecting the coil to the Franklin oscillator, we can find the resonant frequency by locating the frequency of oscillation.

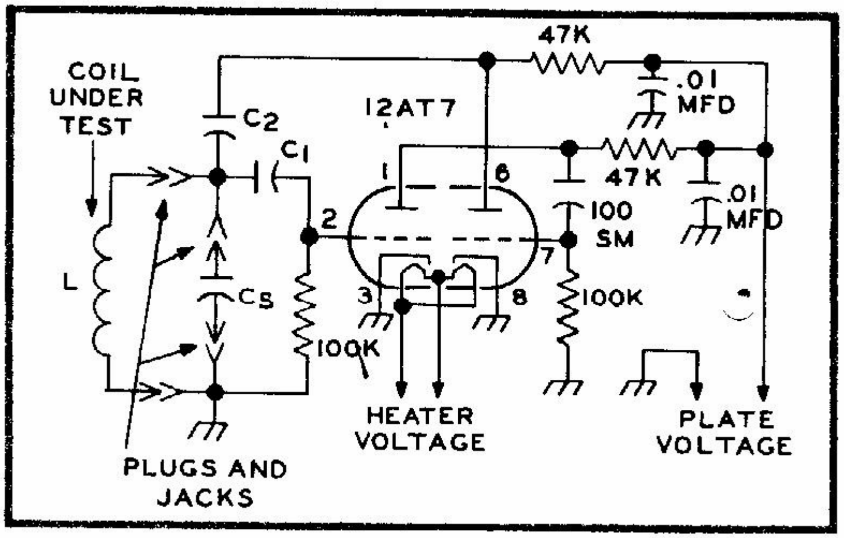


FIG. 1. SCHEMATIC DIAGRAM of a Franklin oscillator with which the measurements outlined in the text may be made. All resistances are in ohms, all capacitances are in mmf, unless otherwise specified. Capacitances C_1 and C_2 should be as small as will permit maintenance of oscillations, usually 1 or 2 mmf each. Values for C_s are given in the text.

If, with C_{S1} across the coil, the oscillation frequency is measured at say 9 megacycles; with C_{S2} across the coil it would be 3.5 megacycles. This information could also be obtained by connecting the coil to a "Q" meter; or measuring the resonance of the coil across the test capacitors with the grid-dip oscillator.

Plot this information on log-log graph paper and connect the two points with a straight line, as shown in Fig. 2.

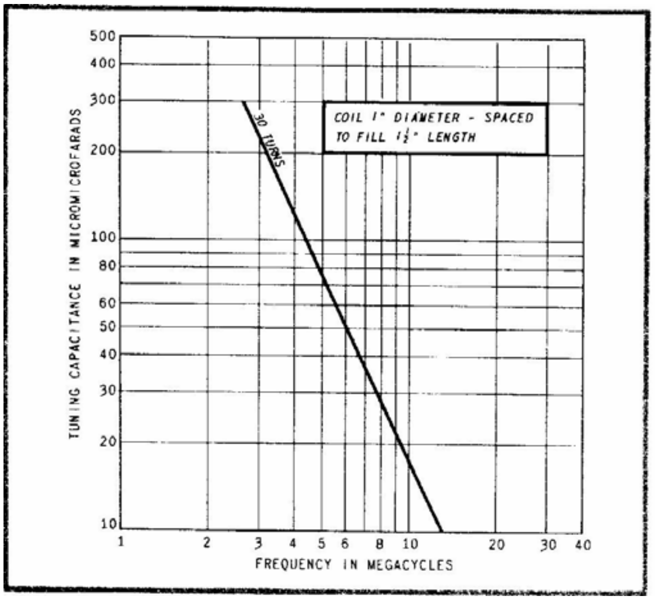


FIG. 2. GRAPH PLOTTED on log paper for a coil, 1 inch in diameter and 1½ inches long, with 30 turns equally spaced. The tuning range with a 140-mmf variable capacitor is approximately from 3.5 to 9 megacycles.

Note that to tune from 3.5 to 4 megacycles requires an approximate capacitance variation from 162 to 121 pF, or a spread of 41 pF.

A total, equaling the fixed, distributed and tuning condenser's minimum capacitance would be 121 pF. The addition of a variable capacitance of 41 pF would spread the 3.5-megacycle band over the entire 180° shaft rotation.

The same coil will tune from 7.0 to 7.3 megacycles with an approximate capacity variation from 36.5 to 33.5 pF, or a spread of 3 pF. A total fixed, distributed and tuning condenser minimum capacitance of 33.5 pF and a 3-pF variable would spread the 7-megacycle band over the 180° shaft rotation.

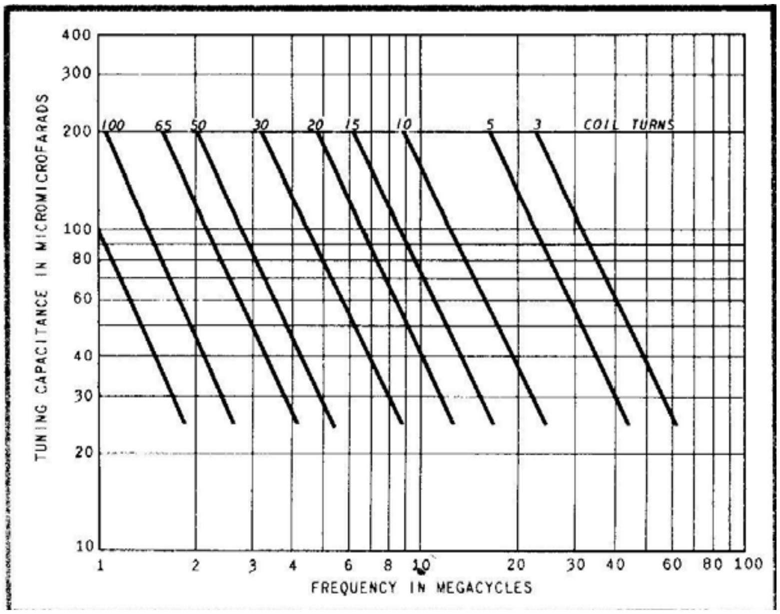
If the distributed and input capacity adds up to 12 pF, a 150-mmf variable will tune both the 3.5 and 7-megacycle bands.

A parallel 50 pF variable and a fixed 100 pF capacitor would make it impossible to tune the circuit to 7 megacycles, and the use of a 50 pF variable alone would prevent inadvertent tuning to 3.5 megacycles in lieu of 7 megacycles.

If the total input, output, and distributed C equals 15 pF, the coil will tune to 10.5 megacycles and will drive a doubler to 21 megacycles.

The system can be further expanded by plotting coils with different parameters as shown in Fig. 3, which illustrates a typical family of curves for coils 1 inch in diameter and 1.5 inches long.

FIG. 3. EXAMPLE OF DESIGN procedure for coils 1 inch in diameter and 1½ inches long, with total turns ranging from 100 (67 turns per inch) down to 3 (2 turns per inch) turns. Accuracy is excellent up to about 200 megacycles since method outlined in text takes into account distributed capacitance and other sources of error usually neglected because of calculation difficulty.



Graphs for each individual coil of given number of turns are constructed as described. Note that the spacing between the graphs for the coils is proportional to the log of the number of turns. A slight slope change and bending of the individual coil plots is noted as the frequency approaches the natural resonant frequency of the tuning element, due to the increased proportional effect of the distributed capacitance, coil leads and terminals, and other factors impossible to eliminate and difficult to calculate in practical coil problems. These factors are usually neglected on impedance charts, making the charts useless for practical applications requiring accurate construction of small inductances.

Precise determination of coil parameters can be obtained by limiting the use of a given chart to a 10-to-1 turns ratio when determining coil parameters from data taken with coils of a few turns.

Figs. 4 and 5 show a similar family of curves for widely used commercial coil forms.

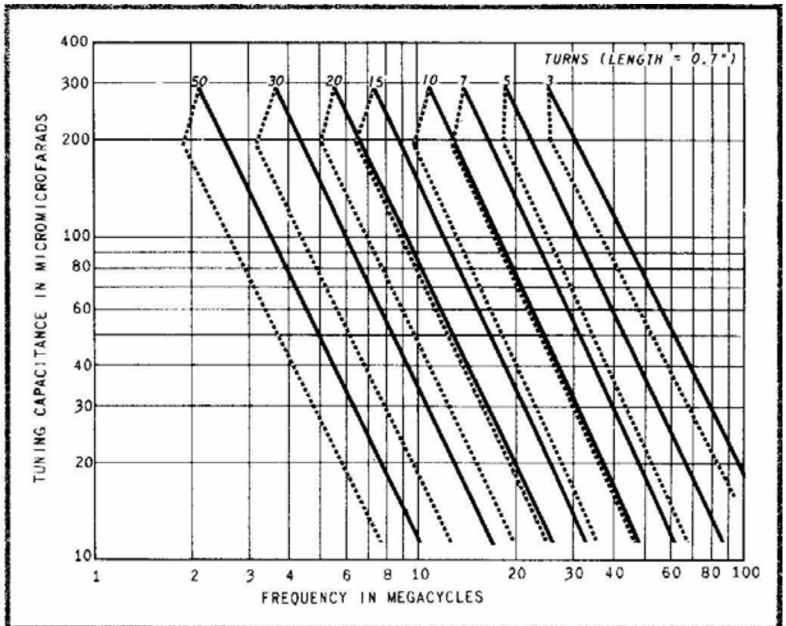


FIG. 4. FAMILY OF CURVES for coils wound on the National XR-50 slug-tuned coil form (3/8 of an inch in diameter; 11/16 of an inch winding length). The area enclosed by dotted lines to the left of each solid line indicates approximate change in inductance possible with XR-50 iron slug. Copper slug produces inductance shift in opposite direction.

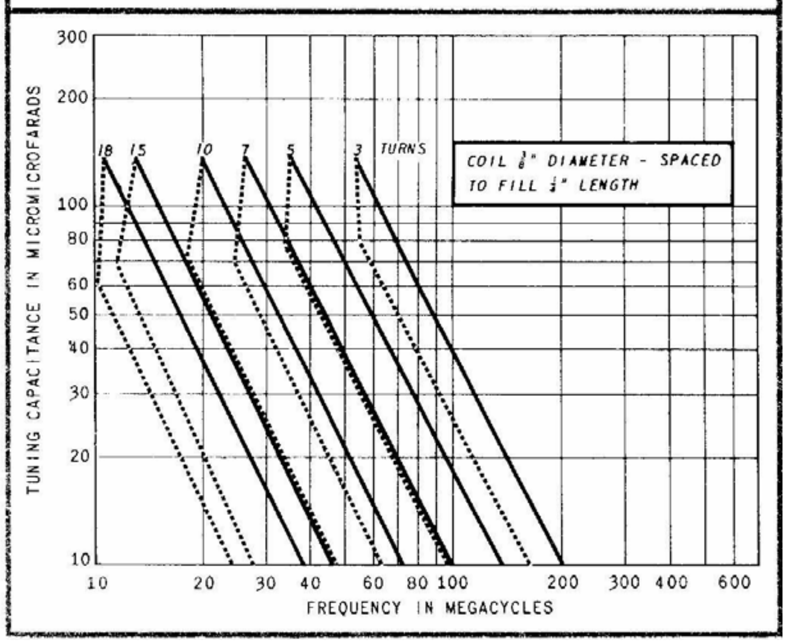


FIG. 5. COIL DESIGN CHART for Cambion LS-3 slug-tuned coil forms with combination iron/brass tuning slugs (3/8 of an inch in diameter; 1/4 of an inch winding length). The solid lines indicate the inductance when the brass slug is within the coil; and, the dotted broken lines indicate the inductance with the iron slug within the coil.

The inductance variation made possible by positioning the slugs is illustrated by the dashed lines.

A useful chart for clipping coils such as B & W Miniductors can be made from a couple of assorted lengths of the size in question. The fact that length and number of turns are changed simultaneously does not void the chart; the slope remains the same but the spacing between graphs of the coils will be slightly changed.

Any number of similar charts may be rapidly prepared. From two or more experimentally plotted graphs of individual elements approximately within the desired range, a family of curves may be drawn to permit accurate selection of the desired tuning elements. Frequency doublers or power amplifiers thus may be accurately ganged.

Note that for a small increment of frequency, such as a typical amateur band, the use of fixed capacitors to set the operating point and a small variable, straight line capacitance will give essentially straight line frequency tuning. The ganging of circuits with straight line tuning is no problem. As charts for progressively larger power coils or doubler coils all have the same slope, the choice of capacitors and inductors to gang and track tuned circuits becomes elementary.

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