The Seven Tube Superhet
Design of the Hartley Local Oscillator Coil and Mixer Coil

The minimum and maximum capacities are set in the schematic. C_2 is 50 pF in parallel with C_3 valued at 35 pF. The total maximum capacity, C_{Max} is 85 pF and the minimum capacity, C_{Min} is about 10 pF if you take circuit and stray capacitance into account.

The ratio of high to low frequency is the square root of $C_{maximum}$ divided by the square root of $C_{minimum}$,

$$\frac{f_{High}}{f_{Low}} = \frac{\sqrt{C_{Max}}}{\sqrt{C_{Min}}} = \frac{\sqrt{85\,pF}}{\sqrt{10\,pF}} = 2.9$$

It is desired to have the optimal bandspread tuning for the CW portion of 40 meters. Ideally, this would be the entire 180 degree rotation of the bandspread capacitor C_3. This would give a 1.07 tuning ratio.

$$\frac{7.1}{7.0} = 1.01$$

This value is well within the tuning range of the variable capacitors.

Another Coil Design Example: Assume *C* is 110 pF max, and 5 pF minimum, with a circuit capacitance is 10 pF and the range of frequencies to be covered is 1.8 to 6 MHz. An available coil form has a 0.75-in. diameter.

Here is the method for determining one frequency extreme if the other is known. Then minimum and maximum capacities must be set to assure that a given tuning capacitor will cover a given range.

In this problem the maximum capacity is 110 pF and the minimum is 15 pF, if you take circuit and stray capacitance into account.

The ratio of high to low frequency is the square root of $C_{maximum}$ divided by the square root of $C_{minimum}$,

$$\frac{f_{High}}{f_{Low}} = \frac{\sqrt{C_{Max}}}{\sqrt{C_{Min}}} = \frac{\sqrt{110\,pF}}{\sqrt{15\,pF}} = 2.7$$

Clearly the frequency range cited in the problem is 6 MHz to 1.8 MHz and it cannot be covered since the ratio is

$$\frac{6\,MHz}{1.8\,MHz} = 3.33$$

There is a choice of using either a tuning capacitor with a higher maximum capacity or designing for a narrower frequency range. We'll settle for a narrower range and use a low frequency limit of 2 MHz. The high frequency limit then becomes 5.4 MHz.

$$\text{Use } 2.7 \text{ as the ratio for the frequency range,}$$
$$\text{with } 2\ MHz \text{ as } f_{Low}$$
$$\frac{f_{High}}{2\,MHz} = 2.7 = 5.4\,MHz$$

Then

$$LC = \frac{25330}{f^2}$$
$$\text{substituting}$$
$$L \times 110\ pF = \frac{25330}{2\,MHz^2}$$
$$L = 57.6\,\mu H$$

If you solve for the high frequency end of the range using 5.4 MHz and 15 pF you'll get the same result.

For the 7 Seven Tube Superhet there is a total 85 pF capacitance in the Hartley oscillator circuit and the Local Oscillator frequency ranges are 7.454 to 7.554 MHz.

Using a frequency range of 7.0 to 7.1 MHz as the desired tuning range, for a 454 KHz oscillator, this would mean a frequency range of 7.454 to 7.554 MHz.

Step 1. Select a design center frequency.

$$\text{Geometric Center Frequency} = \sqrt{f_H \times f_L} = \sqrt{7.554 \times 7.454} = 7.5\,MHz$$

Step 2. Determine Capacitance Ranges.

Capacitor C_2 has a value of 5 to 50 pF and a range of 45 pF.
Capacitor C_3 has a value of 3 to 35 pF and a range of 32 pF.

Step 3. Determine the *LC* Ratio

Use the Geometric Center Frequency

$$LC = \frac{25330}{f^2} = \frac{25330}{7.5\,MHz^2} = 450$$

Step 4. Determine the inductance needed for the known capacitance

The known capacitance is 85 pF. Using the LC ratio

$$LC = 450$$
$$Solve\ \ for\ L$$
$$L = \frac{450}{85\,pF} = 5.29\,\mu H$$

The capacity range and the frequency range have already been determined in the 7 tube Superhet. To assure proper coverage, the value of the inductor and the capacitance range is

$$LC = \frac{25330}{f^2}$$
$$C_H = \frac{25330}{5.29\mu H \times 7.554\,MHz^2} = 83.9\ pF$$
$$C_L = \frac{25330}{5.29\,\mu H \times 7.454\,MHz^2} = 86.2\ pF$$

Step 5. Determine the reactance to assure oscillation.

A minimum reactance of 180 Ohms is required to assure proper oscillation of the circuit.

$$X_L = 2\pi\ f\ L$$
$$X_L = 2\pi \times 7.5\,MHz \times 5.29\,\mu H = 249.2\Omega$$

The important aspect is that the feedback point from the grid of the 6J5 connects to about **25%** of the windings of L_4 from the <u>ground</u> end.

Step 6. Use formulas to determine the winding criteria.

Use a coil form 1.5 inches in diameter with a coil length of 1 inch.

Using Wheeler's Formula:

$$L = \frac{r^2 \times N^2}{9r + 10\,length}$$
$$5.29\mu H = \frac{0.75\,inch^2 \times N^2}{9 \times 0.75\,inch + 10 \times 1\,inch}$$
$$solve\ \ for\ N$$
$$N = 12.5\ turns$$

Using Reyner's Formula for a single layer coil

$$L = \frac{0.2N^2D^2}{3.5D + 8S}$$

$$5.29\,\mu H = \frac{0.2N^2 \times 1.5\,inch^2}{3.5 \times 1.5\,inch + 8 \times 1\,inch}$$

$$N = 12.48\ turns$$

Step 7. Determine tap placement.

The tap connects to about **25%** of the windings of L_4 from the ground end.

$$12.5\ turns \times 25\% = 3\ turns$$

Step 8. Use a proportional scale to determine *L_5*

L_4/L_5 in the schematic has this turns ratio:

$$\frac{L_4}{L_5} = \frac{14}{6} = \frac{12}{x} = 5\ turns$$

MIXER COIL CALCULATIONS

This is coil *L_1*.

The desired tuning range is 7.0 to 7.1 MHz.

The maximum capacitance is 50 pF

The Geometric Center Frequency is

$$Geometric\ Center\ Frequency = \sqrt{f_H \times f_L} = \sqrt{7.1 \times 7.0} = 7.05\,MHz$$

The *LC Ratio* is

$$LC = \frac{25330}{f^2}$$

$$LC = \frac{25330}{7.05\,MHz^2} = 510$$

Find the value for the Inductance

$$L = \frac{510}{C} = \frac{510}{50\,pF} = 10.1\,\mu H$$

Determine the number of turns

Using Wheeler's Formula:

$$L = \frac{r^2 \times N^2}{9r + 10 length}$$

$$10.1\mu H = \frac{0.75 inch^2 \times N^2}{9 \times 0.75 inch + 10 \times 1 inch}$$

$$solve \ for \ N$$

$$N = 17.3 \ turns$$

Using Reyner's Formula for a single layer coil

$$L = \frac{0.2N^2D^2}{3.5D + 8S}$$

$$10.1\mu H = \frac{0.2N^2 \times 1.5 inch^2}{3.5 \times 1.5 inch + 8 \times 1 inch}$$

$$solve \ for \ N$$

$$N = 17.2 \ turns$$

Use a proportional scale to determine L_1/L_2

L_1/L_2 in the schematic has this turns ratio:

$$\frac{L_1}{L_2} = \frac{20}{5} = \frac{17}{x} = 4 \ turns$$

TABLE I

ENAMELED MAGNET WIRE

Gauge No.	Dia. (In.)
14	.0659
16	.0524
18	.0418
20	.0334
22	.0266
24	.0213
26	.0169
28	.0135
30	.0108

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