

The Power-dividing Tank Circuit

Some thought must certainly be given to the design of the power-dividing tank circuit in a system of this type. A very important factor to consider is the loaded Q of this circuit, that is, the ratio of the circulating volt-amperes in the tank to the transmitted watts. If this Q is too low, adjustment of the system is made difficult because the movement of one tap on the tank coil will seriously alter both the current ratios and the phasing of the currents entering the other taps; on the other hand, if the Q is too high, the r-f bandwidth of the system will be too narrow, limiting the sideband content of the radiated signal and causing some distortions of the audio program. The most preferable value of the loaded Q is generally considered to be about 2.5 or 3.0. Let us investigate some circuit conditions which will give us a value in this vicinity.

The first problem is that of deciding upon the actual value of load impedance which is being placed upon the tank circuit. Figure 51-2a shows us the problem; the tank circuit here is being loaded by four taps, each tap presenting a resistive load which is equal to the characteristic impedance of the transmission lines. The taps are placed at different points on the coil, however, so that the currents flowing into the taps are all different. We surely cannot say that the effective load impedance in this case is simply $Z_0/4$, because the taps are not all loading the circuit by the same amount. From the operating-base-impedance computations of the antenna, however, we shall know the amount of power which will be flowing into each branch of the system; we can therefore compute the currents I_1 , I_2 , I_3 , and I_4 which will be flowing out of each tap. Let's now imagine that these four taps are converged into one single tap at the "average" position of the original four. Since the original currents were all in phase, we simply add them together to obtain the current which

would flow in this equivalent single tap. Thus, referring to Fig. 51-2b, we can write the equation

$$I_T = I_1 + I_2 + I_3 + I_4$$

Now, since the transmitted power W has remained unchanged, we may state that $I_T^2 R_L = W$, from which we obtain the value of the effective load impedance R_L :

$$R_L = \frac{W}{I_T^2} \quad \text{ohms}$$

This effective load resistance is an important parameter for use in designing the tank circuit. Although this approach will not tell us exactly where to place each tap on the multiloading tank circuit, it does allow us to

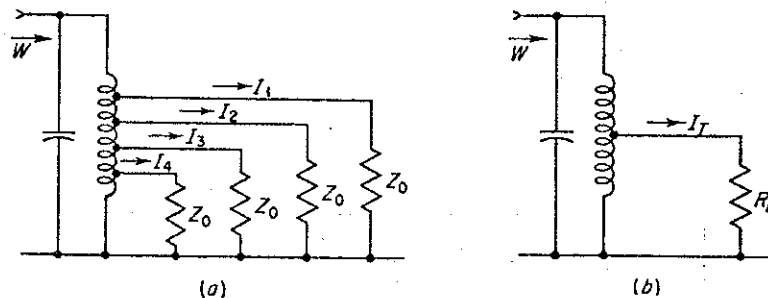


Fig. 51-2. Actual and equivalent loading of a tank circuit.

select the coil-capacitor combination which will produce a tank circuit capable of being adjusted to the conditions which we require, and it tells us at least the "average" location of the taps to produce the desired loading condition. The graphs of Figs. 51-3 to 51-5 give the values of the antiresonant resistance of the tank circuit, the loaded Q , and the reactance of the tank capacitor versus the position of the equivalent single tap on the tank coil. For generality, the reactances of the coil and capacitor and the antiresonant resistance are given in terms of R_L , so that these graphs may be used for any value of R_L which may be encountered. The graphs are based on the use of a coil whose length is twice its diameter.

To take a specific case as an example, let us suppose that the effective load resistance R_L is 40 ohms, that we wish to have an input resistance R_P of 140 ohms, and that the loaded Q of the tank circuit should be 3. We note first that the desired input resistance R_P is 3.5 times R_L ; turning to Fig. 51-3, we find that we can obtain a value of 3.5 for R_P/R_L under several conditions of loading, using different values of coil reactance. These conditions range from placement of the tap at a point 53 per cent up from the ground end of a coil whose reactance is numerically equal to

the load resistance ($X_T = R_L$) to location of the tap 63 per cent up on a coil whose reactance is four times the resistance of the load ($X_T = 4R_L$). In order to decide which value to use, we turn to Fig. 51-4 and locate these values on the X_T curves, connecting them as shown by the dashed line in

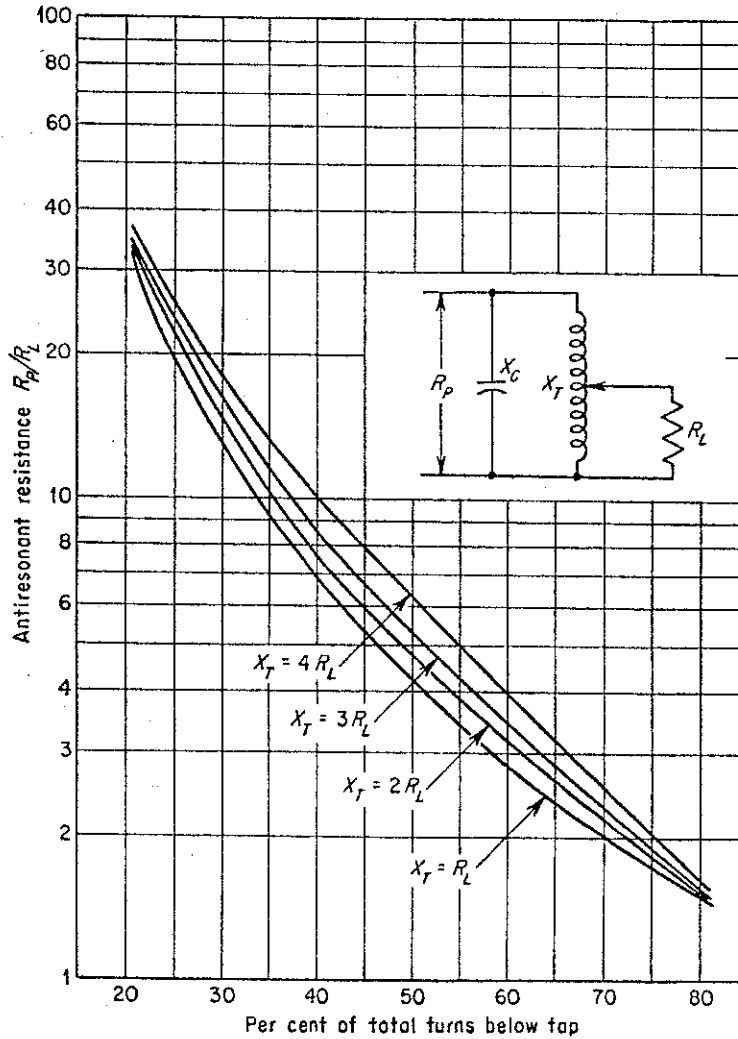


Fig. 51-3. Parallel resistance at antiresonance of a tapped tank circuit.

this figure. All points along this dashed line would give a value of R_P/R_L of 3.5, so we select the specific point which will produce a loaded Q of 3. This, we see from the figure, will occur when $X_T = 1.3R_L$ and the tap is located 55 per cent of the way up from the grounded end of the tank coil.

Referring next to Fig. 51-5, we find that, for a coil of this reactance loaded at this point by R_L , the reactance of the capacitor necessary to anti-resonate the circuit will be $1.2R_L$. We shall therefore design the tank coil in this case to have a reactance of 52 ohms and the capacitor to have a reactance of 48 ohms.

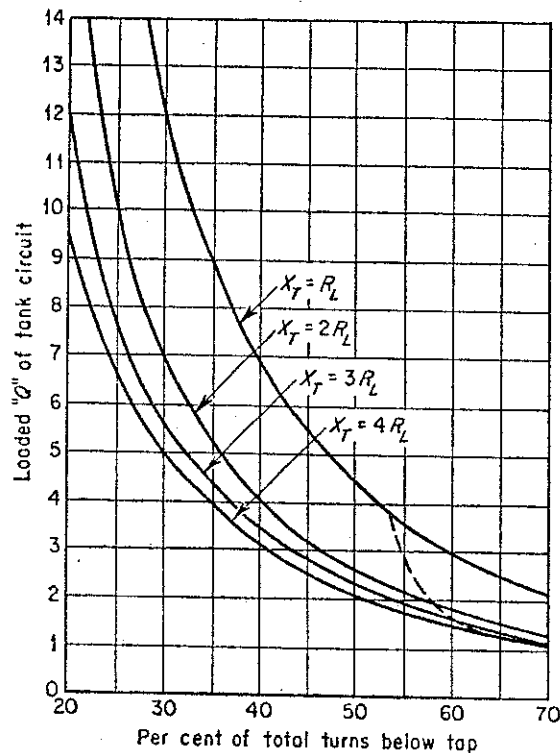


Fig. 51-4. Loaded Q at antiresonance of a tapped tank circuit.

Now we must provide some means of varying the impedance of the load which is presented to the transmitter by the power-dividing tank circuit. This may be done by placing ahead of the tank circuit an L network which is adjustable so that its input impedance may be varied. A particularly useful design is obtained by employing an L network whose resistance-transformation ratio is 2:1, because with this network the input resistance and reactance may be adjusted independently of each other; the input resistance will be controlled by the shunt branch of the L net, while the input reactance will be controlled by the series branch.

In the example on which we have just been working, then, we shall add ahead of the power-dividing tank circuit a network of this type, letting it transform the 140-ohm resistance of R_P down to 70 ohms as a

load for the transmitter. This is a convenient figure, since we can then use a standard 70-ohm coaxial line from the transmitter to the power-division network. Figure 51-6a shows the tank circuit with the L network prefixed, and Fig. 51-6b shows how the shunt branch of the L net is combined with the capacitor of the tank circuit to form a single capacitive branch. The reactance of this combined branch is computed to be 35.8 ohms:

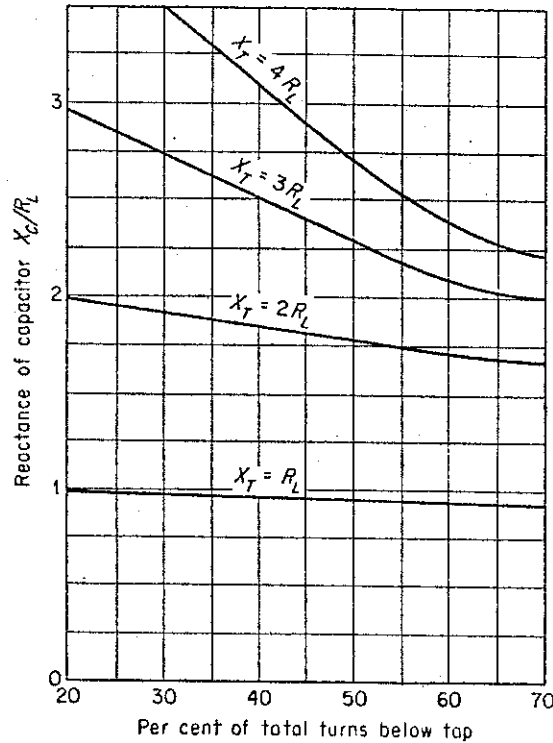


Fig. 51-5. Reactance of tuning capacitor at antiresonance of tapped tank circuit.

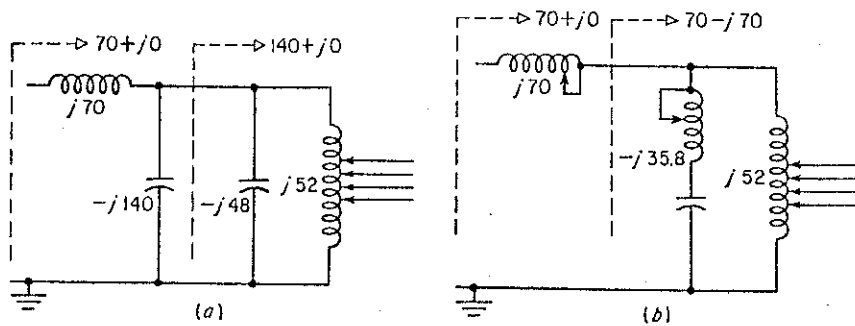


Fig. 51-6. Evolution of the power-division network.

actually we would use a capacitor having a reactance of perhaps 50 ohms or so, with a variable inductor connected in series to allow some range of adjustment about the nominal value.