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Resonant Circuit Calculations

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IN view of the present popularity of radio receivers designed to cover relatively wide frequency bands, the following general data on tuned circuits may be of interest.

The tuned circuit consists fundamentally of a coil in series with a condenser as shown in Fig. 1. If we induce a constant voltage into such a circuit and measure the current flow around the circuit as the frequency of the induced voltage is varied we would find a typical resonant characteristic between the current and the frequency, provided the frequency was varied above and below the resonant frequency of the circuit.

The resonant frequency will be that frequency corresponding to the maximum current. The frequency of resonance is determined by the capacity and inductance of the circuit, and is equal to

$$F = \frac{1}{2\pi\sqrt{LC}}$$

where L is the inductance of the circuit in henries, C is the capacity in farads, and F is the resonant frequency in cycles per second. The derivation of the above formula will be found in standard text books on radio.

In the design of receiver tuning over a wide frequency range, one method whereby a single coil can be made to cover a wider range of frequency is by the use of a switch which cuts a mica condenser into the circuit in series with the main tuning condenser. The effect of the mica condenser in series with the main tuning condenser is to reduce the capacity and thereby to increase the resonant frequency of the circuit.

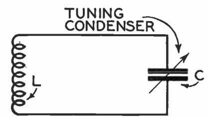

FIG. 1

For example, suppose that the main tuning condenser in a resonant circuit has the maximum capacity of 0.00025 mfd. and that in combination with a coil this capacity will tune to a minimum frequency of 500 kilocycles. If we connected in series with the tuning condenser as shown in Fig. 2 a fixed mica condenser with a capacity of .00025 then the circuit will tune to a minimum frequency of 700 kilocycles.

If we know the range of frequency over which a given circuit will tune then we can determine the frequency range obtained with any given combination of tuning condenser and series fixed condenser by the relationship

$$\frac{F_1}{F_2} = \frac{\sqrt{C_2}}{\sqrt{C_1}}$$

F_1 is the frequency to which the circuit will tune without the series fixed condenser.

F_2 is the frequency to which the circuit will tune with the series fixed condenser.

C_1 is the capacity of the tuning condenser.

C_2 is the capacity of the combination of the fixed condenser in series with the tuning condenser.

For example, suppose a circuit uses a 0.00025 microfarad tuning condenser and tunes from 500 to 1500 kilocycles. The inductance required for such a circuit would be 400 microhenries. In order to tune to a maximum of 1500 kilocycles the equivalent minimum capacity of the entire circuit would have to be approximately 0.0000278 mfd. Assume that we want to change

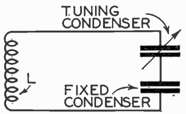

FIG. 2

the frequency range so that the minimum frequency will be 1500 kilocycles instead of 500. This means that with the tuning condenser set at maximum capacity the capacity of the circuit must be 0.0000278.

For two condensers in series the formula is

$$C_1 = \frac{Ct\ C_2}{C_2 - Ct}$$

C_1 is the required capacity for the series fixed condenser.

C_2 is the original capacity for the tuning condenser.

Ct is the required capacity for the two condensers in series.

In this example Ct is 27.8 micro-microfarads. The original capacity C_2 is 250 micromicrofarads. Substituting the formula that we have,

$$C_1 = \frac{27.8 \times 250}{250 - 27.8}$$

$$= \frac{6950}{222.2}$$

= 31.3 micromicrofarads

In other words we would have to connect in series with the tuning condenser a fixed condenser having a capacity of 31.3 micromicrofarads.

It will be noted that the required series capacity 31.3 micromicrofarads is not much different than 27.8 micro-microfarads the minimum capacity of the tuning condenser. Of course, when the circuit is required to tune to higher frequencies, a smaller series condenser will be required.

In the above example as a matter of simplicity we have neglected the distributed capacity of the tuning coil itself in order to simplify the problem. In actual practice, however, the distributed capacity of the coil may be an important factor.

In a future issue we expect to cover in more detail the characteristics of circuits covering wide tuning ranges.

Power Factor Correction with Oil Condensers

The accompanying group of curves, Fig. 1, will prove useful in connection with calculations on condenser capacity required to correct low power factor on motors, power lines, etc.

This group of curves shows the relationship between three factors, the desired power factor, the existing power factor, and the percentage of the kilowatt load required in kv-a of capacitive load.

For example, suppose a system has a power factor of 70% and that the kilowatt load in the system is 1000 kilowatts. Assume that it is desired to correct the power factor to 90%. From the curve it will be noted that the 90% desired characteristic point intercepts the curve of 70% existing power factor at a point corresponding to 53%, as the percentage of kv-a capacity required in capacitive reactive kv-a. In this case the kilowatt load is 1000 and 53% is 530 kv-a. This means that if we connect across the line 530 kv-a of capacitive load then the power factor of the system will become 90%.

The capacity in microfarads required to obtain 530 kv-a can be figured from the following listing:

Low Voltage	Mfds. per Kv-a
110	219.00
220	54.80
440	13.70
550	8.80
1100	2.20
2200	.55
2300	.50

If the system had a voltage of 1100 volts 60 cycles a.c. then the capacity required would be, from the above table, 530 divided by 2.2 or 241 microfarads.

From the chart, Fig. 1, and the table similar examples can readily be worked out.

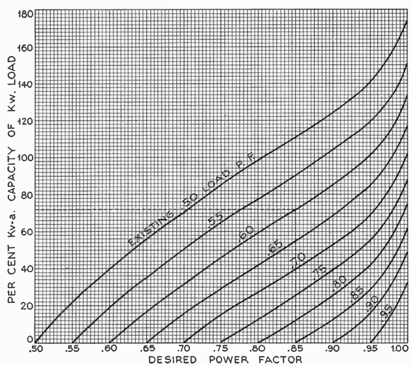

Fig. 1