Design Data (15)

Link Coupling

WHEN it is necessary to use a coupled pair of resonance circuits it is not always convenient to couple them together in any of the conventional ways. It is sometimes mechanically desirable to have the two circuits some considerable distance apart. In a rack-built transmitter, for instance, one circuit may fit best on one deck and the other on a different one; again, in a superheterodyne receiver it is sometimes convenient to build the frequency-changer and I.F. amplifiers as separate units. One circuit of the first I.F. coupling then fits best with the frequency changer and the other with the I.F. amplifier.

In such cases it is customary to use link coupling between the tuned circuits as shown in Fig. 1 (a). The two tuned circuits are L_1C_1 and L_2C_2 and they are coupled by the link circuit which comprises L_3 coupled to L_1 by the mutual inductance M_1 and L_4 coupled to L_2 by the mutual inductance M_2. The two link coils are connected by some form of screened cable, such as a length of coaxial feeder.

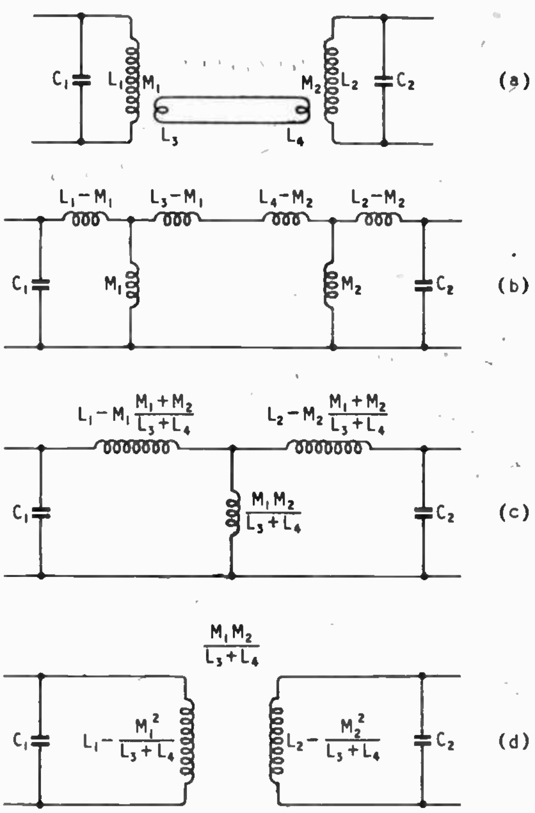

Fig. 1.

If the length of this connecting cable is short compared with a quarter-wavelength the effect of the cable is mainly that of its capacitance. This can usually be made negligible by using sufficiently great step-down and step-up ratios in the transformers at each end.

In most practical applications of link coupling the connecting cable does not exceed a yard in length and is often no more than a foot. Intermediate frequencies do not usually exceed 15 Mc/s or 20 metres, so that the cable is nearly always very short compared with a wavelength.

The case where the cable is comparable in length with a wavelength is comparatively rare. It is usually only met with in a transmitter. It might, for instance, be desired to couple two stages with a link circuit at a frequency of 60 Mc/s or 5 metres. More than a very short cable is likely to approach or exceed a quarter-wavelength, especially as the electrical length of cable is near one-half its physical length.

In such usage it is necessary to exercise very great care in design and the matter will not be dealt with here. In this note only the case of a cable very short compared with a wavelength will be considered, and the effect of the cable will be taken as negligible.

By various well-known transformation theorems, the circuit of Fig. 1 (a) can be reduced to the exact equivalent (d) through the intermediate steps (b) and (c). All the circuits of Fig. 1 are equivalent, and so it can be seen that the link-coupled circuit is no different in its performance from a pair of tuned circuits coupled by mutual inductance between the coils themselves.

When working out the coupling required between two circuits it is usually more convenient to think in terms of the coupling coefficient k than in mutual inductance. If the two circuits have Q-values Q_1 and Q_2 optimum coupling is obtained when

$$k = 1/\sqrt{Q_1Q_2} \quad \ldots \quad (1)$$

In the circuit of Fig. 1 (d) the coupling is

$$k = \frac{\dfrac{M_1M_2}{L_3+L_4}}{\sqrt{\left[\left(L_1 - \dfrac{M_1^2}{L_3+L_4}\right)\left(L_2 - \dfrac{M_2^2}{L_3+L_4}\right)\right]}} \quad \ldots \quad (2)$$

In Fig. 1 (a) there are two coupling coefficients for the two halves of the circuit,

$$k_1 = \frac{M_1}{\sqrt{L_1L_3}} \text{ and } k_2 = \frac{M_2}{\sqrt{L_2L_4}} \quad \ldots \quad (3)$$

Rewriting (2) in terms of k_1 and k_2 we have

$$k = \frac{1}{\sqrt{\left[\left(\dfrac{L_3+L_4}{k_1^2L_3} - 1\right)\left(\dfrac{L_3+L_4}{k_2^2L_4} - 1\right)\right]}} \quad \ldots \quad (4)$$