Interference to Telephone Lines

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Abstract
A paper from 1936 exploring the effects of electrification of country Tasmania and the increasing interference to telecommunication circuits by high voltage power lines installed in close proximity.

Introduction
Optical fibre is ubiquitous in the Australian telecommunications network. One significant advantage is its immunity from electromagnetic interference due to the utilisation of light for the transmission of information, instead of electrical current.

Optical fibre is a relatively new technology, with commercial systems being pioneered in the 1980s. Telecommunication networks over the previous century had to rely on cables and wires to transmit information via electrical currents. Electromagnetic interference can generate noise in these conductors, particularly in proximity to high voltage alternating current power lines.

This interference would not have happened if direct current had been utilised for power reticulation, however by the turn of the twentieth century the world had standardised on alternating current. The contest between alternating and direct current for power distribution is well documented, suffice to say that alternating current was more cost effective, except in special applications such as the Basslink high voltage connection between Victoria and Tasmania.

It is often forgotten that telegraphic communication networks pre-dated electrical power networks in Australia by several decades. Both networks tended to follow the same easements along roads and railways and as the power line voltages increased, so did the electromagnetic interference.

The historic paper (Finlay, 1936 [5]) details a study undertaken in Tasmania between the Postmaster General’s Department and the Hydro-Electric Commission into minimising electromagnetic interference by coordinating the network roll-out planning between the two organisations.

The first half of the paper discusses the underlying principles in dealing with interference problems and gives examples of their application in practice. The second half focusses on the coordination of power and telephone systems and the practical field trial results.
The nature of power distribution networks is such that you can control interference from long runs of balanced three phase circuits using transposition; however in unbalanced spur lines, the interference can induce high residual voltages causing noise in telephone circuits that is difficult to control without coordination.

The paper concludes that great value can be achieved by coordinating the roll-out of power and telephone systems. In Tasmania, a Joint Committee of Engineers representing the Postmaster General’s Department and the Hydro-Electric Commission was created to consider improvements to existing layouts and new construction proposals.

While researching this paper, I discovered a previous reader’s hand written notes which neatly summarised the main conclusions. A copy of these notes has been included at the end of the historic paper for curiosity sake.

References

circuit be balanced within itself. When it is necessary to connect unbalanced apparatus or circuits (e.g., Earth circuit lines) to balanced circuits subjected to Inductive Influence, a transformer to isolate the balanced from the unbalanced portion is always necessary.

CO-ORDINATION OF POWER AND TELEPHONE SYSTEMS—TRANSPOSITIONS.

Having dealt with the fundamental factors and their components in the causation of inductive interference, it is now proposed to discuss the fundamental principles underlying the inductive co-ordination of power and telephone systems.

Besides implying the adoption of proper maintenance and operating methods by both Power and Telephone administrations, so that the Inductive Influence of Power circuits on the one hand and the Inductive Susceptibility of the Telephone circuits on the other are reduced to the minimum possible, the term Inductive Co-ordination also refers to the best relative arrangement and location of transposition in both circuits in order to diminish the inductive coupling and consequently the inductive interference.

Balanced Components of Voltage and Currents—the Effects of Transpositions.

In Figure 3, which represents a telephone line exposed to an untransposed three-phase power circuit for a distance of three miles, the effect of the nearest power wire is predominant and induces "longitudinal" voltages to ground along the wires of the telephone circuit. The voltage on each wire differs in magnitude, the larger, of course, being on the telephone wire nearest to the power lines, and this differential effect is known as "transverse" induction. The effect of inserting a transposition in the telephone circuit is to balance the induced potentials on each leg, neglecting phase change and attenuation, and if the series impedance and admittance to ground of each leg of the telephone circuit are equal, i.e., perfectly balanced, no circulating currents or noise will occur. Any imperfection in the balanced condition due, say, to unequal leashes in each leg or a high resistance joint will permit the longitudinally induced potential to cause current to flow through receivers and consequently generate noise.

In Figure 4, the effect of cutting in one barrel, i.e., a section wherein each power conductor occupies each of the conductor positions for the same distance—by means of two power transpositions (arranged right over left in this instance) and leaving the telephone circuit untransposed can be clearly seen. Here we see that over the section the induced voltage to
ground is, by the neutralising effects of the three sections, reduced to zero on each leg, and also the difference of voltage between the two wires is zero.

In co-ordinated Power and Telephone transposition sections the telephone transpositions are located to balance the transverse induction from the nearest phase wire for each section of a barrel, and the power transpositions are used to reduce to zero in any one barrel the inductive effects from the balanced components of the power system.

**Residual Components of Voltage and Current—**

**The Effects of Transpositions.**

The effect of residual voltage component of 11 K.V. three-phase system with two single-phase extensions is shown in Figure 5.

![Fig. 5](image)

The residual or unbalanced portion of the voltage persists throughout the three-phase and single-phase sections, and its effect can be represented by a single-wire ground-return power line with an E.M.F. equal to the residual voltage.

Figure 5 represents an 11 K.V. line (phase voltage to earth = 7770 volts) with two single-phase extensions, and is a typical example of an unbalanced power system. The vector diagram to the right indicates that the residual voltage on the single-phase extensions is equal to the phase to earth voltage of the system and located + 60 deg. from “A” and — 60 deg. from “B,” i.e. midway between. As this voltage is wholly residual, i.e., totally unbalanced with respect to the neutral point, the insertion of a single-phase power transposition in such an unbalanced system will have no effect on paralleled circuits.

Figure 6 indicates the effect of the residual components of the power system illustrated in Figure 5 on a paralleled telephone circuit.

The residual voltage on the three-phase portion of the system is equal to 1350 volts and the approximate induced potentials on relative sections of the paralleled telephone wires are indicated.

The power transpositions in the three-phase portion neutralise the induced voltage to ground from the balanced components only, but cannot reduce the effect of the residuals. Telephone transpositions are effective against the induced potentials from residual voltages, but only equalise the voltages on each leg to ground.

Generally to obtain a high degree of transverse balance, it is of advantage to have numerous transpositions inserted in circuits erected on the pin positions located at each end of the telephone crossarms. Such well-transposed circuits would tend to shield adjacent circuits and also to reduce the secondary induction from themselves.

Owing to the effects of phase-shift and attenuation the necessity for more numerous transpositions increases with the increase of the frequency of the harmonics to be counteracted. By dividing the exposed circuit into smaller sections...