APPENDIX VII - INTERNAL IMPEDANCE OF STRANDED CONDUCTORS

For power line carrier problems, reasonably accurate attenuation constants are very important. Replacing a stranded conductor by one tubular conductor of equal cross-section is not good enough for such purposes. Instead, the internal impedance formula from [39] should be used

$$R'_{internal} = \omega L'_{internal} = \frac{2.25\sqrt{\omega\mu_o\mu_r\varrho}}{r\cdot\pi\cdot(2+n)\cdot\sqrt{2}}\ \Omega/m \qquad \text{(VII.1)}$$

or with $\rho/(\pi \bullet r^2) = R'$

$$R'_{internal} = \omega L'_{internal} = \frac{4.5\cdot\sqrt{5}\cdot 10^{-4}}{2+N}\sqrt{\omega\mu_r R'}\ \Omega/m \qquad \text{(VII.2)}$$

where

R' = dc resistance of one of the outer strands of a stranded conductor (Ω/m)

μ_r	=	relative permeability
μ_o	=	$4 \bullet \pi \bullet 10^{-7}$ (H/m)
ω	=	angular frequency
ρ	=	conductor resistivity (Ωm)
r	=	radius of each outer strand (m)
n	=	number of outer strands

The factor 2.25 was found experimentally from field plotting in an electrolytic tank. The formula give reasonably accurate results at frequencies above 2-5 kHz for the most commonly used stranded conductors with the number of outer strands either being 6, 12, 18 or 24.

Fig. VII.1 compares measured attenuation constants with those calculated with the above formula. In [39] it is shown that the measured attenuation constants come from the aerial mode which has a slightly slower wave velocity than the other aerial mode. That mode was chosen on the same basis here. However, input data were used which differ slightly from those given in [39]:

(1) Phase conductor 150 mm^2 Aldrey was assumed to have 37 strands (18 on the outside), as defined in DIN 48201, with conductor diameter = 15.8 mm, strand diameter = 2.25 mm, and conductor dc resistance = 0.223 Ω/km (latter from Brown Boveri handbook).

(2) The relative permeability of the steel earth wire was assumed to be 50 to 100 (a Siemens handbook says that these are typical values, with the actual value depending on the current density).

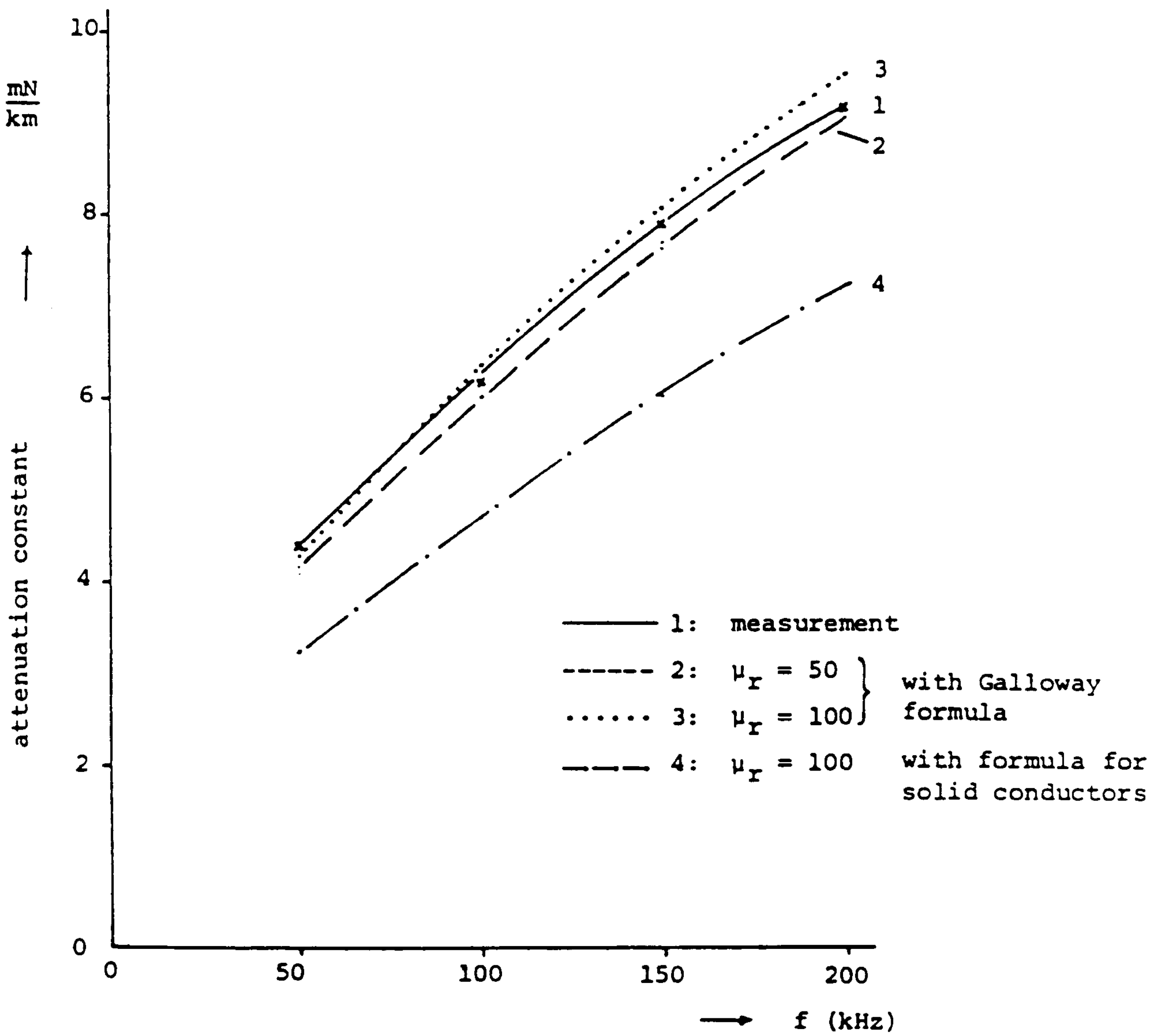

Fig. VII.1 - Comparison between measured and calculated attenuation constants