RECOMMENDATION ITU-R F.275-3*

Pre-emphasis characteristic for frequency modulation radio-relay systems for telephony using frequency-division multiplex

(1959-1966-1970-1982)

The ITU Radiocommunication Assembly,

considering

a) that the pre-emphasis characteristic should preferably be such that the effective (r.m.s.) deviation due to the frequency-division multiplex telephony signal is the same with and without pre-emphasis (Recommendation ITU-R F.404);

b) that, in a frequency-modulation system for frequency-division multiplex telephony, the thermal noise is highest in the top channel and decreases with decreasing baseband frequency;

c) that, in a phase-modulation system, or in a frequency-modulation system with pre-emphasis of 6 dB per octave, the thermal noise is constant over the whole baseband;

d) that the thermal noise in the highest channel of a phase-modulation system is approximately 4.8 dB better than the corresponding channel of a frequency-modulation system, assuming that the two types of system are adjusted to have the same total frequency deviation;

e) that the reduction in frequency deviation with decreasing baseband frequency in a phase-modulation system makes such a system more sensitive to low frequency interference and to the effects of non-linearity in the system;

f) that the loss of advantage in the top channel is quite small and the effects due to non-linearity are not excessive if the range of pre-emphasis is restricted to about 8 dB;

g) that agreement on the pre-emphasis characteristic is desirable to facilitate international connection at radio frequencies or intermediate frequencies;

h) that the pre-emphasis network may be inserted at different places in various types of equipment,

recommends

1 that, where pre-emphasis is used in radio-relay systems for frequency-division multiplex telephony, the same normalized attenuation-frequency characteristic should be used for systems with capacities up to and including 2 700 channels;

2 that the preferred pre-emphasis characteristic is given by the expression:

$$\left.\begin{array}{l}\text{Relative deviation}\\ \text{produced by the}\\ \text{test tone (dB)}\end{array}\right\} = 5 - 10\log_{10}\left[1 + \frac{6.90}{1 + \frac{5.25}{\left(\frac{f_r}{f} - \frac{f}{f_r}\right)^2}}\right] \qquad (1)$$

* Radiocommunication Study Group 9 made editorial amendments to this Recommendation in 2001 in accordance with Resolution ITU-R 44.

where f_r (the resonant frequency of the network) = 1.25 f_{max}, f_{max} is the highest telephone channel baseband frequency of the system, and f is the baseband frequency.

The variation of deviation with frequency is shown in Fig. 1. Table 1 shows f_{max} and f_r for the frequency-division multiplex systems which are the subject of Recommendation ITU-R F.380 and which are mentioned in Recommendation ITU-R F.404;

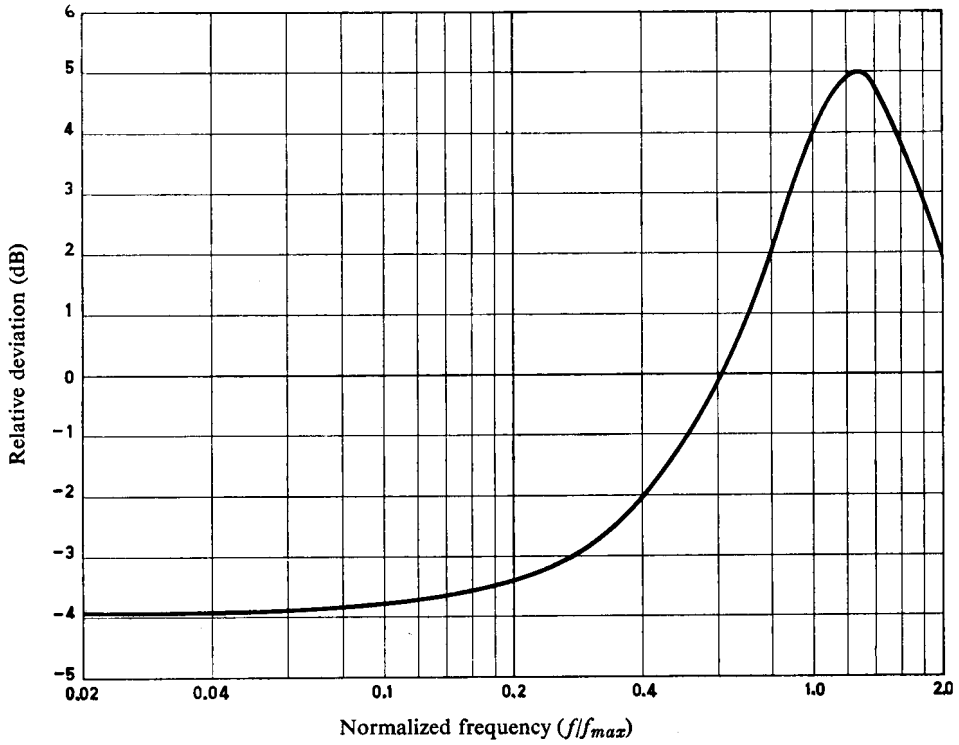

FIGURE 1

Pre-emphasis characteristic for telephony

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TABLE 1

Characteristics frequencies for pre-emphasis and de-emphasis networks for the frequency-division multiplex systems which are the subject of Recommendation ITU-R F.380 and which are mentioned in Recommendation ITU-R F.404

Maximum number of telephone traffic channels (1)	f_{max} (2) (kHz)	f_r (3) (kHz)	f_c (4) (kHz)
24	108	135	66.226
60	300	375	183.96
120	552	690	338.49
300	1 300	1 625	797.16
600	2 660	3 325	1 631.1
960	4 188	5 235	2 568.1
1 260	5 636	7 045	3 456.0
1 800	8 204	10 255	5 030.7
2 700	12 388	15 485	7 596.3

(1) This figure is the nominal maximum traffic capacity of the system and applies also when only a smaller number of telephone channels are in service.

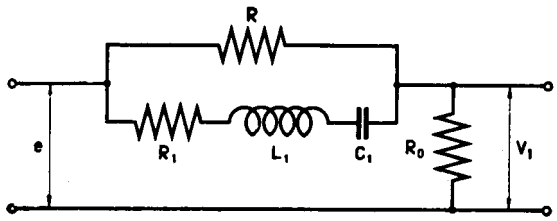
(2) Nominal maximum frequency of the band occupied by telephone channels.

(3) Nominal resonant frequency of the pre-emphasis or de-emphasis network.

(4) Cross-over frequency at which the deviations with pre-emphasis and without pre-emphasis are equal.

3 that the tolerance on the frequency response of the pre-emphasis characteristics, and also on the de-emphasis characteristics should be such that, within the nominal upper and lower limits of the baseband, the departure of the characteristic of a practical network from the theoretical characteristic should be confined within a variation of $\pm(0.1 + 0.05\, f/f_{max})$ dB, f being the baseband frequency, and f_{max} the nominal maximum frequency of the baseband. This corresponds to component tolerances of about ±1% for resistors and about ±0.5% for capacitors and inductors. Further, the magnitude of the departure should exhibit no rapid variations within this frequency range.

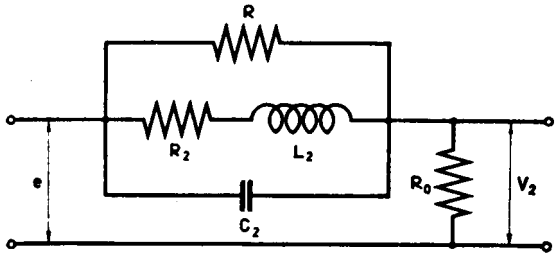
NOTE 1 – It is recognized that it may be desirable to achieve the pre-emphasis characteristic by inserting a network at different places in various types of equipment. An example of a pre-emphasis and de-emphasis network, to work between a constant-voltage source and an open-circuit load, is shown in Figs. 2(a) and 2(b), respectively, and to work between matched resistive input and output impedances is shown in Figs. 3(a) and 3(b), respectively.



$R = 1{\cdot}81\ R_0$
$R_1 < 0{\cdot}01\ R_0$ at f_r
$\sqrt{\frac{L_1}{C_1}} = 0{\cdot}79\ R_0$
$f_r = 1{\cdot}25\, f_{max} = \frac{1}{2\pi}\sqrt{\frac{1}{L_1 C_1}}$

Where f_{max} is the highest baseband frequency

(a) Pre-emphasis network



$R = 1{\cdot}81\ R_0$
$R_2 < 0{\cdot}02\ R_0$ at f_r
$\sqrt{\frac{L_2}{C_2}} = 1{\cdot}47\ R_0$
$f_r = 1{\cdot}25\, f_{max} = \frac{1}{2\pi}\sqrt{\frac{1}{L_2 C_2}}$

(b) De-emphasis network

FIGURE 2

Pre-emphasis and de-emphasis networks to work between a constant-voltage source and an open-circuited load

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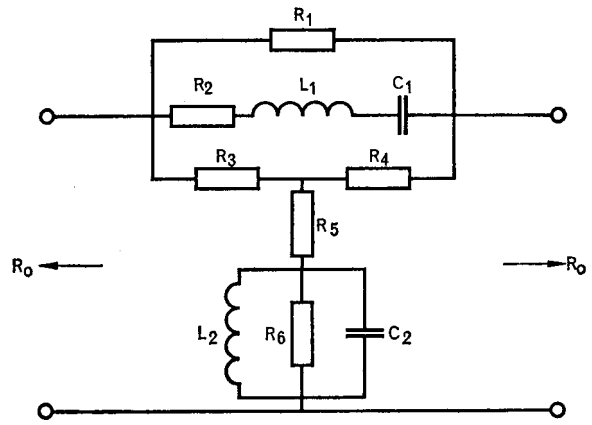
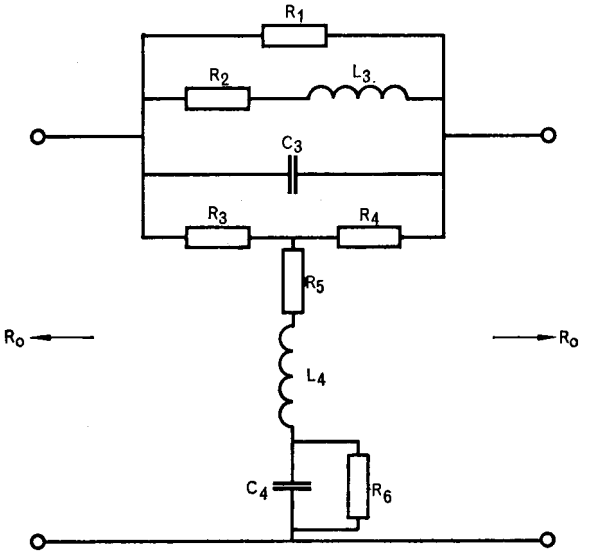
NOTE 2 – In the expression for the relative deviation as indicated in § 2, it should be noted that the frequency at which the deviation with pre-emphasis corresponds to that without pre-emphasis (Recommendation ITU-R F.404) is $0.61320\, f_{max}$. It may be convenient to adopt this frequency for testing the loss between baseband terminal points of systems when these are not in service.

NOTE 3 – It is recognized that it may sometimes be desirable to use a different pre-emphasis characteristic by agreement between the administrations concerned.



$R_1 = 1{\cdot}81\ R_0$
$R_2 < 0{\cdot}01\ R_0$
$R_3 = R_4 = R_0$
$R_5 = \dfrac{R_0}{1{\cdot}81}$
$R_6 > 100\ R_0$
$f_r = 1{\cdot}25\, f_{max} = \dfrac{1}{2\pi}\sqrt{\dfrac{1}{L_1 C_1}}$
$= \dfrac{1}{2\pi}\sqrt{\dfrac{1}{L_2 C_2}}$
$\sqrt{\dfrac{L_1}{C_1}} = 0{\cdot}79\ R_0$
$\sqrt{\dfrac{L_2}{C_2}} = \dfrac{R_0}{0{\cdot}79}$

(a) Pre-emphasis network



$R_1 = 1{\cdot}81\ R_0$
$R_2 < 0{\cdot}01\ R_0$
$R_3 = R_4 = R_0$
$R_5 = \dfrac{R_0}{1{\cdot}81}$
$R_6 > 100\ R_0$
$f_r = 1{\cdot}25\, f_{max} = \dfrac{1}{2\pi}\sqrt{\dfrac{1}{L_3 C_3}}$
$= \dfrac{1}{2\pi}\sqrt{\dfrac{1}{L_4 C_4}}$
$\sqrt{\dfrac{L_3}{C_3}} = 1{\cdot}47\ R_0$
$\sqrt{\dfrac{L_4}{C_4}} = \dfrac{R_0}{1{\cdot}47}$

(b) De-emphasis network

FIGURE 3

Pre-emphasis and de-emphasis networks to work between matched resistive input and output impedances

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