RECOMMENDATION ITU-R S.464-2*

Pre-emphasis characteristics for frequency-modulation systems for frequency-division multiplex telephony in the fixed-satellite service

(1970-1982-1992)

The ITU Radiocommunication Assembly,

considering

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

b) that in a frequency-modulation system for frequency-division multiplex telephony operating well above threshold 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 at 20 dB per decade, operating well above threshold 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 lower than the corresponding channel of a frequency-modulation system, assuming that both systems operate well above threshold and are adjusted to have the same multi-channel r.m.s. 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 noise, especially that arising in threshold extension demodulators operating near to threshold;

f) that for earth stations normally operated above threshold the efficiency of use of satellite transmitter power is practically unaffected by changes in the range of pre-emphasis characteristic from below 6 dB to about 8 dB, but the efficiency of use of radio-frequency bandwidth increases slightly with an increase in pre-emphasis range;

g) the material presented in Annex 1,

recommends

1 that in systems in the fixed-satellite service employing frequency modulation, radio-frequency carriers with capacities of 12 or more telephone channels should be used with pre-emphasis and should use the same normalized pre-emphasis characteristic;

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* Radiocommunication Study Group 4 made editorial amendments to this Recommendation in 2001 in accordance with Resolution ITU-R 44 (RA-2000).

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

$$\text{Relative frequency deviation of the test tone at the frequency} = 5 - 10 \log \left[1 + \frac{6.90}{1 + \frac{5.25}{\left(\frac{f_r}{f} - \frac{f}{f_r} \right)^2}} \right] \quad \text{dB}$$

where:

$f_r = 1.25\ f_{max}$: resonant frequency of the network

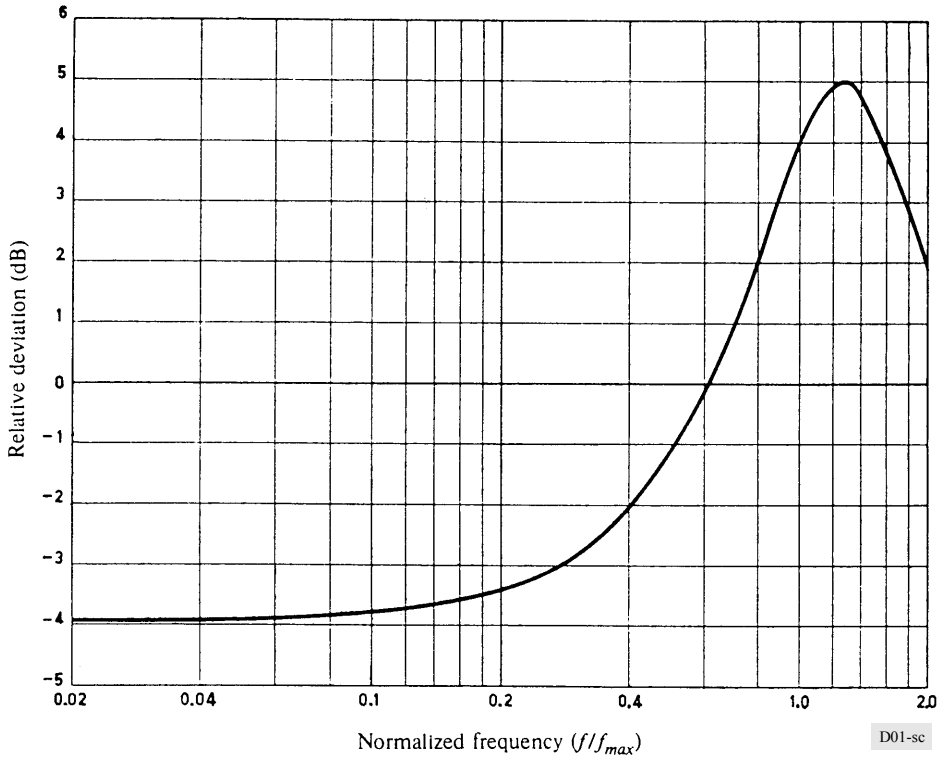
f_{max} : highest telephone channel baseband frequency of the system

f : baseband frequency.

The variation of deviation with frequency is shown in Fig. 1;

FIGURE 1

Pre-emphasis characteristic for telephony



3 that the tolerance on the frequency response of the pre-emphasis characteristic, and also on the de-emphasis characteristic 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 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.

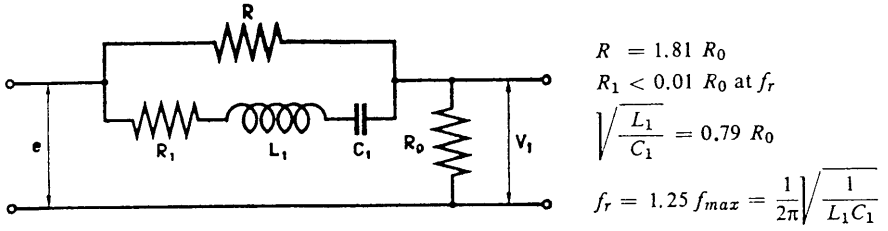
NOTE 1 – It is recognized that it may be desirable to achieve the pre-emphasis characteristic by inserting a network at different places in various types of equipment. An example of pre-emphasis and de-emphasis network, to work between a constant-voltage source and an open-circuit load, is shown in Fig.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

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 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.

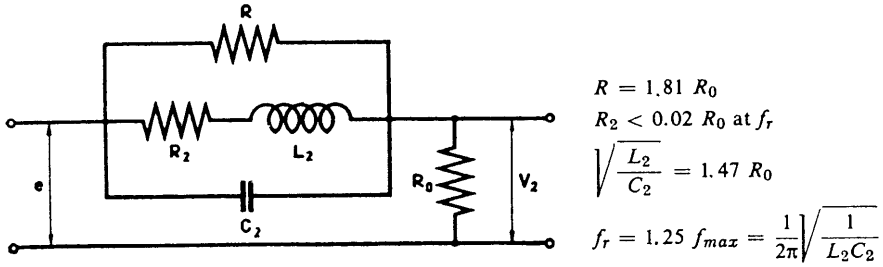
FIGURE 2

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



Where f_{max} is the highest baseband frequency

a) Pre-emphasis network



b) De-emphasis network

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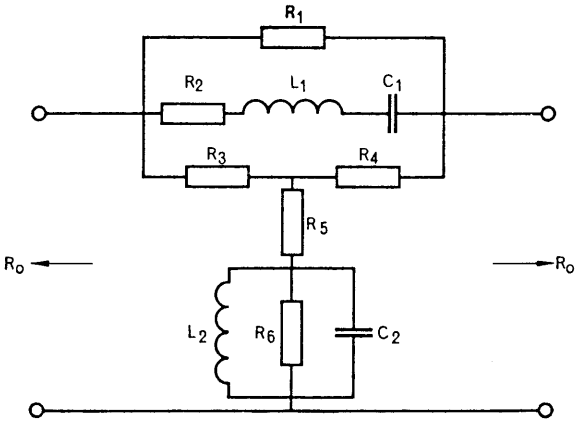
FIGURE 3

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



$R_1 = 1.81\ R_0$

$R_2 < 0.01\ R_0$

$R_3 = R_4 = R_0$

$R_5 = \dfrac{R_0}{1.81}$

$R_6 > 100\ R_0$

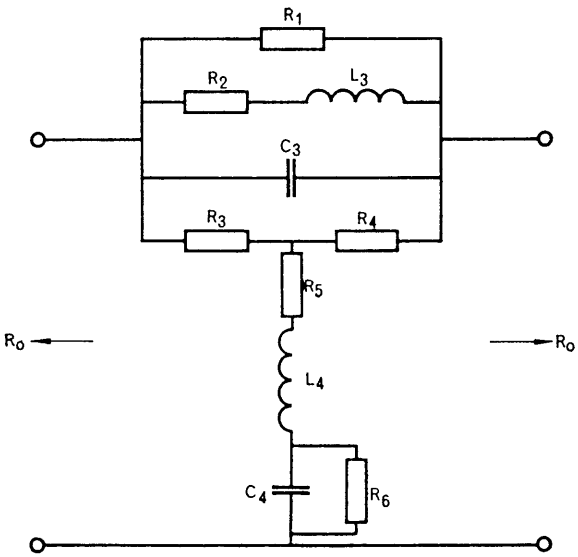
$f_r = 1.25\ f_{max} = \dfrac{1}{2\pi}\sqrt{\dfrac{1}{L_1C_1}}$

$= \dfrac{1}{2\pi}\sqrt{\dfrac{1}{L_2C_2}}$

$\sqrt{\dfrac{L_1}{C_1}} = 0.79\ R_0$

$\sqrt{\dfrac{L_2}{C_2}} = \dfrac{R_0}{0.79}$

a) Pre-emphasis network



$R_1 = 1.81\ R_0$

$R_2 < 0.01\ R_0$

$R_3 = R_4 = R_0$

$R_5 = \dfrac{R_0}{1.81}$

$R_6 > 100\ R_0$

$f_r = 1.25\ f_{max} = \dfrac{1}{2\pi}\sqrt{\dfrac{1}{L_3C_3}}$

$= \dfrac{1}{2\pi}\sqrt{\dfrac{1}{L_4C_4}}$

$\sqrt{\dfrac{L_3}{C_3}} = 1.47\ R_0$

$\sqrt{\dfrac{L_4}{C_4}} = \dfrac{R_0}{1.47}$

b) De-emphasis network

ANNEX 1

Use of pre-emphasis in frequency-modulation systems for frequency division multiplex telephony and television in the fixed-satellite service

1 Introduction

The use of pre-emphasis in systems in the fixed-satellite service for frequency-division multiplex telephony using frequency modulation results in a useful improvement in the signal-to-noise ratio in the higher frequency channels of the system and thus enables the space-station transmitter power and bandwidth requirements to be reduced.

The use of pre-emphasis for television modifies the energy distribution in the radio-frequency emission of systems in the fixed-satellite service, in such a way as to reduce, substantially in some circumstances, the possibility of interference within and between systems in the fixed-satellite service and between systems in the fixed-satellite service and radio-relay systems using the same frequency bands.

The use of pre-emphasis for television may also enable the effective frequency deviation of the system in the fixed-satellite service to be increased, thereby improving the signal-to-noise ratio; however, too large an increase in deviation could offset the reduction of interference potential.

The deviation and pre-emphasis used to obtain the best possible transmission of some television signal standards may differ appreciably from those recommended for telephony.

The use by different administrations of the facilities offered by active systems in the fixed-satellite service, including the shared use of space-station repeaters, would be facilitated by the use of agreed pre-emphasis characteristics for such systems employing frequency modulation.

2 Telephony

The effect of pre-emphasis will be to improve the signal-to-noise ratio in the high frequency channels and to reduce it in the low frequency channels. This may in turn affect the carrier-to-noise ratio at which the noise in the worst channel reaches 50 000 pWp at a point of zero relative level. Each of these effects will have repercussions on the satellite power and bandwidth required to meet the noise objectives of Recommendation ITU-R S.353. Furthermore, the optimum characteristic for a system operated at or below threshold for a considerable proportion of the time may not be the same as that for systems which normally operate above threshold.

The threshold margin of present satellite systems is generally sufficient to prevent them from operating below threshold for all but very small proportions of the time and the same is expected to be true for future systems. For general use, therefore, a pre-emphasis characteristic with a relatively wide range of attenuation will be optimum.

Measurements of signal-to-noise ratios in an operational system have confirmed that the network described in this Recommendation which has an 8 dB range of attenuation, gives satisfactory results in practice.

However, for systems operating nearer to threshold, a narrower range of attenuation may be found to be optimum.

3 Television

Information on the application of pre-emphasis to frequency-modulation systems transmitting television can be found in Recommendation ITU-R F.405 and ex-CCIR Volume XII.