

RECOMMENDATION ITU-R M.1090

**FREQUENCY PLANS FOR SATELLITE TRANSMISSION OF SINGLE CHANNEL
PER CARRIER (SCPC) CARRIERS USING NON-LINEAR TRANSPONDERS
IN THE MOBILE-SATELLITE SERVICE**

(Question ITU-R 87/8)

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The ITU Radiocommunication Assembly,

considering

- a) a) that a number of SCPC (Single Channel Per Carrier) carriers are transmitted via a single satellite transponder in satellite communication systems;
- b) that, for efficient use of satellite power, the transponder would be operated in the near saturation region, in which case intermodulation noise affects signal quality;
- c) that the intermodulation products falling into the frequency slots of occupied signal channels could be reduced by suitably positioning the channels within the available bandwidth;
- d) that bandwidth-efficient frequency plans need to be developed;
- e) the analysis of intermodulation-minimum frequency assignment as described in Annex 1,

recommends

1. that the procedure described in the annex, for minimizing the intermodulation products by appropriately selecting carrier frequency assignments, should be used as a design tool for use in the control system of a mobile satellite system to determine the preferred carrier allocation for minimizing the intermodulation noise.

Note 1 – Further studies are needed in the following areas when considering practical systems:

- dynamic assignment of channels;
- restricted bandwidth which may mean that possible channel selection is limited;
- the carriers will normally be voice activated;
- dynamic power control.

ANNEX 1

**Design of frequency plans for satellite transmission of SCPC
carriers using non-linear transponders**

1. Introduction

In satellite communication systems, a number of SCPC carriers are transmitted via a single satellite transponder. For efficient use of satellite power, the transponder would be operated in the non-linear region, in which case intermodulation noise affects signal quality.

The intermodulation products falling into the frequency slots of occupied channels could be reduced by suitably positioning the channels within the available bandwidth. Babcock spacing is a typical example of this approach where the channels are completely free from third-order intermodulation noise. However, such an intermodulation-free frequency plan would not necessarily be desirable because of its inefficient use of available bandwidth, especially where a large number of channels have to be accommodated. For example, in order to accommodate 20 channels, it would be



necessary to utilize a bandwidth more than ten times the width of a plan using adjacent frequency slots. Hence, bandwidth-efficient frequency plans need to be developed, and one approach is to allow some intermodulation products to fall into the channels, but only to the extent that the degradation of signal quality can be acceptable.

This annex discusses the assignment of frequencies based on this approach, which is referred to hereafter as intermodulation-minimum frequency assignment.

2. Equal level SCPC carriers

2.1 Relationship between assigned bandwidth and intermodulation products

It is difficult to determine theoretically intermodulation-minimum frequency plans. However, the attainable minimum number of intermodulation products falling into the worst affected traffic channel can be estimated by a theoretically derived lower bound.

Figure 1 shows the theoretically derived lower bounds of the number of the $(f_1 + f_2 - f_3)$ type third-order intermodulation products falling into the worst traffic channel as a function of the assigned bandwidth, with the number of traffic channels to be accommodated as a parameter. In this figure, the number of intermodulation products, which is proportional to the intermodulation noise power, is normalized against the number produced in the worst channel in a plan using adjacent frequency slots. The result is then expressed in decibels. For convenience, the latter plan is referred to hereafter as minimum equal-spacing. The assigned bandwidth is also normalized by that required for the minimum equal-spacing plan.

2.2 Intermodulation-minimum frequency plan

Intermodulation-minimum frequency plans have been obtained for practical application by computer calculation. For a small number of traffic channels, the optimum solution can be obtained by examining all possible combinations.

For a large number of traffic channels, the quasi-optimum solution, which may not be optimum but would be considered very close to optimum, can be obtained by an iterative approach.

Comparing them with their lower bounds, it is observed that the number of intermodulation products falling into the worst traffic channel in the intermodulation-minimum frequency plans can be estimated effectively by using the lower bound curve for $K = \infty$ shown in Fig. 1.

3. Multi-level SCPC carriers

In future satellite systems it may be desirable to operate with several standards of mobile earth stations having different G/T values. One possibility would be to transmit signals destined to the various mobile earth station standards with different satellite e.i.r.p. levels. Even within systems that operate with a single mobile earth station standard, different satellite carrier power levels may be used for different services.

However, accommodation of large numbers of carriers of mixed power levels in a single non-linear satellite transponder by placing the carriers in arbitrarily-selected channel assignments could easily lead to situations where intermodulation noise from certain relatively higher-power channels would render several relatively lower-power channels unusable.

3.1 Mixed-level frequency plan alternatives

One type of frequency plan capable of easily accommodating mixed level carriers assigns carriers to channels selected from a set of equally spaced channels using a Babcock spacing. Resultant assignment channels are totally free of third-order intermodulation noise and could consequently be used for carriers of any power level. However, Babcock plans are generally impractical, unless the number of required carrier assignments is small, due to the inefficient use such plans make of the available bandwidth.