REPORT 1019*

SOURCES OF UNWANTED SIGNALS IN MULTIPLE BASE STATION SITES IN THE LAND MOBILE SERVICE

(Question 7-2/8)

(1986)

1. Introduction

The greatly increased use of land mobile services has resulted in a dramatic increase in the number of base stations on any one site, particularly on those sites strategically placed to serve large built-up areas. This has led to instances of severe interference due to unwanted signals being generated at the site. This Report is not intended to examine every possible type of interference but rather to indicate the more commonly occurring sources. It should be particularly noted that transmitters of other services may be involved.

2. Simple frequency relationships

As land mobile frequency bands are used throughout the VHF/UHF spectrum there may be harmonic relationships between frequencies in the various bands. The equipment cabinet, the power supply cabling and land-line cabling can contribute to the level of these unwanted harmonic signals.

Other interfering signals can be caused by simple mixes either in transmitter output stages or at the antenna mast. As an example, if the signal from a VHF broadcasting transmitter at 93 MHz mixes with a signal of the mobile service at 170.5 MHz, a difference signal of 77.5 MHz can be produced. This can cause a problem if it is a receive frequency of the mobile service.

3. Complex frequency relationships

3.1 *Generation of intermediate frequency and/or its derivatives*

Interference can be caused in a receiver where signals are received from two transmitters whose frequencies are separated by an amount equal to the IF, or a submultiple of the IF, of the receiver.

3.2 *Generation of transmit/receive (Tx/Rx) difference frequency*

This problem arises on sites where there are several base stations having "repeater" or "talk-through" facilities, i.e. the transmitters and receivers are in use simultaneously. If the Tx/Rx spacing is constant (D), an incoming signal from a mobile station will produce in the base station transmitter output stage a difference frequency, D. Any other base station transmitter may now mix with D to produce its own receiver frequency in the same band.

4. Intermodulation products

4.1 *Generated external to the site*

Under this heading, products arise from stations on adjacent sites, and, in particular, the third order product i.e. $2f_1 - f_2$, which is prevalent in large built-up areas. In some instances significant intermodulation products up to and including the seventh order have been noted and in exceptional cases the interference has been traced to the nineteenth order.

4.2 *Intermodulation products generated on-site by non-linear junctions on the mast*

More study is required to verify the mechanisms and levels of such interference, which certainly exists in the land mobile bands. However, at lower radiated powers, the significance of these products is reduced, compared with other forms of non-linearity, e.g. § 4.1 and 4.3.

4.3 *Intermodulation products generated on-site by non-linearity in components of the system*

Junctions between dissimilar metals cause non-linearity, and therefore intermodulation products, when subjected to radio frequency currents, and recent work has highlighted such products up to the eleventh order at VHF caused by connectors, cables and dissimilar junctions in what might be regarded as otherwise innocuous components.

For the long-term development of the land mobile radio industry, it may be necessary to define the non-linearity of passive components in the system.

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* This Report should be brought to the attention of Study Group 1.

5. Transmitter noise

Until quite recently, most transmitters on base station sites had valve output stages, which fortuitously were not a major contributor to the noise spectrum compared with the more modern solid-state output stages.

With a valve output stage, the unwanted noise is generally narrow-band, having frequencies which are multiples of the crystal oscillator frequency or a combination derived from the multipliers. However, in the case of solid-state output stages the noise is generally wideband and higher in level.

Figures 1, 2 and 3 give the graphical results of measurements made in the United Kingdom of noise from VHF transmitters with thermionic valve output stages and with solid-state output stages for the VHF "high band" (150-170 MHz) and VHF "low band" (71.5-87.9 MHz).

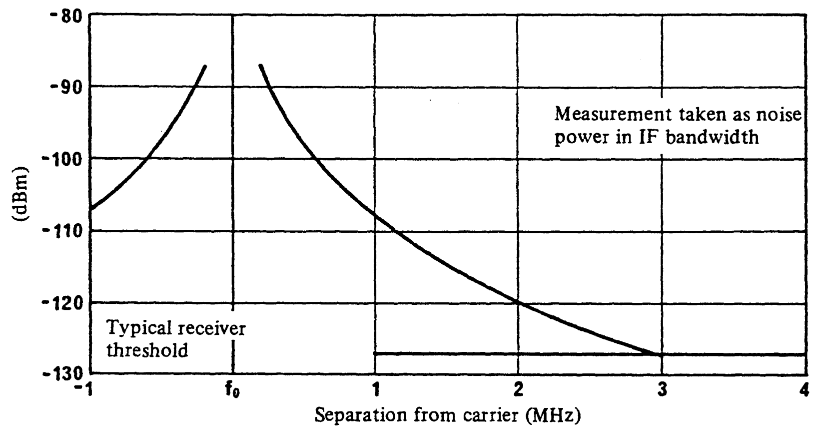

FIGURE 1 – *Typical transmitter noise VHF high band (150-170 MHz): thermionic output stage*

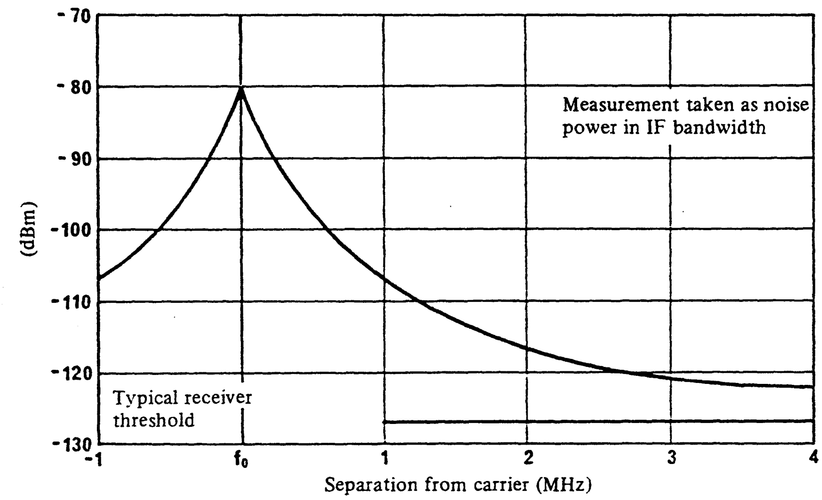

FIGURE 2 – *Typical transmitter noise VHF high band (150-170 MHz): solid-state output stage*

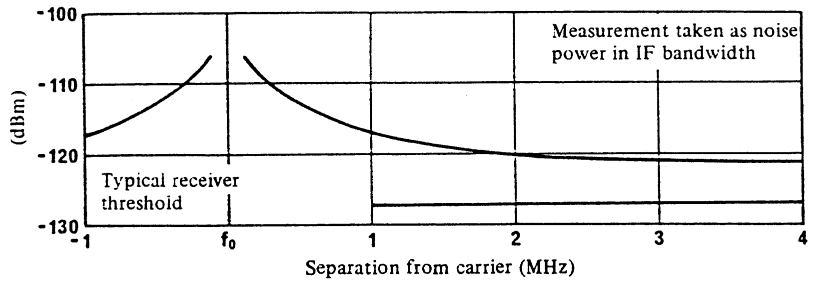

FIGURE 3 – *Typical transmitter noise VHF low band (71.5-87.9 MHz): solid-state output stage*

Figure 4 shows practical operational noise curves for a base station without filtering of spurious emissions and noise from the transmitter output (curves A). These results can be compared with those of curves B which show the benefit of filtering in reducing noise and unwanted emissions by some additional 30 dB.

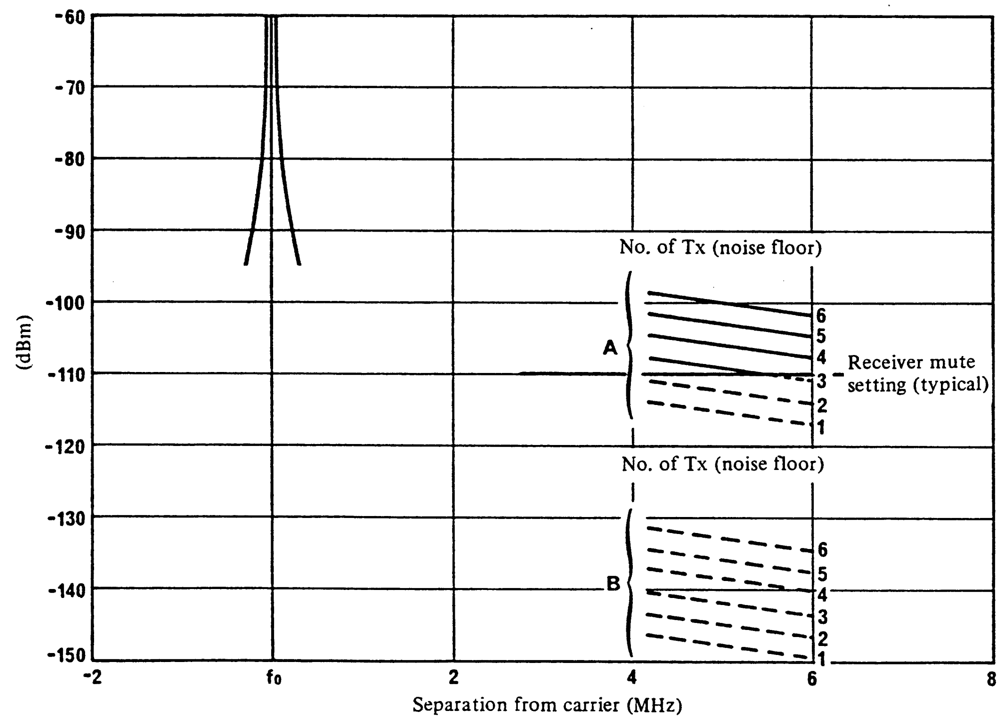

FIGURE 4 – *Practical operational noise curves*

Curves A: site without transmitter filters

B : site with transmitter filters

Minimum isolation at f_{Rx} = 30 dB

All transmitters have solid-state output stages

Carrier power per transmitter typically +43 dBm

Figure 5 shows a typical transmitter filtering system and Fig. 6 shows the detailed response of the spectrum dividing filter shown in Fig. 5.

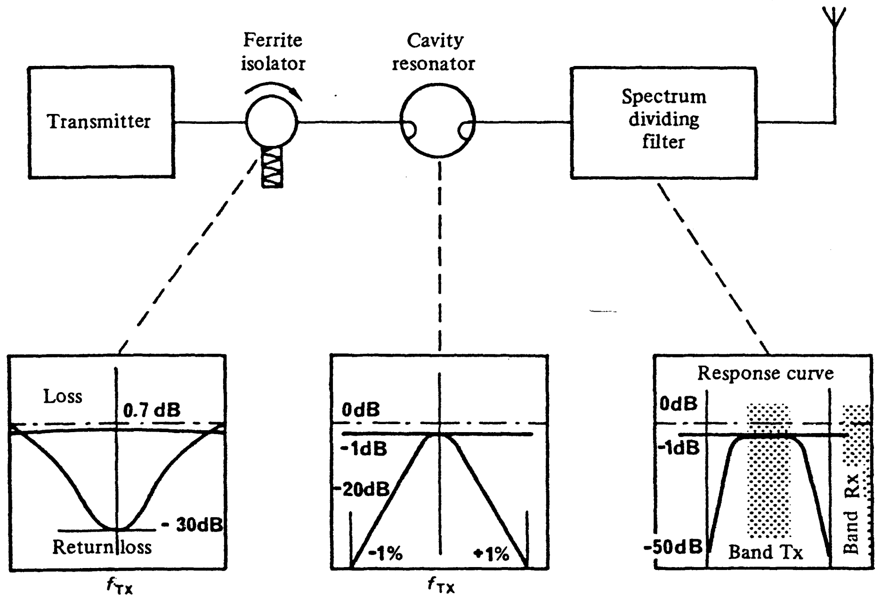

FIGURE 5 – *Typical Tx filter system for talk through operation VHF 150-160 MHz*

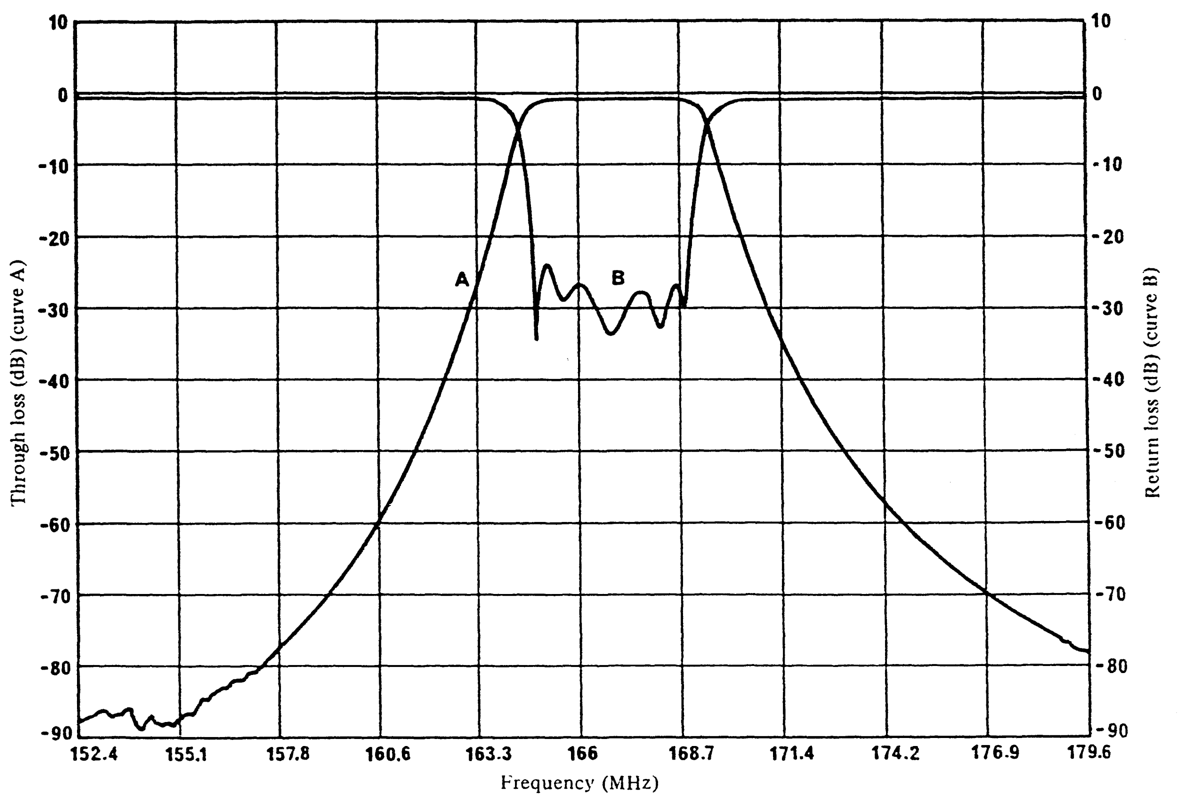

FIGURE 6 – *Spectrum dividing filter response curve*

A typical calculation of the noise levels to be expected on a site with 15 transmitters using the filtering arrangements outlined in Fig. 5 is given below:

Calculation of typical transmitter noise levels
(Tx/Rx spacings 4.8 MHz)
VHF high band 150-170 MHz

Per Tx			
Noise at FRx: (Typical value)			−137 dB (relative to carrier)
Now insert additional isolation:			
Add ferrite (−1 dB)			−138 dB
Add cavity (−30 dB)			−168 dB
Add SD filter (−35 dB) (6 section)			−203 dB
Now take carrier ref. +42 dBm:	Noise	=	−161 dBm
Add say 15 × Tx at (+3 dB/Tx)			+45 dB
		=	−116 dBm
Add say further 5 × Tx at (3 dB/Tx)			+15 dB
Final noise level at *f*Rx		=	−101 dBm
			(i.e. 2 μV p.d.)*

6. External electrical noise

Apart from ignition noise, there are the well-known sources of radio interference, which continue to proliferate, particularly from industrial users, i.e. RF heating, microwave ovens, X-ray and medical equipments. These normally provide a broad spectrum of noise which tends to vary in frequency.

Screening or suppression of the interfering equipment normally reduces the problem to an acceptable level.

There is however, a new family of sources, namely computers and computer peripherals, which are currently causing problems with broadband noise over the VHF spectrum.

7. Summary

There are instances where the present engineering practices in multiple transmitter sites have allowed the generation of excessive unwanted signals. With the increased use of land mobile radio it is desirable to perfect techniques to reduce interference effects in the future. There is a need for better site engineering in order to establish "quiet" base station sites for trunking networks and cellular radio.

The following should be considered:

- spurious emissions from transmitters;
- filtering of transmitter outputs to reduce spurious emissions and noise at frequencies near the carrier;
- use of directive isolators in transmitter output stages;
- additional filtering to provide protection at adjacent frequency bands;
- non-linear effects at all points in the system.

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* μV p.d. is μV potential difference, measured with circuit closed.