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TROUBLESHOOTING TWO-WAY RADIOS WITH THE SPECTRUM ANALYZER

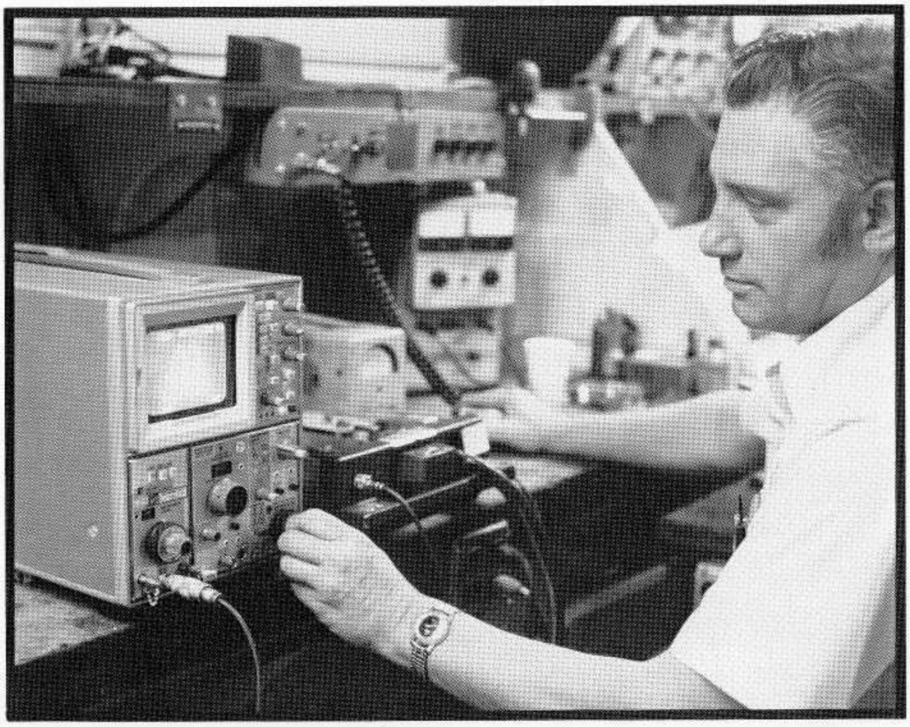

Table of Contents

COVER PHOTO: Two-way radio municipal communications tower above Portland, Oregon. Hugh Ackroyd, photographer.

Introduction:

This application note was prepared to help the two-way radio technician understand the use of spectrum analysis. Two-way repair is a labor-intensive business, and with hourly rates rising, as well as radios becoming more complex, it is important for the radio service technician to rapidly evaluate and pinpoint service problems.

The two-way industry is evolving rapidly and most shops now routinely employ service monitors for each technician. The service monitor is a quick, convenient method for curing most two-way problems; however, it has one big limitation. It is intended to service only one channel at a time. This is analogous to looking at the world through a key hole. You can't get the whole picture! The service monitor approach might insure that a single frequency radio link works, but it does not take into account the effect that a single transmitter might have on adjacent or harmonically related frequencies. A receiver might equally suffer when operated in a noisy environment or in the presence of numerous radio carriers.

The interference potential is, in fact, a major problem in most metropolitan locales today. Spectrum analysis is part of the answer since one can readily look at the entire radio spectrum and spot potential interference problems before they cause trouble. By using some of the techniques described in this booklet, the quality of service as well as the efficiency of the shop will be increased. Think spectrum analysis!

Clifford B. Schrock

Chapter I

A. Two-way Radio Systems

There are three basic transmission systems that could be used for two-way radio transmissions: **amplitude modulation (am), frequency modulation (fm)** and **Single Sideband (ssb).** In the public two-way bands today, **frequency modulation** of the narrowband variety is used almost exclusively. Only Citizens Band uses **am.** Some marine services as well as government two-way services still use single sideband but **fm** is gradually replacing other forms of modulation. Spectrum analysis can be used to evaluate all three forms of modulation, *(Figure 1-1)* and examples are contained herein; however, most of this booklet is devoted to **fm** measurements.

B. Fm and Two-Way

The first uses of **fm** in two-way communications occurred in the late 40's and evolved into the now-obsolete 35 to 50 MHz band. Early **fm** was wideband; that is, it used a deviation of ± 15 kHz. The most obvious advantage of the early, wideband **fm** was signal-to-noise improvement. The equation for signal-to-noise improvement is:

$$\frac{S/N}{C/N} = 3(\beta)^2$$

The modulation index (β) is determined:

$$\beta = \frac{F}{f_m}$$

where:

F is the peak frequency deviation and
f_m is the highest modulating frequency.

Since the highest average modulating frequency can be considered to be 3 kHz, a noise improvement over a comparable **am** system of 75 (18.7dB) could theoretically be realized. However, the theoretical improvements were far from possible since the early systems were fighting many design problems.

Because of bandwidth constraints and a quest for more channels, the wideband two-way **fm** system was replaced in the 60's by narrowband **fm.** Narrowband means that the **fm** signal occupies the same space as a comparable **am** signal. Modern **fm** channels are spaced 20 kHz apart in the 150 and 450 MHz bands with a deviation of ± 5 kHz permissible.

By recalculating the signal-to-noise ratio gain for narrowband **fm,** we can readily see that much of the noise improvement is lost. In fact, for a mod-

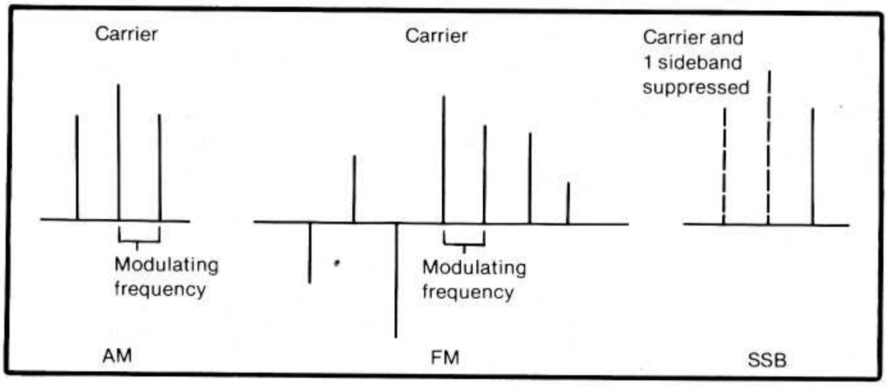

Figure 1-1 Diagrams of 3 major forms of modulation