REDUCTION OF CO-CHANNEL INTERFERENCE BY USE OF PRECISION FREQUENCY CONTROL IN THE ORIGINATING TRANSMITTERS

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Television coverage plans in the United States originally used geographic spacing to provide protection against co-channel interference. Subsequent allocation plans improved the protection by use of offset channels. It was recognized at an early date that an offset of an odd multiple of the horizontal scanning frequency would be optimum, however consideration of the problem of providing protection where more than two channels are involved required the use of an offset which compromised the optimum. An offset of 10 KHz was chosen and stations were assigned "on channel", "+10 KHz offset" and -10 KHz" offset" in a pattern which generally assured that overlapping stations would be separated by either 10 KHz or 20 KHz. Frequency tolerance was set at +- 1 KHz in recognition of the practical difficulties of operating television transmitters, particularly high band and UHF transmitters with lesser tolerance.

There was also early recognition that tighter tolerances would provide more protection . Figures 1 and 2 adapted from a paper by Wendell C. Morrison show the differences in protection afforded by more precise control of carrier frequencies. Changes of 20 or 30 Hz in the beat between two interfering carriers can produce from 10 to 16 db difference in protection tolerance. Even though the ratios of desired to undesired carriers remain the same, the visibility of the beat produced can vary by this amount, 10 to 16 db. Best results are obtained when the beat frequency is an even multiple of the vertical frame frequency and close to the nominal 10 or 20 KHz. The offsets usually chosen is 10.010 KHz and the resulting co-channel beats are either 10.010 KHz or 20.020 KHz. A "zero beat" is of course possible during freak propagation conditions. This 10.010 KHz offset is the 334th harmonic of the vertical frame frequency (29.97 Hz in an NTSC color system). It is considered that frequency tolerance for best results should be +- 5 HZ or even better. This is a tolerance of only 1 part in $6X10^8$ in the low band, 1 part in $2X10^8$ in the high band 1 part in $6X10^9$ at the high end of the UHF band.

Although the principles of co-channel interference reduction by precision offset have been known for some time - almost twenty years - the technique has been applied only by major market stations operating on low band channels, particularly channel 2. Precision oscillators were expensive and difficult to maintain and precision frequency measurements were very difficult. In recent years there has been some resurgency of interest in precision offset due to the availability of good quality oscillators at moderate cost and improved easier techniques for precision frequency measurements. High quality quartz crystal oscillators and precision rubidium vapour oscillators are available as practical frequency standards for the control of television transmitters. Digital counter techniques and precision phase comparators make measurement and reference to National Bureau of Standards easy and practical.

The principles of precision offset and details of the equipment and techniques available for its implementation have been widely discussed within the television broadcast engineering fraternity in recent years. This presentation has been intended to acquaint cable television engineers with these principles and to suggest precision offset as a technique for alleviating co-channel problems in CATV reception.

Cable television systems often find themselves equidistant from two co-channel stations, struggling heroically to select the desired station by use of directional antennas, bucking arrays and special baseband traps and filters. If the television stations involved are not both using precision offset it is possible to get a 10 to 16 db improvement in interference rejection by persuading the two television stations involved to install precision offset frequency control equipment. Cost is less than $51,000 per station and the benefit extends to all receivers affected by co-channel between these stations, whether receiving by CATV or direct. The benefits apply to all channels, low band, high band and UHF. Although the technique has usually been used only by low band stations and particularly those on channel 2 it works

just as well on any channel.

When you have tried every other co-channel reduction technique consider an appeal to the television stations involved. I realize that some very complex and touchy situations might arise. One of the stations may see no advantage in co-operating even if the other parties offered to pay for the equipment. Documentation of such cases might build a case for a petition to the FCC to make precision frequency control mandatory on all television transmitters. Although I am not aware of it ever having been done, it might be possible to control only one transmitter in such a way as to keep it spaced from a second transmitter by the required offset. This would require a complex feedback loop over a long geographic distance, but could be done if the situation warranted the expense and trouble. A possible implementation of such a technique is shown in figure 3.

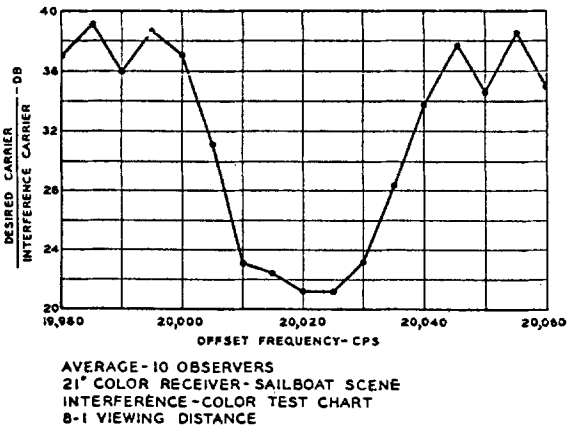

FIG. 1. The difference in db required to produce a tolerable picture with carriers offset by approximately 20 KHz.

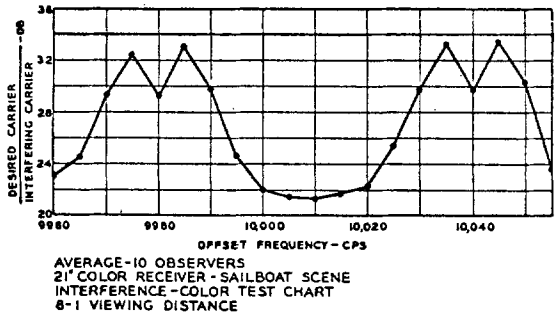

FIG.2. As above but carriers offset approximately 10 KHz.

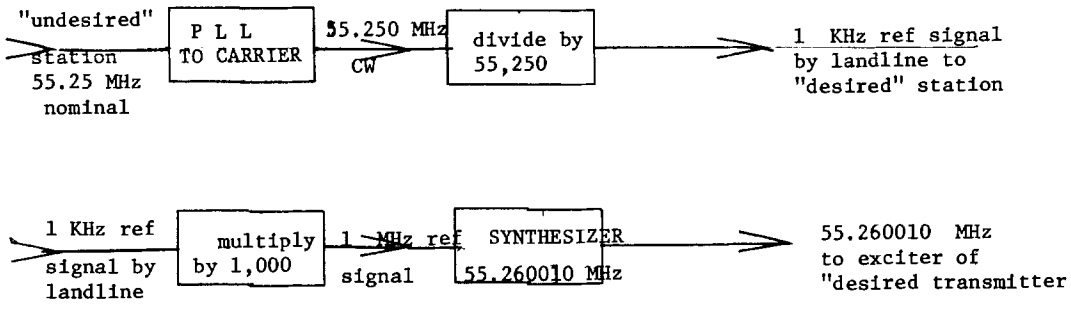

Figure 3. A receiving station within range of the "undesired" station receives the signal, locks a CW carrier to it and divides by 55,250 to produce a 1 KHz reference signal derived from the "undesired" station which is then transmitted by land line (or radio link) to the"desired" station.

At the desired station the 1 KHz reference signal is multiplied up to 1 MHz to drive a synthesizer (or may be used directly in a special synthesizer) which is set to produce the desired offset carrier, 55.260010 MHz in this case, to drive the exciter of the desired transmitter. The "desired" transmitter is referenced to the "undesired" but is offset by the desired amount.