THE PHAZAR, A NEW INTERFERENCE REJECTION DEVICE

Peter Conte — CATV Components Co., St. James, N.Y.

Steven I. Biro — Biro Associates, Princeton, N.J.

The PHAZAR, a recently introduced interference reduction system eliminates the need to know the direction of the off-the-air interference source, and in most cases makes the application of an auxiliary antenna unnecessary. A sequential manipulation of the controls will result in a 20 to 30 dB interference rejection.

In this paper the authors give a brief summary of the conventional interference rejection methods used before. Than, using block diagrams and phasor charts, the authors describe the theory and operation of the PHAZAR SYSTEM "A".

Finally, the interference rejection capabilities of the PHAZAR will be demonstrated simulating harmonic type and co-channel interference conditions.

Off-the-air interference problems, such as co-channel interference, the harmonics of local FM stations and Citizens Band transmitters, adjacent channel carriers, high voltage power line noise, reflections (ghosting) have impaired the CATV picture quality for a long time. In order to ascertain the best picture quality CATV engineers used one or more of the following approaches to protect subscribers against interference problems:

1. Better antenna site selection. To prove by an on-site survey that the location is free of interference.

2. Phased antenna-arrays, forcing an antenna radiation pattern null in the direction of interference.

3. The application of bandpass filters and traps.

While the use of filters and traps might bring satisfactory relief against strong adjacent channels, where the interfering carriers fall outside the received channel, filters and traps are useless against co-channel or harmonic type of interference if the spurious signal shows up between the video and sound carrier. (FIGURE 1).

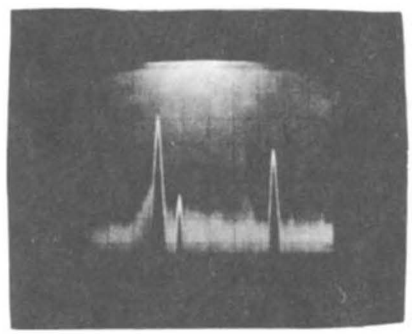

FIG. 1

This spectrum analyzer picture shows a spurious signal .75 MHz (3/4 Division) above the video carrier. No trap or filter could be applied to eliminate the interference.
Horizontal scale: 1 MHz/Division
Vertical scale: 10 dB/Division

The PHAZAR, a recently introduced interference rejection device, greatly simplifies the task of interference reduction or elimination. The advanced (SYSTEM "A") version of the PHAZAR even eliminates the need to know the direction of the interference source, or the installation of a second (auxiliary) antenna-array, thus rendering an attractive and economical solution combating off-the-air interference.

The concept of interference cancellation, employing a bucking antenna, oriented toward the interference source, has been known for a number of years in the CATV industry. External attenuator pads were used to equalize the amplitude of the interfering signals, and different length of coaxial cables were introduced to achieve out-of-phase (cancellation) conditions. However, the process was somewhat crude and tedious, the monitoring instrumentation inadequate. After many disappointing field applications the bucking antenna method slowly faded away.

The PHAZAR, a passive interference rejection device, operates basically on the bucking antenna principle. The first input port of the PHAZAR is connected to the main antenna array (FIGURE 2), receiving the desired station plus the undesired interferences. The second input port is connected

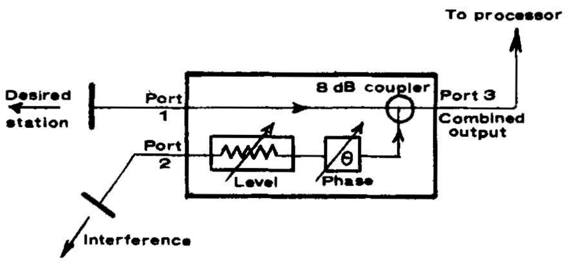

FIG. 2

Schematics of the PHAZAR concept

to the auxiliary antenna, oriented toward the interference source, picking up primarily the interference, and a fraction of the desired signal. A portion of the interference signal is than added out-of-phase to the desired signal, resulting in a more or less complete cancellation, as illustrated on the vector diagram of FIGURE 3.

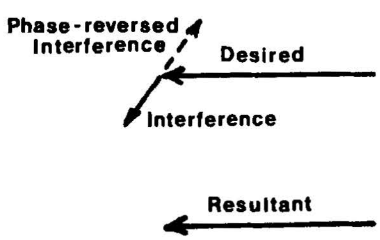

FIG. 3

Vector diagram of interference cancellation

The cancellation (phasing and shaping) process of the PHAZAR is convenient and effective because the instrument is head-end rack mounted, and has built-in attenuators and phasing controls. (FIGURE 4).

The instrument controls provide:

1. A maximum of 40 dB attenuation of the undesired signal by step-attenuators.
2. 0 to 360 degree phase variation through 10 and 90 degree step controls.
3. A continuously variable 0 to 2 dB attenuation, and a 0 to 10 degree fine tuning phaseshift vernier.

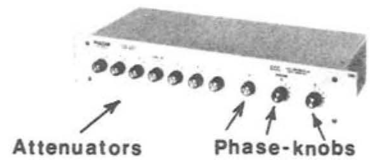

FIG. 4

Rack-mounted version of the PHAZAR

It is the fine and continuous variation of amplitude and phase which makes the PHAZAR really successful, the nulling so effective, producing a minimum of 20 dB, occasionally as high as 40 dB interference rejection.

The PHAZAR SYSTEM "A" is a more advanced version of the PHAZAR concept, using, beside the PHAZAR, a sum-difference hybrid combiner, which replaces the original 3 dB hybrid splitter (combiner) of the antenna array (FIGURE 5). If the system already has a two-·ay or quad antenna-array working on the problem channel, there is no need for the installation of an auxiliary antenna.

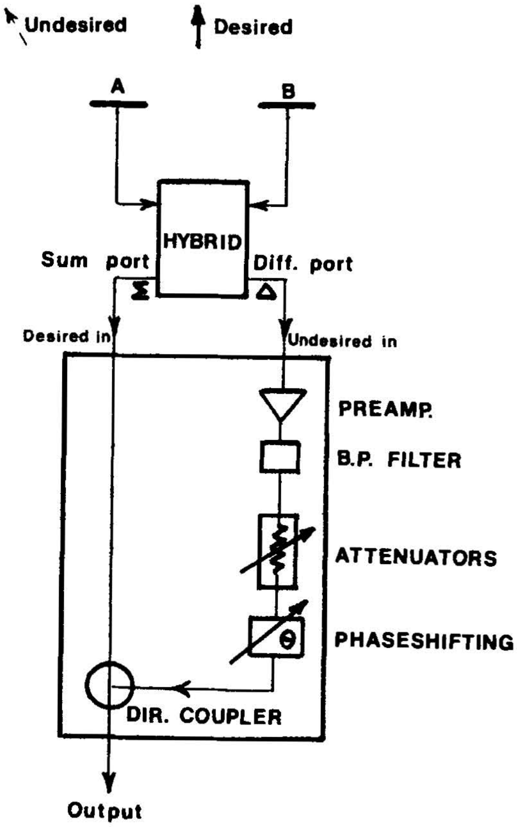

FIG. 5

Schematics of the PHAZAR SYSTEM "A"

When both antennas of a horizontally stacked antenna-array are oriented toward the desired station, the output from the hybrid sum port will be the desired signal, plus an interference signal component. The output from the difference port will not contain any desired signals (see the split lobes of FIGURE 6), only the interference signal will appear at this port with a considerable amplitude.

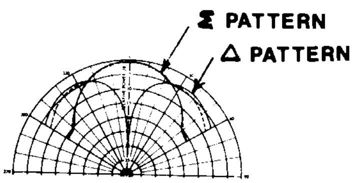

FIG. 6

The split-lobe radiation pattern shows that the desired station is received at a -25 dB level. The deep null also falls in the direction of the desired station.

Connecting the sum port to the "DESIRED IN" port of the PHAZAR, and the difference port to the "UNDESIRED IN" port of the PHAZAR, we are ready to adjust the level and phase controls on the PHAZAR to achieve interference cancellation. There is a built-in preamplifier after the undesired-in port ascertaining an initial high interference signal whioh is than attenuated to the exact cancellation level.

The theory of operation is illustrated with the aid of the vector (phasor) diagarams of FIGURE 7. The signals received from antennas A and B are vectorially added at the sum port, and vectorially subtracted at the difference port. Assuming that antennas A and B have received the desired signals in-phase, and they also have equal gain, the two desired signals simply add at the sum port (FIGURE 7/a). The interference signal received by antenna A is arbitrarily shown as in-phase with the desired signal. The interference signal picked up by antenna B has a phase angle θ relative to the signals of antenna A. The dashed line represents the resultant interference vector.

FIGURE 7/b depicts signal conditions at the difference port. The desired signals are equal but 180° out-of-phase, thus resulting in a perfect cancellation. (No desired signal at the difference port). The resultant interference signal is made up by the interference signal of Antenna A and the interference signal of Antenna B. However, the latter vector shows a reverse direction to indicate subtraction. The dashed vector of FIGURE 7/b pointing downward is the resultant of the interference signals.

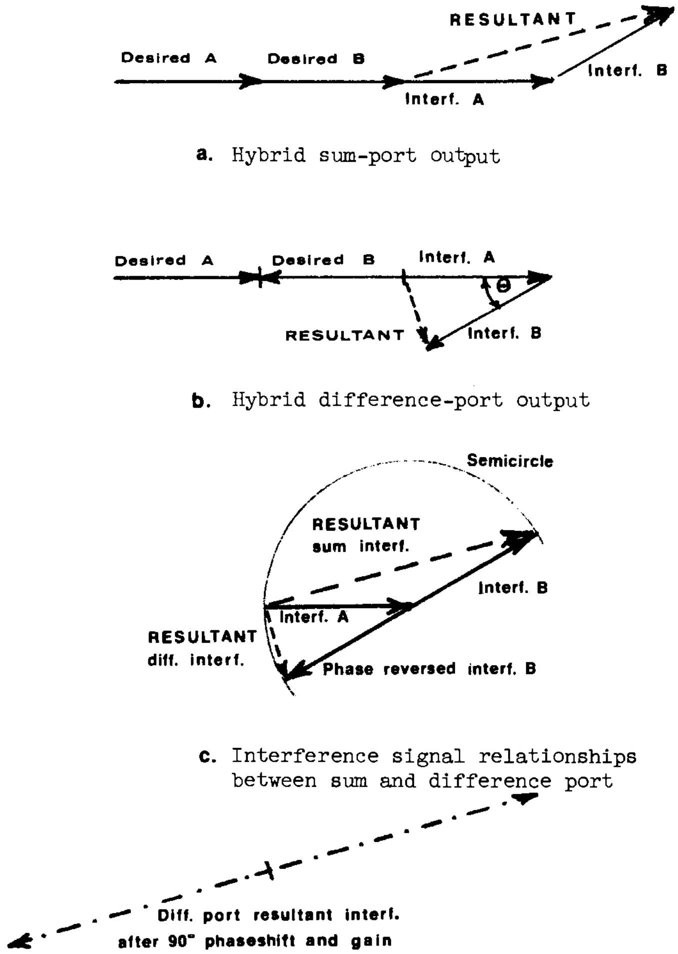

FIG. 7

Phasor diagrams for the PHAZAR SYSTEM "A"

FIGURE 7/c illustrates the relationship between the sum and difference port interference vectors. By noting that interference vectors A and B are equal in length, it can be seen that these vectors describe a semicircle in which vectors A and B represent the radii of the semicircle. Second, the resultant interference vectors (dashed lines) are always at right angle relative to each other (Thales principle).

The remaining task is to rotate clockwise the difference port interference vector by 90° and make it equal amplitude with the resultant sum port interference vector. (FIGURE 7/d).

This critical amplitude shaping and phasing process is achieved by the built-in preamplifier, the step and fine tuning attenuators and phase shifters.

Since there is a fixed 90 degree phase relation between the two (sum and difference ports) resultant interference signals, the PHAZAR's phase controls can be set to a predetermined position corresponding to the 90 degree difference. Then, only the level (attenuation) controls need to be varied sequentially in order to find the setting of the best cancellation. This, in turn, substantiates our statement in the introduction that the direction of souce must not be known to achieve cancellation.

The PHAZAR and PHAZAR SYSTEM "A" are trade names of the CATV Component Company, St. James, N.Y. Patent application is currently being processed. It is the authors firm opinion that the above discussed interference rejection technique, when properly applied, will provide CATV operators with a convenient and economical tool to combat co-channel interference, ghosting, local RF and AC interference conditions, resulting in a much improved picture quality, less service calls, and hopefully, an increased demand for CATV services.

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