# Method for determining the direction to the interference source without use of additional antennas

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**Abstract.** A method for determining the direction to the source of interference without the use of additional antennas is proposed. It provides interference suppression in the direction of the side lobes of the radiation pattern due to additional synthesis of the antenna pattern for the central beams without complicating the calculation algorithm and without using additional antennas.

## 1. Building a Multibeam Hybrid Mirror Antenna

The developed algorithm allows determining the direction of interference without the use of additional antennas. The use of the system of "targets" located on the hexagonal structure provides finding the direction of the interference source in most cases.

If several interference signals operate from close directions, the interference suppression system, using a single cluster and setting different signal suppression options, can realize the suppression of several interferences at the same time. If the interference is spaced at a sufficient angle, the second cluster is used.

As a basis, we take a hybrid mirror antenna with an irradiator in the form of an antenna array built according to the cluster type [1, 2]. In the initial state, in the absence of interference, 7 beams are formed at different frequencies, allowing to exclude the influence of the beams on each other.

If the signal-to-noise ratio (SNR) threshold is exceeded in one of the beams, the adaptation mechanism is started [3]. Next, by searching for possible antenna-feeder array embedded in the memory of the noise suppression system, the possibility of suppressing the interference is checked. Since in a hybrid-mirror antenna, each beam corresponds to a certain service area, it is possible to a priori determine the direction of interference in a small area, which reduces the time of operation of the interference suppression system by selecting the necessary interference suppression options.

The memory variants of the antenna-feeder array form dips along the hexagonal structure within the main lobe of the antenna directional diagram at the level of minus 3 dB. The number of options is from 7 to 37 (depending on the width of the directional diagram), which is likely to form a failure in the direction of interference.

In the mode of the formed cluster (adaptation), within a certain period of time (any period is possible, set by software), the noise suppression system polls the threshold device about the possibility of exceeding the threshold value of the signal-to-noise ratio over a period of time. If the excess was observed, the interference suppression system saves the cluster and the distribution on it. If there was no exceedance for the specified period, then the interference suppression system returns to the first mode of operation (non-adaptive). This ensures the stability of the adaptive hybrid mirror antenna to intermittent interference.

For the case when the adaptive system could not provide the required level of suppression at the standard location of the " targets " (by hexagonal structure), the algorithm calculates the coordinates of the interference position, based on the following arguments:

– "targets" for the forming zeros of the directional diagram are located on a hexagonal grid. The coordinates of each "target" for antenna-feeder array synthesis are known and set programmatically;
– the angular width of the directional diagram formed by the antenna is small and is 1x1° or 2x2°;
– for each antenna directional diagram about 19 targets are set, which guarantees close zero formation of the directional diagram relative to the interference;
– three "targets" will be selected from the set of "targets", for which the best results on the value of the signal-to-noise ratio will be obtained;
– for each of the targets its own useful signal level + signal interference will be received. we find the maximum and normalize the other two relative to it.

"Target" means the possible position of the interference for the irradiating grid synthesis of the antenna-feeder array, as well as the requirements for the signal level in the rest of the service area. Consider two options [4]:

– signal levels are the same;
– after normalization values of 0.83 and 0.45 were obtained.

For the case wheт the signal levels are the same, the bottom zero should be located in the center of an equilateral triangle (figure 1, a), where each corner of the triangle corresponds to the position of the "target".

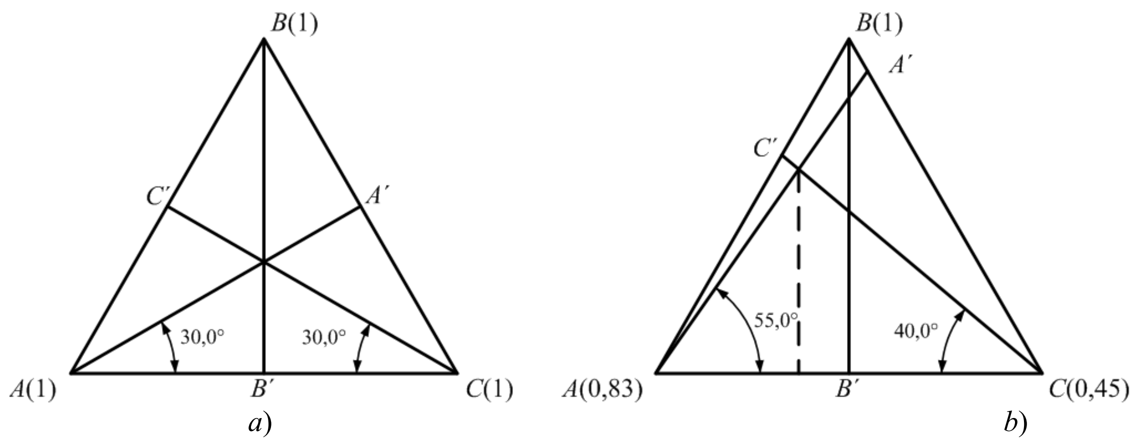



**Figure1.** Determining the direction to interference signal source: *a* – signal levels are equal; b - signal levels are 0.83 and 0.45.

Since the aspect ratios and angles are known based on the coordinates of the “targets,” one can easily calculate the zero coordinates of the directional diagram to suppress interference. For the second variant with unequal levels of interference signal, the angle of 30° is multiplied by the obtained value for each "target". We obtain the angles of 25 and 10 °. Adding the obtained angles to the angles of inclination of the lines AA and CC, respectively (figure 1, b). The intersection of the lines AA and CC will give the zero coordinates of the directional diagram.

Thus, the final goal of the noise suppression system is to calculate the coordinate of the noise and the irradiating grid synthesis of the antenna-feeder array for its suppression.

**2. The operational algorithm of adaptive multibeam antenna**

Above, we considered the option of suppressing one interference, when the predetermined versions of the antenna-feeder array allowed to suppress the interference and provide the specified value of the signal-to-noise ratio. For the option when the interference suppression system could not find the required one for the antenna-feeder array, and the option with several interference within one cluster, this method is not suitable, since the interference suppression system will need to calculate the necessary in the grid of the antenna-feeder array to suppress several noise. The interference suppression system includes software designed by the antenna-feeder array. The designed parameters are set using a text file, which sets the position of the "target" $X_Ц$, $Y_Ц$. For each "target" the required gain coefficient $E$ is set at a certain point in the service area, and the file contains a set of target coefficients was an intention for the maximum signal value for the given "target" or its suppression (figure 2).

| | Column 1 | Column 2 | Column 3 | Column 4 |
|---|---|---|---|---|
| Line 1 | $X_{Ц1}$ | $Y_{Ц1}$ | $E_1$ | $W_{Ц1}$ |
| Line 2 | $X_{Ц2}$ | $Y_{Ц2}$ | $E_2$ | $W_{Ц2}$ |
| … | … | … | … | … |
| Line n | $X_{Цn}$ | $Y_{Цn}$ | $E_n$ | $W_{Цn}$ |

**Figure 2.** Text file format of initial data for computing.

Thus, using the adaptation system, it is possible to a priori determine the direction of interference with a small error; for this, we assume that for each beam a set of seven “targets” for signal suppression is possible. Figure 3 shows an example of the arrangement of “targets” for four beams, each beam includes a set of seven “targets”, respectively, each “target” can set the signal suppression for different directions.

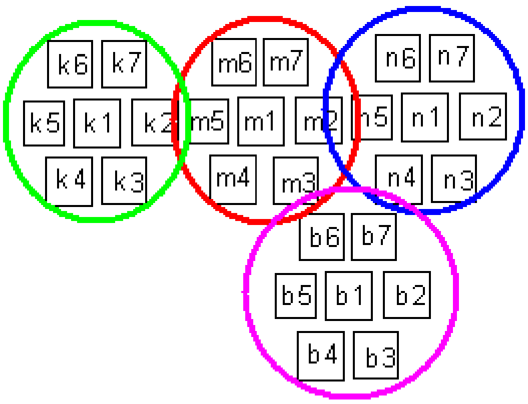



**Figure 3.** The Principle of location "targets" for each of the beams.

If the interference is close, the interference suppression system, using a single cluster and specifying the signal suppression options with the help of “targets”, will implement the suppression of several interference at the same time. If the interference is spaced at a sufficient angular distance, then the second cluster should be used. The calculation of each suppression option will take up to two seconds, so the system can form the required failsin the directional diagram in two minutes.

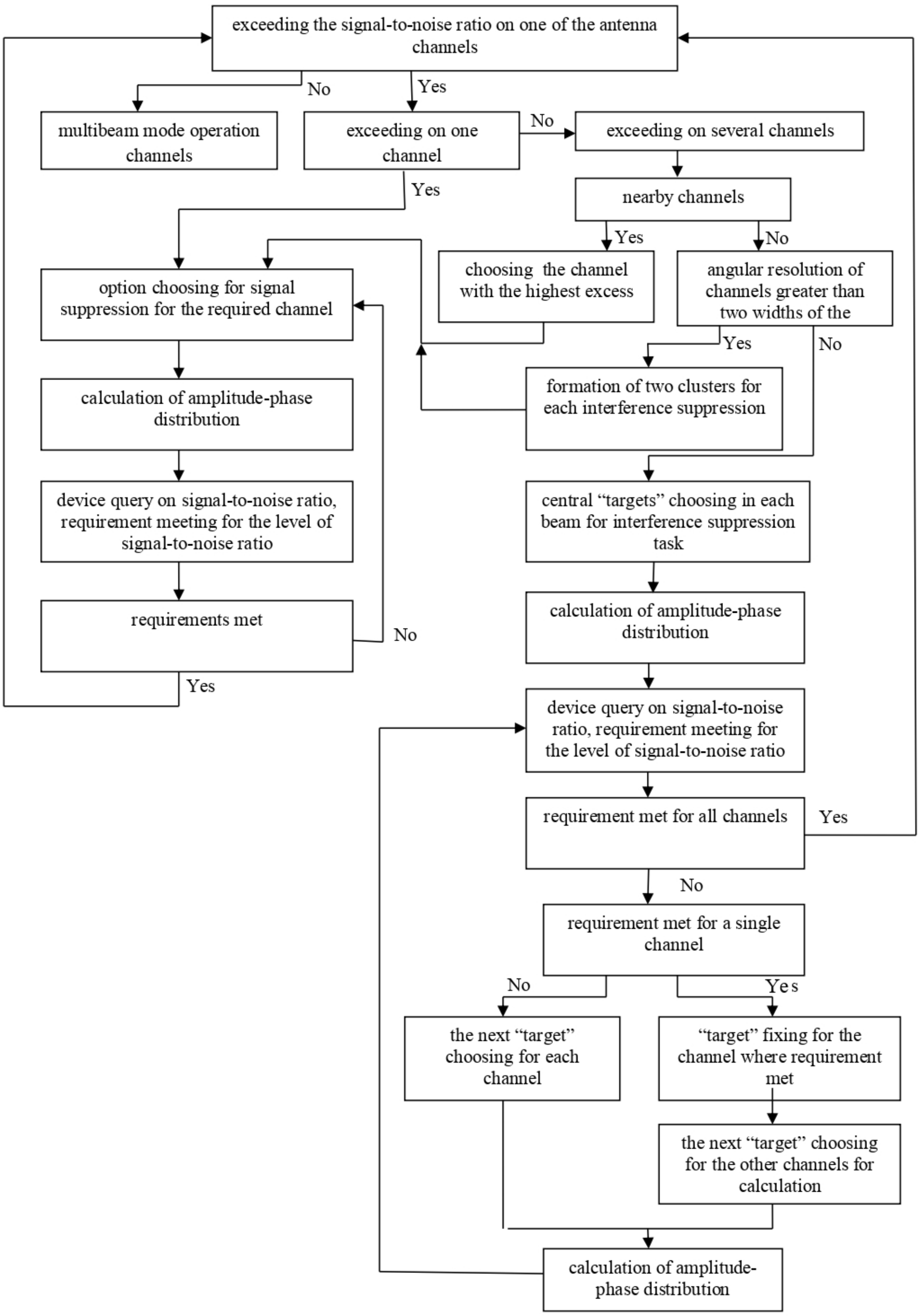



**Figure 4.** The algorithm of calculating the adaptive multibeam antenna system of antenna-feeder array with the interference affect.

For two interference at the same time, the interference suppression system initially forms a failure for the central "target" of each channel, then goes along the hexagonal grid. While observing the threshold signal-to-noise for a single channel the interference suppression system saves the position of "target" and continues to search for “targets” for the second interference to achieve the required suppression.

Figure 4 shows the algorithm block diagram of the adaptive multi-beam antenna.

Let's consider the principle of operation on the example of seven beams with a width of 1×1°. For their formation, the antenna grid consisting of 19 irradiators is required. In the absence of interference, the specified antenna forms a set of 7 beams (figure 5).

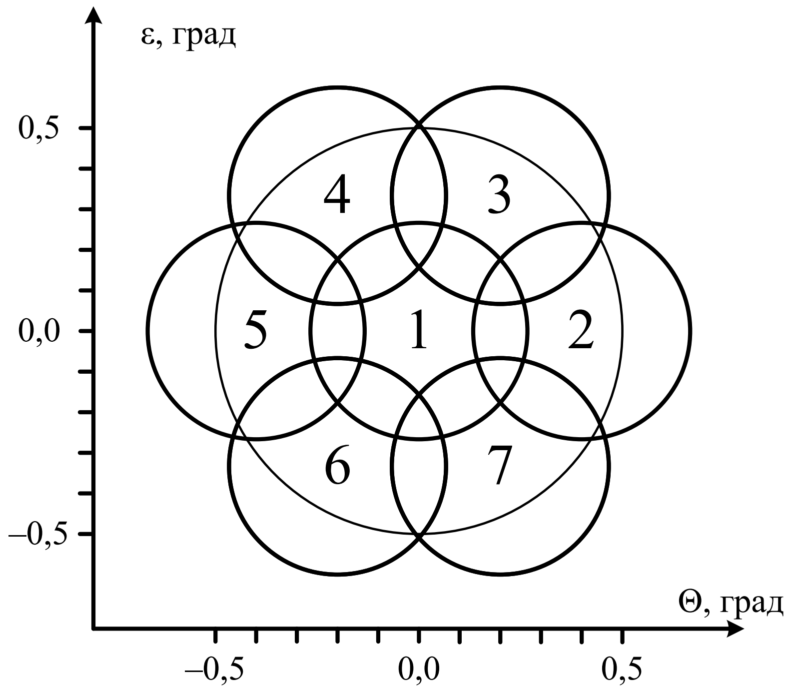



**Figure 5.** Seven beam set for the adaptive hybrid mirror antenna with cluster diagram of the irradiating grid.

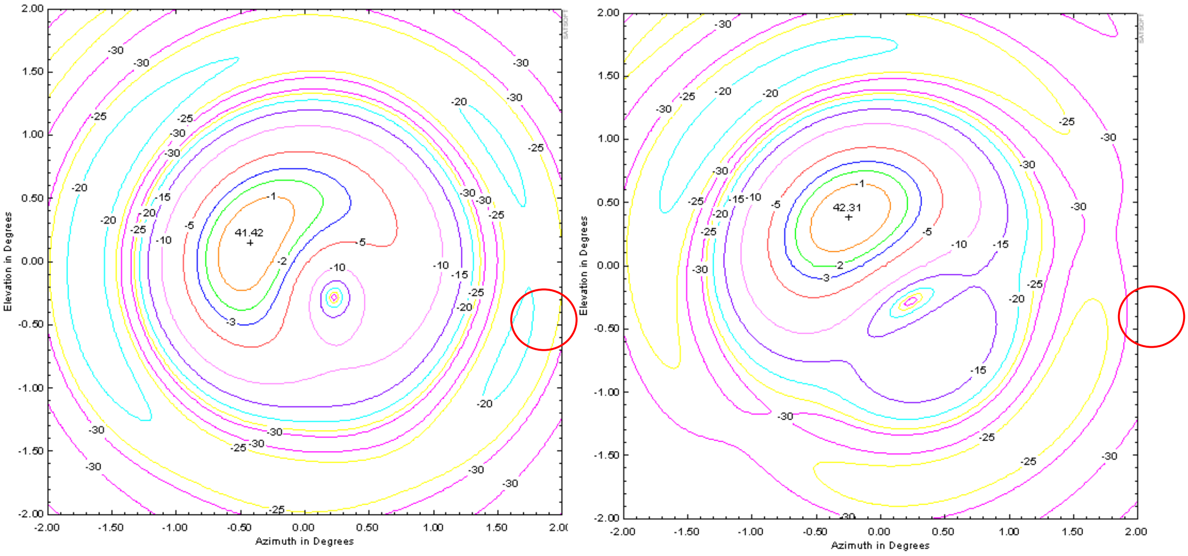
Since the beams operate independently of each other and are frequency-separated, the antenna-feeder array synthesis of a seven-element cluster is carried out for each of them to suppress interference. Due to the frequency separation of the beams, the adaptation of this seven beams will not affect the neighboring beams.

To speed up the operation of the whole system when one of the beams finds the position of the interference, the information about the position of the interference is automatically recorded in the antenna-feeder array synthesis algorithm for the other beams. This allows to increase the speed of the system as a whole significantly.

Since each beam of the adaptive hybrid mirror antenna, built on a cluster scheme, forms a failure independently of the other beams, for distant beams it is necessary to ensure the suppression of the lateral lobes of the directional diagram, which can be affected by interference.

Let us make an assumption for the considered seven beams, and in particular for the central beam №1, that simultaneously with the suppressed interference there is another one, the position of which corresponds to the side lobe of the central beam. The second interference will be suppressed by distant beams by analogy with the seven ones. As a result of the antenna-feeder array synthesis and interference search, fails in the directional diagram will occur and the position of the interference will be determined. Information about its position will be stored in the system memory.

Further, for the considered central beam №1, it is necessary to synthesize the antenna-feeder array to suppress the lateral lobe of the radiation pattern in the direction of interference. Figure 6 shows the results of antenna-feeder array synthesis and directional diagram lateral lobe suppression.




*a*) *b*)

**Figure 6.** Directional diagram lateral lobe suppression of the adaptive hybrid mirror antenna central beam : *a* – directional diagram before lateral lobe suppression; *b* – directional diagram after the antenna-feeder array synthesis and lateral lobe suppression. Interference direction is red marked.

Thus, from the obtained results it can be concluded that the considered scheme of the adaptive hybrid mirror antenna construction allows to suppress one interference within the central lobe of the directional diagram and up to 3-4 interferences within the lateral lobes of the antenna directional diagram. This saves the signal level in the rest of service area while suppressing four interferences at the same time.

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