Research on Chromatography Feature Extraction from Echo Waveforms of Coherent Radar Targets

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Abstract — **The extraction process of chromatography features from echo waveforms is layered. This paper first puts forward the ideas and methods of waveform grouping. When the echo waveform is layered, the three methods of determination of threshold is given, and then using the method for grouping of the radar target echo, and the target echo after the grouping is processed, the chromatographic characteristics of the echo is obtained. Finally, a large number of experimental tests are carried out on the characteristic parameter group which consist of the basic characteristics and chromatographic characteristics. After comparing the result of the test data processing, the most significant feature of the distinction between specific target categories is extracted to be the main information for accurate automatic target recognition and classification of all kinds of air targets. Practical tests show that our work provides some parameter groups of effective description of aircraft target feature.**

Keywords - the coherent radar; Grouping processing; Threshold parameters; Tomography characteristics; Feature extraction;

I. INTRODUCTION

Radar target recognition [1] is to extract feature of various target radar, select the relevant information logo about target and stable characteristics and to assess the type of the target, true and false, and properties, etc. Radar target echo [2] is a kind of time series, it is a function of the target type, distance and position, all kinds of targets of different categories, the echo is different, radar target feature extraction is to extract one or more characteristics directly related to the target properties from radar echoes of the target, used as a source of information for target recognition. Radar target feature extraction must analyze target radar characteristics of interest to compare the similarities and differences between them, to extract the most striking features distinguished between a target and other objectives, used in target recognition.

II. GROUPING PROCESSING

A. The idea of grouping processing

Due to the modulation of target shape, structure and materials, the radar echo waveform of plane target contains rich information about the target. For the coherent radar [3], the judgment of skilled radar operator to aircraft target sorties is mainly based on the texture structure and the jump of several adjacent target waveform of each batch on A. show. To develop and utilize the information of waveform texture figure is the effective ways of enhancing the coherent radar aircraft sorties classification discriminate ability, this undoubtedly shows to the necessity of echo grouping.

B. The method of grouping processing.

1) According to the specific circumstances of the radar echo signal amplitude changes, determine to set an proper threshold.

2) A certain feature of each echo in echo group compared with the threshold, according to the result of the comparison to the preprocessed echo group is divided into two parts: echo waveform group 1 is greater than the threshold, echo waveform group 2 is smaller than the threshold.

3) The maximum of each echo in echo group compared with the threshold, according to the result of the comparison to the preprocessed echo group is divided into two parts: echo waveform group 1 is greater than the threshold, echo waveform group 2 is smaller than the threshold.

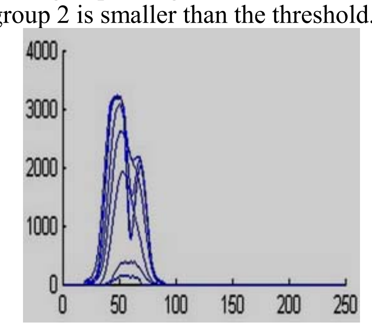

Figure 1 (a) Echo group before grouping

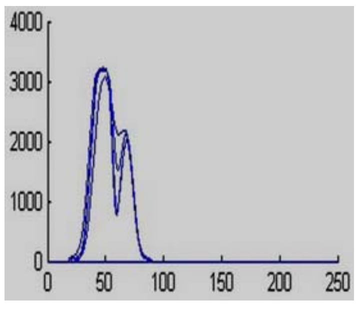

Figure 1 (b) Echo grouping

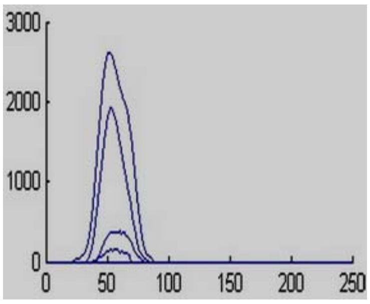

Figure 1 (c) Echo grouping

Figure 1 Echo grouping

C. The determination of threshold parameters

The determination of the threshold for the feature extraction of the target echo waveform has significant influence, if the threshold is too big or too small, are directly affect the effectiveness of the proposed feature extraction. The determination of the threshold has the following three methods of judgment:

1) Fixed threshold binary method

When using the i threshold rules to segment mage, all pixel of gray level is equal to or greater than a certain threshold were sentenced to belong to the object. All pixel of gray value is less than the threshold value of pixels are excluded.

2) Otsu binarization method

Otsu method is a nonparametric and unsupervised adaptive threshold method, is also a kind of histogram method. Otsu method is simple, it through the use of zero order, first order cumulative moments of the histogram to maximize the discriminant function, choose the best threshold value.

3) Ridler adaptive threshold value method

Ridler [6] is another kind of adaptive threshold value method. Ridler method can bypass excessive area of low gray value point in histogram, finally got satisfied results, Ridler method is an iterative method.

4) the advantages and disadvantages of comparison of three kinds of method to determine threshold value ,

If all the target and background are almost the same contrast, using fixed threshold binary method, choose a fixed global threshold tend to have better effect. When the background is complex, Otsu method can be used to choose the best threshold. low grey value point of Radar images is too much, resulting in an obviously low threshold by means of Ostu, Ridler method can bypass excessive area of low grey value point in histogram, finally got satisfied results. Prestressed algorithm, generally 5-10 times is enough.

III. THE TARGET ECHO CHROMATOGRAPHY FEATURE EXTRACTION

A. Tomographic characteristics of target echo

First filtering pre-processing to the original waveform group [7] and get the processed waveform data for X (N * K). Aircraft target radial motion, random yaw, pitch and roll motion have three main effects to the radar echo, The degree of influence the waveform is mainly composed of the following characteristics to reflect:

1) Beating degree

Beating degree reflects the waveform overall change of the echo waveform group 1,seek the waveform area to echo group 1 for the sample X all meet its maximum value is greater than the threshold value

$$X_{\max i} > median(X_{\max i})/2$$

order $Area = \frac{1}{N}\sum_{i=1}^{N} Area_i$

the wave group's overall beating degree is:

$$WV = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(1 - \frac{Area_i}{Area})^2} \quad (1)$$

The target sorties respectively were a small plane, a large plane, two small aircraft case, take some sample group to compare the extracted beating degree, as shown in the following figure 2:

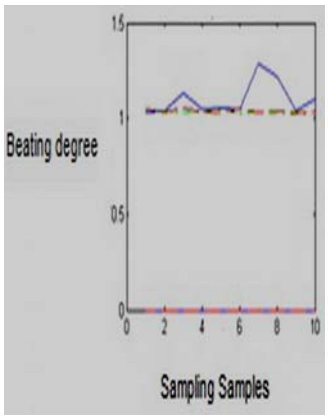

Figure 2（a）A small plane

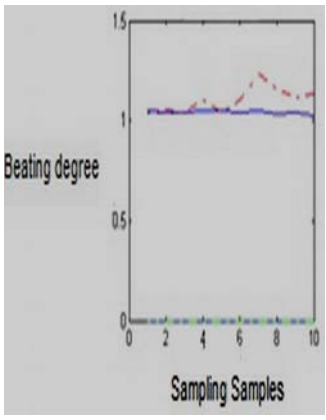

Figure 2（b）A large plane

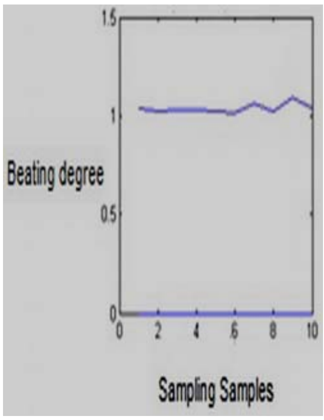

Figure 2（c）Two small plane

Figure2 Beating degree characteristic comparison table

2） Walking degrees ID

Walking degree reflects the correlation degree of echo group1 of every two adjacent waveform order

$$C(l,k) = X_l \otimes X_k$$

The data convolution sum of the L waveform sampling and the K waveform data sampling, adjacent waveform Walking degrees:

$$ID_i = f_i(x_i, x_{i+1}) = \frac{C(i, i+1)}{\sqrt{C(i, i) * C(i+1, i+1)}} \quad (2)$$

The target sorties respectively were a small plane, a large plane, two small aircraft case, take some sample group to compare the extracted Walking degrees, as shown in the following figure:

For a set of waveform, Walking degrees:

$$ID = median(ID_i)$$

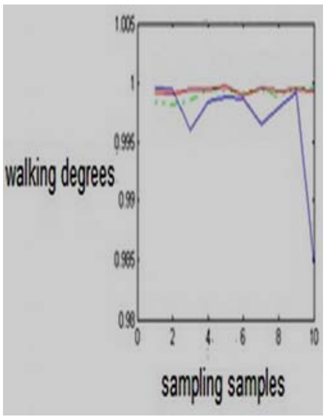

Figure 3（a）A small plane

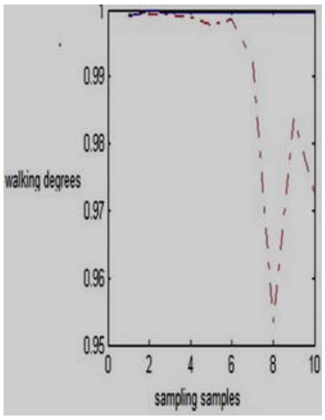

Figure 3（b）A large plane

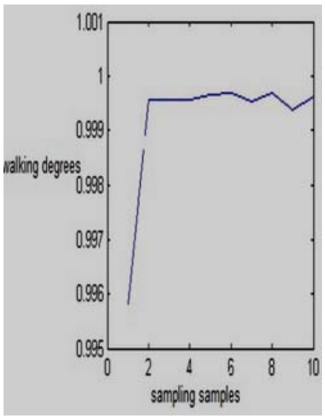

Figure 3（c）Two small plane

Figure3 Walking degrees characteristic comparison table.

3） Concavity (peak roughness)

Concavity reflects the echo waveform grouping 1 peak jitter, For a single echo waveform, all sample Xi for the sample X meet seek peak roughness Si ,order

$$\max(X_i) > median(X_{\max i}) / 2$$

$J_i = median\{j | X_i(j) > E\}$ is the wave center of meeting the conditions,

$$x_i = \{X_i(j) | J_i - EW_i / 6 \le j \le J_i + EW_i / 6\}$$

Is valid data sequence to be processed, Then the coefficient of variation (peak roughness)

$$S_i = \frac{\delta}{\overline{x}} = \frac{\sqrt{\mathrm{var}(x_i)}}{mean(x_i)}$$

For a set of waveform, peak roughness

$$S = \max(S_i)$$

The target sorties respectively were a small plane, a large plane, two small aircraft case, take some sample group to compare the extracted Concavity, as shown in the following figure:

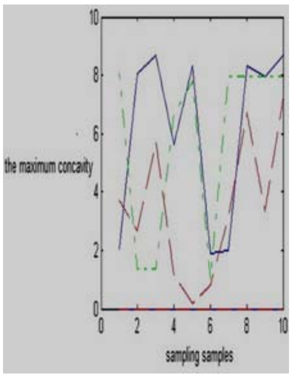

Figure 4（a）A small plane

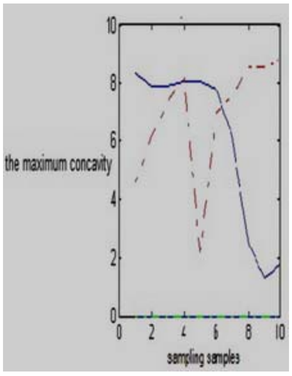

Figure 4（b）A large plane

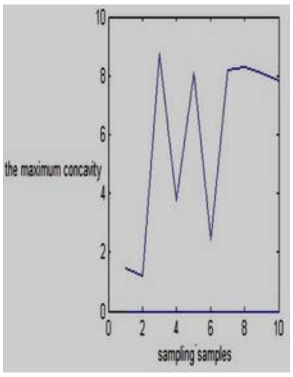

Figure 4（c）Two small plane

Figure4 The biggest concavity Characteristic comparison table

4）Symmetry coefficient

All waveform for echo waveform group1 meeting its maximum value greater than the threshold value

$$SYD_i = \frac{\sum_{j=J_{\max}+1}^{J_N} (j - J_{\max}) * X(i, j)}{\sum_{j=J_S}^{J_{\max}-1} (J_{\max} - j) * X(i, j)} \tag{3}$$

$X_{\max i} > median(X_{\max i})/2$ is sought for symmetry of SYDi:

J_E: The last nonzero end points

J_S: The first nonzero starting point

$J_{\max}$: The amplitude of the median point

For a set of waveform: Symmetry coefficient

$$SYD = \frac{\sum_{i=1}^{N} SYD_i}{N} \tag{4}$$

The target sorties respectively were a small plane, a large plane, two small aircraft case, take some sample group to compare the extracted symmetry, as shown in the following figure:

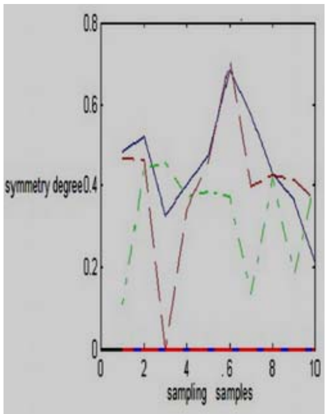

Figure 5（a）A small plane

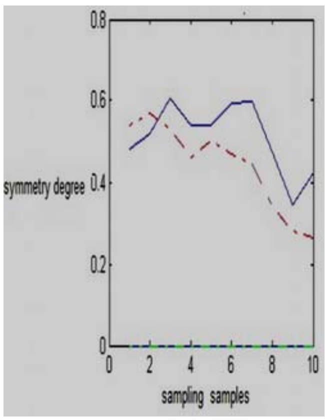

Figure 5（b）A large plane

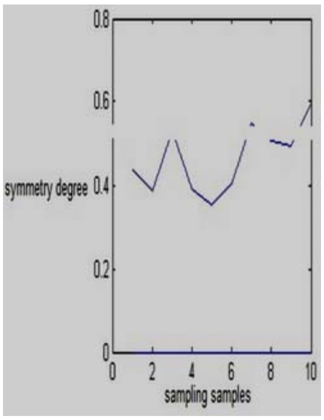

Figure 5（c）Two small plane

Figure 5 Symmetry Characteristic comparison table

5) Comb tooth width

Comb tooth width is by describing the overall on the plane to reflect the change of wave group,

As a result of the antenna pattern modulation, amplitude values of A cycle can present certain change back. The preset threshold gate, the maximum of each waveform compared with threshold (Xmax (I) compared with gate), if big ,then X (I, j) = X (I, j) - gate, if small then X (I, j) = 0; The first k segment Hydrophobic tooth width length (k) =The first k segment continuous wave number, for A set of waveform: $length = \max(length(k))$

The figure Below gives grouping of radar target echo for one aircraft and the two planes, its echo group 1 were respectively related to processing, the respective comb tooth width can be obtained.

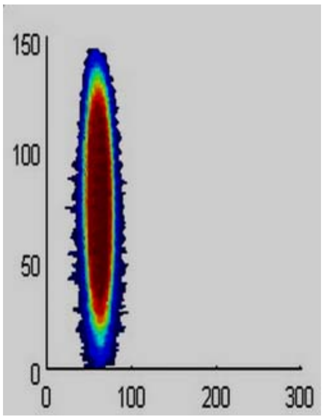

Figure 6 (a) The projection plane of single plane echo

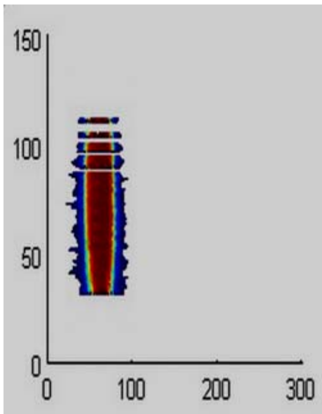

Figure 6 (b) The plane projection of single plane echo group 1

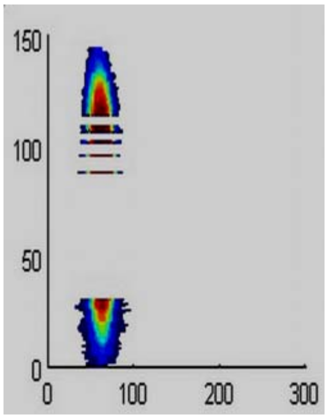

Figure 6 (c) The plane projection of single plane echo group 2

Figure 6 The plane projection of single plane echo

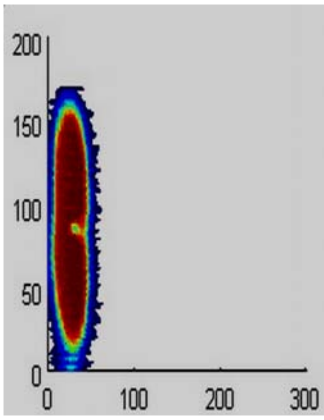

Figure 7 (a) The projection plane of two plane echo

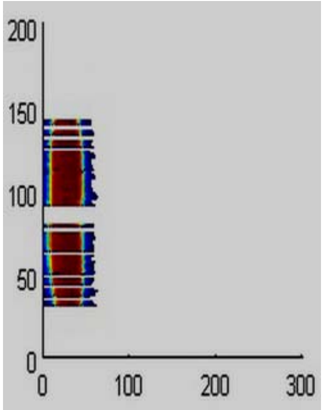

Figure 7 (b) The plane projection of two plane echo group 1

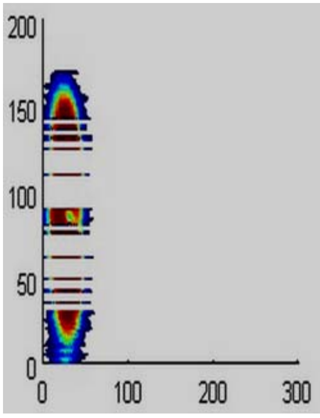

Figure 7(c) The plane projection of two plane echo group 2

Figure 7 The plane projection of two plane

The target sorties respectively were a small plane, a large plane, two small aircraft case, take some sample group to compare the extracted the biggest comb tooth width, as shown in the following figure 8:

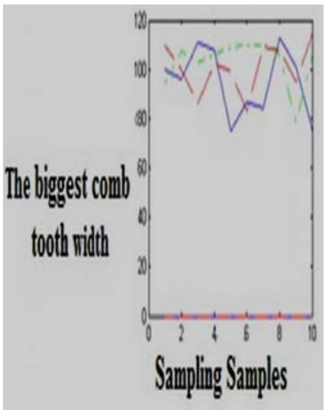

Figure 8（a） A small plane

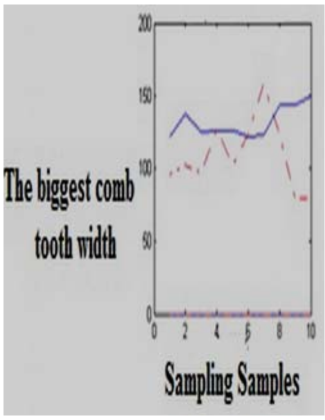

Figure8（b） A large plane

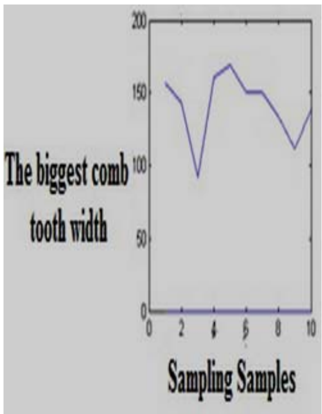

Figure 8（c） Two small plane

Figure 8 The biggest comb tooth width feature

6) Curve fitting

Processing object is data X(i, j) of waveform group2 after waveform grouping, compared with the threshold, if big ,then date is (I, b) = 0; if Small, then write down its position, its center position P (xi, yi) of each segment after the projection is sought. For individual special isolated point P (xi, yi) for cutting processing. the P (xi, yi) point sequence after processing for ellipse fitting.

For individual special isolated point P (xi, yi) for cutting processing. the P (xi, yi) point sequence after processing for ellipse fitting . estimated long axis bb, X0, Y0, substitute into $ratio = \sqrt{\frac{bb^2 - (Y - Y0)^2}{(X - X0)^2}}$

Get a set of data ratio, for the whole operation to the set of data ratio, then the partition interval interval number step=max(ratio)-min(ratio),calculate the maximum frequency interval, ratio data of the highest frequency are to obtain fitting ellipse ratio by calculating mean.

The target sorties respectively were a small plane, a large plane, two small aircraft case, take some sample group to Compare the extracted ellipse fitting the ratio of the long axis and short axis, as shown in the following figure 9:

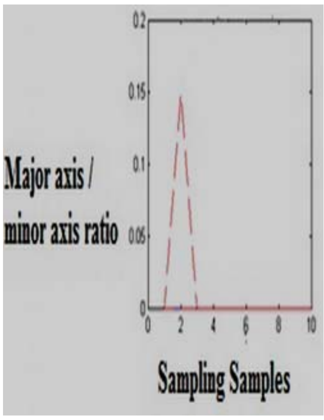

Figure 9（a） A small plane

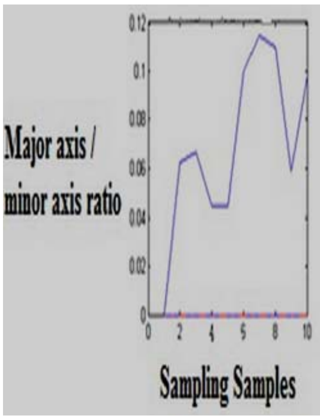

Figure 9（b） A large plane

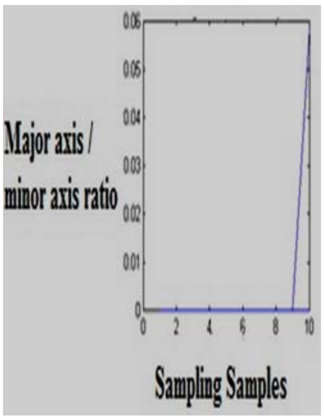

Figure 9（c） Two small plane

Figure 8 Fitting ellipse Major axis / minor axis feature comparison table

B. Topographic characteristics test

1)The experimental test results

(1）concavity

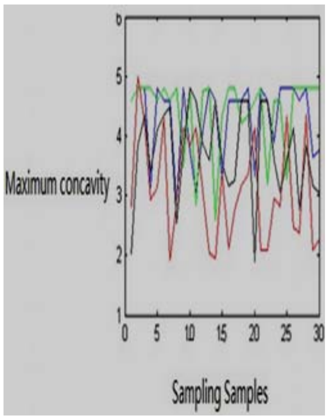

Figure 10 Maximum concavity feature comparison table

(2）Walking degrees

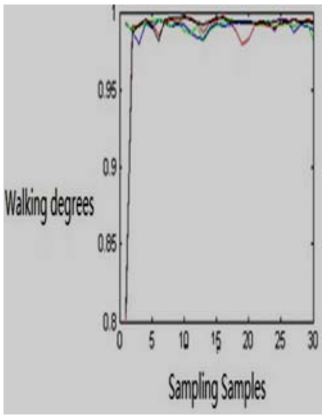

Figure 11 Walking degrees feature comparison table

(3）symmetry

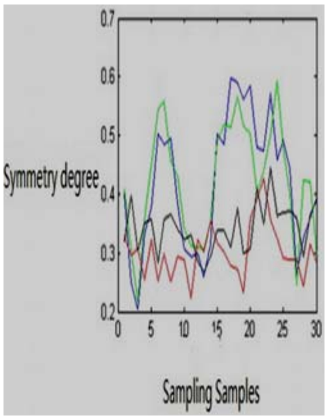

Figure 12 Symmetrical feature comparison table

(4）Beating degree

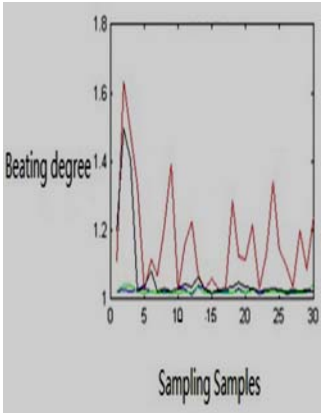

Figure 13 Beating degree feature comparison table

2) The comparison of chromatographic characteristics

When scanning target for tontinuous tracking, the chromatographic characteristics of same target has certain stability, and the basic characteristics of different types of target changes quite different, and the extracted characteristics change trend present certain regularity.

IV CONCLUSION

The low resolution radar echo signal contains a certain characteristics such as target structure, material, movement, the characteristics can be obtained by modern signal processing technology, and as a feature of low resolution radar target recognition, but for different low resolution radar, different target, different environment to obtain stable and reliable characteristics, In order to design the effectiveness of classifier Using this feature, we need to do a lot of experiments and research; in addition to commonly used for ascertaining the presence of signal and determining the time variable amplitude and time delay of target distance, the time variable frequency, phase, polarization can try to use.

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