ATLANTIS PRESS
Advances in Engineering Research, volume 118
2nd International Conference on Automation, Mechanical Control and Computational Engineering (AMCCE 2017)

Analysis of Anti-Radiation Missile Antagonizing Active Decoy Technology

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Keywords: anti-radiation missile; passive radar seeker; anti-active decoy technology.

Abstract. With the constant innovation of active decoy technology, it threatens the effectiveness of anti-radiation missile strike capability. This paper introduces the characteristics of ARM passive radar seeker, analyzes the current situation of active decoy technology, and based on this, advances the method of antagonizing active decoy technology.

Introduction

Anti-Radiation Missile (ARM) is a kind of "hard kill" electronic attacking weapon, which uses radar and other signal radiation sources as targets. It detects, identifies, locates and attacks radar by receiving radar signals. So it is called "radar killer". In order to resist the ARM attacks, a variety of targeted defensive measures are also emerging, such as the use of bistatic radar, low probability of intercepting radar and active decoy, etc. And active decoy technology has great influence on the hit accuracy of antiradiation missile, which is one of the main methods to combat ARM. In order to fully guarantee the anti-radiation missile achieve a favorable trend in electronic warfare and result in effective damage, it is very important to analyze anti-radiation missiles, active decoy technology features and the development trend of the Anti-active decoy technology.

Analysis of development of Anti - radiation Missile

Development of Anti - Radiation Missile.

Anti-Radiation Missile (ARM), also known as Anti-Radar Missile, is a tactical missile specifically designed to attack electromagnetic radiation sources such as radar. It uses the signals emitted by the enemy radiation source as a guide to track and destroy its antenna or the entire radiation source system, which is essential in modern electronic warfare magic weapon. Today, the ability to win the war depends on the strength of electronic warfare capabilities. The war in Kosovo and the war in Iraq have given the world a lesson, and whoever wins the electromagnetism will lead the way. At this stage of the ARM to passive guidance system-based, at the same time with other guidance methods, such as inertial guidance, satellite navigation guidance, active millimeter wave radar guidance and infrared guidance. At present, the development of ARM has gone through three generations, the first generation of ARM is the typical representative of the United States AGM-45-type "Shrike" missile. since the battlefield has made brilliant achievements in the Vietnam War, it took the fatal blow to Vietnamese military guidance radar. As the first generation of anti-radiation missiles, there are many inherent defects, limited by the passive radar seeker, narrow frequency band, susceptible to interference, low receiver sensitivity, low hit rate, no anti-off capability and small power, so quickly out of the stage of history.

To the second generation of anti-radiation missile, it has made a considerable improvement in performance, seeker bandwidth increases, intercept radar signal frequency band extension, high receiver sensitivity, and can be guided by radar beam sidelobe signal. At the same time the ARM increases the target memory device, when it is against target radar shutdown tactics, ARM can carry on the boot memory according to the target position, and hit the intended target. The missile is expensive, however, production is not easy. And the ability of anti radar shutdown can not reach the desired effect in actual combat. So they cancelled the production plan and put into operation a few years alone.

The third generation of anti-radiation missile based on actual combat, all aspects of performance are improved effectively. Covering almost all the radar frequency band, with a high flying speed, range far, the power of the characteristics. Seeker responsive, Strong anti-electromagnetic interference capability can solve the problem of target radar suddenly shutting down. It uses the composite guidance technology to greatly improve the hit probability.[7]

Such as AGM - 88 type missile "ham", in the United States and the Syrian conflict, cause crushing to the prevention and control system, and in the gulf war, almost destroyed all Iraqi air defense radar.[8]

Figure 1 AGM-88C "Ham" anti-radiation missiles

Refer to US, the research and development of anti-radiation missile locates in the world's leading position. In this century, they also advanced anti-radiation missile program and the "fast crossbow plan", and kept innovativing technology. The US military is equipped with AGM-45, AGM-78, AGM-88 and AGM-136, as well as missiles for carrier-based missiles. Other Western countries have also joined the ranks of R & D, with the US ARM to compete, such as the British Alarm missile, Russia's AS-6, AS-9, AS-11 and other missiles.

Characteristic Analysis of Passive Radar Seeker.

PRS is the core component of the anti-radiation missile. It is mainly composed of target selection system, gain control system, signal forming system, state conversion system and so on. Among them, the target selection system is one of its core. Its main task is to search the radar, identify and measure the angular coordinates, and classification. In general, it according to the angle information quickly and accurately determine and distinguish the radiation source, and according to frequency characteristics, repetition period, energy level, pulse width, signal type sorting.

a)The Advantages of Passive Radar Seeker.

The key that ARM is different from other missile guidance technology is that characteristic of passive radar band width can deal with the frequency agility radar and good frequency selectivity can be effective for the signal sorting, processing, target detection and recognition. So it can deal with almost all of the foundation control radar. Compared with the radar main lobe, PRS to receive more remote emitter signals, direction-finding location in a timely manner.

b)Defects of Passive Radar Seeker

1)PRS sensitivity limit. PRS sensitivity is mainly determined by the direction of the receiver part and the signal separation and selection system. To receive the frequency agile radar signal, the bandwidth of the receiver is usually 500MHz [1], the sensitivity is low. If you set the front of the ultra-wideband low-noise amplifier to improve sensitivity, the system's dynamic range will be reduced. To solve this problem, an electronic attenuator can be added before the microwave preamplifier. However, increasing the electronic attenuator will destroy the two-way amplitude and phase frequency of the consistency, whether it is the use of specific amplitude or phase the direction finding method, will reduce the accuracy of direction finding. Therefore, the sensitivity of PRS is difficult to improve, and it can not precisely positioning [2].

2)Anti-active ability is poor. There is an inherent flaw in the PRS. Due to the limitation of the diameter of the missile, the aperture of the antenna is small, so the angular resolution of the traditional seeker is low. This defect does not appear when there is only one target in the missile seeker's field of view, and anti-radiation missiles tend to be deflected when the active decoy is placed near the target radar. Passive radar seeker uses a single pulse system, in the direction of the method, can not distinguish multi-source signal which is overlap in time domain or frequency

domain, similar to airspace. Therefore, in the face of two-point source or multi-point source at the same time, anti-radiation missiles will be directed to several radiation source power center

3)PRS and target signal mismatch. PRS passively receives various types of unknown radar signals, so the PRS receiver can not match the received signal. Radar signals are known, but the received signal is transmitted signal reflected by the reflector back signal. So the radar receiver can be relatively easy to match the received signal. Such as pulse compression radar, the receiver can be fired with a number of sub-pulse synthesis of pulse conjugate match, the wide pulse compression into a narrow sub-pulse, so that the amplitude increased by about 20dB. PRS can not know the type of received signal and therefore can not match. Such as the pulse compression signal, only as a low amplitude wide pulse signal processing. This is equivalent to reducing the sensitivity of the PRS. Such as a pulse compression radar, whose receivers can match wide pulses combined with multiple sub-pulses emitted. The wide pulse is compressed into a narrow sub-pulse, so that the amplitude increased by about 20dB. PRS can not know the type of received signal and therefore can not match. Such as the pulse compression signal, only as a low amplitude wide pulse signal processing. This is equivalent to reducing the sensitivity of the PRS.

The current research status of active decoying technology

The flight speed of ARM is so high, and the maneuverability in the flight is so poor, that it is difficult to effectively amend the flight attitude at the end. At the same time, in order to hit the radiation source, PRS mostly use single pulse technology to track the direction of the radiation source. In view of these two shortcomings, countries propose active decoy technology, which is an effective anti-ARM means

The Principle of Active.

Flight orbit of the anti-radiation missile is completely controlled by the passive radar seeker. The PRS keeps track of the target by receiving the signal from the opposing radiation source and continuously corrects the attack angle. Before the target, ARM has detected the target radar signal parameters, and transmitted the data to the aircraft carrier and seeker to process the signal, which make the missile has the ability to self-tracking target. However, if two (or more) point sources emit signals simultaneously, they overlap in the frequency domain and time domain so that the seeker traces the gradient direction of these signals to synthesize the electric field, so as to achieve the decoying effect. Defined active decoy system [3] is: Radiation source cluster composed of the radar protected and a number of matching simplex radiation source. Its role is to control the distribution of electromagnetic fields around the space, confuse the incoming ARM passive radar seeker, so that it can not hit the target. The active decoy is a simplex radiation source which emits only a signal without receiving. In order to successfully decoy anti-radiation missile, the active decoy system can be constructed by setting the parameters match the target radar, and deploying it according to the number of decoys

When the anti-radiation missile is far away from the target radar position, the angle formed between the radiation source and the missile is less than the minimum resolvable angle of the PRS. At this time, the PRS will follow the gradient direction of the synthesized electric field. By changing the distribution of synthetic electric field, the direction of the gradient does not point to any one radiation source, but rather point to a known as the "missile trap" of the open space. As the missile approaches the target, the angle that each source relates to the PRS is equal to the minimum resolution angle of PRS. At this point the missile go into the case of balance, so PRS can distinguish the radiation source and start tracking one of the radiation source. The PRS will keep tracking the radiation source when the angle that each source relates to the PRS is greater than the minimum resolvable angle of the PRS. Due to the limit of volume of missile,the antenna aperture of PRS is smaller, and resolution angle is larger. when the ARM is close to the target position, we can identify one of the radiation sources and track it. However its overload capacity is limited and it is difficult to shift in time, which makes it difficult for ARM to accurately hit the target radar. As shown in Figure 2.

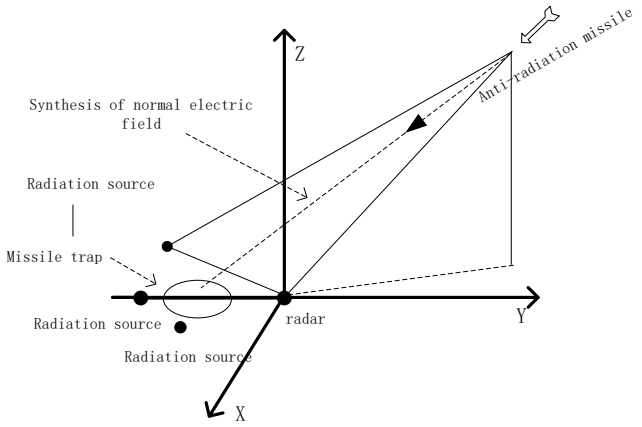

Fig.2 Schematic diagram of active decoy system

Development status at home and abroad.

Due to the great threat of ARM, many countries pay more and more attention to active decoy technology, the foreign advanced a new generation of air defense missile weapon system, which is used to develop the active decoy system and equipment. The AN / TLQ-32 active decoy system has been specially developed for the protection of land-based AN / TPS-75 radars. The active decoy works in the S-band, and the pulse parameters of the radiation source match the parameters of the AN / TPS-75 radar. Each transmitter group consists of three modular boxes and a top hat antenna, and a 2.5KW portable generator for power supply. The AN / TLQ-32 active decoy system has been specially developed for the protection of land-based AN / TPS-75 radars. The active decoy works in the S-band, and the pulse parameters of the radiation source match the parameters of the AN / TPS-75 radar. Each transmitter group consists of three modular boxes and a top hat antenna, and a 2.5KW portable generator for power supply. The target radar and 3 bait together constitute an active decoy system, which can protect a radar station from the successive launch or simultaneous launch of multiple missiles attack.

The AN / MPQ-53 phased array radar of the Patriot air defense system is protected by three to four active decoys. The bait operates at a frequency of 4.4 to 5.6 GHz with a pulse power of about 15 kW and an average power of 450 W. Each bait transmitter is only launched in a direction covering 120 ° of protected airspace.

The AN / TPS-59 and GE-592 radars each have their own dedicated bait system. The bait antenna does not rotate, covering the 45 ° zenith angle, and the antenna gain is 5dB. The computer make radiation pulse of bait match the radar pulse, effectively decoying ARM. British and French joint development of the carrier system "Sybil" is a comprehensive automatic "flexible" missile fake target system, equipped with a floating ARM bait, which can effectively deal with the missile attacks from all directions.

Russia specifically developes C - 125 radar KPT3-125-2M bait system, which is used to deal with "ham" anti-radiation missile. The decoy system consists of 4 ~ 12 decoy transmitters arranged on a circumference of 300m (at least 290m) circumference with a certain distance from the radar. The adaptive decoy algorithm is used to control the operation of the circular bait transmitter array. The probability of the system dealing with an anti-radiation missile attack is greater than 0.9, and two anti-radiation missile attack probability is greater than 0.8.

Developed countries pay more and more attention to the radiation of the alarm system and configuration, such as the AN/TPQ - 44 radar warning system (developed for the AN/TPS - 75 radar)of the United States, the AN/SAR - 8 infrared alarm device, the AN/AAR - 54 ultraviolet warning devices and AN/AAR - 47 laser warning equipment, etc.

In general, with the development of anti-radiation warning and active decoy technology, active decoy has higher fidelity and more flexible timing control. The signal of active decoy and the signal of radar emission domain, the frequency domain tends to overlap completely and the modulation parameters of the signal are exactly the same as the target radar, making the PRS more and more difficult to correctly identify and track the radiation source.

ARM Anti - active Technology

Analysis of ARM Anti – active.

In fact, the single decoy decoy system is rarely used to protect the ground-based radar, and most of the bait or bait use a double decoy of the decoy system, while the bait radiation power and other parameters are strictly constrained. In this case, ARM anti-decoy process can be divided into three stages.

a) Point to the guidance section

Boot from seeker to missile reached so far "spatial separation point", so-called "pointing guidance segment".The missiles are far away from the radar position. In this stage, the signal-to-noise ratio of the seeker is low. The angles of the radiation sources in the system are small and the signals overlap in the time-frequency domain and are difficult to distinguish. In this section, a new angle estimation algorithm is proposed to combine the truncated signal with the improved dual-beam range-finding method [3]. This method can effectively resist the two-source decoy under certain conditions. As long as the route of the missile attack does not fall on the center plane of the two radiation sources, the difference in the distance between the two sources and the ARM seeker inevitably results in a time difference when the pulse signal reaches the seeker. The time difference between the arrival of the two signals is converted into the signal power difference by truncating the signal, and the power difference is transformed into the angle difference by the improved double beam ratio and direction finding method. Finally, the angle difference is used to bias the missile flight path to one of the two radiation sources , to achieve the purpose of anti-active decoy.

b) Target guidance section

The second stage from the missile to the "space separation point" to a certain target locked up, known as the "target guidance section." With the ARM close to the radar position, it is difficult to identify a number of radiation source problems will gradually appear, because of the angular resolution limit, than the amplitude direction algorithm has been unable to achieve the effect of anti-active decoy. This section is to adopt the symbolized intra-pulse feature extraction technology [4], to process the multi-target signal received. When the relative distance is shortened, the PRS can guarantee the acquisition of all the radar signatures, and the pulse deinterleaving can effectively improve the target sorting performance. Therefore, the feature extraction is the key process of the signal source separation identification. The signal characteristics of the radar emitter signal are obtained by transforming the time series of radar emitter signals into discrete symbol sequences in the frequency domain. And then the symbolic symbol of the radiating source signal and the sampling delay of the autocorrelation function of the radiation source signal in the process of symbolization are taken as the two-dimensional eigenvector. The method has the advantages of high efficiency and insensitivity to noise, can simplify the classifier design, quickly and efficiently identify the multi-target, and guided missile lock one of the radiation source [4].

c) Information detection section

The third stage from a target locked until the warhead detonated, known as "information detection section." At this time, the missile is close to the radar position, the signal-to-noise ratio of the received signal is high and the angle of each radiation source relative to the ARM is larger. This situation is very conducive to the detection of the radiation source target, as long as the real-time access to multiple radiation sources and missile relative angle, combined with ARM's own coordinate information, theoretically able to accurately locate the target radiation source. Therefore, the ARM can be used as a reconnaissance platform to obtain the target angle information and transmitted through the data link back to the launch position, into the radar radiation source feature library, you can effectively improve the next wave of ARM Hit probability. Because the duration of this phase is very short and the DOA of the target signal changes quickly, it is necessary to use the multi-target angle tracking algorithm with high computational efficiency to realize the automatic correlation of multi-target angle. In the passive mode, the angle tracking of the target can be divided into two parts, DOA estimation and angle correlation of the moving target. By combining subspace tracking and fast rooting MUSIC, the DOA estimation of moving target is achieved. The computation of subspace reaches the lower limit of theory. The new algorithm has the least amount

of computation compared with the similar algorithm. At the same time, the method of zero tracking is used to synchronize the estimation of the angle and the correlation, which satisfies both the need of the seeker for multi-target angle tracking and the high computational efficiency. [3]

Research status of ARM Anti-active decoy.

Because of the inherent short comings of PRS, you can use a variety of technical means against PRS. For the present, active decoy technology is the most obvious effect, the most widely used as a means. Therefore, it is of great strategic significance to carry out anti-radiation missile anti-active decoy technology research.

At present, methods of PRS anti-active decoy by the domestic and foreign research are divided into the following categories:

a)Data were averaged [5].

When the two-point source transmitting the signal amplitude ratio is $\beta > 1.25$, the radar seeker no longer tracks the power center of gravity of the two sources after averaging multiple data accumulations, but tracks the power source. Due to the manufacturing process, the power of the two sources can not be exactly equal, and the signals emitted can not be exactly the same, making the power of the two point sources reach the seeker different, which provides a breakthrough point for PRS against two point sources . And for the two-point source that transmits the pulse signal or the continuous wave signal, it is suitable to track the high-power source in the two-point source by means of averaging multiple data accumulation.

b) Pulse Leading Edge

Tracking and Time Selection. This method can effectively identify and track single signal, and can resist multi-path interference and multi-source interference. Time selection technology is to use the selected signal itself produces a gate, the signal in the time domain to select the signal of interest to achieve a stable tracking. When the three target signals enter the receiver, the first signal into the receiver will trigger a narrow-gate generator, and trigger another monostable to produce a wide pulse, and the wide pulse down phase with the narrow-wave phase, which will close the signal after the narrow gate, the follow-up signal is no longer a wave gate. It is also possible to set the multiresonator repetition frequency according to the a priori data and to block the subsequent signal in the repetition period of the multiresonance. This eliminates the second and third signals and generates a gate. Pulse frontier technology is inserted in the two analog delay line, as long as delay for $0.1 \sim 0.2\mu s$, and then narrow the door to change the time to move the wave gate, the system adjustment, the narrow gate is adjusted to just cover the front of the pulse pulse signal, The pulse width of the narrow gate is $0.1\mu s$. So that the leading edge of the strobe signal can eliminate the interference signal.

c) Sideband tracking and isolated pulses.

In the battlefield environment, the enemy may use two (more) noise FM interference source of our anti-radiation weapons interference, because at the same time in a small angle direction may have two sources of interference, ARM to attack one of the sources of interference Is very difficult [6,7]. Therefore, in the presence of two continuous-wave noise FM source, how to make the seeker to track the stability of one of the sources is to ensure that the actual battlefield environment, the normal role of anti-radiation weapons, the key. There are two interference sources that may exist in different frequency bands and the basic overlap of two cases.

For a two-point source with different frequency bands, one of the sources is tracked using the side-band tracking method. That is, the receiver bandwidth is less than half of the total interference bandwidth, because the frequency band of the two interference sources is not completely covered, by changing the receiver local oscillator frequency, making the two interferers mixed into the receiver band-pass filter power becomes different. The average value of the measured angle or find out the maximum angle measured histogram peak, you can track the source of the larger power.

For a two-point source with a substantially overlapping frequency band, it can be divided into "wideband" and "narrowband" interfering signals. For the "wideband" signal, one of the sources is tracked by using the method of isolated pulses, that is, by selecting the appropriate receiver bandwidth so that the isolated output pulses form an isolated pulse and the probability of

overlapping the isolated pulses of the two interfering signals is less than 50% Histogram statistics for a period of time can theoretically show peaks at the deviations of the two sources, so that the declination of the two sources can be obtained and one of them can be tracked.

Conclusion

Anti-radiation missiles as a "radar killer" is the future of electronic warfare essential to winning the magic weapon, who mastered the anti-radiation missiles, who would account for the war opportunities, access to "information system". With the progress of science and technology, the performance of anti-radiation missiles will be more and more advanced, to bring the survival of the radar a great threat. Accordingly, the technology of active decoy which can effectively interfere with anti-radiation missile will continue to progress. We must understand the status quo and keep abreast of the development trend of anti-radiation missiles, base ourselves on the foundation, innovate boldly, continuously fill in technological loopholes, solve the inherent defects of missiles, and strive to improve the accuracy of anti-radiation missiles, the ability of effectively damaging. Through these methods in the future information war to obtain a favorable form.

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