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THE RESEARCH OF SATELLITE ANTI-INTERFERENCE TECHNOLOGIES

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The Research of Satellite Anti-interference Technologies

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Abstract: In this paper we will present the current status and the trends of the satellite's anti-interference technologies, introduce the characters and important usage of anti-interference technologies, clarify the models and methods of anti-interference technologies. Then we will analyze and compare some of the commonly used anti-interference technologies. From the analysis, we can find the weakness and give some advice and views for the improvement of these technologies.

Key Words : Anti-interference, Communication Anti-interference, Radar Anti-interference, Anti-radiation Reinforce , Anti-nuclear Reinforce, Anti-satellite Weapon

1 . Introduction

From the time that the Soviet Union launched the first satellite into the space and broke the peace of the space in 1957, US and the Soviet Union began the military space competition. 30 years later, US and the Soviet Union have launched thousands of satellites into the outer space, the main function of these satellites is to service the military goal. From 1959 for US, from 1962 for the Soviet Union, they began launching electronic reconnaissance satellite, communication satellite, navigation satellite, early-warning satellite, airship, space shuttle, and space station, etc. The appearance of these military satellites one after another, boosted the development of the anti-satellite technologies.

In the middle of the 70's, the US began to implement and dispose anti-satellite plan, reinforce the space defense ability, several billions dollars were spent. The beginning of the Soviet Union's anti-satellite weapon is early, they had done more than 20 times anti-satellite tests, had some actual combat ability. It can be said that the Soviet Union was leading in this area. In order to change this situation, in March 23, 1983, the US president Reagan announced a plan called the Strategic Defense Initiative (SDI) so-called "Star War" by the westerner. This plan was approved by the congress and was completely put into practice in 1984. From 1984 till now, 3 billion dollars have been spent to study the advanced and new technology of anti-missile system.

After the Soviet Union broke up, the cold war finished, the SDI plan slowed down, but never stopped. The research of all kinds of new and advanced technologies are continuing. For example, in January, 25, 1994, the US launched the Clementine-1 unmanned airship to test the remote sensor and the transducer used for missile tracking in the SDI plan. This airship is as big as a small sedan, total costs about 75 million dollars.

The space weapon will create a new space war besides air, land and sea. Outer space war will bring more severe danger to the human being. So the research of satellite anti-interference technologies has been the key task for the military department of every advanced country.

Currently, there are two ways of satellite anti-interference technology, the first one is anti-destroy method. This method means to develop space interceptor, intercepting satellites, missiles, laying space mines and other directional energy weapons, using weapons to confront weapons thus to achieve the goal of defending own system. The second method is electronic confrontation, mainly to develop electron reconnaissance, electron interference and electron anti-interference, photoelectric confrontation, laser and microwave beam and other electron warfare equipment.

The adoption of the weapon destroy method need that the equipment system is relatively complicated, it includes the target detection, capture, identification, tracking, guidance, instruction and other systems. It is necessary that these systems are precise. Moreover, they can only be used once and will be destroyed with the target, so utilization rate is low, consume is high, prime cost is high. Despite these wastes, the advanced countries are actively developing this kind of confrontation system.

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The adoption of the electronic confrontation method has some unique advantages compared with destroy method, its prime cost is low, utilization time is long, moreover, it is flexible, do not need huge launching system. So, we will emphasis these electronic confrontation methods.

2 . Satellite Anti-interference Technologies

The satellite depends too much on the electronic equipment, it is easily interfered by the enemy in the modern war and in the future space warfare. So, when the US and the Soviet Union are developing the satellite technologies, they also paid a lot of attention to the research of satellite's anti-interference technologies. Adopt effective anti-interference scheme, to improve the self-defense and survival ability of the equipment in the satellite and the whole satellite system.

2.1 The satellite's anti-radiation reinforce technology

The research of the satellite's anti-radiation reinforce technologies is to make sure that the electronic equipment in the satellite and the main subsystems can work normally under the radiation environment. The subsystems and the whole system will not fail without finish the task even some units or modules are affected by the radiation. Thus, it is necessary to adopt effective anti-interference reinforce method to protect electronic components, materials and microelectronics circuits, to enhance the on orbit survival ability of the satellite.

2.1.1 The anti-radiation reinforce technology of electronic components and devices in the satellite.

To resolve this problem, at first we must clarify the anti-radiation ability of the components and devices made in our country, then study the radiation effect of the materials and the devices, analyze its mechanism, suggest the anti-radiation indicator that the materials and the devices must meet. Also we should ask the companies who produce these materials and devices to improve the production techniques in order to meet the anti-radiation specifications.

2.1.2 The anti-radiation reinforce technology of satellite subsystem

It includes the anti-radiation design and analysis of the circuits, the fault tolerant and redundant design, the adoption of eluding technologies, the application of components and devices parameters reduction and compensation technologies. Some devices which are sensitive to the radiation but must be used in satellite, such as MOS, the design of their interface circuits, the structure of the subsystem, the placement of the devices, all these must consider in the anti-radiation problem. If they can't meet the specification after the adoption of special production techniques in the factory, special measures must be adopted in the satellite design engineering, these measures include active shielding and passive shielding technologies. To enhance the anti-radiation ability of the subsystems, the passive shielding technology is commonly used due to the practical technological consideration.

2.1.3 The anti-radiation reinforce of the whole satellite system

From the view of the whole satellite system, it is necessary to give consideration to the different need of different parts, balance the allocation of the anti-radiation indicator. When configuring the structure and the quality of the whole satellite, we must emphasis the anti-radiation optimization design of the radiation sensitive devices, and the key subsystems to enhance the anti-radiation ability of the devices in an local area or the main part of the subsystem. The key point of this problem is to construct the analysis model of the interaction between the satellite system and the radiation environment. We need to use Computer Assistant Engineering (CAE) to analyze and simulate the radiation effect, to set up the criterion and develop the software to evaluate the anti-radiation effect of the whole system. Combine the satellite anti-radiation design with the whole satellite design process, to utilize the strong points of the integrated system design, and thus achieve the goal of enhancing the anti-radiation ability of the whole system.

2.2 Appearance Design and Usage of New Materials

It is important to cut the radar reflection area as much as possible in the satellite appearance design. At the same time, it is necessary to consider the anti-nuclear and anti-laser radiation in order to simplify the installation of anti-radiation shielding and other protect shields. It is reported in the US that the carbonic phenolic material and composite carbonic material can be used in anti-laser radiation. Also the absorption material can be considered for hiding, and not being discovered easily in the space warfare. In order to cut the volume of the satellite, it also could be considered that to use isotope battery instead of solar battery. The average life time of isotope battery is seven to eight years, for ordinary military satellite, the life time is long enough.

Finally, the interaction of the satellite and the plasmasphere such as the ionosphere and the magnetosphere will cause critical charge accumulation on the surface of the satellite. The satellite in the earth synchronous orbit the high tension square array satellite in the polar orbit will be charged to negative voltage of several thousands volts. The unbalanced charge in the satellite surface exceeds the insulating voltage between the insulators of the neighboring satellite surface, thus the insulators are punctured, the discharging arc emits electromagnetic pulse

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also will disturb the missile's normal operation. In order to control the satellite's non-uniform charging status effectively, to ensure the reliability of the satellite's operation, it is necessary to develop the conductive coating (also named thin-film). Commonly used thin-films include IO, ITO, TO and so on. As for ITO, this is a kind of SnO2-doped In2O3 thin-film (briefly called ITO). It is a kind of rather ideal conductive thin-film, its resistivity is 0.0002 Ohm-cm, the transmisivity of the visible light reaches 90%, infrared reflectivity is 90%. It belongs to the n model semiconductor thin-film, can be used as anti-electronstatic shield coating.

In the condition that the barometric pressure is between 1000 Pa to 0.001 Pa, we can see that, for IO, ITO or TO film, their surface electric conductivity almost don't change with the fluctuation of the environment, especially when ρ is below $\rho < 10^8 \Omega \cdot cm$, it is not sensitive to any pressure fluctuation.

From the experiments we can see that, if the energy of the irradiation doesn't exceed the range of 5 ~ 20 KV, so long as $\rho < 10^8 \Omega \cdot cm$, , the electric conductivity of these films won't change with the change of the irradiation condition, no matter the value of the beam current and the bean energy. What also need to be appointed is the ρ value of IO is relatively big at the beginning, but when the density of the electron beam is higher than 0.2 nA/cm^2, it will drop to about $10^9 \Omega \cdot cm$, that is advantageous for controlling the surface voltage.

2.3 Add Self-defense Warning Equipment and Acceleration Maneuver Equipment

It is also an important step for anti-interference to add electronic early-warning detector, laser early-warning detector and acceleration maneuver rocket in the satellite. When the satellite is threatened by the laser irradiation or other threats, the detector can detect these threats in time and control the defense devices to protect the satellite's photoelectric infrared camera and other devices and instruments. Moreover, when the satellite finds itself in the danger of being attacked, it can automatically ignite the acceleration maneuver rocket and change orbit to escape from attack.

2.4 Development of Space Shuttle

The US and the Soviet Union began to develop the space shuttle energetically from the 80's, not only because it is a kind of huge space flight carrier that can be used repeatedly, but also because it is a kind of important weapon in the future space warfare. Now its pay load capacity is up to 30 tons. For each Kg of pay load it carries to the low orbit, is only 1/5 of that the booster rocket. Moreover, there are extensive application of the space shuttle, it can carry all kinds of satellites into the space orbit, recovery and service the satellite, carry all kinds of interference equipment and space weapon equipment, implement different interference to all kinds of spacecraft, catch the enemy satellite. The space shuttle is flexible and effective, it is one of the important weapon system for destroying other spacecraft.

3. The Satellite's Effective Pay Load Anti-interference Technologies

3.1 The space communication anti-interference technology

The emergency of the space communication anti-interference technology promotes the advancement of the space anti-interference technology. Currently, in other countries, the communication equipment and technical facilities that have the anti-interference ability include:

a) Pseudo-random sequence spread spectrum communication system

Pseudo-random code has the random property, the signal being modulated by this code is somewhat like pseudo-random noise, implement it into the secret communication, the adversary has difficult to reconnaissance and identify the modulated signal with ordinary electronic reconnaissance equipment, it has the deceiving ability of anti-reconnaissance. Because the spread spectrum signal is demodulated in the receiver by the correlator, only when the local code is identical to the emission pseudo-random code, the base band signal could be released, in secret communication, it is difficult for the adversary to interpret the signal. In order to interpret the signal, the adversary must know the length of the pseudo-random code that the sender uses, the type of the code and its initial phase. It is rather difficult to detect the base band signal. Moreover, because the spread spectrum communication spreads the spectrum of the base band signal, lowers the flux density per unit band width, it can be used in the space communication to avoid the interference to the ground communication. From these analysis, we can say that the adoption of spread spectrum communication greatly enhances the anti-interference ability of the space communication.

b) Frequency-Hopped Communication System

The carrier wave frequency of the frequency-hopping communication jumps with some pseudo-random sequence frequency. A frequency controller is used to control the carrier wave frequency to instantaneously jump with some specified increment according to the demand of the frequency-hopping pattern. This frequency controller includes a pseudo-random code sequence producer

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and a frequency-hopping synchronization unit. The pseudo-random code controls the output power of the radio station's frequency synthesizer. Only when the frequency synthesizer of the sender and the receiver can jump synchronically, the communication can be established. Each frequency-hopping order forms a pattern, a frequency-hopping station can form many patterns, but the selection of which pattern is secret. The frequency-hopping rate is a important norm to measure the performance of the frequency-hopping station, it is the inverse of the frequency-hopping period, and the frequency-hopping period is the sum of the staying time and the tuning time, so the frequency-hopping rate can be expressed as :

$$H = \frac{1}{t_a + t_b} \qquad \text{Equation 1}$$

where H is the frequency-hopping rate (times per second), ta is the staying time (second), tb is the tuning time (second).

The staying time is the time that the frequency-hopping station stays in one frequency, the tuning time (also called frequency conversion time) is the sum of the break time, the cut-off time and the cut-in time. When the frequency-hopping rate is high, it is difficult for the ordinary reconnaissance equipment to proceed direction-finding, also it is difficult for the aiming answering interference device to aim at the frequency used in the frequency-hopped communication. Therefore, the frequency-hopping communication system is a rather good anti-interference communication system.

3.2 The Millimeter Wave Communication System

The millimeter wave can penetrates the high density plasma, so it is suitable for the communication system between the ground and the satellite, the space station, the space shuttle, and the airship, etc. Especially after the nuclear explosion, the ordinary communication will be interrupted, but the millimeter wave can pass the high density plasma, so it is a method to ensure the communication in the nuclear war. Moreover, the millimeter wave has the characteristics of narrow wave beam, high directing property, and wide frequency band, etc., so it has some anti-reconnaissance and anti-interference ability.

3.3 The Adaptive Zero Adjustment Antenna Technology

The ultra-short wave radio station that employs this kind of technology can make the antenna's wave beam adaptively aim the communication direction, and the zero position of the antenna pattern aim the interference devices. After the adoption of the adaptive zero position technology, the suppression to useless signal usually can reach 20 to 30 dB. If this technology combining with the frequency-hopping technology, it can resist the speedy tracking interference and the wide band comb high power jamming interference which are the most critical for the frequency-hopping radio station.

4. The Space Radar Anti-interference Technologies

The microwave imaging radar, millimeter wave radar, non-sinusoidal wave radar, frequency scanning microwave holographic radar, harmonic radar and so on, can be placed in the satellite. The outstanding advantage of the microwave imaging radar is its high resolving power. The pulse compression system makes the distance high resolving power into the reality. The synthetic aperture radar developed by the US has been applied in the aerial battlefield warning, the space shuttle and airship. The realization of the synthetic aperture radar's azimuth high resolving power is obtaining a series of the echo waves in the flying lane, and synthesizing those echo waves into a long radar aperture.

The space radar can enhance greatly the space surveillance ability. For example, the covering area of a space radar is as large as that of tens of the fairly big ground radar. This kind of space radar has relatively strong survival ability, is difficult to be destroyed. So the radar can place in the asynchronous satellite that is 200 Km to 600 Km high, or the synchronous satellite that is 36,000 Km high.

The space radar can adopt the single base system, also can adopt double bases system. The single base system is usually the synthetic aperture radar (SAR), such as the L band SAR radar in the sea satellite which was launched in 1978 by the US, its array antenna's aperture size is 10.7 m * 2.2 m, provide the images of wave, ice covering, iceberg and coast, the resolving power is 25 meters,. The double bases space radar system places the irradiator in the satellite, cooperates with the phase controlled multiple beam receiver on the ground to construct the double bases radar and establish the relatively large range of space searching. The distributed array radar also is on the basis of the space radar. These space radar all have some anti-destroy and anti-stealth ability.

Since there are many kinds of space radar, we can't analysis each radar's anti-interference ability, the things we can do is only to synthetically and generally talk some of them, introduce some typical ones. If we give a detailed description, we can write a big book, it is impossible.

Currently, the modern radar anti-interference technologies is developing rapidly, there are over one hundred kinds. If being divided by the subsystem and the system characteristics, they can roughly divided into those types:

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1. The transmitter anti-interference technologies

a) Frequency --- frequency Prompt changing, frequency Diversity, multiple frequency band, frequency shifting, inter pluses frequency shifting, new frequency band and so on;
b) Power --- raise the output power, power administer and so on;
c) Pulse repetition frequency (PRF) --- pulse compression, flutter PRF, parameter PRF, and PRF prompt changing, etc.
d) Waveform --- coded waveform, continuous waveform, noise/spread spectrum, pulse Doppler

2. The antenna anti-interference technologies

a) Goniometer Technologies --- single pulse, mixed single pulse, adaptive angular scanning modulation, compensated cone scanning modulation, hidden receiving, multiple concurrent working antennas, phase controlled array, scanning rate amplitude modulation, varying scanning rate;
b) Main lobe pattern characteristic --- circular polarization, increase angular resolving power, main lope blanking, and polarization diversity/selector, etc.
c) Side lobe characteristic --- side lobe blanking, side lobe masking, side lobe reduction/suppression, use absorbing material to suppress the side lobe

3. The receiver/signal processing anti-interference technologies

a) Pre-detection --- wide band receiver, sweep frequency local receiver, passive receiver, compression intermediate frequency amplifier, intermediate frequency amplitude limit, matched filtering, narrow band amplitude limit, and moving target indication (MTI), etc.
b) Detection --- correlation detection, detector post offset, detector balanced offset, double thresholds;
c) Post scanning --- audio frequency amplitude limiter, auto correlation signal processing, the automatic compensation of the extended target, automatic visual frequency noise correction, cone scanning safeguard frequency band, constant false alarm probability (CFAR), cross correlation signal processing, uncorrelated accumulation, logarithmic FTC, logical ECCM processing, visual frequency distance gating, wide band amplitude limit, and wide pulse blanking, etc.

4. The system anti-interference technologies

a) Control/analysis of the radar data --- acceleration limit, adaptive wave beam formation, passive angular trace, and passive detection and trace, etc.
b) The objective data from other sources --- infrared trace, visual light trace, sound monitoring, very high frequency (VHF)

communication direction finding, and homing trace for the interference equipment, etc.

In a word, during the confrontation between the radar designer and the Electronic CounterMeasure (ECM) designer, many confronting methods have been developed. Some of them have good performance and are extensively used by all kinds of radar. Now we introduce some typical examples.

1) The frequency prompt changing

The frequency prompt changing is to change each pulse's carry frequency. It can not only improve the radar's performance, but also a effective radar anti-interference technology. It can suppress the noise interference, as well as deceiving interference.

Assume that the bandwidth of the prompt changing is Ba, in order to generate the effective interference, it is necessary that the bandwidth of the interference equipment Bj >= Ba. The power of the interference equipment must be distributed within the whole bandwidth Ba. This bandwidth is much wider than that the common radar occupies instantaneously. Because the bandwidth of prompt changing frequency can be 500 to 1000 times wider than radar's, so the noise interference power that in the radar's frequency band is reduced greatly.

The noise density of the interference equipment can be defined as $P_j = \frac{P_j}{B_i}$, if fix the radar's frequency, Bj is approximate equal to 4B, thus the attenuation due to the bandwidth ratio is about 6 dB. If the radar frequency is prompt changing, Bj >= Ba, can be 500 to 1000 times as wide as B, the attenuation due to the bandwidth ratio is 27 dB ~ 30 dB. From above analysis we can see, if we have a suitable B/Bj value, the self shielding range can increase greatly. In this case, the noise interference losses its effect.

Moreover, the prompt changing can avoid the deceiving interference producing the false target which is closer to the radar than itself. Because the frequency of the next pulse repeating interval is different from the previous one, before receiving the next pulse signal, the interference equipment can't identify its frequency. In addition, using frequency

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prompt changing technology can also avoid the synchronous leading-in of the range gate pulse.

2) The phase controlled array

The phase controlled array antenna can provide the flexibility in the advanced radar wave beam control scheme. Because the antenna is provided by the independent unit or sub-array, it can obtain the best adaptive antenna pattern in the ECM environment. In the receiving antenna's pattern, the establishment of multiple zero points can be achieved by the phase changing of the fixed radiation unit, or the phase and amplitude changing, or the sub-array weighting. The phase controlled array radar uses the digital beam formation receiver, it is because of the creation of instant multiple wave beams by digital technology and the adoption of the real time adaptive processing equipment. When it forms the instant multiple wave beams, at the same time it can do adaptive zero adjustment to the interference source and get the performance of ultra-high resolving power and ultra-low side lobe. So it can effectively confront the advanced synthetic interference system. The waveform and the blocking time of the phase controlled array radar can be adjusted according to the need of the noise environment. Its different correlation short pulse width, PRF sequence and the amount of the short pulse train can all be changed according to the simple or complicated sea/ground environment, meteorological environment and the foil noise environment. The radar wave beam sequence can directly fit the waveform demand. The use of the phase controlled array radar makes the ECM system unable to identify the radar antenna's scanning characteristic that is needed for the effective modulating the irradiated signal by the ECM system.

3) The side lobe masking and the side lobe blanking

The side lobe masking is a kind of technology to confront side lobe interference. It needs that the gain of a auxiliary antenna is less than the gain of the main antenna's main lobe, but bigger than that of the main antenna's side lobe. Compare the input signals of these two antenna's receivers, if the signal in the main antenna's receiver is bigger, we can say this is the signal when the antenna aims at the target, after being gated, it enters the signal analysis circuit. If the signal in the auxiliary antenna's receiver is bigger, this is the signal that enters from the side lobe, this signal isn't be gated and can not enter the signal analysis circuit. In the common pulse radar, the signal is masked on the basis of the pulse interval when the pulse arrives the two receivers. In the Doppler radar, the signal is masked on the basis of the Doppler frequency, not the arriving time, it is because that the Doppler filtering is the most fundamental gating method in the Doppler radar.

The side lobe masking does not work with the continuous wave or noise interference, only the side lobe blanking technology should be used. In this case, detecting the signals in the two receivers, if the signal power level in the auxiliary antenna's receiver is higher, the blanking technology is necessary to adjust the amplitude and the phase of the interference signal through the blanking feedback circuit in a close loop to make the interference signal reaches the smallest in the main receiver. Using this technology we can get the blanking ratio of 30 dB, but for each interference source in the side lobe, this technology need a independent blanking device. In fact, in order to achieve good performance, at lease five blanking devices are needed.

4) The Low Probability of Interception (LPI) Technology

In order to make the radar signal difficult to be detected, the spread spectrum technology is employed to produce the signal that is smaller than the ECM receiver detection threshold. Usually, some kind of the pseudo-random noise modulation waveform is used to spread the irradiation energy into a very wide frequency band, it is a effective anti-reconnaissance technology. The intermittent working radar is also a important low probability of interception anti-reconnaissance technology. Only when the radar information is need does the radar irradiate the electron signal, and only irradiate in a fan shape area of interest. Sometimes, under certain circumstances it is not necessary to have the radar with the longest detection distance and the highest irradiation power, at this time, the low probability of interception could be achieved by lowering the radar's output power. The automatic irradiation system is to decide the amount of the irradiated signal according to the information needed. The computer automatically controls the amount of the irradiated signals and the irradiation power to acquire the information interested. Selecting suitable radar working frequency band and the passive locating system are also the important anti-reconnaissance methods.

There are not many kinds of radar developed in other country that the low probability of interception is its whole characteristic, only the HARD developed by Sweden, TWS-QR and AN/TPS-73(V)2 by the US. For example, the HARD radar (its advanced model is HR-3000), of Sweden, its working frequency is E/F band (2 ~ 4 GHz), prompt changing frequency band is 12%, plain array antenna size is 4.8 m * 6 m, pencil beam 1.7° x 1.1°, azimuth mechanical scanning, elevation angle phase scanning; action range, 320 Km for the target sized 1 m^2 ; anti-interference technologies: prompt frequency changing

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low peak power, waveform coding, Doppler processing, multiple frequency, narrow wave beam, ultra low side lobe, moving target detection, and high resolution, etc. The low probability of interception radar mentioned above all have the inter-pulse anti-interference ability.

5. Some Opinions and Advice

5.1 Continue the research of the satellite anti-radiation technology

The research of the satellite anti-radiation technologies includes that in the natural charged particle radiation environment and in the specific upper air nuclear explosion environment, also includes the research of the satellite anti-radiation reinforce technologies. The research of this kind of technology is important for the realization quality of the satellite's task and the on orbit survival ability. So it is the key factor of the application satellite research. Other countries pay great attention to these technologies, we must pay great attention too.

In addition, we should continue to track the SDI plan, continue the research of the conductive coating, the surface material of anti-charge, discharge and ablation, the radiation environment and the protection of the manned cabin, the anti-radiation feature of the silicon solar battery and so on.

5.2 Strengthen the Research of the New Devices

Currently, there are many kinds of new devices related to the advancement of the radar technology. In order to enhance the radar's performance, add the anti-interference ability, we should strengthen the research of the new devices. For example, the monolithic microwave integrated circuit (MMIC), it is mainly used in radar as the phase controlled array's transceiver module. The very high speed integrated circuit (VHSIC), the development of many new radar technologies depends on the high speed computation ability of the VHSIC. So we should develop and apply VHSIC technology, solid state devices, solid state transceiver module, hybrid microwave integrated circuit (HMIC), very large scale integrated circuit (VLSIC) technology, programmable computer technologies, and all kinds of algorithms and software. In addition, the photoelectric devices, including optical fiber delay line, photoelectric A/D converter, optical gate and other functional devices. Moreover, we should study the high power microwave devices.

The development of the high power microwave devices has very important effect on the advancement of the new generation military electronic equipment. The people who do the research in the electronic technology area all know that the microwave devices are the heart of the electronic equipment, are the radiation source of the output power. Some researchers in the foreign countries said that "the microwave power devices are the key devices in the advancement of the modern radar and electronic warfare." The development of the super radar and the super interference equipment in the 90's depends on the development of the high power microwave devices.

power microwave devices.

5.3 Continue Strengthening the Satellite's Quality Management

The design and manufacture of the satellite itself is a system engineering, so we must manage the quality of the raw material, devices, technical test and the whole system as in the system engineering. On the basis of the previous management experience, we should set up a good management system, clarify the management model, cooperate with each other, rationally divide the labor, each one does his duty, make out joint efforts. These are very important for the successful satellite launching and finishing the scheduled task. In a sense it is also one of the important measures to enhance the anti-interference ability. At last, the research of the anti-interference technologies started late in our country, there is a relatively big gap compared with the foreign countries. If we work as one, we believe that it does not need a long time for us to catch up with the foreign countries and set up a set of our own satellite anti-interference system.

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Reference

1. N83 - 19799
2. N83 - 19801
3. Wen-ming Zhu, The Research of Satellite Anti-radiation, The No. 501 Department of Astronautics Industry Corporation
4. Yong-wei Zhang, The Review of The Satellite Anti-radiation Research of Our Country, , The No. 501 Department of Astronautics Industry Corporation
5. Military Satellite: Squeezing the Most of Space, DEFENSE ELECTRONICS, 1993: (25)11; 50 ~ 54
6. N82 - 19647
7. Radar Handbook 1990
8. Xi-bo Lin, The Space Synthetic Aperture Radar, Shanhai Astronautics, No. 6, 1991

9. Shi-fan Ji, The Laser Technology Research And Development in Russian, Abroad Inspection Report, No. 1, 1994

10. AD/A - 677869

1 N83 - 19799

2 N83 - 19801

3 朱文明. 卫星系统抗辐射研究. 航天总公司 501 部

4 张永维. 我国卫星抗辐射研究的回顾. 航天总公司 501 部

5 Military Satellite: Squeezing the Most of Space DEFENSE ELECTRONICS 1993; (25) 11; 50 − 54

6 N82 - 19647

7 Radar Handbook 1990

8 林溪波. 星载合成孔径雷达. 上海航天. No. 6, 1991

9 计世藩. 俄罗斯激光技术研究与开发情况. 出国考察报告 No. 1, 1994

10 AD/A - 677869