

ACTIVE PHASED ARRAY RADAR

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An active phased array radar (APAR) is a type of phased array radar whose transmitter and receiver functions are composed of numerous small solid-state transmit/receive modules (TRMs). In an active phased antenna array, each element of the lattice or a group of elements have their own miniature microwave transmitter, without needing a big transmitter tubes used in radar with passive phased array. In an active phased array, each element consists of a module that contains a slot antenna, a phase shifter, a transmitter and a receiver. APARs aim their "beam" by broadcasting radio energy that interfere constructively at certain angles in front of the antenna. They improve on the older passive electronically scanned radars by spreading their broadcasts out across a band of frequencies, which makes it very difficult to detect over background noise. APARs allow ships and aircraft to broadcast powerful radar signals while still remaining stealthy.

In the usual passive phased array radar one power transmitter of several kilowatts feeds several hundred items, each of which emits only tens of watts of power. A contemporary microwave transistor amplifier, however, can also produce tens of watts and a radar with an active phased array of several hundred modules, each with a capacity of tens of watts, creates a whole powerful main radar beam.

While the result with the passive phased array is similar, the active grating is much more reliable, since in case of a failure of one of the transmitting and receiving element of the lattice distort the antenna in such a way which is slightly degrades the characteristics of the radar, but in general it remains operational. Catastrophic failure of the transmitter tube, which is a problem of conventional radar systems, simply can not happen. The added benefit is weight savings without a large lamp of high power, an associated cooling system and a large power supply voltage.

Another feature that can only be used in active arrays is the ability to control the gain of individual receiving-transmitting modules. If this can be done, the range of angles through which the beam can be deflected significantly increased, and thus many of the limitations of the geometry of lattices, which are conventional phased arrays possess can be eliminated. Such lattices are called lattices of superincrease.

The main advantages of the usage of APAR are the following:

1. Low probability of intercept.

Radar systems work by sending out a signal and then listening for its echo off distant objects. A radar's received energy drops with the fourth power of distance, that is why radar systems require high powers, often in the megawatt range, in order to be effective at long range.

The radar signal being sent out is a simple radio signal, and can be received with a simple radio receiver. It is common to use such a receiver in the targets, normally aircraft, to detect radar broadcasts. The target's receiver does not need the reflection and thus the signal drops off only as the square of distance. This means that the receiver is always at an advantage over the radar in terms of range - it will always be able to detect the signal long before the radar can see the target's echo. Since the position of the radar is extremely useful

information in an attack on that platform, this means that radars generally have to be turned off for lengthy periods if they are subject to attack; this is common on ships.

2. High jamming resistance.

Jamming is much more difficult against an APAR. Traditionally, jammers have operated by determining the operating frequency of the radar and then broadcasting a signal on it to confuse the receiver as to which is the "real" pulse and which is the jammer's. This technique works as long as the radar system cannot easily change its operating frequency. When the transmitters were based on klystron tubes this was generally true, and radars, especially airborne ones, had only a few frequencies to choose among. A jammer could listen to those possible frequencies and select the one being used to jam. Since an APAR changes its operating frequency with every pulse, and spreads the frequencies across a wide band even in a single pulse, jammers are much less effective. APAR is much more difficult to detect, and much more useful in receiving signals from the targets, that they can broadcast continually and still have a very low chance of being detected. This allows the radar system to generate far more data than if it is being used only periodically, greatly improving overall system effectiveness.

3. Other advantages. Each element in a APAR is a powerful radio receiver, active arrays have more functions compared with a traditional radar. One use is to dedicate several of the elements to reception of common radar signals, eliminating the need for a separate radar warning receiver. The same basic concept can be used to provide traditional radio support, and with some elements also broadcasting, form a very high bandwidth data link. The F-35 uses this mechanism to send sensor data between aircraft in order to provide a synthetic picture of higher resolution and range than any one radar could generate. APARs are reliable since each module operates independently of the others, single failures have little effect on the operation of the system as a whole. Additionally, the modules individually operate at low powers, perhaps 40 to 60 watts, so the need for a large high-voltage power supply is eliminated.

The Shortcomings: the technology of APAR has two key challenges:

1. Power dissipation.

The first problem is power dissipation. Because of the shortcomings of microwave transistor amplifiers (MMIC), the efficiency of the transmitter module is less than 45%. As a result, APAR emits a large amounts of heat to be dissipated to prevent the transmitter chips from melting and turning into liquid. Traditional air cooling used in conventional computers and avionics, is ill-suited for high density packaging elements of APAR. Compared with a conventional radar, fighter aircraft, air-cooled, APAR is a more reliable, but will consume large amounts of electricity and require more intensive cooling. But APAR can provide a much greater transmission capacity that is needed for longer-range target detection.

2. Cost. Another problem is the cost of mass production of modules. For a fighter radar, requiring typically from 1000 to 1800 units, the cost of APAR is unacceptable, if the modules are worth more than a hundred dollars each. Early modules cost about 2 thousand dollars, which did not allow for mass use APAR. However, the cost of such modules and MMIC-chips is constantly decreasing. Despite its drawbacks, an active phased array radar antenna appears to be superior to conventional in almost all respects, providing greater tracking ability and reliability, as well as some decrease in complexity and possibly cost.