Journal of Computations & Modelling, vol.9, no.2, 2019, 37-61
ISSN: 1792-7625 (print), 1792-8850 (online)
Scienpress Ltd, 2019

Passive Radars and their use in the Modern Battlefield

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Abstract

The use of stealth technology in the design of military aircraft is widespread nowadays, playing a crucial role in military affairs. The research on technologies that would help counter stealth threats has also drawn considerable attention. Passive radar systems have been coined as an anti-stealth technology. These systems exploit existing radio emissions, such as FM, TV and cellular telephony signals, trying to detect echoes which would indicate the potential presence of a flying target. Taking into account that most stealth aircraft have been optimised for higher frequency bands (where most fire control radars operate), as well as for monostatic type radars, trying to minimise specular reflection at their front sector, passive radars seem to be a viable approach, since they involve lower frequency bands and multistatic type scattering. Furthermore, passive radars cannot be detected, allowing for covert operation. On the other hand, the coverage of such systems is limited up to medium altitudes, since there is practically no broadcast at

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Article Info: *Received:* August 31, 2018. *Revised:* October 10, 2018.
Published online : April 1, 2019.

higher altitudes. The use of active, low frequency band radars, along with passive radars covering the lower tier, would provide an ideal combination against stealth threats. The purpose of this work is the presentation of passive radar systems and the study of a practical implementation of a passive radar concept based on low cost Software Defined Radio (SDR) technology.

Keywords: Passive radar, Passive Coherent Location, anti-stealth, Electronic Support Measures, Software Defined Radio, Doppler effect.

1 Introduction

Stealth technology and Countermeasure Systems are critical elements in the effectiveness of fighter aircraft, that can change radically the outcome of military operations. In order to deal with threats exhibiting these two capabilities, Passive Radar Systems have been proposed, also known as Passive Coherent Location (PCL) radars, which feature some certain advantages.

The operation of PCL radars is based on the exploitation of existing transmissions. At all times, there are various transmissions (e.g., FM, DAB - Digital Audio Broadcasting, TV, HDTV, GSM, 3G), covering significant parts of the lower airspace, especially over populated areas. A basic passive radar is comprised of a “reference” antenna, directly receiving the broadcast of a transmitting source, and a “target” antenna, searching for echoes of this broadcast, indicating that a target might be there. If a target is present, then the signal from the transmitting station will be reflected on it and the echo received by the “target” antenna will be shifted in time (due to the longer distance covered to and from the target), shifted in frequency (due to the Doppler effect, since the target is moving), and of course at a considerably lower power level (due to the longer distance and the reflection on the target). Comparing the direct signal of the “reference” antenna and the signal received by the "target" antenna, taking also into account the relevant geometry (positions of antennae and of the transmission source), the position of the target can be estimated [1] [2] [3].

For a stealth aircraft, the key factor is the proper design, in a way that, when "illuminated" by a radar, the incident radiation is not reflected back but scattered towards other directions. This technique is effective against all common, monostatic radars, where the same antenna is used for both transmission and reception. The multistatic nature of passive radars, where the transmitting and receiving antennae are in different positions, allows in most cases a more suitable geometry that favors the detection of the target. Even more so, as the frequencies used are relatively low, the corresponding wavelengths become comparable to the target-aircraft structural parts (wings, empennage, stabilators etc.), so that resonance phenomena appear, triggering scattering modes that increase the target's echo. Finally, Radar Absorbent Material (RAM) coatings are less efficient at lower frequency bands. In consequence, hiding an aircraft from a passive radar becomes much more difficult.

At the same time, modern countermeasure or self-protection systems detect emitters in a wide frequency band, warning the pilot for potential illumination by hostile radars and proposing to apply appropriate jamming or decoy techniques. The importance of a passive radar system is apparent, as it does not emit any kind of radiation, so it cannot be detected or jammed. Additionally, it cannot be threatened by an anti-radar weapon (e.g. anti-radiation missile), which seeks an emitter and is directed onto it.

Moreover, passive radars offer low procurement and operation costs, and do not require any kind of licensing for their use. Therefore, this kind of radar is ideal for use in electromagnetically dense environments, such as civil airports.

On the other hand, they present some drawbacks, such as the dependence on the geometry and on signals not optimized for radar use, the increased computational requirements, the inability to reveal targets at higher altitudes (since there is practically no broadcast above 10000 – 15000 feet), and the difficulty to provide 3D tracking (many PCL radars are 2D).

Despite these issues and difficulties, a grid of passive radars could act as a "gap filler" to a network of low frequency band active radars, covering the low tier. Such combination of active and passive systems would exhibit outstanding surveillance capabilities, efficiently covering a given airspace against all kinds of stealth threats (aircraft, ballistic/cruise missiles, UAVs etc.), as discussed in [4].

It seems that many countries are developing PCL radars, even if they do not admit to do so. Recently, the emergence of low-cost Software Defined Radios, as well as the abundance of computational power, have allowed the implementation of PCL systems, not only by radar manufacturers, but also by amateurs.

Figure 1: The Airbus Defence and Space Passive Radar (ex Cassidian, EADS Group), presented in 2012 [20]

The unique capabilities offered by the PCL approach in the context of the modern battlefield, in combination with covert operation and low cost, impose the thorough examination and the experimental implementation of such a system. In this work, the PCL concept is presented and put in the relevant historical perspective, taking into account also recent developments. Passive radars are discriminated from devices utilising target emissions. Finally, a simple PCL implementation based on an a low cost TV Dongle (with a Software Defined Radio - SDR receiver) is analysed and simulation results are provided.

2 Passive Radar Review

2.1 Classification of Radar Systems

Radars can be classified into different categories. As already mentioned, based on the number and location of the antennae being used, they are characterized as monostatic, if they have only one antenna, or multistatic, if they have more than one transmission or reception antennae, at different positions. The majority of radars are monostatic: the same antenna is used for transmission and reception, with a special microwave switch (Duplexer) isolating the receiver during transmission and the transmitter for the remaining time. A subclass of multistatic systems is the bistatic radar, with one transmitting and one receiving antenna, at different positions.

Considering the emission of radiation, radars are divided into active or passive. Active systems include a transmitting antenna, exploiting signal reflections from potential targets, while they may be either monostatic (the usual case) or multistatic. Passive radars have only receiving antenna/-e and take advantage of the radiation that is already present in the environment, coming from non-cooperative transmitters. Such sources could be, for example, television, radio or mobile telephony broadcasts. As mentioned above, passive radars are multistatic, since the transmitting antenna is at a different position from the receiving antennae. This radar category is the subject of this article [1] [2] [3] [4].

2.2 Early Implementations of Passive Radar Systems

Development of passive radars started earlier than what is generally believed, initially taking place in parallel with the development of active radars. The first attempt to implement a passive radar is documented in 1924 by Appleton (later honoured with the Nobel Prize) and Barnett, who exploited one BBC Broadcasting Station in Bournemouth (at the south coast of the United Kingdom) and one receiver in Oxford, in order to determine the height of the ionosphere [1].

Later, on Feb. 26, 1935, the “Daventry experiment” took place by Watson-Watt and Wilkins, who used a short wavelength broadcast BBC station at Daventry (at 6.1 MHz), detecting a Heyford bomber, 8 miles away. The experiment was deemed successful and led to the development of the early warning system “Chain Home”, which covered the eastern side of the UK [1] [7].

During the 2nd World War, the German engineers developed the bistatic passive radar “Klein Heidelberg”, a parasitic system that utilized the British Chain Home as a non-cooperative source of radiation, featuring long range and significant effectiveness, as has been recently found [8].

Figure 2: The AULOS Passive Radar of Leonardo
(ex SELEX SI, the Finmeccanica group) [17]

In the 1960s, the first post-war implementation was the “Sugar Tree” system, in the USA. It constitutes an Over-the-Horizon system, which used short wave illuminators in order to detect a possible Soviet rocket launch. This system seemed to have been inspired by Klein Heidelberg, as it exploited the opponent's signals, i.e., Soviet HF signals [1].

In the early 1980s, the first experiments at the University of London were carried out, using analogue television broadcast to detect aerial targets [1]. Since then, and especially after the appearance of low observable technology and stealth aircraft, interest in the PCL approach has increased considerably [5].

2.3 Modern Passive Radar Systems

In 1999 the passive radar “Silent Sentry 2” from Lockheed Martin (USA) was presented [1] [5] [9] [21]. This system used FM and TV broadcasts (both analogue and digital) providing detection with high precision, while maintaining the ability to track 100 targets (or even 200 targets according to other sources [10] [21]) up to 220-280 km. It could monitor aircraft, missiles, ships and surface targets, with an accuracy of 250 m for the horizontal, 1000 m for the vertical and ± 2 m / sec for speed, at acquisition and operating costs lower than a conventional radar. The system is no more exhibited and all relevant references have been removed from the company’s website.

A little later, BAE Systems and Roke Manor Research developed the CELLDAR, a passive radar exploiting cellular phone broadcasts for target tracking [11] [12] [13]. The system’s characteristics were not announced and no further information concerning its development has been released ever since.

In 2005, the Homeland Alerter 100 was introduced by Thales Air Systems, France. It covers low and medium altitudes, protecting high value assets. It uses FM and TV signals, with a range of 100 km (200 km based on others reports [13]) and an upper limit of 20,000 feet. Norway acquired in 2007 an updated HA 100 [14]. In 2010, it was used by the French Air Force to monitor the airspace over Paris, at the French national holiday of 14 July [15] [21]. Thales has also developed Ground Alerter 10 (GA 10), an anti-artillery radar based on the same principle that can locate projectiles within a radius of 10 km [13].

Recently, the interest in the development of passive radar systems in many countries has increased, as their capabilities have been established [11] [21]. Indicative examples are listed below:

- AULOS Passive Covert Location Radar: launched in 2012 by Selex Sistemi Integratti, now Leonardo (Italy). It uses radio broadcasts (FM, DAB) and DVBT - Digital Video Broadcasting Terrestrial and has a 360 km range. It comes in a fixed and a mobile version [16] [17] [21].
- At the same time, a similar system was announced by Cassidian of the EADS Group, now Airbus Defence and Space (Germany). Simply referred to as Passive Radar, it can be fitted into a van [18] [19] [20] [21].

With the spread of low cost electronic receivers and the availability of high-performance PCs, passive radar systems are being developed worldwide, and not only by government agencies. The widespread use of radio technology controlled by software (SDR), used on TV receivers (USB TV Dongle), has allowed many enthusiasts and students in electrical engineering to build low cost passive radars, according to various online reports [6] [22] [23].

Regarding terminology, apart from the terms “passive radar” and “Passive Coherent Location - PCL”, Passive Bistatic Radar - PBR, Passive Covert Radar, and Parasitic Radar are also used [1].

2.4 Comparison of Passive with Conventional Radar Systems

The advantages of a passive radar, compared to a conventional (active) one, are summarized in the following [1] [3] [4] [5] [6]:

- It can provide covert detection - tracking.
- It is highly likely to reveal stealth targets as it is based on low frequency broadcasts (compared to common air defence radars), while it is multistatic. Note that stealth aircraft have been designed to hide from conventional monostatic radars, mainly aircraft fire control radars, operating in the X-band (8-12 GHz).
- It involves lower procurement and operating costs, as it does not have a transmitter, which has considerable power consumption, while it is usually based on a TWT - Traveling Wave Tube, with a high replacement cost.
- It is very difficult to jam.
- It cannot be targeted by anti-radiation weapons, such as the Raytheon AGM-88 HARM, or loitering munitions such as the IAI HARPY. Furthermore, without a transmitter, which would produce heat due to amplifying elements (either tubes or transistors), it will also exhibit low thermal signature, making it difficult to be targeted by IR systems.
- It allows easy installation without any licensing, an important benefit in saturated areas, such as an airport, where there are many different emitters.

However, a passive radar also presents the following disadvantages - constraints:

- It presents a certain algorithmic complexity and requires increased processing power.
- Its effectiveness depends on the relative geometry and existing emissions.
- It is necessary to deal with synchronization problems between the receivers.
- There is particular difficulty in measuring the altitude of the target.
- It depends on non-cooperative emitters.
- The most important limitation is that it offers limited altitude coverage, because there is not enough radiation to be exploited at higher altitudes (above 10000 – 15000 ft) .

2.5 Differences between Passive Radars and ELS Systems

At this point, it is necessary to distiguish passive radars from systems that detect potential emissions of the targets themselves. Although they are often referred to as passive radars, the more appropriate term for such systems is "Emitter Locating System – ELS", as they fall into the category of Electronic Support Measures (ESM). These systems exploit IFF/SSR/ADSB, V/UHF, tactical data links (e.g. Link 16), radio navigation (TACAN/DME), jammer and other transmissions. As far as the radar is concerned, it exhibits high directivity (as opposed to the above mentioned broadcasts, which are more or less omni-directional), which makes detection much more difficult. To identify the targets, techniques such as the Angle of Arrival - AOA Estimation or Time Difference of Arrival - TDOA, also known as "Multilateration", are used [24].

Emitter Locating System can detect targets at long distances, at 300 to 600 km. This is due to the fact that their operation relies on the direct reception of signals emitted by the target, and not signals scattered from the target, as in the case of the radar (active or passive). However, if the invader knows that the opponent has ELS systems, he will apply emission control, depriving himself at the same time of some functionalities, such as the use of tactical networks.

Examples of Emitter Locating Systems are the following ones:

- The Vera NG of the Czech company ERA, a pioneer in this field [21], [24]. It is the evolution of the older Ramona and Tamara systems. Serves since 2004 at the army of the Czech Republic and has been exported to several countries (including USA). It has also joined NATO rapid reaction forces [25]. ERA is developing also "Silent Guard", a PCL system [21].
- The Kolchuga-M of the Ukrainian state company Topaz, based in Donetsk (now under the control of pro-Russians) [26].
- The Russian ELectronics INTelligence - ELINT system VEGA 85V6A [27].
- The Chinese system DWL002 of CETC International, evolution of the older YLC20. They are reported to be based, in part, on the aforementioned Vera and

Kolchuga [28] [29].

Figure 3: The passive ESM tracker VERA NG of the Czech ERA at IDET2017, Brno, Czech Republic. This is an example of an Emitter Locating System, which exploits emissions of the target to locate it. If a target is under complete emission control, it will not be detected by such a system.

3 Theoretical Approach

The design of a passive radar presents certain difficulties: it exploits echoes at extremely low levels, coming from non-cooperative sources, whose emissions are unknown and not optimised for radar use. This is an attempt to address some of the problems that arise, while keeping the implementation costs low.

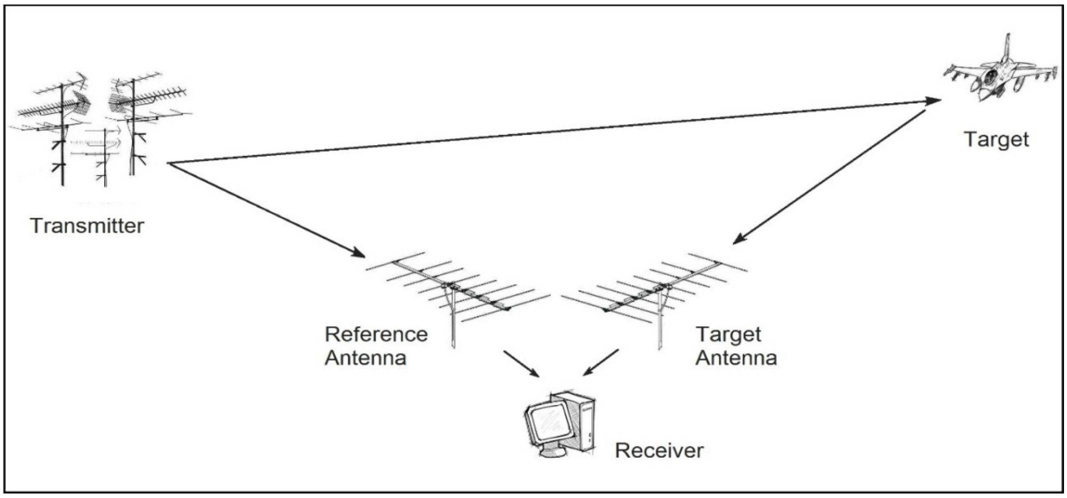

Figure 4: A passive radar system includes a “Reference Antenna”, facing a source of radiation, and a “Target Antenna”, looking at the direction of the target. This is a proof-of-concept and searching issues are not considered.

3.1 Layout of Antennae

Let's assume the existence of at least two antennae, one of which is pointing to an existing emitter, while the other is looking at the area of a target (initially, the issue of scanning will not be considered). The signal from the first antenna will be the reference signal and this antenna will be called the “reference antenna”, while the second one is the “target antenna”. The role of the target antenna, as shown in Figure 4, is to receive any signal resulting from scattering of the emitted radiation on the target. It is not necessary to use only one target antenna. Multiple target antennae would provide greater accuracy. The signals from all antennae will be compared and processed in order to extract information concerning the potential target.

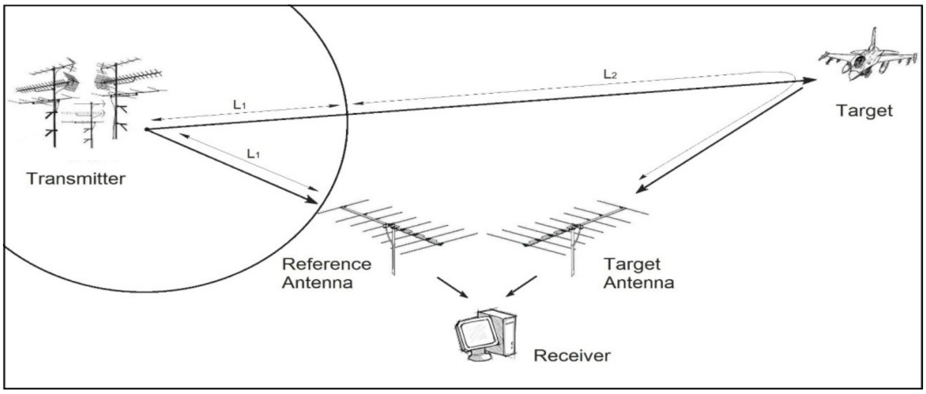

Figure 5: Calculation of the target position from the time difference of the signals.

3.2 Estimating the Target Position

The technique that can be used for detecting and calculating the position of the target depends mainly on the geometry of the system and the surrounding environment. Usually, the time deviation between the signals received by the receivers of a bistatic passive radar is being exploited. Since the signal obtained by each antenna has traveled a different distance, the calculation of the time delay between the received signals can be used to estimate the target position.

If the distance between the reference antenna and the emitter is L_1 (as shown in Figure 5) and the processing of the received signal gives a time difference corresponding to a distance L_2, the sum $L_1 + L_2$ equals to the total distance traveled by the target signal. This information leads to the conclusion that the object is located in a position that satisfies the equation of an ellipse, which is the locus of points in a plane, such that the sum of distances from two fixed focal points (the foci) is constant. Therefore, the target's position is at a point of an ellipse with foci the radiation source and the target antenna.

In other words, the measurement of the time deviation between the reference and target signals is translated to a distance. Then, this information is combined with the ellipse equation. If there are multiple target antennae, for the n^{th} antenna, the target position is identified as some point on a curve given by the formula [6]:

$$\frac{[x\cos\varphi + y\sin\varphi - (-\gamma_1 + \gamma_n)]^2}{\left(\frac{L_1 + c\cdot\Delta t_n}{2}\right)^2} + \frac{(-x\sin\varphi + y\cos\varphi)^2}{\left(\frac{L_1 + c\cdot\Delta t_n}{2}\right)^2 - \left(\frac{\gamma_n}{2}\right)^2} = 1$$

Where:

L_1: The distance from the radiation source to the reference antenna,

Δt_n: The time delay of the n^{th} antenna signal with respect to the reference signal,

γ_1: The distance of the first target antenna to the radiation source,

γ_n: The distance of the n^{th} target antenna to the radiation source,

φ: The angle composed by the first antenna, the radiation source and the n^{th} target antenna

So far, a curve of the possible target locations has been calculated. For the calculation of the exact location, various methods can be used. One technique is the intersection of the curves resulting from different receivers, while another is the use of an antenna with sufficient directivity, to sweep across the area of interest and utilise one elliptic curve only (Figure 6).

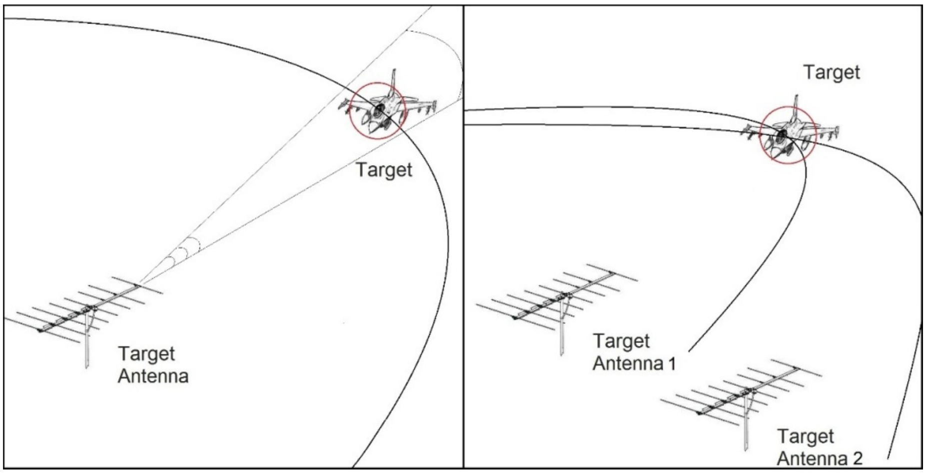

Figure 6: Methods of calculating target range by a passive radar:

(a) Pencil beam antenna, which scans rapidly the area of interest and exploits the elliptic curve to calculate the target's distance.

(b) Several antennae, finding the intersection of the multiple elliptical curves.

3.3 Computing the Target Speed

A number of different techniques can be applied on the issue of estimating the target's speed. One of the straightforward approaches is to keep track of the different positions in which a target was spotted at different times. In short, the information resulting from the calculation of the target position can be used to estimate the distance that this object has covered between two successful detections.

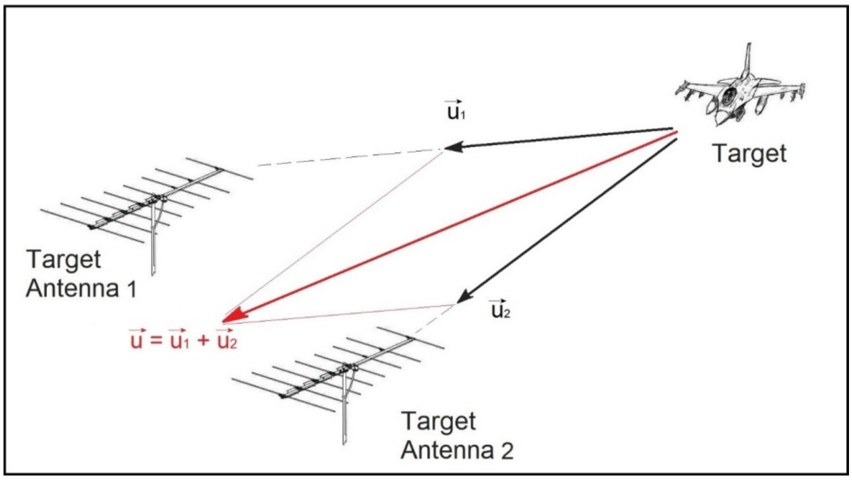

Figure 7: Target speed calculation by the parallelogram method.

This method requires the knowledge that the origin of the received radiation is a real target. Otherwise, other methods should be used, ensuring that the reflection received by the radar does not come from an obstacle but from an actual target. One such method could be based on the Doppler effect. Recall that a moving target, when illuminated by a wave, causes reflection in a shifted frequency. This difference in frequency is proportional to the component of the target's velocity in the direction of the receiver. Therefore, the determination of the frequency deviation between the target and reference signal can provide information on the component of the target's speed in the direction of the receiver.

For the calculation of the target's velocity vector, a second target antenna (or more antennae for greater accuracy) is required, in order to use the parallelogram method, as in Figure 7. The results of this technique can be combined with the results of the previous one, which uses the successive positions of the target.

The most important advantage of using the Doppler effect for calculating the target's velocity is that the results acquired can be "filtered" by a speed threshold, so as not to falsely detect fixed or slowly moving targets, which occur probably from obstructions or/and noise.

3.4 Side Lobe Signal Cancellation

The antennae usually form a main transmitting/receiving lobe and inevitably a set of sidelobes. In order to examine a realistic model, the fact that the target antenna receives the reference signal through a sidelobe should be considered. This signal is added to every other signal obtained, constituting a very powerful noise. Compared to the attenuated signal that comes from the reflection on the target, this noise can essentially conceal the useful signal and therefore should be removed.

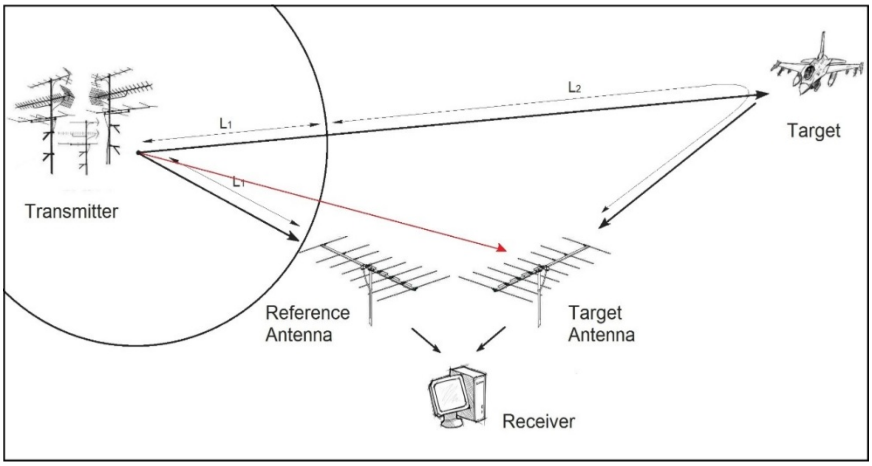

Figure 8: Apart from the main lobe, the reference signal is obtained by the side lobes of the target antenna, as well.

The power of the reference signal, received through the target antenna`s side lobe is given by:

$$P_{side} = \left(G_t \frac{A_e}{4\pi L^2}\right) P_t = \alpha P_t$$

α: The ratio of emitted and received reference signals,

L: The distance between the target antenna and the radiation source.

For the removal of this parasitic signal, a Doppler filter can be used, which rejects signals with almost zero Doppler shift, regardless of the signal level. At the same time, other techniques, like sidelobe suppression, physical separating or canceling techniques, should also be used.

4 Implementation – Performance Assessment

An approach to the practical implementation of the passive radar concept analyzed in the previous section is presented below. The system is comprised of a front end receiver based on Software Defined Radio (SDR) and a PC running all necessary signal processing algorithms.

The use of SDR in passive systems allows the employment of digital processing techniques right after down conversion and sampling of the received signal. Advanced receivers can be designed in this way, capable of being easily modified and upgraded without requiring any physical change in their hardware, since their function is mainly defined by software [30] [32]. Furthermore, the lack of sophisticated analog devices makes them quite affordable. The use of both GNU Radio and MATLAB is quite common for this kind of applications [30].

The current implementation was based on an FM/DVB-T USB dongle, built around the RTL2832U IC, a low cost SDR (figure 9). The USB dongle acts as a front end receiver capturing the signals of interest, down converting and sampling them. The implemented algorithms for both range and Doppler processing were implemented in MATLAB. FM radio signals were used as source of radiation.

4.1 Assessment of Performance

To test the performance of the system, a simulation environment was set up. The code used can be divided into two parts, as summarized below [6]:

The first part of the code takes the digitized reference signal as input and creates a realistic simulation of a target. Given the parameters of a hypothetical target (speed, distance, RCS), it produces the expected scattered signal. In order to achieve this, the code introduces changes that would result from the Doppler effect (according to the given target speed), from time delay of the signals (according to the given target distance), as well as from noise (according to a given value of Signal to Noise Ratio - SNR). Note that the level of the signal received from the reflection of the target is several orders of magnitude weaker than the direct reference signal (can be up to -100 dB).

The second part of the code is essentially the implementation of the passive radar. Using the reference and target signals as inputs, it performs signal processing in both frequency and time domain to estimate the target parameters (speed, distance) specified in the first part of the code.

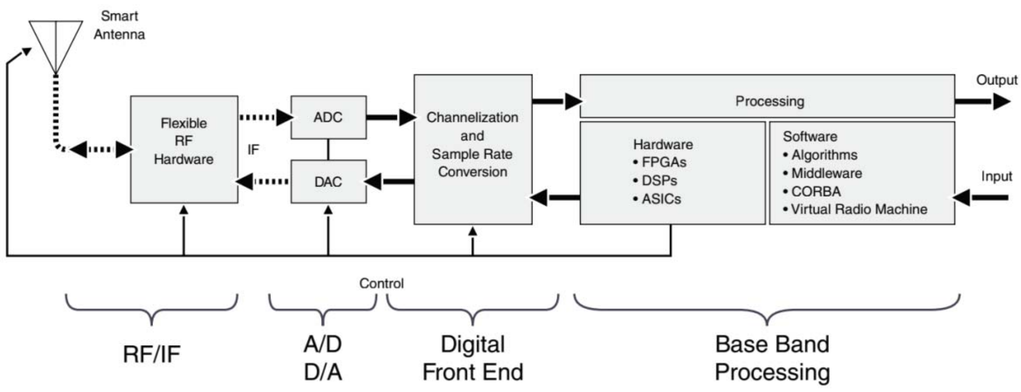

Figure 9: Block diagram of a Software Defined Radio - SDR transceiver [32].

4.2 Results – Evaluation

The above mentioned procedure allows the performance evaluation of the algorithm implementing the radar system by constructing realistic target signals, which can be used to calculate the output of the radar system, at different scenarios. To estimate the passive radar performance, the tested algorithm was executed multiple times, each time with different parameters. The parameters maximizing effectiveness and accuracy depend on the geometry and the radar objectives, and can be specified by a testing procedure similar to the above.

The sampling rate is associated with the receiving bandwidth and is limited within a relative frequency range. An increase in sampling rate, within that range, will positively affect the accuracy and reliability of the output, at the cost of increased requirements in processing power. In the measurements used for performance evaluation the receiver was tuned to 94.5 MHz, listening to an actual FM station with a strong signal, and the sampling rate was 18 MHz, in an effort to reduce the processing requirements and maximise the system’s accuracy.

Regarding the time and frequency "windows" used in the process of cross-correlation, the appropriate values also differ for each application. In the present configuration, a temporal window of 350 msec and frequency windows from 2.0 to 4.4 MHz were used. The above configuration gives a range resolution of about 1.1 km and speed resolution of about 0.5 Mach.

The results of the tests are considered acceptable, since a real reference signal (FM radio broadcast) and a sufficiently realistic signal target have been used. Based on these results, the maximum range of the radar under test was estimated at approximately 2-2.5 km and the speed accuracy to around 0.5 Mach. These values would be rather unacceptable for a real world military application but are reasonable for such a low cost system. Whatsoever, increasing the range and improving the analysis in the speed estimation can be easily accomplished by using more advanced hardware and properly tuning the system.

Either way, the main purpose of this effort was to study the feasibility of implementing a passive radar system using low cost hardware, focusing on the development of the receiver software algorithms. The use of more advanced front section hardware would allow for a more thorough evaluation of the developed algorithms and more reliable conclusions.

Regarding the performance of the implemented radar system in a real-life noisy environment, tolerance to Signal to Noise Ratio (SNR) up to -45 dB was accomplished. In the case that target speed estimation in not required, the radar system can be effective even at SNR -60 dB. It is believed that these tolerances can be further improved too, if more advanced front end receivers are used.

5 Future Research

The following actions focus on building a complete system, using real antennae and the algorithm above or an improved version of it. For a task like this, a study is required to determine the most efficient operating parameters, such as the sampling rate, depending on the needs and requirements of the intended application. In any case, the cost is expected to remain relatively low, as shown by the number of similar applications published on the Internet over the last few years [30] [31] [32].

A further step would be the use of a special transmitter producing suitable signals, in order to facilitate the receiver`s function. Using a high power transmission, long range can be achieved. In this way, the radar becomes an active multistatic system, with increased accuracy and capabilities, while retaining the ability to switch to a fully passive operation, if required (e.g., in case of unavailability of the associated transmitter).

6 Conclusion

The development and use of advanced radar technologies is a vital priority for an air force to counter stealth threats, as well as the sophisticated countermeasure systems of modern fighters. Passive radar systems exploit existing broadcast radiation, offering coverage at very low, low and medium altitudes, as well as low cost operation. Furthermore, passive radars are considered as a quite promising anti-stealth approach, combining geometry advantages and operation at lower frequency bands. In this way, the advantages of low observable technology are largely canceled, since stealth aircraft are optimized against conventional, monostatic radars, emitting at standard radar frequencies. Finally, a passive radar exhibits covert operation and cannot be detected or jammed by the self-protection system of target aircraft, nor targeted by an anti-radiation weapon.

This article presents an attempt to implement a basic passive radar system utilizing low cost Software Defined Radio (SDR) hardware, albeit limited in capabilities. An algorithm was developed to detect targets and calculate their position and speed. Evaluation tests for this implementation were performed, using realistic signals, in order to determine the performance in terms of range, accuracy and noise tolerance. Although the range and speed calculation resolution are not adequate for practical applications, it is believed that the proposed approach could be significantly improved, with the use of more elaborate front-end hardware and with appropriate parameterization. In any case, it is evident that the construction of a passive radar is feasible, while the cost of developing a fully operational system can be low compared to a conventional active radar.

Taking into account the covert operation of passive radars, their benefits and especially their potential against stealth threats, it is considered that their deployment and use, in combination with active, low frequency band radars, would offer important advantages in terms of early warning and control of a given airspace.

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