International Journal of Latest Engineering Research and Applications (IJLERA) ISSN: 2455-7137

Volume – 02, Issue – 04, April – 2017, PP – 37-42

Enhancement of Flycatchers Using Radar for Tracking of Aircrafts Which Aviates at Lower Levels

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Abstract: Upgrade Flycatcher system is mainly applicable for effective defense against attacking aircraft hovering at lower levels which provide timely warning, radar warning, data display, target tracking, weapon control and various auxiliary operations. This can be achieved by radar subsystem, computer subsystem and display subsystem as they combined together for the functioning of flycatcher system. In the radar subsystem, the search antenna produces ricochet which is tracked by tracking antenna. The target specification is done by the combination of search radar and IFF system. TV tracking system is included which make use of either 'track radar take-over' or 'TWS take-over' standard procedures for target indication on the PPI with the joystick. The computer subsystem is fretful with the calculations required for target tracking and control of gun data receivers. The display subsystem is helpful for staging of targets. Index term: Hovering Ricochet Fretful Staging.

I. INTRODUCTION

The Enhancement Flycatcher system consists of: a detachable Enhancement Flycatcher mounted on a wheel train equipped with a motor generator, two sets of communication equipment, a set of installation material, two maintenance kits, two Gun Data Receivers (GDR's). The crew comprises two men. Hereinafter they are called operator 1 and operator 2. Viewing the control and display panel, operator 1 is seated on the left-hand side and operator 2 is on the right hand side. The purpose of the weapon system is to provide an effective defense against attacking aircraft flying at low and very low levels. The task of Enhancement Flycatcher is to provide: timely warning, and effective fire control. In performing this task, Enhancement Flycatcher is capable of fulfilling the following functions: radar warning, data display, target tracking, weapon control, and various auxiliary operations. It should be noticed that Enhancement Flycatcher as it is cannot control a missile launcher although arrangements have been made for the application of missiles at a later date. For this purpose, for instance, compartment E includes a missile control unit with connections to: SMR-MU unit, Supply circuits The container is already provided with the wiring and connectors for coupling the data link system to: SMR-MU unit, supply circuit, the data-link telephone lines (outside the container) The system philosophy on which the Enhancement Flycatcher system is based manifests itself in the following system characteristics: allweather capability; this is achieved by the application of radar operating in a continuous search mode for the detection and positioning of targets. The short reactions time obtained by fast data processing, adequate resolution, optimum relation between the beam dimensions of the search antenna and the tracking antenna enabling quick target take-over by the tracking antenna, two-dimensional tracking of up to three targets by means of the track-while-scan system, Noise suppression and ECCM.

Simultaneous noise suppression and ECCM are effected in the following way:

a) For the search radar by:

1. MTI, using a digital canceller and a digital video correlator in X-band.
2. Fast switching between various frequencies in Xband.
3. Floating false alarm level in X-band.
4. PRF (staggered or pseudo-random).

b) For the tracking radar by:

1. Monopulse pulse-Doppler system (X-band).
2. FFT processor in Ka-band for acquisition,
3. Facility for passive tracking of a target (X-band).
4. Fast switching between various frequencies in Xband.
5. Burst staggered PRF for Ka acquisition.
6. Simultaneous tracking in two frequency bands (Xand Ka-band).
7. Facility for optreonic take over using Ka-band.

8. Easy operation.

The integrated radar system, controlled and monitored by the digital computer, may be operated by one person. The operator has the disposal of a joystick for quick target indication, and various Controls and indicators on the control panels. The weapons can also be controlled from these panels: Mobility, to comply with the mobility requirements, the entire system is housed in a compact container. The search and tracking antenna assembly can be retracted into the container. The container design permits the system to be transported by ship, truck, cargo-plane and crane-helicopter. A wheel train of special design assures the mobility even in adverse field conditions.
A high level of operability is achieved owing to:
High MTBF (Mean Time between Failures), short MTTR (Mean Time to Repair).
The latter results from the application of:
- A modular structure, and
- Automatic and integrated fault finding and reporting system.

The system has been divided into the following subsystem: radar subsystem, computer subsystem and display subsystem.

II. Radar Subsystem

The radar subsystem comprises an X-band search radar, a combined (X-band and Ka-band) tracking radar and a combined search and tracking antenna system. The antenna system comprises two separate antennas, a search antenna and a tracking antenna, both rotating about the same vertical axis. The IFF antenna is integrated with the search antenna. The tracking antenna is a combined X-band/Ka-band antenna with a TV camera attached. The beam energy transmitted by the search antenna rotating at about 2/3 Hz (44 rpm) is to scan the air space. The reflected energy (echoes) is shown on a panoramic display (PPI). The operator may indicate an echo on this panoramic display with the joystick and have it subsequently tracked by the tracking radar. For the identification of targets, the search radar is combined with an IFF system. The following items describe the search radar, the IFF system and the tracking radar, in this order.

A. Search Radar

The X-band transmitter generates RF pulses which are applied to the search antenna and the tracking antenna through a power divider. The position of the power divider determines the distribution of the energy between the two antenna systems. The search performs a continuous clockwise rotation in bearing at about 44 rpm. The elevation of the beam transmitted by the search antenna is so low that very low flying targets too, are illuminated. The search receiver amplifies the echo signals received through the search antenna and converts them into 30 MHz IF signals. The search receiver is provided with an MTI channel and a linear channel. The first channel is the most important, because it produces video signals which are different for fixed targets and moving targets. The MTI circuits of the MTI channel (which are in the radar interface unit) are capable of discriminating the signals and to eliminate the echoes of fixed targets. The above echoes are displayed on the PPI. The radar interface unit also includes a TWS (Track While scan) circuit, enabling two-dimensional tracking of up to three air target by means of the search radar.

B. IFF System

Identification of friend or foe (IFF) radar is also named as secondary surveillance radar (SSR). IFF is basically radar bacon system employed for the purpose of general identification of targets. IFF is an electronic system which can determine the intent of an aircraft with the speed of the fastest computer. The targets visible on the PPI may be interrogated with the IFF system; this may be done both automatically and manually. A target equipped with a transponder and activated by an interrogation signal will transmit a code response. The IFF interrogator checks the reply signals for its code. When it is accepted (friend), the echo in question is labeled with a marker on the PPI. When the interrogated target produces an incorrect reply or no reply at all, the echo on the PPI is not labeled with a marker. The output of the IFF Interrogator consists of three RF pulses. The RF output is applied to an IFF antenna through a RF switch unit. The transmitted pulses are received by the transponder fitted in aircraft. The coded replies from the transponder are received, amplified, detected and fed to decoder.

C. Tracking Radar

The tracking radar is dual i.e. it comprises an X-band radar and Ka-band radar. The X-band tracking radar employs the X-band part of the tracking antenna which is connected to the X-band transmitter through the power divider. The beam of the X-band tracking antenna is symmetric and 2.4° wide. Target tracking is initiated by target take-over. This is achieved with X-band radar and proceeds as follows: Using the joystick, the operator indicates the echo of the target to be tracked; he then transfers the target coordinates (azimuth and distance) thus indicated to the tracking radar. In case of jamming acquisition is through Kaband pulse Doppler system. The tracking antenna turns to the azimuth indicated and starts an elevation search movement. At the same time the range tracking circuit of the dual tracking unit settles on the distance indicated at the same time. As soon as the target has been found, the dual tracking unit derives such control voltages from the incoming X-band tracking video that the target is automatically tracked in three coordinates. Through the radar interface unit, the target data are transferred from the dual tracking unit to the SMR-MU unit for the calculation of the target track. As soon as the target track generator has settled, the SMR-MU unit (the computer) takes the control of the range tracking circuit and the angular control of the tracking antenna. Like the X-band search receiver, the X-band track receiver is a super heterodyne with an intermediate frequency of 30 MHz Moreover, the X-band tracking radar and the search radar are Pulse-Doppler radars which results in an improved tracking performance for low-flying targets (in spite of ground reflections). The tracking radar is called a monopulse radar because it derives all the target coordinates from a single echo signal. As a result of the considerable beam width (2.4°) of the X-band tracking radar, undesired image reflections of low-flying targets may occur, this presents the risk of tracking a fictitious target instead of the real target.

This is one of the reasons for the application of another tracking radar, operating in the Ka-band. The Ka-band tracking radar has an 8 mm wavelength which is a quarter that of the X-band tracking radar. This means that the beam width, too, is four times smaller, i.e. 0.6°. That no image reflections occur with such a narrow beam, even at very low elevations.

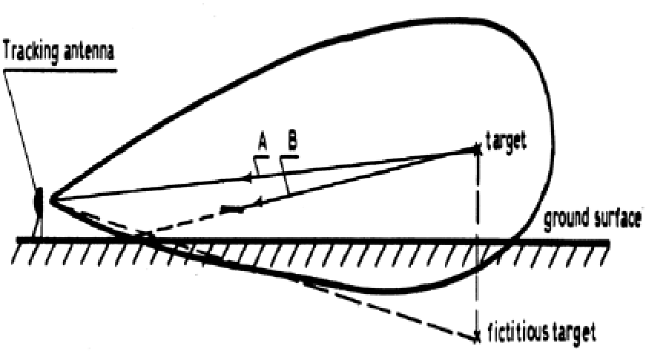

Fig. 1-2 Image effect with X-band tracking radar

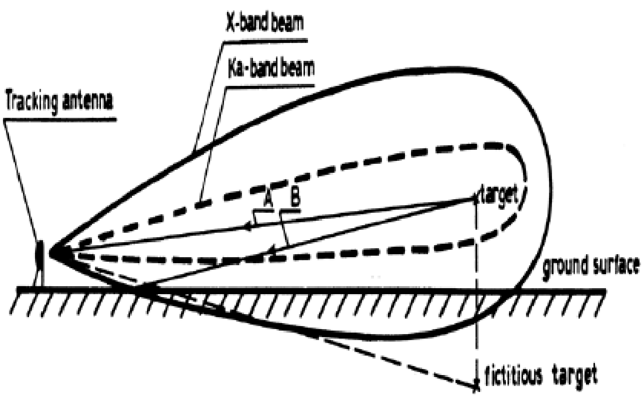

Fig. 1-2 Image effect with combined X-and Ka-band tracking radar

The Ka-band radar is of the conical-scan type. In other words, the Ka-band tracking antenna is provided with a rotating nozzle which causes the transmitter beam to perform a rotational movement.

The Ka-band tracking radar operates on the Pulse- Doppler system for target acquisition and pulseamplitude system for target tracking. During target acquisition phase, full range search program is used during polar diagram takeover and opsonic takeover. For TRTO and TWS takeover, range search for a window of 1 km is carried out. Range tracking program is used during tracking. The above features enable independent Ka band takeover of the target without X-band tracking radar. In normal conditions, target acquisition is always performed by means of the X-band tracking radar, while in a jammed situation acquisition is possible through Ka-band radar. As both the X-band tracking radar and the Kaband tracking radar employ the same antenna, the Ka-band beam will be aimed at the target as soon as the X-band beam has arrived at a target. The dual tracking unit continuously derives error voltages for elevation, azimuth and range from the changes in the incoming target echoes. The computer employs the error voltages for the generation of control signals for the servo systems in the tracking antenna and the range tracking circuit. When a target is tracked, the tracking radars may function alternately. The signal with the better signal-to-noise figure is applied to the SMR-MU unit. The data exchange between the radar subsystem and the SMR-MU unit is handled by the radar interface unit.

1. TV Tracking System

The TV tracking system consists of:
TV camera mounted on the tracking antenna yoke
- TV monitor installed in compartment E
- TV track circuits, being part of the radar interface unit
- Operational TV tracking control panel, installed in the control desk.

In the TV tracking mode, the movements of the camera are under TV control. TV tracking is started with target acquisition by means of the tracking radar, to enable range tracking by radar.
The standard procedure consists of target indication on the PPI with the joystick followed by 'track radar take-over' or 'TWS take-over'. After the target has been acquired properly (in X-band) the target video is visible on the TV-monitor in the center of electronically generated crosshairs.

2. TWS

The Track-While-Scan is a mode of radar operation in which the radar allocates part of its power to tracking the target or targets while part of its power is allocated to scanning, unlike the straight tracking mode, when the radar directs all its power to tracking the acquired targets. In the TWS mode, the radar has a possibility to acquire additional targets as well as providing an overall view of the airspace.

In TWS tracking are involved:
- TWS-circuitry in the radar interface unit
- TWS control panel on the control desk

Enhancement Flycatcher has basically the feature of tracking up to three targets in two dimensions, using search radar information; it is called Track-While- Scan (TWS). After breaking a track e.g. after successful engagement, the track radar can start immediately tracking of a target out of a selection of three. In this way the reaction time of the Enhancement Flycatcher is reduced considerably.

III. Computer Subsystem

The SMR-MU unit (computer) performs all the calculations required for target tracking and the Control of the gun data receivers. It also processes the data to test the system operation and the alignment data input by the operator. The Enhancement Flycatcher data input unit enables the operator to introduce data required for the fire control, such as the parallax of the weapons, V, of the projectiles, and meteor data.

The interface unit controls the data exchange between the computer and the units connected ('peripherals').

IV. Display Subsystem

The display subsystem handles the presentation of the targets detected or data on these targets.
The display subsystem consists of:
- PPI unit
- A-scope
- Numerical indicators (3 groups)
- TV camera
- TV monitor
- Fault indication unit.

The following items briefly describe these units in the order of mentioning.

A. PPI Unit

The Plain Position Indicator (PPI) is the most common type of radar display. The radar antenna is usually represented in the center of the display, so the distance from it and height above ground can be drawn as concentric circles. As the radar antenna rotates, a radial trace on the PPI sweeps in unison with it about the center point. The intensity modulated circular display on which echo signals produced from the reflecting objects are shown in plan position with range and azimuth angel displayed in polar co-ordinates forming a map like display. An offset or PPI has zero position of the time base at a position other than at the center of the display to provide the equivalent of a larger display for a selected portion of the service area. PPI is also referred to as P-scope. This unit contains a color raster scan display to present the echoes of (moving) targets. The range rings presented on this display enable the distance and the azimuth of the targets detected to be determined. The range scale is selectable between 10 km and 20 km. To facilitate the interpretation of the picture by the operator, a number of markers are displayed. One of them, the target indication marker, may be placed in any position on the display by means of the joystick. The panoramic display also shows the information of the IFF system so that it is immediately visible whether an echo originates from a friendly or hostile target. TV picture information is additionally provided on the monitor along with PPI picture. Changeover between PPI and TV full screen is possible.

B. A-Scope

The original radar displays, the A-scope or A-display, shows only the range, not the direction, to targets. Some people referred to these displays also as Rscope for range scope. The primary input to the Ascope was the amplified return signal received from the radar, which was sent into the Y-axis of the display. The A-scope displays the X-band tracking video and Ka-band tracking video received from the dual tracking unit each on its own time base. The range of the two time bases is 10 km or 20 km corresponding with the range selected on the PPI unit. When tracking commences, a 2 km time base, centered about the target echo tracked, is written.

C. Numerical Indicators

There are three groups of numerical indicators to display one of the following five selectable types of information:
- PARALLAX DATA i.e. parallax angle, horizontal and vertical parallax.
- MUZZLE VELOCITY DATA, i.e. the measured or manually input Vo value for each gun.
- TRACK DATA i.e. azimuth and elevation of the tracking antenna and the target distance.
- TARGET DATA i.e. horizontal heading, height and horizontal speed of the target.
- METEO DATA i.e. altitude of probe, or ballistic temperature, air pressure, barometric Pressure, wind direction and speed.

D. TV Camera and Monitor

The TV camera is mechanically connected to the tracking antenna. Consequently, it always 'looks' in the same direction (azimuth and elevation) as the tracking antenna. The camera is remote controlled, it has a supply unit of its own, and supplies the TV monitor with a composite video signal. This results in a picture of the target on the TV monitor.

E. Fault Indication

Unit The fault indication unit is intended for technical purposes. It shows in which module or function of the radar/fire control system a fault occurred. There are two types of fault indications:

1. Type a: The fault indication is accompanied by the full or partial breakdown of the system. The fault is stored in a memory which is cleared when the system is switched on again.
2. Type b: The fault is continuously indicated, though all the system remains normally operating. Measures have been taken to prevent that a fault indication from a certain module would cause a fault indication from other modules connected with the first module. The fault indication unit contains 55 fault indication LEDs in all.

Conclusion:

The aim of this paper is to provide an effective defense against attacking aircrafts flying at very low levels with the help of upgrade flycatcher system which make use of radar. In future, it can be further extended the application of upgrade flycatcher for the control of missile launcher.

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