

Moving Target Indication Radar

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Abstract –

MTI measuring systems are engineered for several years, supported system ideas evolved within the early 1950s. Digital techniques currently allow easier implementation however do not modify the fundamental concepts; staggered repetition periods to eliminate blind speeds; and MTI cancellers with the speed response formed by feed forward and feedback techniques. Radar MTI may be specialized in terms of the type of clutter and environment: airborne MTI (AMTI), ground MTI (GMTI) or may be combined mode: stationary and moving target indication (MTI). The foremost common approach takes advantage of the propagation. Several of the present systems square measure terribly productive considering their performance, measured in terms of MTI improvement issue or sub muddle visibility. In this paper the basic MTI concepts and definitions are presented.

I. Introduction

RADAR (Radio Detection and Ranging) is a system used mainly in defense applications which is used to locate the target, that is, to find its exact position in the range which it covers. The drawback of conventional pulse RADAR is that it can determine only the range, that is, the

distance of the target from RADAR antenna. It cannot determine whether the target is moving or not and in which direction it is moving. Thus in order to determine the motion of the target we use MTI (Moving Target Indication) RADAR. MTI RADAR has become a boon for detecting motion of the targets in the field of RADAR Engineering. MTI RADAR is defined as the RADAR in which the Doppler Effect can be employed to differentiate between stationary and moving targets, with the former suppressed and only the latter displayed. In this process, the permanent echoes as well as those from very slow moving objects (if desired) are not displayed on the PPI (plan position indicator), and the radar controller can pay attention to the real aircraft. Along with the detection of moving targets it also eliminates the effect of stationary objects or stationary clutters. This can be achieved by using the Delay line canceller.

II. Evolution of radar

Previously, RADAR systems were very simple. There were no separate antennas for transmitter and receiver. A single antenna used to function as transmitter and receiver. A gaseous device was called as duplexer was used to separate the transmitter and receiver subsystems. For certain time the single antenna used

to work as a transmitter while for other time it used to function as a receiver. The transmitting and receiving functions were time multiplexed. The received echo was demodulated, amplified and compared with the threshold level. But the disadvantage was that the Doppler frequency shift due to motion of the target was not detected. Thus such RADAR could not detect moving target. It was used only to detect stationary targets. After World War-I when aircrafts were used in war for the first time there was a need to detect moving targets in which the conventional RADAR failed. Also as the aviation industry progressed there was also a need to control the motion of aircrafts to prevent fatal accidents. Thus a special RADAR system to detect moving targets was developed called as MTI (Moving Target Indication) RADAR was developed. Another type of RADAR used to detect moving targets was Pulse Doppler RADAR. Both the RADAR systems used the concept of Doppler frequency shift or Doppler Effect to detect the moving targets. History was made when Croydon airport of London was the first airport to use ATC (Air Traffic Control) system in the year 1921. It used the RADARS used to detect moving targets.

III. Doppler frequency shift

Doppler shift is an apparent change in frequency (or wavelength) due to the relative motion of two objects. Either one or both of the objects may be moving with respect to the ground. Radar systems exploit the Doppler shift to provide an indication of relative speed. When the two objects are approaching each other (closing), the Doppler shift causes a shortening of wavelength - or increase in frequency.

When the two objects are receding from each other (opening), the Doppler shift causes a lengthening of wavelength - or decrease in frequency. In case of an MTI RADAR, when the target is moving towards the RADAR, the frequency of the echo received from the target increases whereas if the target is moving away from the RADAR, the frequency of the echo received from the target decreases. Difference in the transmitted frequency and received frequency from the target is called as Doppler frequency and is denoted by f_d .

IV. Difference between pulse Doppler radar and MTI radar

Both this RADAR basically depends on same principle of Doppler frequency shift. But there are some differences that are some differences. MTI RADAR uses low pulse repetition frequency while pulse Doppler uses high and medium pulse repetition frequency. MTI RADAR has no range ambiguity while range ambiguity may occur in pulse Doppler. Improvement factor need not to be improved in MTI RADAR while in pulse Doppler improvement in Improvement factor is needed. Usually magnetron oscillator is commonly used as transmitter; in pulse Doppler high power klystron amplifier is used as transmitter. MTI RADAR uses analog delay line canceller while in pulse Doppler it uses analog filter banks. MTI RADAR receives less clutter signal while pulse Doppler radar receives more clutter signals.

V. Working

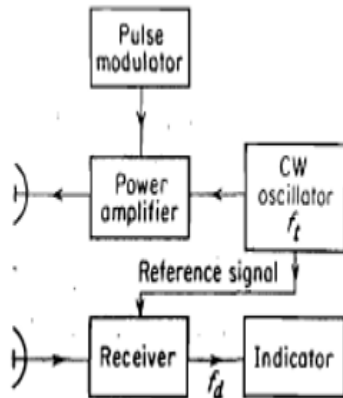


Fig.1 - Pulse Radar

Simple CW radar consists of a transmitter, receiver, indicator, and the necessary antennas. In principle, the CW radar may be converted into a pulse radar as shown in Fig. 1 by providing a power amplifier and a modulator to turn the amplifier on and off for the purpose of generating pulses. The chief difference between the pulse radar and the CW radar is that a small portion of the CW oscillator power that generates the transmitted pulses is diverted to the receiver to take the place of the local oscillator. It acts as the coherent reference needed to detect the Doppler frequency shift.

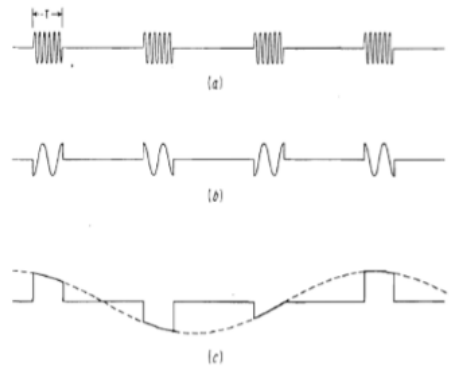


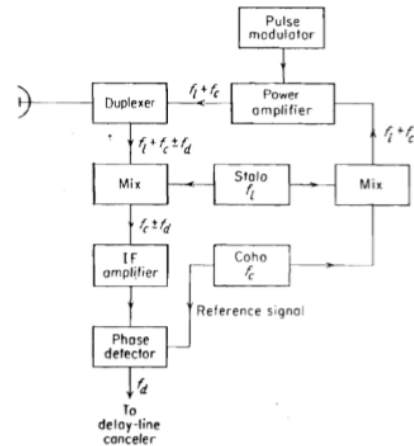
Fig.2 - A scope display

Moving targets may be distinguished from stationary targets by observing the video output on an A-scope (amplitude vs. range). A single sweep on an A-scope might appear as in Fig.2. This sweep shows several fixed targets and two moving targets indicated by the two arrows. On the basis of a single sweep, moving targets cannot be distinguished from fixed targets. (It may be possible to distinguish extended ground targets from point targets by the string of the echo pulses. However, this is not a reliable means of discriminating moving from fixed targets since some fixed targets can look like point targets, e.g., a water tower. Also, some moving targets such as aircraft flying in formation can look like extended targets.) Successive A-scope sweeps (pulse-repetition intervals) are shown in Fig. Echoes from fixed targets remain constant throughout, but echoes from moving targets vary in amplitude from sweep to sweep at a rate corresponding to the Doppler frequency.

VI. MTI operation

The block diagram of more common MTI radar employing a power amplifier is shown. The significant difference between this MTI configuration and that Figure is the manner in which the reference signal is generated. In Fig.3,

the coherent reference is supplied by an oscillator called the Coho, which stands for coherent oscillator. The Coho is a stable oscillator whose frequency is the same as the intermediate frequency used in the receiver. In addition to providing the reference signals the output of the Coho is also mixed with the local-oscillator frequency. The local oscillator must be a stable oscillator and is called stalo. The RF echo signal is heterodyned with the stalo signal to produce the IF frequency just as in the super heterodyne receiver. They serve in both the receiver and the transmitter mode. The characteristic feature of coherent MTI radar is that the transmitted signal must be coherent (in phase) with the reference signal in the receiver. This is accomplished in the radar system diagrammed in Fig.3 by generating the transmitted signal from the Coho reference signal. The function of the stalo is to provide the necessary frequency translation from the IF to the transmitted frequency. Although the phase of the stalo influences the phase of the transmitted signal, any stalo phase shift is canceled on reception because the stalo that generates the transmitted signal also acts as the local oscillator in the receiver. The reference signal from the Coho and the IF echo signal are both fed into a mixer called the phase detector. The phase detector differs from the normal amplitude detector since its output is proportional to the phase difference between the two input signals.



VII. Blind speed limitation

The response of the single-delay-line canceller will be zero whenever the argument $\Pi f_d T$ in the amplitude factor of is $0, \Pi, 2\Pi, \dots$, etc., or when

Where $r = 0, 1, 2, \dots$, and $j =$ pulse repetition frequency. The delay-line canceller not only eliminates the d-c component caused by clutter ($n = 0$), but unfortunately it also rejects any moving target whose Doppler frequency happens to be the same as the prf or a multiple thereof. Those relative target velocities which result in zero MTI response are called blind speeds and are given by $v = n\lambda/2T = n\lambda f_p/2$

$$n = 1, 2, 3, \dots$$

where v_n , is the n th blind speed.

The blind speeds are one of the limitations of pulse MTI radar which do not occur with CW radar.

They are present in pulse radar because doppler is measured by discrete samples (pulses) at the prf rather than continuously. If the first blind speed is to be greater than the maximum radial velocity expected from the target, the product $f_p \lambda$ must be large. Thus the MTI radar must operate at long wavelengths (low frequencies) or with high pulse repetition frequencies, or both. Unfortunately, there are usually

constraints other than blind speeds which determine the wavelength and the pulse repetition frequency. Therefore blind speeds might not be easy to avoid. Low radar frequencies have the disadvantage that antenna beam widths, for a given-size antenna, are wider than at the higher frequencies and would not be satisfactory in applications where angular accuracy or angular resolution is important. The pulse repetition frequency cannot always be varied over wide limits since it is primarily determined by the unambiguous range requirement.

VIII. Staggered Pulse Repetitive Frequency

The use of more than one pulse repetition frequency offers additional flexibility in the design of MTI Doppler filters. It not only reduces the effect of the blind speeds, but it also allows a sharper low-frequency cutoff in the frequency response than might be obtained with a cascade of single-delay-line cancellers with \sin^2 response. The blind speeds of two independent radars operating at the same frequency will be different if their pulse repetition frequencies are different. Therefore, if one radar were "blind" to moving targets, it would be unlikely that the other radar would be "blind" also. Instead of using two separate radars, the same result can be obtained with one radar which time-shares its pulse repetition frequency between two or more different values (multiple prf's). The pulse repetition frequency might be switched every other scan or every time the antenna is scanned a half beam width, or the period might be alternated on every other pulse. When the switching is pulse to pulse, it is known as a staggered prf. An example of the

composite (average) response of an MTI radar operating with two separate pulse repetition frequencies on a time-shared basis is shown in Fig. 7. Repetition frequencies are in the ratio of 5 : 4. Note that the first blind speed of the composite response is increased several times over what it would be for radar operating on only a single pulse repetition frequency. Zero response occurs only when the blind speeds of each prf coincide.

XI. Conclusion

Here we have presented a special application of radar i.e. MTI radar which is far more superior to ordinary radar. The basic principle involved and its operation has been elaborated along with its limitations. MTI radar can be used for various air borne as well as well as ground based applications and shows a lot of promise in the near future.

References

- [1] Livingstone, C. E., et al. "An airborne synthetic aperture radar (SAR) experiment to support RADARSAT-2 ground moving target indication (GMTI)." *Canadian Journal of Remote Sensing* 28.6 (2002): 794-813.
- [2] Skolnik, Merrill I. "Introduction to radar." *Radar Handbook* (1962): 2.
- [3] Soumekh, Mehrdad. "Synthetic aperture radar signal processing." A *Wiley-Interscience publication, United States of America* (1999).
- [4] Chiu, Shen, and M. V. Dragošević. "Moving target indication via RADARSAT-2 multichannel synthetic aperture radar processing." *EURASIP Journal on Advances in Signal Processing* 2010 (2010): 7.