Survey on Electronic Counter Counter Measure Techniques for Radar Signal Processing Applications

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ABSTRACT
Electronic counter-counter-measures (ECCM) plays a vital role in Electronic Warfare (EW) which attempt to reduce or eliminate the effect of electronic countermeasures (ECM) on electronic sensors aboard vehicles, ships and aircraft and weapons such as missiles. The various ECCM techniques are pulse compression, frequency hopping, sidelobe cancellation, sidelobe blanking, polarization and radiation homing. Hence detecting the target in the presence of noise is a daunting task. While detecting the targets, many signals which are not actually a target may come which are called as false alarms. To detect those false alarms, Constant False Alarm Rate (CFAR) is used. In all the above ECCM techniques, detection of targets increases the detection of false alarms in clutter environment. In this paper, a survey on different ECCM techniques employed in radar signal processing is discussed.

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INTRODUCTION

A single received radar pulse is characterized by a number of measurable parameters. The availability, resolution, and accuracy of these measurements must all be taken into account when designing the deinterleaving system because the approach used depends on the parameter data set available. Obviously, the better the resolution and accuracy of any parameter measurement, the more efficiently the pulse-sort processor can carry out its task. The carrier frequency is the next most important pulse parameter for deinterleaving. A common method of frequency measurement is to use a scanning superheterodyne receiver that has the advantage of high sensitivity and good frequency resolution. The objectives of an ECM system are to deny information (detection, position, track initiation, track update, and classification of one or more targets) that the radar seeks or to surround desired radar echoes with so many false targets that the true information cannot be extracted. liberate transmission or retransmission of amplitude, frequency, phase, or otherwise modulated intermittent, CW, or noise-like signals for the purpose of interfering with, disturbing, exploiting, deceiving, masking, or otherwise degrading the reception of other signals that are used by radar systems. A jammer is any ECM device that transmits a signal of any duty cycle for the sole or partial purpose of jamming a radar system. ECM includes both jamming and deception. Jamming is the intentional and deliberate transmission or retransmission of amplitude, frequency, phase, or otherwise modulated intermittent, CW, or noiselike signals for the purpose of interfering with, disturbing, exploiting, deceiving, masking, or otherwise degrading the reception of other signals that are used by radar systems. Radio signals by special transmitters intended for interfering with or precluding the normal operation of a victim radar system are called active jamming. The other major type of active jammer is deceptive ECM (DECM). Deception is the intentional and deliberate transmission or retransmission of amplitude, frequency, phase, or otherwise modulated intermittent or continuous-wave (CW) signals for the purpose of misleading in the interpretation or use of information by electronic systems. The most common type of deception jammer is the range-gate stealer, whose function is to pull the radar tracking gate from the target position through the introduction of a false target into the radar's range-tracking circuits.

Objective of ECCM Techniques:

The primary objective of ECCM techniques when applied to a radar system is to allow the accomplishment of the radar intended mission while
countering the effects of the enemy’s ECM. In greater
detail, the benefits of using ECCM techniques may
be summarized as follows:
(1) prevention of radar saturation
(2) enhancement of the signal-to-jamming ratio
(3) discrimination of directional interference
(4) rejection of false targets
(5) maintenance of target tracks
(6) counteraction of ESM
(7) radar system survivability.

Specific electronic techniques take place in the
main radar subsystems, namely, the antenna,
transmitter, receiver, and signal processor. Suitable
blending of these ECCM techniques can be
implemented in the surveillance and tracking radars,
as discussed.

II ECCM Techniques On Radar Antenna:

The antenna represents the transducer between
the radar and the environment, it is the first line of
defense against jamming. The directivity of the
antenna in the transmission and reception phases
allows space discrimination to be used as an ECCM
strategy. Techniques for space discrimination include
antenna coverage and scan control, reduction of
main-beam width, low sidelobes, sidelobe blanking,
sidelobe cancelers, and adaptive array systems.
Blanking or turning off the receiver while the radar is
scanning across the azimuth sector containing the
jammer or reducing the scan sector covered are
means to prevent the radar from looking at the
jammer. Two additional techniques to prevent
jamming from entering through the radar’s sidelobes
are the so-called sidelobe blanking (SLB) and
sidelobe cancelers (SLC). The purpose of an SLB
system is to prevent the detection of strong targets
and interference pulses entering the radar receiver via
the antenna sidelobes. By suitable choice of the
antenna gains, one may distinguish signals entering
the sidelobes from those entering the main beam, and
the former may be suppressed.

![SLB Architecture](image1)

**Fig. 1:** SLB Architecture.

The objective of the SLC is to suppress high
duty cycle and noise-like interferences (e.g., SOJ)
received through the sidelobes of the radar. This is
accomplished by equipping the radar with an array of
auxiliary antennas used to adaptively estimate the
direction of arrival and the power of the jammers
and, subsequently, to modify the receiving pattern of
the radar antenna to place nulls in the jammers’
directions.

![Block Diagram of SLC](image2)

**Fig. 2:** Block Diagram of SLC.

Another method to reduce the effect of main-
beam noise jamming is to increase the transmitter
frequency (as an alternative means to the use of a
larger antenna) in order to narrow the antenna’s
beamwidth. The different types of ECCM are related
to the proper use and control of the power,
frequency, and waveform of the radiated signal.

Other special processing circuits can be used in
the radar to avoid saturation, i.e., fast-time-constant
(FTC) devices, automatic gain control (AGC), and
constant-false-alarm rate (CFAR).
III Pulse Compression:

Pulse compression involves the transmission of a long coded pulse and the processing of the received echo to obtain a relatively narrow pulse. The increased detection capability of a long-pulse radar system is achieved while retaining the range resolution capability of a narrow-pulse system. Transmission of long pulses permits a more efficient use of the average power capability of the radar. The average output power of the radar may be increased without increasing the pulse repetition frequency (PRF) and hence decreasing the radar's unambiguous range. An increased system resolving capability in doppler is also obtained as a result of the use of long pulse.

Digital pulse compression techniques are routinely used for both the generation and the matched filtering of radar waveforms [6]. The digital generator uses a predefined phase-versus-time profile to control the signal. This predefined profile may be stored in memory or be digitally generated by using appropriate constants. The matched filter may be implemented by using a digital correlator for any waveform or else a “stretch” approach for a linear-FM waveform. Digital pulse compression has distinct features that determine its acceptability for a particular radar application. The major shortcoming of a digital approach is that its technology is restricted in bandwidth under 100 MHz. Frequency multiplication combined with stretch processing would increase this bandwidth limitation. Digital matched filtering usually requires multiple overlapped processing units for extended range coverage.

IV Doppler Filtering:

The term pulse doppler (PD) is used for radars where they utilize coherent transmission and reception. Each transmitted pulse and the receiver local oscillator are synchronized to a free-running, highly stable oscillator. Pulse doppler use a sufficiently PRF to be ambiguous in range. Pulse doppler employ coherent processing to reject main-beam clutter, enhance target detection and aid in target discrimination or classification. Pulse doppler is applied principally to radar systems requiring the detection of moving targets in a severe clutter environment [8].

Doppler filter bank is used for main-beam clutter rejection and coherent integration. The filter bank is usually realized by using the Fast Fourier Transform (FFT) or by the Discrete Fourier Transform (DFT) for a small number of filters. Appropriate weighting is employed to reduce the filter sidelobes. The voltage envelope at the output of the FFT is formed by using an I/Q combining approximation.

By using windowing functions, we can further enhance the ability of an FFT to extract spectral data from signals. Windowing functions act on raw data to reduce the effects of the leakage that occurs during an FFT of the data. Leakage amounts to spectral information from an FFT showing up at the wrong frequencies. The people who first studied the effect thought of the spectral information as “leaking” into adjacent frequency values. We can’t avoid leakage, but by applying windowing functions to your data prior to performing an FFT, you can reduce its ill effects.

V Conclusion:

Thus a survey on various ECCM techniques encounters the probability of detection and probability of false alarm in severe clutter environment. Various techniques have been proposed in the literature for decreasing the probability of false alarm thereby increasing the probability of detection to improve signal to noise ratio.

REFERENCES


