SEARCH FOR COMMUNICATION EMITTERS

Introduction

Communications Electronic Warfare (EW) is above all about communication. Therefore, we will be discussing the nature of communication signals, propagation, and hardware in reasonable detail. The main emphasis will be on tactical battlefield communication in the VHF, UHF, and low-microwave frequency ranges.

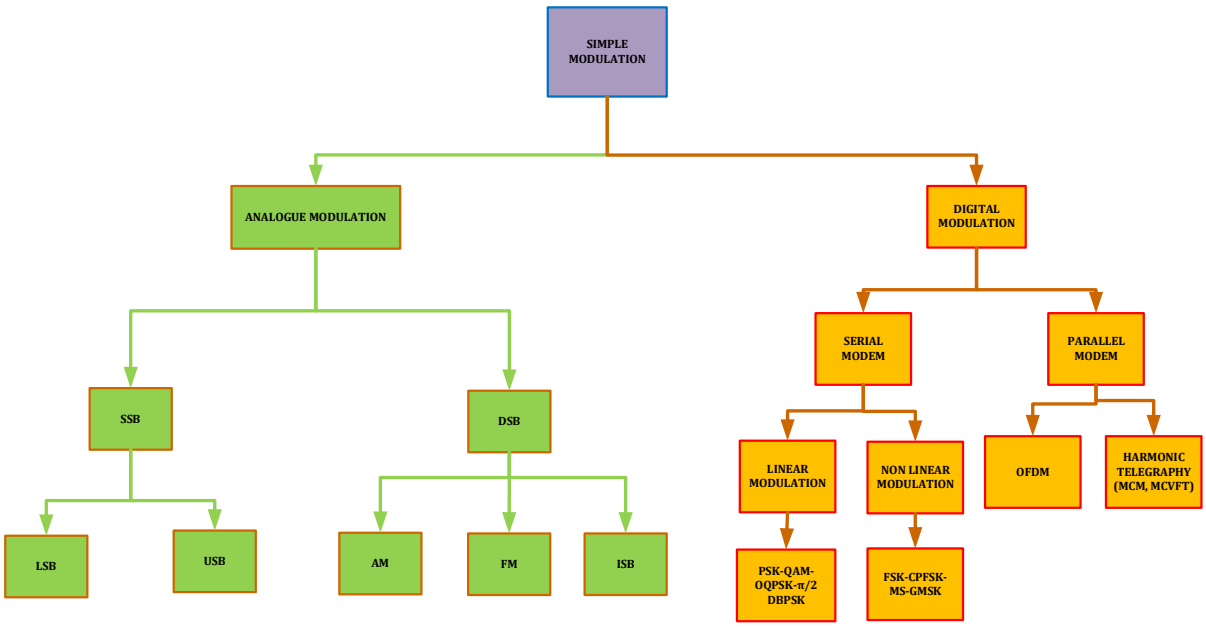
However, there is some coverage of lower frequency band propagation, digital command and data links, and satellite communication.

The purpose of communication is to take information from one point to some distant point, thus (unlike radar) communication is inherently one way. Although there is “burst” communication which involves very short signals, most communication is more or less continuous for periods from a few seconds to continuous.

Communication signals are typically rather narrowband, although there are some modulations which artificially spread the signal far beyond the bandwidth required to carry the information. This is done to prevent detection or to diminish the effects of unintentional or intentional interference.

Communications signals can be either analog or digital, with digital signals becoming more common as time goes by. There are significant differences in the way EW systems deal with these two classes of signals. For digital communication signals, there are many ways in which an enemy can make the EW tasks more difficult by use of sophisticated techniques for the preservation of signal integri

Modulation



Communication Signal

AFSK = Audio FSK

AM = Amplitude Modulation

CPM = Continuous Phase Modulation

DSB = Double Sideband

FM = Frequency Modulation

FSK = Frequency Shift Keying

GFSK = Gaussian FSK

GMSK = Gaussian MSK

ISB = Independent Sideband

LSB = Lower Sideband

Modem = Modulator / Demodulator

MSK = Minimum Shift Keying

MCM = Multi Carrier Modulation

MCVFT= Multi Channel Voice Frequency Telegraph

N0N = un-modulated carrier

OFDM = Orthogonal Frequency Division Multiplex

OOK = On Off Keying

OQPSK = Offset QPSK

PSK = Phase Shift Keying

QPSK = Quadrature PSK

QAM = Quadrature Amplitude Modulation

SSB = Single Sideband

USB = Upper Sideband

Search Strategies

Military organizations go to great trouble to keep their operating frequencies from being known by enemies. However, in general, it is necessary to know the frequency at which an enemy is operating in order to perform the various EW operations.

Thus, frequency search is an important EW function. When an EW receiving system employs directional antennas, angular search is also an issue.

However, because so many communications receiving systems use 360° coverage emitter-location systems, the main emphasis is on frequency search. It starts with general search considerations, then covers search techniques for conventional

communication signals, and finally covers search techniques for low probability of intercept (LPI) signals.

Ideally, the receiving part of an EW system would be able to see in all directions at once—at all frequencies—for all modulations—with extremely high sensitivity. While such a receiving system could be designed, its size, complexity, and cost would make it impractical for most applications. Therefore,

the practical EW receiving subsystem represents a trade-off of all of the above mentioned factors to achieve the best probability of intercept within the imposed size, weight, power, and cost constraints. This problem has been made significantly more difficult by the presence and increasing use of communication.

Seraching for communication emitters

Probability of Intercept (PoI)

Other definitions of probability of intercept are used, but in EW, the following definition is generally accepted:

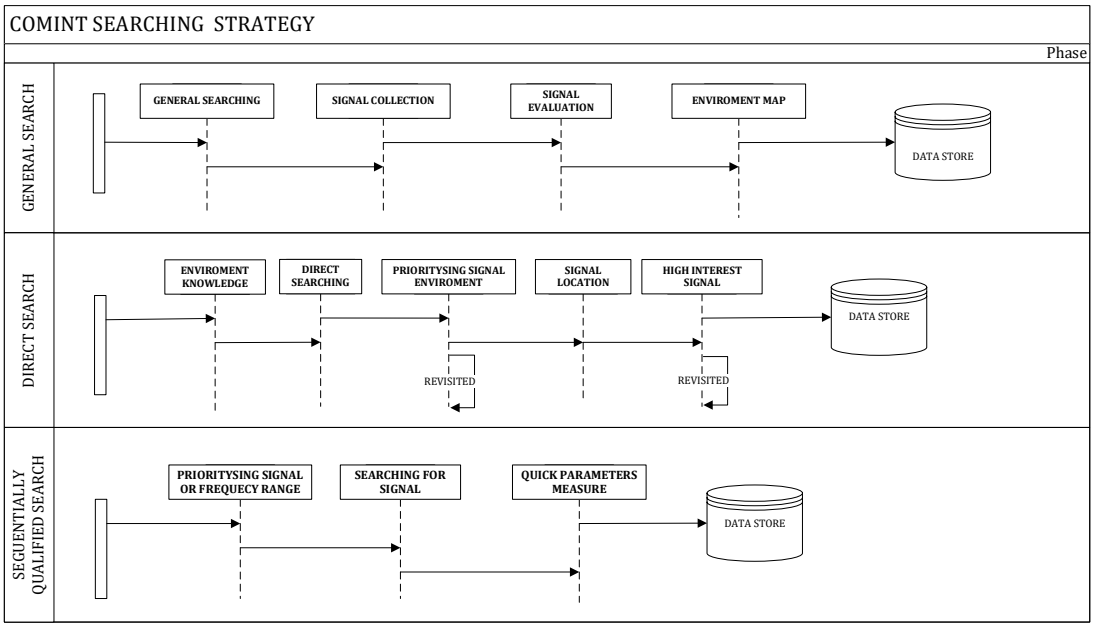
The probability that the EW system will detect the presence and some parameters of a particular threat signal between the time it first reaches the EW system's location and the time at which it is too late for the EW system to do its job.

Most EW receivers are specified to achieve a probability of intercept of 90% or 100% for each of the signals in its threat list, when a specified set of signals is present in a specified scenario, within a specified time.

Search Strategies

In general, the approach used in search for threat signals is one of the following:

- General search;
- Directed search;
- Sequential qualification.



General Search

General search assumes no prior knowledge of the presence of specific signals of interest. It is often called “the first day of the world” approach. It is also called the less dignified, “garbage collection.” Every possible direction of arrival and frequency is considered without preference or priority. The product

of a general search is a “map” of the environment that allows more sophisticated subsequent search or direct action against important enemy assets discovered.

Directed Search

Directed search takes advantage of some knowledge of the environment. It is practical to store the frequency, modulation, and priority of many signals, even in small-scale receiving systems.

When specifc signals of interest are assigned high priority, those frequencies (and directions of arrival if appropriate) are recalled from memory and checked first. Then, the rest of the environment is covered in priority order. The most important (or perhaps the most dangerous) frequency bands or locations are checked next, and then the rest of the environment is searched.

Frequencies or locations known no to be of interest are skipped to save time. Frequencies and locations of high-interest signals are revisited often, while lower priority signals are revisited less often.

Sequentially Qualified Search

Sequential qualification involves the quick measurement of some parameter of any signal found, so that priorities can be applied to determine if it is worth more time to look for more emitter parameters. In general, the parameters which can be measured in the least time are the first sorting parameters.

The most common approach is to first search a prioritized frequency range for any signal energy. This may take only microseconds per channel. When energy is found, the time is taken to determine the next parameter. The second step may be to determine the modulation of the signal or its general location.

The modulation can be determined by spectral analysis, which is quite fast when fast Fourier transforms (FFT) can be employed. The general location (i.e., is the emitter in friendly or enemy territory) is generally available in minimum time when the EW system has emitter-location capability.

Emitter-location systems generally make multiple data collections and calculations which are averaged before a full-accuracy emitter-location report is generated. The first calculation is generally complete in a very small part of the report generation time. If this first calculation result is available, it will generally be of much lower precision than the final report, but good enough to determine if milliseconds should be invested in the determination of additional qualification parameters in the search. Several such levels of qualification may be used before long-duration collection or analysis of a signal is initiated.