Comparison of Analog IFM and Digital Frequency Measurement Receivers for Electronic Warfare

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***Abstract*— Measurement of the incoming signal's frequency is one of the most important topics of an EW receiving system. The continuous performance and reliability improvement of Analog to Digital Converters and FPGA pushed the operation frequency of these devices up to tens of GHz, thus making possible the design of quasi-full digital wideband EW receiving systems.**

In this paper a comparison between a traditional analog microwave IFM receiver and a modern digital frequency measurement receiver is carried out, dealing with architectural, technological and performance differences, enhancement capabilities and lifetime.

I. Introduction

Electronic Warfare (EW) receivers design is based on the trade-offs between probability of intercept of the threats, operating and instantaneous bandwidth, sensitivity, dynamic range and capability to detect and process simultaneous signals.

Current receiver types include wide-open (WO) and scanning super-heterodyne (SH) systems. WO receivers have a very high probability of intercept, but have generally low sensitivity and are not able to process simultaneous signals. Super-het receivers instead can reach high sensitivity and achieve good frequency selectivity, but have poor probability of intercept and suffer from spurious signals detection problems [1]. WO receivers are largely used in warning applications and in discovery of unknown emitters, since they generally have simultaneous coverage of the whole operating frequency band, dynamic range and space volume.

The carrier frequency is considered one of the most important parameter, since it is employed in many tasks:

- sorting and deinterleaving, even in dense environment;
- emitter identification and classification;
- correlation of similar emitter reports from different stations or over long time intervals, to allow emitter location.

A further role is in active Electronic Counter Measures (ECM) systems, where the estimated frequency value is used to designate the threats to the countering system, and also to define bands for noise or deception actions, so optimizing output power utilization and jamming effectiveness.

Depending upon the type of receiver, WO or SH, different solutions can be adopted to implement the frequency estimation function, mainly related to the instantaneous bandwidth.

Most of the currently WO systems use one or more Instantaneous Frequency Measurement (IFM) receivers. IFM is based on interferometric analysis by means of microwave delay lines and phase discriminators.

Basing on improvements in Analog to Digital Converter (ADC), FPGA technology and digital signal processing techniques, modern digital frequency measurement receivers can be developed, due to the high sampling and processing frequencies achieved.

In particular, developing of digital serial communications has made available sampling devices which can achieve sampling frequencies of 10GHz or more. Such devices are similar to a conventional ADC, but with only one bit of resolution, and can be used to sample a very large frequency band, that is 5GHz or more. In the following this sampler will be called Monobit ADC. Together with high sampling speed, this kind of devices have also very wide input bandwidth, so being suitable for use in EW receivers for direct RF sampling.

These considerations are the first step to realize a digital Monobit receiver [2].

This paper provides a review of architectural solutions, technological aspects and performance analysis of a traditional IFM receiver and a modern Digital Frequency Measurement (DFM) receiver based on the Monobit technique and developed by Elettronica S.p.A.. The aim is to compare the two solutions, highlighting their advantages and disadvantages.

II. Key Requirements

EW systems are employed to provide early and quick detection and suppression of threats within complex operating environments. To fulfil this provision the receivers must have excellent performance [3] while fitting into small spaces to be suitable for all types of platforms, such as naval, airborne, modern unmanned vehicles (UAVs), and human (man portable systems).

In particular the frequency measurement function should be implemented with minimum space and weight.

The key requirements of a modern frequency measurement receiver are listed hereafter:

- instantaneous frequency band: E to J;
- operating dynamic range: 60dB;
- minimum input SNR: 0dB;
- frequency measurement accuracy: 1MHz;
- Modulation On Pulse detection and analysis;
- maximum dimensions of one 6U card, according to [4].

III. Architectural and Technological Comparison

Architectural and technological characteristics of the IFM and DFM receivers are discussed and compared in this section.