# DRFM as an Electronic Countermeasure for RADAR

## Introduction

RADAR is a ubiquitous technology used for everything from weather mapping to catching speeders on the highway. In the military, RADAR is one of the primary technologies used for engaging targets with missiles or anti-aircraft fire. The ability to deceive target locking RADAR can keep friendly pilots safe and allow them to carry out their mission. Techniques like "dumb jamming" are useful for taking a RADAR installation out of commission, but more sophisticated electronic warfare attacks can make the enemy think their RADAR is still working when it is actually reporting incorrect target range and velocity information. This paper reviews a particular technique of that variety called digital radio frequency memory (DRFM) and discusses available systems that use it, its operating principals, and methods for implementation.

## Available DRFM Modules

Since DRFM modules use bleeding edge techniques, the kinds of modules available and their functions are often classified. However, there are at least two modules that have public details. The first is offered by a British company called Herley and operates from 6-18 GHz. It has a bandwidth of 400 MHz, a built in Doppler modulator, and can be used as flight hardware or by itself as part of a hardware-in-the-loop simulator [1]. It is easily controlled using a standard interface to a computer, and is rack mountable. The output power is 0 dBm, so it requires an external amplifier and antenna.

A second module that has public information available is made by an American company called Kor Electronics. It has 1 GHz bandwidth and built in real time Doppler, amplitude, phase, and multi-scatter simulation [2]. Kor lets the customer define the range of frequency operation, but it can be as low as 20 MHz or as high as 18 GHz. No public information is available on the exact cost of either the Herley or Kor modules, but according to the Department of Defense, costs for such modules can range from $150,000 to $700,000 per system depending on capability [3]. The mean time to fail of such systems is greater than 500 hours, and all systems cover at least the 7-11 GHz band. Higher end systems cover the 2-18 GHz band.

## Technology of DRFM

The principals behind DRFM take advantage of the assumptions a RADAR system makes when identifying a target. The first assumption a RADAR makes is that the only possible reasons for a shift in frequency, phase, amplitude, or polarization is due to a reflection off of a material with a very different permittivity than air [4]. DRFM defeats this assumption by artificially shifting any or all of those physical wave properties and sending them back to the RADAR [5]. This causes the RADAR to make incorrect deductions about the material, velocity, and range of what it thinks are reflections off of a surface. Another assumption that RADAR makes is that electronic countermeasures used against it will not be able to keep up with the sliding time slot that it samples in and that the countermeasure won't be able to find the RADAR's frequency precisely enough. This was true before 1999, when DRFM systems first came into use [6]. With the proliferation of high dynamic range ADCs, fast FPGAs, and more efficient processors, it is now possible to very quickly and effectively find a RADARs frequency and keep up with its sampling rate [7].

**Implementation Methods**

RADAR pulses are often very high frequency, so it's important to have an extremely fast sampling and processing abilities. All RFDM modules have fast ADCs with high dynamic range which feed directly into a large, fast FPGA like a Virtex-5 [2]. To actually receive and retransmit the RADAR signal, an RF frontend is necessary. A typical RF frontend will contain an antenna, filter or filter bank, amplifier, and if the design is superheterodyne, a mixer and LO [8]. DRFM for more advanced RADARs that use techniques like pulse compression involves detecting any additional modulation imparted to the incident waveform and accurately recreating it using Direct Digital Synthesis (DDS) in real time [9]. Handling advanced RADAR signals like pulse compression is active area of research, almost all of which is classified.

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