Doppler Generation for Moving Target Testing

Flight testing, without the flight costs.

The development, qualification, and testing of Radar systems is an important challenge for test system designers. Testing can include simulators, modelling software, and field tesing. Each of these techniques must deal with and present a variety of signals found in the real-world environment including main and secondary target returns, sea and ground clutter, multipath, jamming, interference, electromagnetic noise, and stationary and moving targets.

Each testing approach has advantages, and while field testing is the most compelling it has some serious draw-backs. Field testing is expensive, time consuming, often requires regulatory approval, and does not always provide an opportunity for troubleshooting problems and performing system optimization. Field testing can require the coordination of a variety of costly assets and platforms including aircraft, ships, and vehicles, the logistics of which can delay projects for long periods. This coordination presents safety hazards (both physical and radiation hazards) along with environmental and financial costs due to fuel expenditures. Simulations and modeling software are excellent tools, but they cannot in all cases provide accurate results, particularly for the development of new radar systems. This is true because the simulator design must be developed to operate with the radar system under test. This requires some understanding of the new system operation which is neither practical nor desirable.

Figure 1. Doppler Generator

An alternate approach to the testing problem is to re-create the actual environment in which the radar system must operate. This re-creation, or Channel Environment Replicator (CER), must include all of the above features

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and accept any radar system characteristic variation including operating frequency, frequency agility, pulsed or CW, encryption, and power level. CER systems should include the propagation delay and loss associated with a desired target along with multiple target reflections. It should also include the radar target cross-section and target velocity, if any. For a moving target the CER must vary the target position (distance from the radar to the target) and produce the frequency shift (Doppler Frequency) associated with the target velocity (See Figure 1).

The Doppler frequency F_d of a target moving at velocity v is given by:

$F_d \approx 2\, v/\lambda$ where λ is the radar operating wavelength.

The target velocity relative to the radar system source depends on the speed and direction of the target. The three possible target velocitiy vectors are shown in Figures 2 – 4.

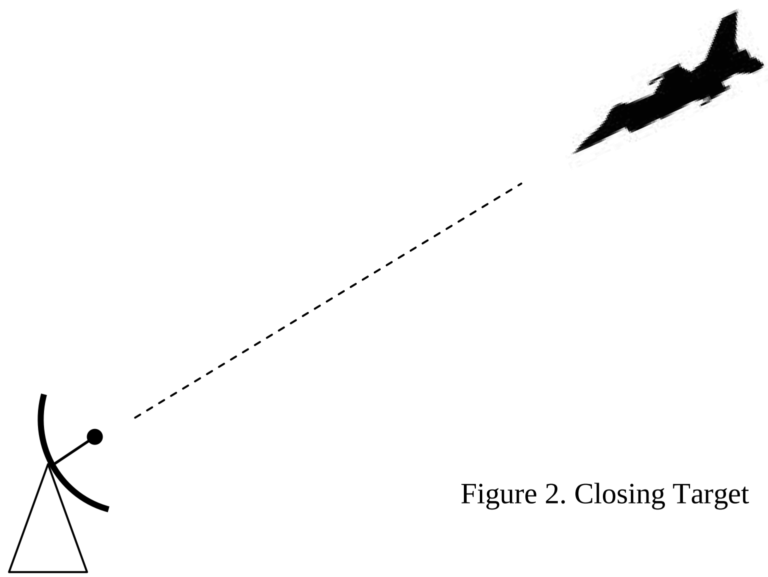

Figure 2. Closing Target

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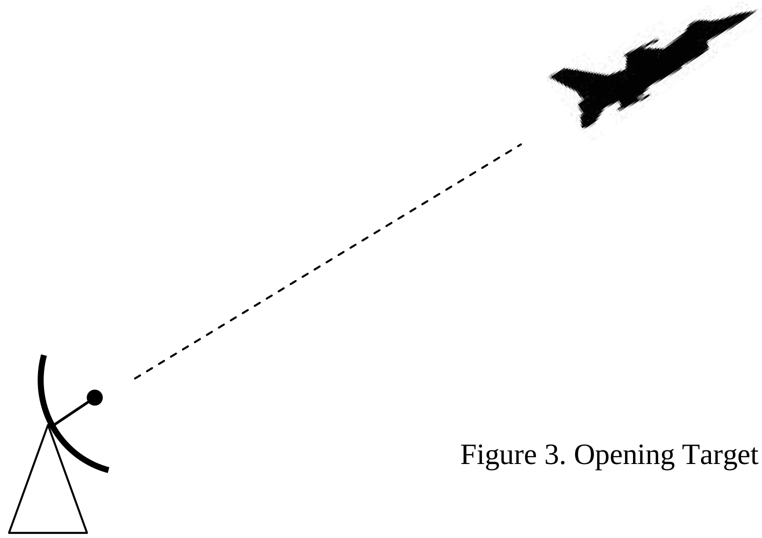


Figure 3. Opening Target

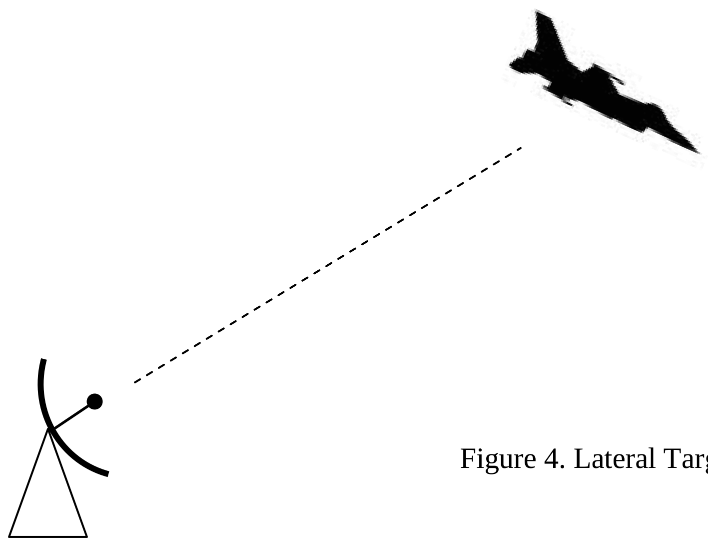


Figure 4. Lateral Target

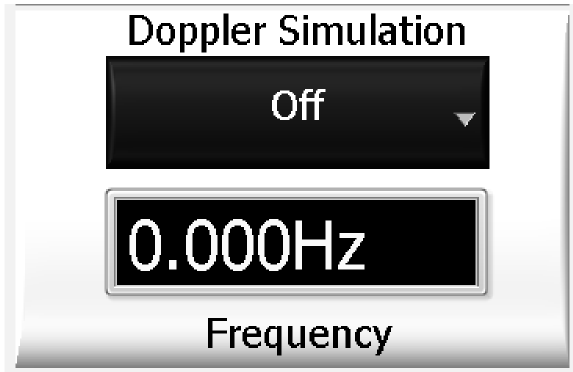
An effective method for reproducing the target propagation delay and loss is an optical fiber CER. This CER system can vary both the target distance and the signal level for a given radar cross-section. It can also create multiple signal paths to replicate clutter and multi-path. The final component of the CER is the Doppler frequency generation associated with the target velocity. A signal modulator is a relatively broad-band approach to Doppler generation. While these systems normally operate over octave bandwidths they may be extended with only minor performance degradation.

Figure 1 shows a version of a moving target generator which covers radar frequencies from 1 – 18 GHz. These compact systems provide target generation with Doppler frequencies from 0 to ±12 kHz, and allows the user to set target and radar target speeds and directions including opening, closing, and lateral motion. Systems may be operated remotely using wireless control with scenario generator features including flight path replication, moving source and targets, and multiple target options. Data may be entered in multiple formats including target and radar speed and direction, start-stop LONG-LAT and speeds, and directly with pre-programmed map placements. All Eastern OptX Series 5000 Doppler Generators may be used together with the Eastern OptX Series 3000 CER delay lines to create both Doppler and step-wise target and source movements along with propagation loss associated with a given radar cross-section. This combination creates a complete moving target replication.

Typical Doppler Generator Specifications and User Interface

Parameter	Specification	Notes
Doppler Range	0 to 12000 Hz	Other ranges available
Slew Rate	100 ms	Jump time to any freq.
Typical RF Loss	12 dB	
Input Return Loss	15 dB	Minimum
Target Direction	Opening, Closing, and Lateral	Programmable
1 dB Input Compression	-15 dBm	Minimum
Noise Figure	12 dB Typical	Lower NF optional
Step Size	0.5 Hz	Depending on max freq.
RF Connector	SMA (Jack)	Other Types Available
Dimensions	3” x 12” x 14”	
Control	MS Surface	Supplied with system (USB PC control capable)
Modes	Synchronous, free running, phase inverting	External trigger required

Part Number	Primary Band (GHz) (35 dB typical side-band suppression)	Broad Band (GHz) (20 dB typical side-band suppression)
5000-1	1 to 2	0.5 to 2.5
5000-2	2 to 4	1.5 to 5
5000-3	4 to 8	3 to 10
5000-4	8 to 12	6 to 14
5000-5	12 to 18	6 to 19
5000-7	Use defined center frequency	



Typical Control Software

In conclusion, Doppler Generators are an important component in the CER system which, together with target distance and cross-section, can create real-world radar testing in the laboratory. The CER represents a considerable reduction in cost, schedule time, and environmental problems associated with radar field testing. It also eliminates the need for regulatory approval to radiate, the risk of radiation safety hazards, and security concerns associated with the transmission of sensitive signal profiles. The CER provides a laboratory test environment for radar system development, troubleshooting, optimization, and improvement.