Application Note

Dynamic Frequency Selection Radar Simulator and Analyzer Test Suite

This application note describes how to use the Aeroflex DFS Radar Simulator and Analyzer test suite in conjunction with Aeroflex PXI 3000 series RF modular instruments.

Scope

This application note assumes the DFS test system is already fully configured.

For information relating to Aeroflex 3000 series PXI hardware and software installation refer to ref 1 and 2 which are supplied with PXI hardware (CDROM 46886/028)

See also the relevant installation instructions and minimum PC requirements for the Aeroflex DFS Radar Simulator and Response Analyzer software which is supplied on CDROM 46885/055 or ref 4.

The DFS application deals with requirements for products entering the US market as defined by FCC requirements ref 3.

References

1) "Common Installation Guide" part number 46892/663*
2) "Common installation guide for chassis", part number 46892/667*
3) DFS standard MO&O FCC 06-96
4) "DFS data sheet" part number 46891/334*

* available from http://www.aeroflex.com/pxi

Background

Commercial devices operating in or near the UNII frequency band (5-6 GHz) must be compliant with DFS requirements to ensure they do not interfere with operating radar systems. The DFS standard (ref 3) defines a series of radar simulations, against which commercial devices must be validated to ensure proper systematic radar avoidance. Many of DFS test waveforms demand complex sequences requiring specialized test equipment, as well as specialized analysis tools to verify the device under test responds appropriately. All this is facilitated by utilizing the unique features of the Aeroflex DFS application and the 3000 series PXI modular RF instruments.

In an actual DFS product test, the EUT may be tested in either a radiated or conducted environment. Both the master devices (e.g. 802.11A access point) and the client devices (e.g. laptop 802.11A wireless interface) must be tested. Setups for a typical conducted test can be seen below in figures 1 and 2.

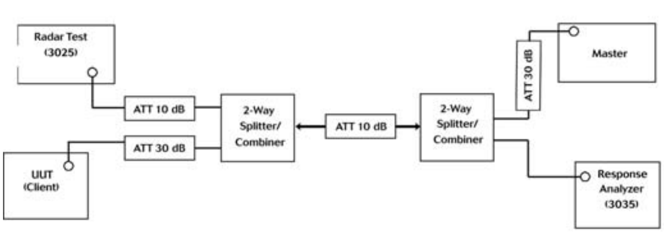

Figure 1: Example Conducted setup where UUT is a client and Radar Test Waveforms are injected into the master

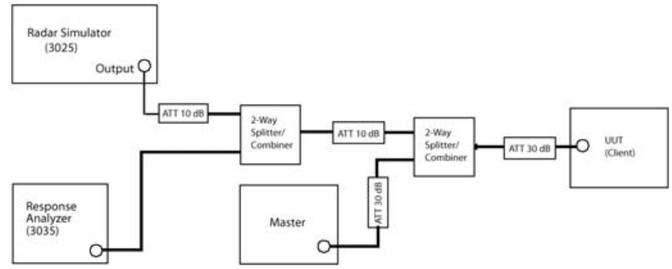

Figure 2: Example Conducted setup where UUT is a client and Radar Test Waveforms are injected into the client

Typical radiated test setups for master and client devices can be seen below in figures 3 and 4.

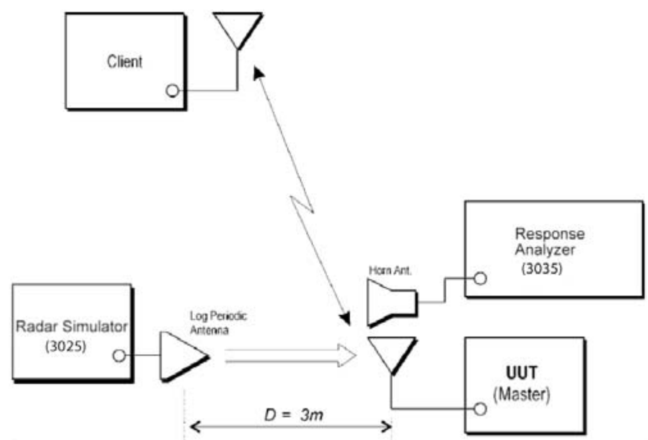

Figure 3: Example Radiated setup where UUT is a master and Radar Test Waveforms are injected into the master

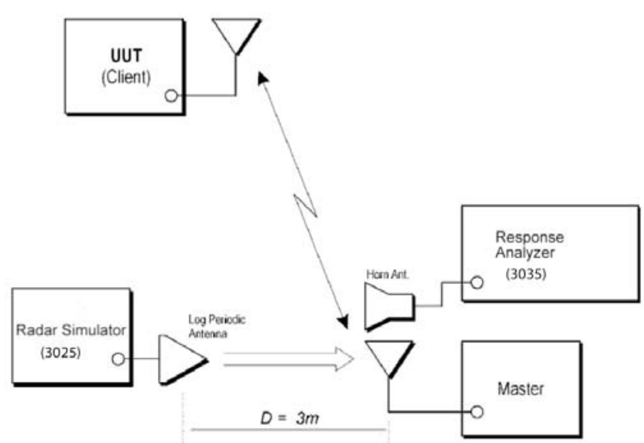

Figure 4: Example Radiated setup where UUT is a client and Radar Test Waveforms are injected into the master

Appropriate responses depend on whether the EUT is a master, a client, or an assisting client and are defined in the standard.

Generating Waveforms

Simulation of all DFS waveform types is supported within the DFS application.

FCC DFS standard FCC 06-96 identifies six radar simulation "types", consisting of three basic categories of radar waveform simulations. It is presumed that each of these waveforms must appear at the EUT frequency of operation (at least once in the case of the type 6 radar waveform), so it is incumbent on the operator to ensure this happens properly.

a) Short Pulse Radar Test Waveform – The short pulse radar simulation is essentially a conventional amplitude pulse with varying pulse widths, pulse rate intervals, and number of pulses. General characteristics for these types and number of repetitions required by the standard are as follows:

Radar Type	Pulse Width (μsec)	PRI (μsec)	Number of Pulses	Minimum Number of Trials
1	1	1428	18	30 (single waveform)
2	1-5	150-230	23-29	30
3	6-10	200-500	16-18	30
4	11-20	200-500	12-16	30

Table 1 Short Pulse Radar Test Waveforms

Type 1 is the only radar simulation that reuses the same waveform all 30 times, all the rest are required to be unique.

b) Long Pulse Radar Test Waveform – The long pulse radar simulation is actually a 12 second concatenated series of chirps, randomly chosen as per FCC 06-96. The general characteristics for types 5 and number of repetitions required by the standard are as follows:

Number of Bursts	Number of Pulses per Burst	Pulse Width (μsec)	Chirp Width (MHz)	PRI (μsec)	Minimum Number of Trials
8-20	1-3	50-100	5-20	1000-2000	30

Table 2 Long Pulse Radar Test Waveforms

c) Frequency Hopping Test Waveform – The frequency hopping radar simulation emits 9 conventional 1 μs amplitude pulses with a 333 μs spacing on a randomly chosen frequency, hops to another randomly chosen frequency, emits another 9 pulses and then continues this sequence for 100 different frequencies chosen using a pseudo random sequence defined by FCC 06-96. General characteristics for type 6 and number of repetitions required by the standard are as follows:

Pulse Width (μsec)	PRI (μsec)	Pulses per Hop	Hopping Rate (kHz)	Hopping Sequence Length (msec)	Minimum Number of Trials
1	333	9	0.333	300	30

Table 3 Frequency Hopping Radar Test Waveforms

The DFS Radar Simulator and Response Analyzer application manages creation of these waveforms by allowing the user to create a "project". The application creates a folder by that name and then creates subfolders identifying each waveform type. analysis results from the application are then dumped into these same folders. In this way, all programmatically generated waveforms and analysis files for a given project are stored in a common project folder under their appropriate waveform folders for referral or re-use at a future date, facilitating the documentation process. The application will generate each new waveform (with the exception of type 1) using appropriately randomized values within the defined limits, as required by the standard.

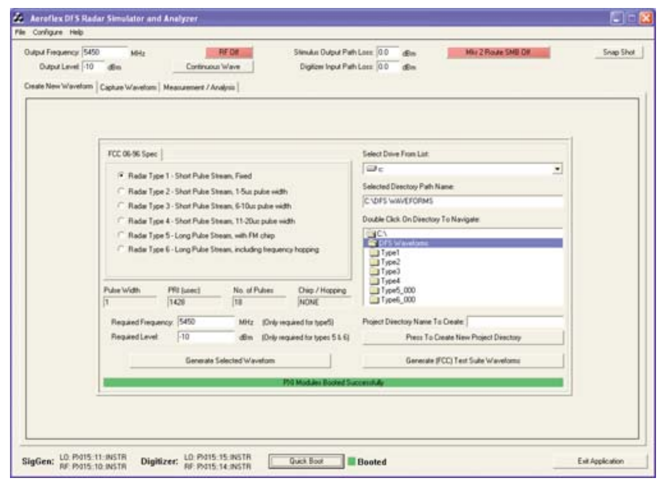

Figure 5 – DFS application screen shot 'Creating a project directory'

To set up the application, first create a project directory (the example in figure 5 above shows the project directory "DFS TEST-WRK"). Next select the radar signature type using the radio selection buttons. If type 5 or 6 are used, level and frequency parameters are also required. Alternatively, one can use "Generate (FCC) Test Suite Waveforms", which will generate the minimum number of waveforms required by the standard for an entire test battery (see tables 1 to 3 for individual quantities or refer to the standard). Once generated, the waveforms can be viewed and selected for play by navigating to the appropriate sub directory in the "Capture Waveform" tab (explained below).

The *Play* function on the "Capture" tab will play the radar simulation waveform without any associated response capture and analysis. This is the primary mode of use for the application, as EUT response analysis measurements are required in only a few test cases, whereas, the majority of the waveforms identified above are only played, allowing the compliance engineer to build a statistical response record required by the standard to determine whether the EUT has a sufficient probability of recognition of the defined radar signature simulations.

Analyzing EUT Responses

The EUT, whether it is a master or client device is tested under two condition states: (a) when initiating a net, and (b) while actively supporting a net.

I. Initiating a Net - Channel Availability Check

Before the EUT can start transmitting, such as when it is first powered up; masters, clients and assisting clients must all monitor the channel for a minimum of 60 seconds before commencing transmission to verify that no radar traffic is observed. If a radar signature is observed, the EUT is then not permitted to transmit for a minimum of 30 minutes in order to assure non-interference with local operating radar.

a) Channel availability check, no radar - the 60 second test is designed to verify the EUT makes no attempt to transmit on frequency during it's required 60 second channel availability check, as it looks for possible radar signatures following power up. In the channel availability 60 second test, the user sets a power threshold level used by the RF digitizer (response analyzer) as a trigger condition. If the detected power exceeds the user defined threshold, the DFS Radar Simulator and Response Analyzer application will capture a time record of EUT transmission output and time stamp the event. If the trigger condition occurs within the first 60 seconds, the software reports a fail condition. The software will report a pass condition with a time stamp in the event of no trigger or if the trigger condition is met between 60 seconds and 150 seconds.

b) Radar at the beginning of the channel availability check - the EUT must also be tested in the presence of a radar signature introduced 10 seconds into its channel availability check. This test verifies that if the EUT observes a radar signature, it will inhibit transmission on that channel for a minimum of 30 minutes. Thus the channel availability 30 minute (beginning) test is similar to the channel availability 60 second test in that the test is initiated manually and the user sets a level threshold. However, once the radar signature is fired, the channel availability 30 minute (beginning) test must verify the EUT makes no attempt to transmit for a minimum of 30 minutes.

Alternatively, channel availability tests could be conducted manually using PXI Studio to play radar signature waveforms on the signal generator in a single shot mode.

c) Radar at the End of the channel availability check - As (b) above but with the EUT receiving a radar signature introduced 50 seconds into its channel availability check.

II. After a Net is Established - Channel Closing Time, Channel Move Time, and Non-occupancy Tests.

In the second case, where a net has been established and active data exchange is in progress, masters and assisting clients must continue observation of the channel for the appearance of radar signatures and vacate the channel if a valid radar signature is seen. The EUT must then not transmit on that channel for a minimum of 30 minutes. This dynamic frequency selection capability must be verified with actual plots for all six radar signature types. The channel closing time/channel move time requirements are validated in one test and the 30 minute non-occupancy requirement is performed separately.

a) Channel closing time/channel move time - The play & capture manual and play & capture auto tests are designed for channel closing time and channel move time verification. (See figure 2, the play provides a waveform play-only function for use when the capture feature is not required). Recommended settings for Types 1 to 4 and Type 6 verification plots are 12 second captures, sampled at 5 M samples/sec. The recommended settings for the Type 5 capture are 24 seconds at a 2.5 M sample/sec rate.

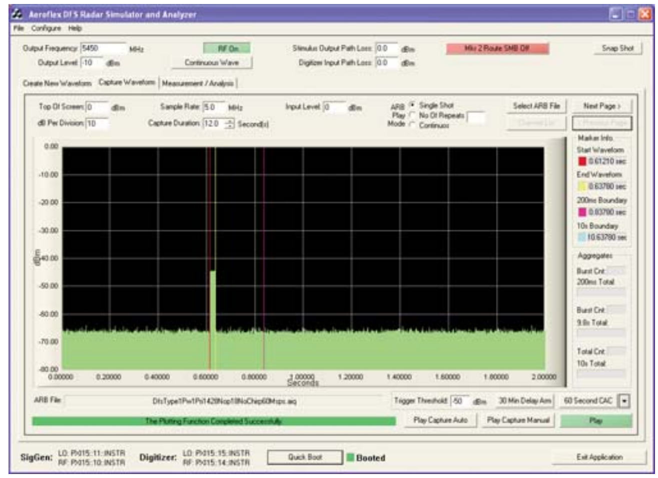

Figure 6 Example of Channel Closing Time measurement – display shows waveform start (red marker), the end of waveform (yellow marker), and the 200 ms boundary (purple marker). The 10 second boundary would be seen on a subsequent page. All marker aggregate measurements are shown at the right.

When an active UNII band system such as a 802.11A net detects a valid radar signal it is permitted to continue transmission for up to 200 ms. During the following 9.8 seconds, however, it is only permitted to transmit for an aggregate total of 60 ms. All these various responses must actually be measured in order to validate channel closing time and channel move time. Once the 10 second boundary is passed, however, no further transmissions are allowed for a minimum of 30 minutes - another feature which must also be validated. Thus, for the play & capture manual and play & capture auto tests, no transmission is acceptable after 10 seconds, but, in the typical Types 1-4 and Type 6 captures, only 12 seconds is captured. Therefore, the remaining 30 minute component (specifically 29 minutes, 50 seconds) required to validate the non-occupancy feature is tested using the 30 minute test. Markers on the play & capture manual and play & capture auto plots, then, identify the beginning of arbitrary waveform play, the end of the waveform (which is when timing starts as far as the standard is concerned), the 200 ms boundary, and the 10 second boundary (9.8 seconds after the 200 ms boundary).

Once a buffer of data has been captured, the user can select the measurement/analysis tab, select the desired level threshold and execute a post process that examines the acquired buffer, adding up aggregate transmissions for the 200 ms period, the 9.8 second period, and the 10 second total of both. These values are then ported back on to the capture waveform tab results.

Finally, the play & capture auto test automatically performs the capture function, executes the aggregate measurement post processing function, and generates a complete set of adobe acrobat plots stored into the same folder as the waveform that was played to acquire the data, using a name identifying what waveform was played and unique (number) identifier for each plot. Additionally, it captures a .TXT file using the same naming convention, containing all the aggregate measurements. This fully integrated feature enables the user to fully document the EUT's response with the push of a button.

b) Non-occupancy testing - The 30 minute non-occupancy response component is performed using the 30 minute non-occupancy test, which fires the selected waveform then waits 10 seconds before arming the user defined power level detection trigger. The 10 second delay allows for channel closing and channel move time to complete.

Conclusions

The Aeroflex DFS Radar Simulator and Analyzer Test Suite provides a complete stimulus and analysis DFS verification tool. channel availability checks, channel move time, channel closing time, and non-occupancy can all be validated using this unified test solution. The application directly facilitates the documentation process required by the FCC, making the DFS verification process orders of magnitude less complicated for both the pre-conformance engineer and the validation test house.

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Part No. 46891/990, Issue 1, 04/10