Proposed New Radar Waveform Bin 1 DFS Certification Protocol[1]

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March 9, 2010

This white paper describes the waveform characteristics and pass/fail criteria for the Bin 1 waveform Federal Communications Commission test certification procedures for Unlicensed National Information Infrastructure (U-NII) devices operating in the 5250-5350 MHz and 5470-5725 MHz bands. These devices must be equipped with Dynamic Frequency Selection (DFS) so that radars such as the Federal Aviation Administration (FAA) Terminal Doppler Weather Radar (TDWR) system operating in the 5600-5650 MHz portion of the band are protected against interference.

NTIA has received documentation from the FAA describing anticipated future TDWR pulse-emission characteristics, as well as current TDWR pulse characteristics. Based on this documentation, future TDWR pulse widths and modulations will remain unchanged from their current values (i.e., 1.1 μs pulse width and pulse modulation). Pulse repetition interval (PRI) values of TDWR emissions will be constant within each burst of pulses.[2]

The existing DFS certification protocol for radar waveform Bin 1 requires that a minimum of 30 trials be performed on 30 bursts of pulses, with one trial per burst and each burst consisting of a series of 18 pulses with a single, fixed PRI from each pulse to the next. The pass/fail criteria for the current DFS certification tests require a minimum of not less than 60 percent successful detections of test radar pulses by the DFS device under test (DUT) in any single radar waveform-bin category (including Bin 1), and not less than 80 percent successful detections when test results are averaged across four of the six radar waveform test bins (Bins 1-4).

NTIA proposes that the new Bin 1 protocol should still be a total of a minimum of 30 trials, and that the pass/fail criteria should remain unchanged from the current protocol of a minimum of 60 percent for Bin 1, and that the average of Bins 1 through 4 remain at 80 percent. However, under this proposal the current series of a minimum of 30 bursts of fixed-PRI pulses for Bin 1 would be replaced by a set of waveforms as described in Table 1. Pulse widths used for Bin 1 testing will all be 1 μs, and the PRI within each burst will continue to be constant. Consistent with the current DFS test waveforms the new test waveforms would apply across the 5250-5350 MHz and 5470-5725 MHz bands.

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1. The existing Bin 1 waveform will be used for the channel availability and detection bandwidth tests called for in the U-NII DFS device certification.

2. The current radar waveform Bin 1 DFS certification protocol has one PRI, which does not vary across the current range of TDWR PRI values.

Table 1. Proposed Modified Radar Waveform Bin 1 Certification Tests Protocol for DFS Certification.

Test Name	Description	Pulse Repetition Interval (PRI)	Number of Pulses Per Burst	Total Number of Trials
Test A	From the list of 23 PRI values in Appendix A, 15 unique PRI values will be selected randomly for 15 DFS certification trials (bursts of pulses). The PRI will be constant within each burst.	15 unique PRI values randomly selected from the list of 23 PRI values	Determined by the TDWR antenna 10-dB beamwidth and antenna rotation rate, using Equation 1.	15
Test B	15 trials will be performed using unique PRI values that will be randomly selected from within the PRI range of 518-3066 µs. The PRI will be constant within each burst.	15 unique PRI values randomly selected within the range of 518-3066 µs, with a minimum increment of 1 µs.	Determined by the TDWR antenna 10-dB beamwidth and antenna rotation rate, using Equation 1.	15

For Test B, after a PRI has been selected and used for a trial, its use will not be repeated. For example, if the PRI of 3066 (Table A-1) has been randomly selected and used for a trial, it will be unavailable for any more trials. This exclusion applies to any of the 15 PRI values that have already been used in Test A. Since Test A will use 15 different PRI values, the total pool of PRI values available for Test B will be ((3066-518) – 15) = 2533.

Following current practice, DFS certification testing labs will be allowed to perform more than 30 trials in order to obtain better statistics on DFS radar-detection performance. If more than 30 trials are performed, the additional waveforms will be generated using the methodology of Test B.

For 5 GHz DFS-equipped devices that operate in either the 5250-5350 MHz and 5470-5725 MHz bands, these updated Bin 1compliance tests will be required. Test frequencies may be selected at random in either of the 5250-5350 MHz and 5470-5725 MHz bands. The burst lengths (number of pulses per burst) will be computed as follows:

$$N_{burst} = \left[\left(\frac{\theta_{10dB}}{360} \right) \cdot \left(\frac{\tau \cdot 10^6}{pri} \right) \right] \qquad \text{Equation 1}$$

where:

N_{burst} = number of radar pulses in a DFS certification-trial burst;
θ_{10dB} = 10-dB beamwidth of the TDWR antenna (degrees); (θ_{10dB} = 1 degree);
τ = rotation time of the TDWR antenna (seconds); (τ = 19 seconds);
pri = pulse repetition interval of TDWR pulses (microsecond);

The number of pulses computed using Equation 1 will rounded up to the nearest integer.

Example. Since the effective 10-dB beamwidth of the TDWR antenna is 1 degree, with a rotation rate of 19 seconds, Equation 1 gives the following result for this set of parameters, when the PRI value is 3066 µs:

$$N_{burst} = \left[\left(\frac{1}{360} \right) \cdot \left(\frac{19 \cdot 10^{6}}{3066} \right) \right] = 17.2 \, pulses$$

In the proposed implementation, the number of pulses will always be rounded up to the next integer. In this example, the actual number of pulses used in this burst, with this PRI, would therefore be 18. Because 3066 is the longest PRI in Table A-1, it generates the smallest number of pulses per burst that will be used in a Bin 1 DFS certification waveform. With the shortest possible PRI value of 518 µs, the largest possible number of pulses per burst is 101.9, which will be rounded up to 102.

Appendix A

Table A-1. Pulse Repetition Intervals Values for Test A

Pulse Repetition Frequency Number	Pulse Repetition Frequency (Pulses Per Second)	Pulse Repetition Interval (Microseconds)
1	1930.5	518
2	1858.7	538
3	1792.1	558
4	1730.1	578
5	1672.2	598
6	1618.1	618
7	1567.4	638
8	1519.8	658
9	1474.9	678
10	1432.7	698
11	1392.8	718
12	1355.0	738
13	1319.3	758
14	1285.3	778
15	1253.1	798
16	1222.5	818
17	1193.3	838
18	1165.6	858
19	1139.0	878
20	1113.6	898
21	1089.3	918
22	1066.1	938
23	326.2	3066