Dynamic Frequency Selection

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Axxcelera Broadband Wireless
1600 E. Parham Rd.
Richmond, VA 23228

support@axxcelera.com
www.axxcelera.com

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1 CHANGE HISTORY

REVISION	DATE	EDITOR	DESCRIPTION
0.1	25-Jan 2008	Jseger	First Draft
0.2	8-Jan 2010	Jseger	Second Draft
0.3	14-Jan 2010	TMasters	Issue for Release

2 INTRODUCTION

The purpose of this document is to explain the purpose and the mechanisms for Dynamic Frequency Selection (DFS) as it relates to the Axxcelera Broadband Wireless family of wireless communication devices.

As the proliferation of wireless devices increases, the need to share radio spectrum with other radio systems becomes a paramount concern. Regulatory bodies have begun to require DFS operation in select frequency bands to make the spectrum available to Wireless Wide Area Network (WWAN) operators while minimizing interference to incumbent radio systems, primarily Radio Detection and Ranging (radar) systems. The mechanism required to detect and avoid frequency channels used by radar systems is called Dynamic Frequency Selection.

The main purpose of DFS is to assure WWAN systems do not interfere with radar systems. Specifically in the United States, the mid-U-NII band (5250-5350 MHz) and the worldwide-U-NII band (5470-5725MHz) bands are required to employ a DFS mechanism to serve this purpose. The requirements can vary widely based on the country of operation and Regulatory Body with jurisdiction over the deployment area. Consult your local Regulatory Authority to obtain the regulations relevant to your area prior to deployment.

3 History of DFS

In May of 2003, the Federal Communications Commission (FCC) issued a Notice of Proposed Rulemaking (NPRM FCC 03-110) that made it a requirement of operating in the mid-U-NII and worldwide-U-NII bands that all equipment would employ DFS and Transmit Power Control (TPC). This proposed rule did not specify the testing requirements for equipment capable of operating in these frequencies. Subsequent to NPRM FCC 03-110, the FCC released Memorandum and Order 06-96 in June 2006, which formally opened the worldwide-U-NII band for operation and set forth DFS test parameters by which all equipment would be evaluated for approval for WWAN use.

The FCC rules are recorded in 47 CFR Part 15, subpart E (15.407) – Unlicensed National Information Infrastructure Devices (http://edocket.access.gpo.gov/cfr_2008/octqtr/pdf/47cfr15.407.pdf).

3.1 Channel Assignments

The IEEE has defined a channelization plan for the 5GHz unlicensed bands according to the following formula:

$f_c = 5000\text{MHz} + (5 * \text{channel number})$

This channelization plan is widely used and forms the basis for channel assignment within DFS operation. Table 1 illustrates an example channelization definition employing a 10 MHz channel bandwidth operating in the worldwide-U-NII band.

Table 1 - Example channelization plan for 10 MHz channel in the 5470-5725 MHz band

Channel Number	Frequency (MHz)
99	5490-5500
101	5500-5510
103	5510-5520
105	5520-5530
107	5530-5540
109	5540-5550
111	5550-5560
113	5560-5570
115	5570-5580
117	5580-5590
119	5590-5600
121	5600-5610
123	5610-5620
125	5620-5630
127	5630-5640
129	5640-5650
131	5650-5660
133	5660-5670

Channel Number	Frequency (MHz)
135	5670-5680
137	5680-5690
139	5690-5700
141	5700-5710

3.2 Types of Radar

As stated previously, the main objective of DFS is to provide some level of assurance that WWANs do not interfere with other radio systems, specifically radar that operate in the same RF spectrum as outlined above. In general terms, there are three types of radars that were considered when the FCC issued FCC 06-96. These radars are discussed below.

3.2.1 Civilian and Maritime Radars

Civilian navigation and maritime radars are typically used by ships and as such, are primarily encountered near waterways. They are used for collision avoidance and to track and guide ships. Occasionally, private companies and TV weather stations use these for tracking storms. In general, these are short to medium range radars that have power levels in the range of 10-50 kW. Pulse patterns associated with civilian and maritime radars are generally straightforward with a PRF from 800-4000 pulses per second with rotation speeds of 10 rotations per minute.

3.2.2 Weather Radars

Weather radars are used to locate precipitation, track storm motion, give an idea of the type of precipitation generated by a storm and to forecast weather in general. These radars are common and generally are present throughout the world. The most common type used today is the Doppler Radar. Pulse patterns employed by weather radars are generally variable depending on the type of radar used. Typical pulse patterns are fixed PRF, single pulse based PRF and packet based staggered PRF. Typical PRF ranges from 250 Hz to 1200 Hz. Conducted power levels can range from 100 to 230 kW with antenna gains up to 45 dBi. Rotation speeds are generally in the range of 1 to 6 rotation per minute.

3.2.3 Military Radars

In general terms, little of the technical details of military radars are commonly known due to national security considerations and are classified. Military radars utilize many of the aspects of both Marine/Maritime and weather radars but also employ more complex techniques. Their detection and avoidance remains the same as other types of radars.

4 DFS Operation and Requirements

4.1 Channel State Operation

The requirements for how DFS shall operate in FCC jurisdictions are clearly defined by the FCC under 15.407 of the CFR. In the most general terms, there are 5 "states" in which channels exist in a DFS enabled frequency band. Every channel configured on a WWAN device exists in one of these 5 states when DFS is enabled.

The state transition diagram for each configured channel is indicated in Figure 1.

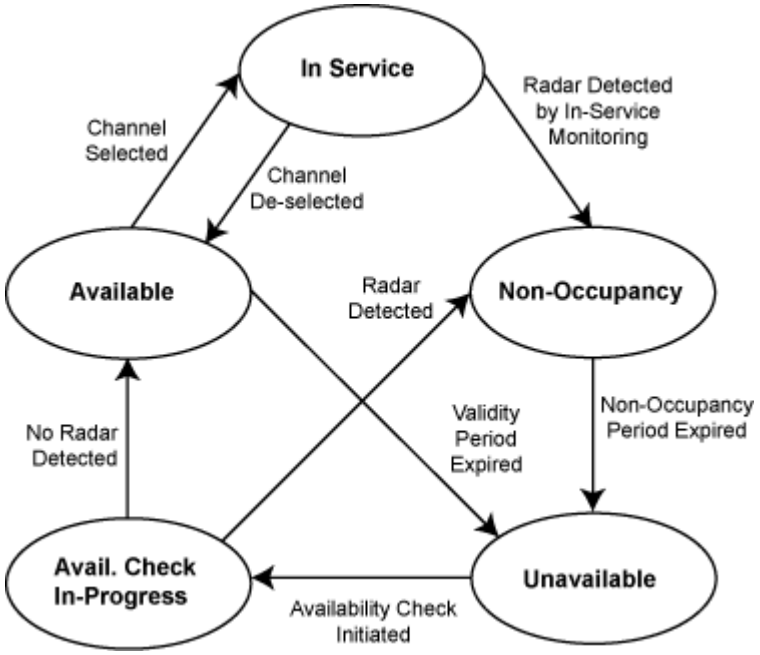

Figure 1 - DFS channel state transition diagram

The logic and timing controlling the state transition behaviour is defined by the FCC and the operator is not allowed to change this behaviour. Software operating in the AP controls the DFS behaviour based on the country selected. It is the operator's responsibility to ensure that the country identified in the AP matches the actual deployment site.

4.1.1 Channel Unavailable

Every channel in a DFS enabled frequency is considered unavailable until a Channel Availability Check (CAC) is performed on it. Prior to placing a channel in to service, it must be scanned for the presence of radar with this CAC. The WWAN system must perform a CAC on all channels to be placed in to service for each sector of WWAN operation.

4.1.2 Availability Check In-Progress

During the CAC process, each channel is listed in this category. During this CAC dwell time, the frequency is "scanned" for the presence of radar. The CAC dwell time is defined by the Regulatory Authority. Per the FCC guidelines at the time of this document, that time is 60 seconds. Channels in this status category only reside here until the dwell time of the CAC expires.

4.1.3 Available

Once the CAC completes and if there is no radar present (detected), the channel is “tagged” as ‘available’. CACs are only valid for a 24-hour period. When the 24 hour validity period expires, the channel status is changed to Unavailable. If this channel is to be placed in service, another CAC will be required. A channel in the "Available" category is available to be placed in service.

4.1.4 In-Service

Following the CAC when there is no radar present, the operator can select a channel for operation of the WWAN sector. An active channel is considered in service and the base station (Access Point) and all Subscriber Station devices communicate on this channel. The FCC requires that In-Service Monitoring be performed while the channel is in service in the event radar operates sporadically in that given frequency. In-Service Monitoring is performed by the Base Station or Access Point. If no radar is detected, the WWAN continues to operate on that channel. If radar is detected, the channel is moved to the Non-Occupancy status category and the channel of the WWAN system is changed to another available channel from the pool for that sector. This change must occur within 120 ms per FCC guidelines.

4.1.5 Non-Occupancy

If radar is present during the CAC or if it is detected during in-service monitoring, the channel is placed in a “hold” status and cannot be used for a period of 30 minutes. This 30-minute hold time is referred to as the Non-Occupancy Period. When the Non-Occupancy Period expires, the channel is placed back in the unavailable status category and the CAC process begins again.

4.2 Transmit Power Control (TPC)

The FCC stated that “U-NII devices operating in the 5.25-5.35 GHz band and the 5.47-5.725 GHz band shall employ a TPC mechanism. The U-NII device is required to have the capability to operate at least 6 dB below the mean EIRP value of 30 dBm. A TPC mechanism is not required for systems with an EIRP of less than 500 mW.” All Axxcelera equipment designed to operate in these bands employs TPC in accordance with FCC Guidelines.

5 Conclusion

The FCC has mandated DFS as a requirement of operating in the 5.25-5.35 GHz and 5.47-5.725 GHz bands of the RF Spectrum. There is an opportunity for WWAN operators to utilize this spectrum provided their system conform to the FCC guidelines set forth in 47 CFR Part 15, subpart E (15.407). Axxcelera equipment provides WWAN operators with the option of utilizing spectrum which has historically been reserved for radar usage.