

REPORT ITU-R M.2034*

Impact of radar detection requirements of dynamic frequency selection on 5 GHz wireless access system receivers

(2003)

1 Introduction

Recommendation ITU-R M.1652 recommends that, in order to facilitate sharing with radars, mitigation techniques be implemented by wireless access systems including radio local area networks (RLANs) (WAS) in the bands used by radars at 5 GHz. It describes a mitigation technique, named dynamic frequency selection (DFS), which requires a radar detection mechanism to be implemented. In addition, the Recommendation also gives the detection and response requirements with which the DFS should comply with.

This Report considers how radars operating in the 5 GHz band can be detected by WAS without extreme constraints on the RF front-end design or on the system capacity of the WAS.

Radar detection may only be possible during the time there is no active transmission in the WAS cell. During channel availability check time, there is no transmission for a significant time (e.g. 60 s). During in-service monitoring the detection can take place during moments of no uplink or downlink traffic.

The detection of a radar pulse of power above the so-called DFS threshold triggers a DFS procedure, and the access point must leave the channel within a short delay. In this Report the interplay of DFS threshold T_{DFS} , WAS false alarm rate and radar detection failure rate by WAS are presented and discussed from the point of view of implementation of radar detection in a WAS receiver.

2 Abbreviations and acronyms

ACT:	(channel) availability check time
DF:	detection failure probability
DFS:	dynamic frequency selection
FA:	false alarm probability
OFDM:	orthogonal frequency division multiplexing
PDF:	probability density function
PRF:	pulse repetition frequency
RLAN:	radio local area network
RSS:	received signal strength
T_{DFS} :	DFS threshold
WAS:	wireless access system

* This Report was jointly prepared by Radiocommunication Study Groups 8 and 9, and any further revision will also be undertaken jointly.

3 Assumptions and methodology

Radar detection by a WAS is characterized by two performance metrics:

3.1 Detection failure probability (DF)

This is the probability that a radar is present in the channel but no radar pulse is detected by the WAS. DF must be as low as possible not to interfere with radars. A value of $DF = 1\%$ is set as a target. The probability of detection varies with the power of the radar signal relative to the detector threshold setting in the receiver – a higher power level increases the detection probability.

3.2 False alarm probability (FA)

This is the probability that when a radar signal is not present in the channel, interference pulses are detected by the WAS, triggering an unnecessary DFS procedure. This can happen when a noise or interference burst is mistaken for a radar pulse. Such a burst may be caused by WAS devices in the vicinity operating on the same channel or on the adjacent RF channels of the WAS system. A high interference/noise floor ratio in the WAS receiver will obviously increase the FA. However, this probability should be low as possible in order not to trigger unnecessary DFS procedures, which would severely limit the WAS capacity especially in dense deployment scenarios. During channel availability check time, it is sufficient to be sure that the channel is not measured as occupied for some small percentage of the time. It will be seen that this percentage is a very sharp function of the WAS DFS threshold setting, with a few dB altering the FA probability by many orders of magnitude.

The WAS performs power measurements averaged over a duration rss_meas_duration , the measurements signal_rss being spaced by the averaging duration. Therefore, during channel availability check time (ACT), for example, the number of measurements performed is:

$$\text{nb_trials} = \text{round}(\text{ACT}/\text{rss_meas_duration})$$

The radar signal is received at a level of radar_pulse_power (dBm), (equivalent to T_{DFS} in the notation of Recommendation ITU-R M.1652) and pulses have a duration of $\text{radar_pulse_duration}$ (ns). The radar signal bandwidth (MHz) is denoted by B . Many radars send pulses periodically, at a pulse repetition frequency (PRF) rate. For a rotating radar, the WAS will periodically receive a burst of pulses, such that the number of pulses occurring during the channel ACT, denoted by $\text{nb_RADAR_pulses_per_ACT}$ will be greater than one. The 5 GHz orthogonal frequency division multiplexing (OFDM) RLANs sampling period used is $T = 50$ ns.

4 Detection criteria

The detection criterion used here is based on absolute signal power measurements. If the measured power exceeds a certain threshold, then a radar is assumed to be detected.

It is assumed that the signal samples are averaged white Gaussian noise. Therefore, a measurement performed during rss_meas_duration consists of $(\text{rss_meas_duration}/T)$ independent complex

Gaussian variables. Thus, the probability density function (PDF) of the noise is χ^2 centred on noise_floor with:

$$\text{noise_free_deg} = 2\text{rss_meas_duration}/T$$

degrees of freedom.

There is no data available on received signal characteristics or statistics of a radar pulse, propagated over an urban, rural or other environment. In some cases, the radar pulse duration can be shorter than rss_meas_duration. The radar signal bandwidth is normally smaller than an OFDM signal bandwidth of 18 MHz, so that radar pulse samples collected during the power measurement will be correlated. If the radar pulse was sampled at a rate of $T_{\text{RADAR}} = 1/B$, the samples would be uncorrelated. It is assumed here that the PDF of the power when measuring a radar pulse is χ^2 centred on:

$$\text{meas_avg_radar_power} = \text{radar_pulse_power} + 10 \cdot \log_{10}(\min(\text{radar_pulse_duration}, \text{rss_meas_duration})/\text{rss_meas_duration})$$

with degrees of freedom equal to:

$$\text{radar_free_deg} = 2 \cdot \text{round}(\min(\text{radar_pulse_duration} / T_{\text{RADAR}}, \text{rss_meas_duration} / T_{\text{RADAR}}))$$

The PDF of the power measurements noise_rss_pdf and radar_rss_pdf are plotted in dBm in Fig. 1 for a radar of type K received at a level of -67 dBm, and an interference/noise floor of -84 dBm (see § 5).

Once the two distributions noise_rss_pdf and radar_rss_pdf are known, the DF and FA probabilities can be computed.

$$DF = (\text{prob}(\text{radar_rss_pdf} < \text{rss_threshold}))^{\text{nb_RADAR_pulses_per_ACT}}$$

$$FA = 1 - (1 - \text{prob}(\text{noise_rss_pdf} > \text{rss_threshold}))^{\text{nb_trials}}$$

Note that rss_threshold is the WAS receiver RSS threshold setting, whose value should be set between noise_floor and meas_avg_radar_power such as to meet the required DF and FA probability criteria.

5 Results

The following values are used in the calculations:

$$\begin{aligned} \text{rss_meas_duration} &= 1 \mu\text{s} \\ \text{radar_pulse_power} &= -67 \text{ dBm}, -64 \text{ dBm}, -62 \text{ dBm} \\ \text{radar_pulse_duration} &= 1 \mu\text{s} \\ \text{interference/noise_floor} &= -84 \text{ dBm} \\ B &= 4 \text{ MHz} \\ ACT &= 60 \text{ s} \\ \text{nb_RADAR_pulses_per_ACT} &= 1, 10 \end{aligned}$$

Figures 1 to 6 plot FA and DF using various values chosen from the above list.

It can be seen that the form of DF steepens as the number of pulses increases. Increasing T_{DFS} by a number of dB moves the DF curve the same number of dB along the x-axis.

It should be noted that an interference/noise floor increase will move the FA curve horizontally to the right also.