International Telecommunication Union

ITU-R

Radiocommunication Sector of ITU

Recommendation ITU-R BT.1893

(05/2011)

Assessment of impairment caused to digital television reception by a wind turbine

BT Series

Broadcasting service (television)

International Telecommunication Union

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SM	Spectrum management
SNG	Satellite news gathering
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Note*: This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.*

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RECOMMENDATION ITU-R BT.1893

Assessment of impairment caused to digital television reception by a wind turbine

(Question ITU-R 69-1/6)

(2011)

Scope

This Recommendation provides a method to assess the potential impairment caused to digital television reception by wind turbine installation consisting of a single machine.

NOTE 1 – Recommendation ITU-R BT.805 provides "Assessment or impairment caused to analogue television reception by a wind turbine".

The ITU Radiocommunication Assembly,

considering

a) that severe degradation of television reception can be caused by reflections from moving objects such as the blades of a wind turbine;

b) that these effects are particularly serious because the impairment caused can be quasi-permanent, being reduced only during periods when the wind turbine is not rotating;

c) that it is important to have available a simple method for calculating the potential impairments which could be caused by the installation of any proposed wind turbine;

d) that reflection cancellation techniques are being investigated and that these may offer some amelioration of the impairment caused by wind turbines;

e) that reflected signals may have different effects on digital television signals;

f) that reflected signals may have different effects depending on the digital modulation systems;

g) that wind turbine blades are typically made of composite materials which have different reflection coefficients than metal;

h) that the design of wind turbine blades may include additional elements that may also impact televisions signals;

j) that scattering from wind turbine pylons must also be taken into account;

k) that the location of wind turbines and their scattering patterns have an impact on the level of impairment in the vertical and horizontal plane;

l) that the number of wind turbines at a location will have an impact on scattering patterns,

noting

a) that Report ITU-R BT.2142 provides an extensive analysis of the effect of the scattering of digital television signals from wind turbines;

b) that the method given in Annex 1 is a simplified version of the complete analysis, *recommends*

1 that the method given in Annex 1 may be used to assess the potential interference from a single wind turbine to digital television reception,

further recommends

1 that work should be carried out to refine the simplified model given in Annex 1, particularly to consider pylon scattering, the effect of rotating blades, non-metallic blade composition, and the elevation pattern for scatter;

2 that work should be carried out to investigate the impairment caused by multiple wind turbines;

3 that the temporal nature of the impairment caused by a wind turbine should be investigated.

Annex 1

Simplified model of impairment caused to television reception by a wind turbine

Figure 1 shows the plan view of the wind turbine problem of backscatter.

At any receiving location, *R*, the wanted field strength is *FSR*. At the wind turbine site, *WT*, the field strength is *FSWT*. It is assumed that the receiving location is at distance *r* (m) from the blade[1] of the wind turbine. A "scattering coefficient", ρ, which includes the free-space path loss for the path from the wind turbine site to the receiving location, may be defined as:

$$\rho = \frac{A}{\lambda r} g(\theta)$$

where:

$$g(\theta) = \mathrm{sinc}^2\left(\frac{\overline{W}}{\lambda}(\cos\theta - \cos\theta_0)\right)\sin\theta$$

and:

$\overline{W}$: mean width of the blade (m)

λ: wavelength (m)

A: blade area (m^2)

θ_0: angle of the incident signal at the blade

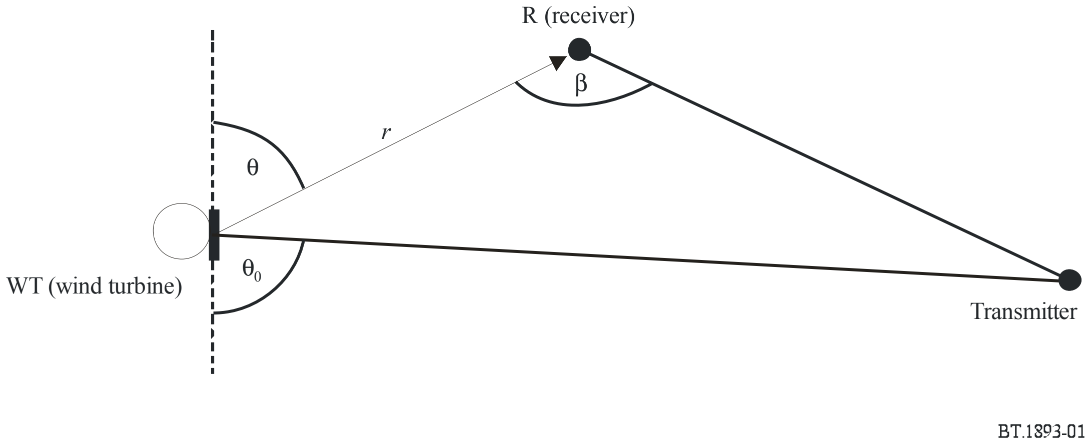
θ: angle of the scattering signal from the blade.

[1] This analysis assumes that the wind turbine blades are metallic and approximately triangular. However, typically blades are fibreglass or other composite materials which results in 6 to 10 dB less scattering than metallic blades.

The maximum value of this scattering coefficient due to a blade in the vertical position occurs when both the incident and scattering directions are normal to the blade and is given by:

$$\rho_{max} = \frac{A}{\lambda r}$$

FIGURE 1



In the case of a free-space path, of length r (m) between the wind turbine and the receiving location, the unwanted field strength may be calculated as:

$$FSWT + 20 \log \rho$$

The scattering coefficient ρ only accounts for backscatter from the blades. It must be noted that the metallic support pylon also contributes significant static backscatter. Forward scatter from the blades may be significant, but has a lower amplitude than backscatter and is more complicated to calculate. Forward scatter from the pylon is minimal. It should also be noted that scattering pattern changes by at least 10 dB as the blades rotate. For full analysis, refer to Report ITU-R BT.2142.

The receiving antenna directivity discrimination as a function of β (as shown in Fig. 1) is given in Recommendation ITU-R BT.419 and this should be applied to determine the ratio of the wanted to unwanted signal for any specific receiving location.

An example of the use of this method is given in Appendix 1.

Appendix 2 provides a brief guide to the impact on threshold *C*/*N* ratios for the situations where the wind turbines degrade the signal quality of the DVB-T system. The potentially increased *C*/*N* threshold demand in areas affected by wind turbines are of interest to broadcasters, system planners and administrations.

Appendix 1
to Annex 1

Example of use of simplified assessment method

As shown in Fig. 1 of Annex 1, identify the point of any receiver location, near the site of a proposed wind turbine.

As a first step, calculate or, preferably, measure the field-strength values, *FSR*, at the various receiver locations.

It is unlikely to be necessary to extend the investigation area to more than about 10 km from the proposed wind turbine site (or sites, if there are multiple turbines). However, if there are special circumstances, for example buildings which are screened from the wanted transmitter but which are line-of-site to the wind turbine, then the area may need to be extended.

Calculate or, preferably, measure the field strength, *FSWT*, at the wind turbine site, near the height of the centre of rotation of the blades.

For each of the receiving points, *R*:

– calculate the scattering coefficient, ρ, for the path between the wind turbine and the receiver;

– calculate the unwanted field strength using $FSWT + 20 \log \rho$;

– calculate the wanted field strength *FSR*;

– calculate the wanted-to-unwanted signal ratio, taking account of the receiving antenna directivity discrimination;

– using the information of Appendix 2, assess the potential impairment to digital television reception given the calculated wanted-to-unwanted signal ratio at the receiving point.

The results of the study may then be presented in the form of a map showing the areas/locations where reception impairment may occur.

It should be noted that the process is more complicated if there are multiple wind turbines on a given site as there are then several possible sources of impairment at each receiving location. Report ITU-R BT.2142 provides example predictions for a large wind farm.

Appendix 2
to Annex 1

Impairment caused to DVB-T system

In most of the situations where the impact of a wind farm to DVB-T reception quality was analyzed, the threshold *C*/*N* ratios obtained were similar to those expected in environments with the absence of wind farms. More precisely, the DVB-T reception quality does not seem to be affected in the forward scattering region of the wind turbines. In the case of the backscattering region, in those situations where the scattered signals from wind turbines are significant in amplitude and variability, the threshold *C*/*N* ratio necessary for QEF condition is higher.

An increase in the threshold *C*/*N* ratio is more likely when the wind turbines are located near the receiver antenna or in the vicinity of the TV transmitter (less than 2 km).

The threshold *C*/*N* ratio tends to increase with the amplitude of the echoes. The time-varying nature of the multipath due to wind turbines is an additional factor in the increase in the required *C*/*N* threshold. Reception areas where the dynamic multipath levels are less than 25 dB below the direct signal may experience increments in the *C*/*N* threshold ratios for QEF condition by up to 8 dB[2].

This time-varying multipath may cause DVB-T reception problems in the above-mentioned situations, especially in case of reception in non-line-of-sight to the transmitter but in line-of-sight to the wind farm.

Report ITU-R BT.2142 (Annex 3) includes full explanation about this matter.

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2 These observations, as outlined in Report ITU-R BT.2142, were performed with the DVB-T using 8k, 64-QAM modulation and 2/3 FEC code rate.