16 January 2018

Senior Director
Spectrum Planning and Engineering
Engineering, Planning and Standards Branch
Innovation, Science Economic Development Canada
235 Queen Street
Ottawa, Ontario K1A 0H5

Re: Consultation on the Technical and Policy Framework for White Space Devices (SMSE-018-17)
Canada Gazette, Part 1, November 2017

Introduction

The North Queens Business Hub, a small community group in rural Nova Scotia, have been conducting TVWS trials(10) to determine if the technology is a viable option to the lack of broadband Internet access in the area. The trials were funded by the Canadian Internet Registry Authority.

There have been a number of TVWS trials around the world. The purpose of ours was to determine the efficacy of the technology in the terrain and vegetation of rural Nova Scotia, which is common to a large part of rural Canada. As such, the main focus of our trials has been on RF propagation.

We are please to comment on section 9. Technical rules for white space devices.

9. Technical rules for white space devices

The data base

1) The data base and DBSS-01 table 3 (1) determines that when we are operating within the protected contour of a TV station we have to protect the adjacent channel plus channels n2 to n4 plus and minus. The result of this is that, for every occupied channel, we end up protecting 9 channels and losing the use of 54MHz of spectrum. This seems to go well beyond what reasonable caution would suggest.
Although not a great problem in rural areas yet, this has resulted in no TVWS spectrum being available in the more populated areas of Canada. We note the following:

- Given the current very tight emissions profiles that TVWS devices have to meet we don't believe this level of protection is required in the TV bands (see annex A)
-This extraordinarily conservative usage rule is unique to Canada. No other standard, actual or proposed, exists anywhere else in the world.
- The FCC allows TVWS devices to operate in these channels and with reduced power in part (3Mhz) of the adjacent channel

Channel Bonding/Aggregation

The Canadian Telecommunications Commission has set a target of download speeds of 50Mbs and upload speeds of 10Mbs for 90% for Canadians by 2021(11)
We cannot achieve this with the current 6Mhz channel width limit.

To meet this goal we would need to bond more than 2 channels whilst maintaining a constant EIRP per 6Mhz channel (constant spectral power density).
The FCC have adopted a 2 stage approach:
1) Contiguous channels which allow that the signal of a white space device would be centred on the boundary between the two vacant television channels. As this approach uses part of the adjacent channel power is limited to 20dBm EIRP as a precaution.
2) Channel bonding of an unlimited number of vacant channels, this approach requires a minimum of 4 vacant channels between active DTV channels and permits full power operation per 6Mhz channel. These approaches are illustrated in Annex B.

Pending further research on the use of adjacent channels we think a similar approach would work well in Canada. It is worth emphasizing that the regulator is able to implement such a strategy at extremely low risk thanks to the white space authentication database which offers unprecedented control for the regulator to detect and redress interference issues in the unlikely event that they should occur.

RF Power Levels.
Our trials(10) clearly show the high level of attenuation experienced due to the dense foliage of the boreal canopy in our region. Allowing high power output for TVWS radios would directly address this problem. What is at issue is determining what power levels would constitute an unacceptable risk of causing interference. Other bodies have adopted these standards:

Federal Communications Commission (4) FCC part15h 40dBm EIRP in uncongested areas although this is unusable due to the very tight emissions mask.

European Telecommunication Standards Institute(5)(ETSI) 40dBm in rural areas

Dynamic Spectrum Alliance (6)(DSA) up to 10w (40dBm) EIRP

Independent Communications Authority of South Africa (7)(ICASA) 41.2dBm EIRP in rural areas

All the above bodies have a recommended non-rural maximum power level of 36dBm EIRP as does Canada. We recommend Canada also adopts a similar maximum power level for rural areas as these bodies.

Emissions Masks (9)
The need for a very tight emissions masks on a few occasions ie. when operating in an adjacent channel or between 2 active channels without any guard channels has been a major challenge for TVWS manufacturers.

We are unaware of a single manufacturer that has produced a production device that is capable of operating at the maximum 36dBm EIRP level and meeting the -72dBm Adjacent Channel Leakage Ratio (ACLR) required under FCC or ETSI class 1 rules. Neither of the two Canadian manufacturers

that we know of have been able to produce an affordable production device capable of exceeding 29.5dBm EIRP.
This severely limits what we are able to do at the present time(8) and is a fundamental barrier to wide spread adoption.
We are currently unable to purchase suitable equipment for our proposed project.
The current emissions mask is 35dB more stringent than the industry standard for WiFi and 20dB more stringent than the 4G cellular technologies, such as LTE. This results in the requirement for complex active analogue filters that, according to one estimate**(9),** add 65% to the cost of fixed customer premises equipment.

The ETSI and DSA have recognized this challenge and have adopted different classes of devices with different emissions masks and ACLRs that can be used under different conditions and controlled by the data base.

We illustrate this concept in annex C

Most bodies recognize 5 different emissions classes. We offer no opinion as to how many would be desirable in Canada as we are limiting our comments to our rural area.

With regard to rural areas, at least two emissions classes would be desirable:

1) A less stringent emissions mask, similar to ETSI class 4 or 5 rural or the latest DSA recommendations(14), to allow operation at sufficient separation in frequency to an active TV channel to prevent any interference due to the relaxed ACLR and higher EIRP. This would be the case in much of rural Canada.

2) At the present standard 36dBm EIRP -72dBm ACLR for when we need to operate as close as possible in frequency to an active TV channels at higher power levels.

We are not commenting on the required level of protection for mobile operators using the 3GPP of LTE standards but recognize they may need different higher levels of protection than DTV devices if we are operating in the re-purposed 600Mhz band.

Respectively Submitted Colin Mudle

North Queens Business Hub
9793 Highway 8
Caledonia
B0T 1B0

(1) DBS-01 Data Base specifications
http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf10928.html

(2) Recommendations and learning from the Cape Town TVWS Trials section 8.6.2.4 page 39
https://www.tenet.ac.za/tvws/recommendations-and-learnings-from-the-cape-town-tv-white-spaces-trial

(3) Recommendations and learning from the Cape Town TVWS Trials section 8.6.2.2 page 38
https://www.tenet.ac.za/tvws/recommendations-and-learnings-from-the-cape-town-tv-white-spaces-trial
The Cape town TVWS Trial
https://www.tenet.ac.za/tvws

(4) FCC part15h Electronic Code of federal regulations
https://www.ecfr.gov/cgi-bin/text-idx?SID=3f57719f50963d7ae3741331f96b19ca&mc=true&node=pt47.1.15&rgn=div5#sp47.1.15.h

(5)
http://www.etsi.org/deliver/etsi_en/301500_301599/301598/01.01.01_60/en_301598v010101p.pdf

(6) DSA Suggested Technical Rules and Regulations for the use of TVWS
http://dynamicspectrumalliance.org/assets/submissions/Suggested Technical Rules and Regulations for the use of TVWS.pdf

(7) ICASA draft regulation on the use of TVWS
https://www.techcentral.co.za/wp-content/uploads/2017/04/Draft-RTVWS-Regulations-Govermment-Gazette-No.-40772_gen283.pdf

(8) North Queens TVWS trial, specifications section
http://queenstvws.com/Effects of Technical Specifications.htm

(9) A Critique of FCC TVWS regulations figure 4 & 5
https://www.microsoft.com/en-us/research/wp-content/uploads/2016/07/fcc.pdf

(10) North Queens TVWS Trials
http://queenstvws.com/index.htm

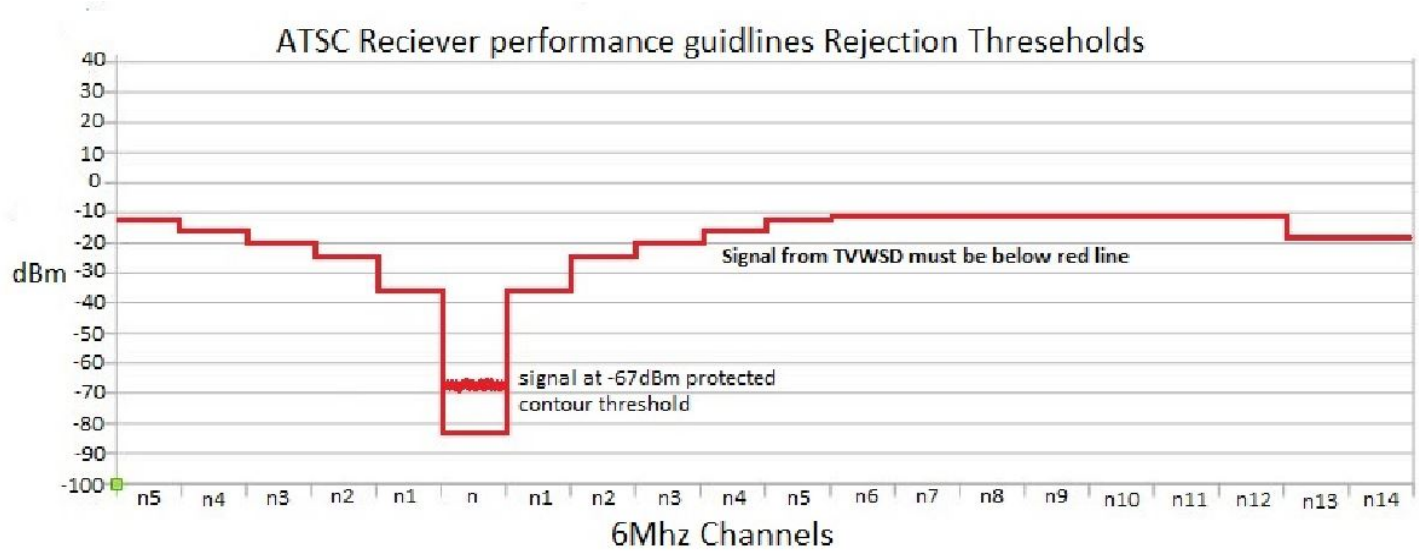
(11) CRTC Closing the Broadband gap
https://crtc.gc.ca/eng/internet/internet.htm

(12) A Critique of FCC TVWS regulations page 24 section 4
https://www.microsoft.com/en-us/research/wp-content/uploads/2016/07/fcc.pdf

(13) FCC-15-99A1
https://apps.fcc.gov/edocs_public/attachmatch/FCC-15-99A1.pdf

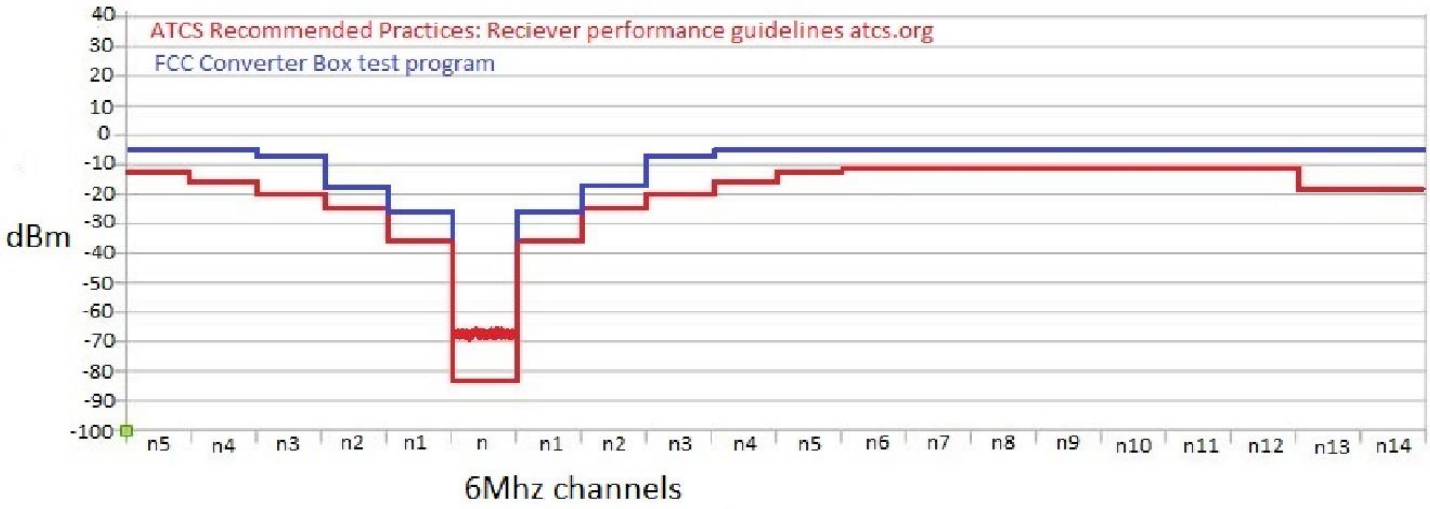
(14) DSA Model Rules and Regulations for use of TVWS v2, December 2017
http://dynamicspectrumalliance.org/wp-content/uploads/2018/01/Model-Rules-and-Regulations-for-the-use-of-TVWS.pdf

Annex A
Emissions Profiles
In this section we attempt to illustrate how present proposed and enacted standards protect ATSC DTV receivers.



The above diagram shows the suggested ACRR (adjacent channel rejection ratio) and co channel rejection ratio as suggested by the Advanced Television Systems Committee for a weak signal.
The signal strength from a TVWSD device **must be under the red line** at the receive site to avoid interference

source https://www.atsc.org/wp-content/uploads/2015/03/Receiver-Performance-Guidelines.pdf tables 5.1, 5.2 and 5.3



Here we have added the results of performance tests the FCC did on 116 DTV converter boxes (in blue) showing the average converter box had a performance 10dBm better than than the guidelines.

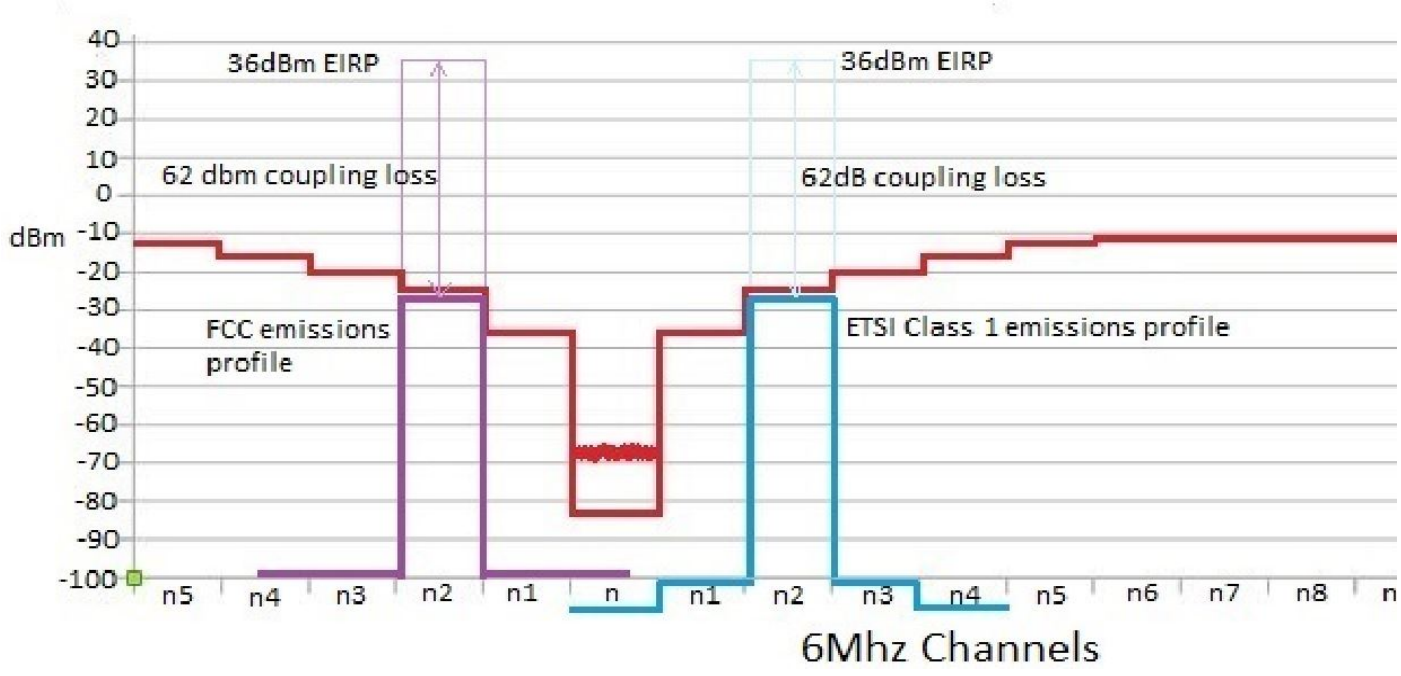
Note measurement above -5dBm were limited by the test equipment's capabilities.

Source https://transition.fcc.gov/oet/info/documents/reports/9TR1003-ConverterBoxTestReport.pdf

Throughout out this document we continue to use the more conservative ATSC guidelines in red.

Coupling Loss

Below we show two TVWSD operating at channel +/-n2, using the FCC and ETSI class 1 operating modes.
ISED emission profiles are very similar at the power levels shown.



In both cases these devices could operate closer to the occupied channel in n1 the adjacent channel if they reduced their power levels or we assumed a higher coupling loss, like wise if we moved further away from the occupied channel to +/- n3 or beyond we could increase our power level or relax the emissions mask.

In our opinion the **most important factor** in determining how close in frequency and at what power level we can operate at without causing interference is our assumptions about the coupling loss.
The shape of the emissions mask is an important factor when trying to operate close to an occupied channel but <u>after +/-n3 it's importance rapidly diminishes.</u>

So what is a reasonable assumption of the minimum coupling loss when operating within the protected contour of a DTV station?

As shown above FCC assumes ~62dB by allowing operation in channels +/-n2 within the protected contour at 36dBm EIRP
In the Dynamic Spectrum Alliances Suggested Technical Rules and Regulations
for the Use of Television White Spaces, annex C part 3 they assume 60dB

3. WSD coupling loss
The coupling loss between a White Space Device and other types of receivers is assumed to be 60 dB.(9)

(9) The coupling loss accounts for a multitude of factors, including the separation distance between devices, antenna discrimination, polarization discrimination, building attenuation, physical obstructions, etc.

Source [Dynamic Spectrum Alliances Suggested Technical Rules and Regulations](#) annex C part 3

Annex B

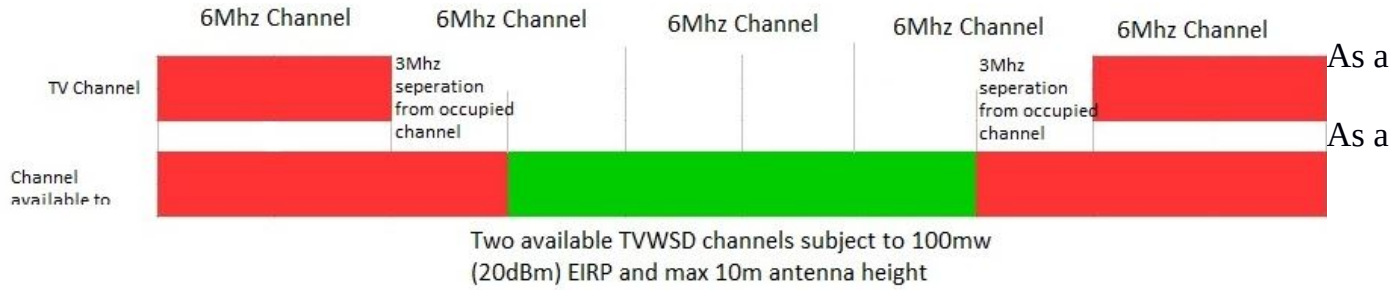
Channel Bonding and Contiguous Channels

Recent changes to FCC rules are illustrated below in an attempt to make more TVWS available in congested areas the FCC is now allowing that the signal of a white space device would be centred on the boundary between the two vacant television channels.
Source FCC 15-99A1 page 15
https://apps.fcc.gov/edocs_public/attachmatch/FCC-15-99A1.pdf

Old Standard

New Standard

Or This



As a precaution power is limited to 20dBm, in the South African Cape Town trials TVWSD-(2) that met FCC requirements were operated adjacent to and in the single guard channel between 2 active channels at 4W EIRP with no interference being detected. Since these trials used a different television standard and a different bandwidth we agree with this cautious approach until such times as trials can confirm that interference is or is not a problem.

Annex C

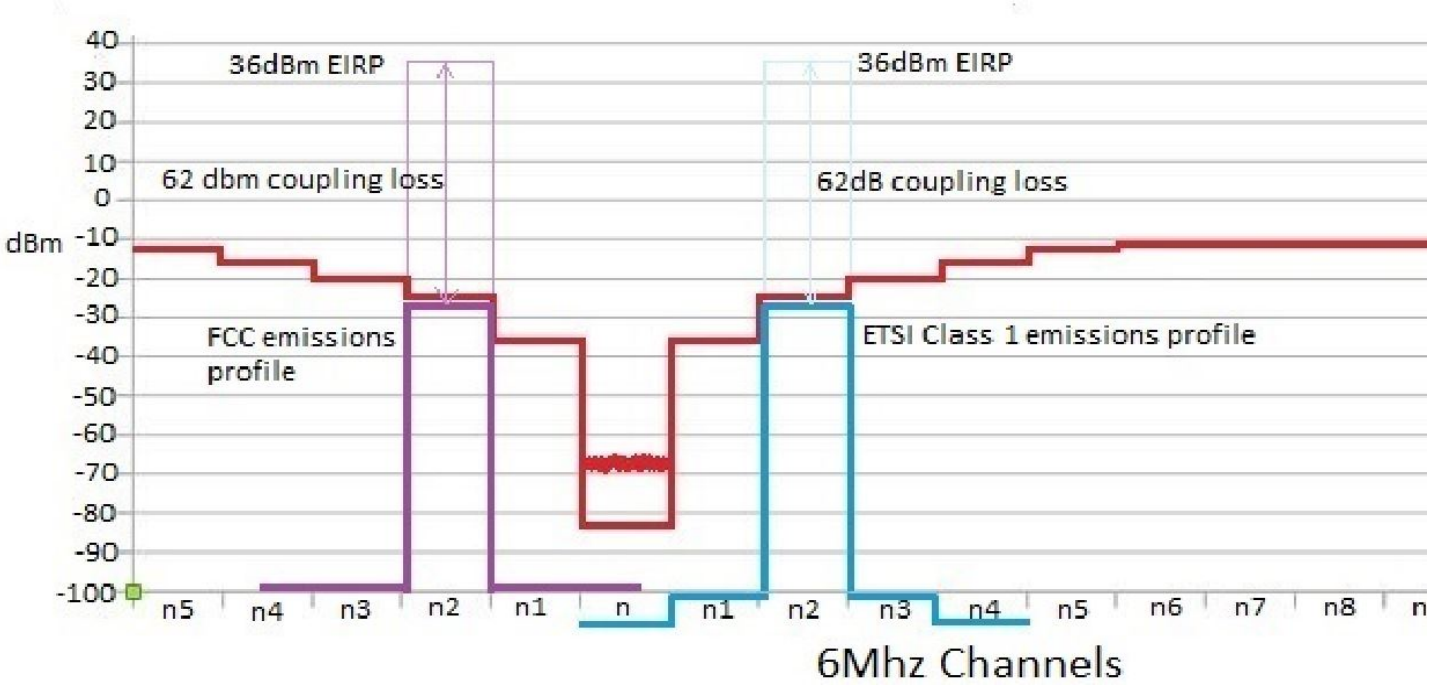
Proposed Emissions Classes and operating Modes

The ETSI define 5 device classes thus

n^{th} adjacent channel number	Adjacent Channel Leakage Ratio (dB)				
	Class 1	Class 2	Class 3	Class 4	Class 5
n = ± 1	74	74	64	54	43
n = ± 2	79	74	74	64	53
n >= 3 or n <= -3	84	74	84	74	64

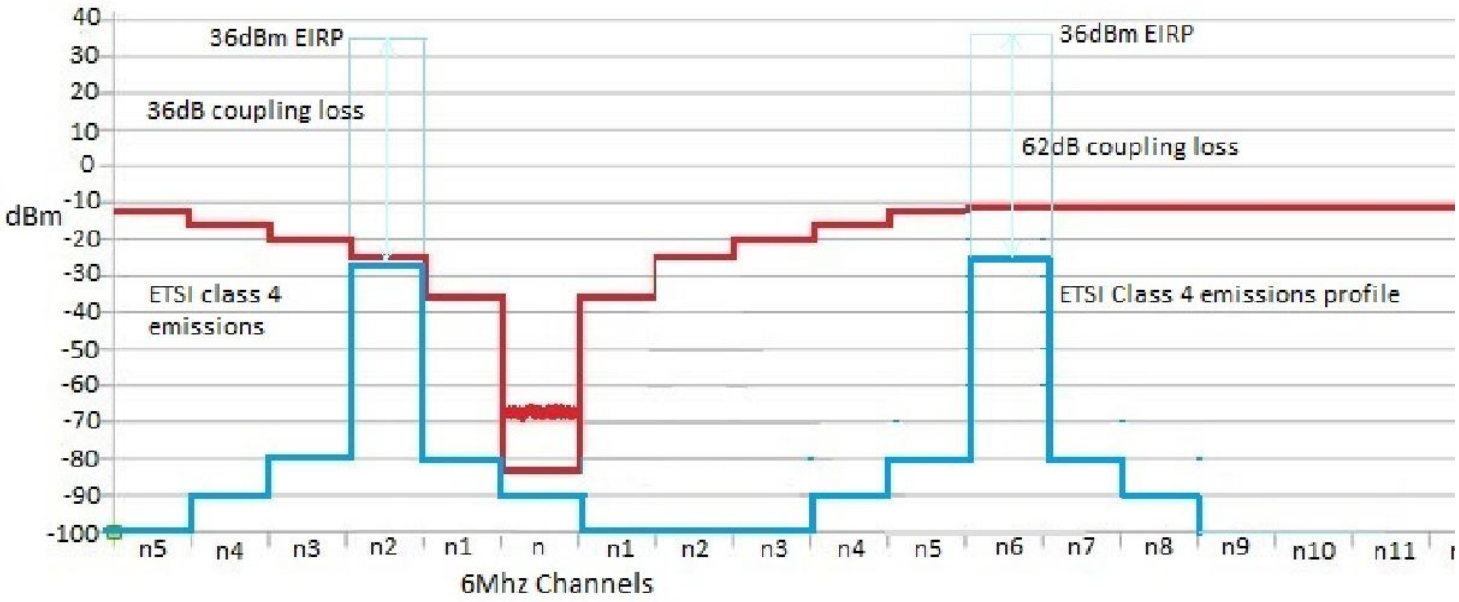
Below we look at how devices with these emissions classes can operate and stay within safe emission limits below the red line depending on the channel separation and power limits.

Class 1 device operating mode



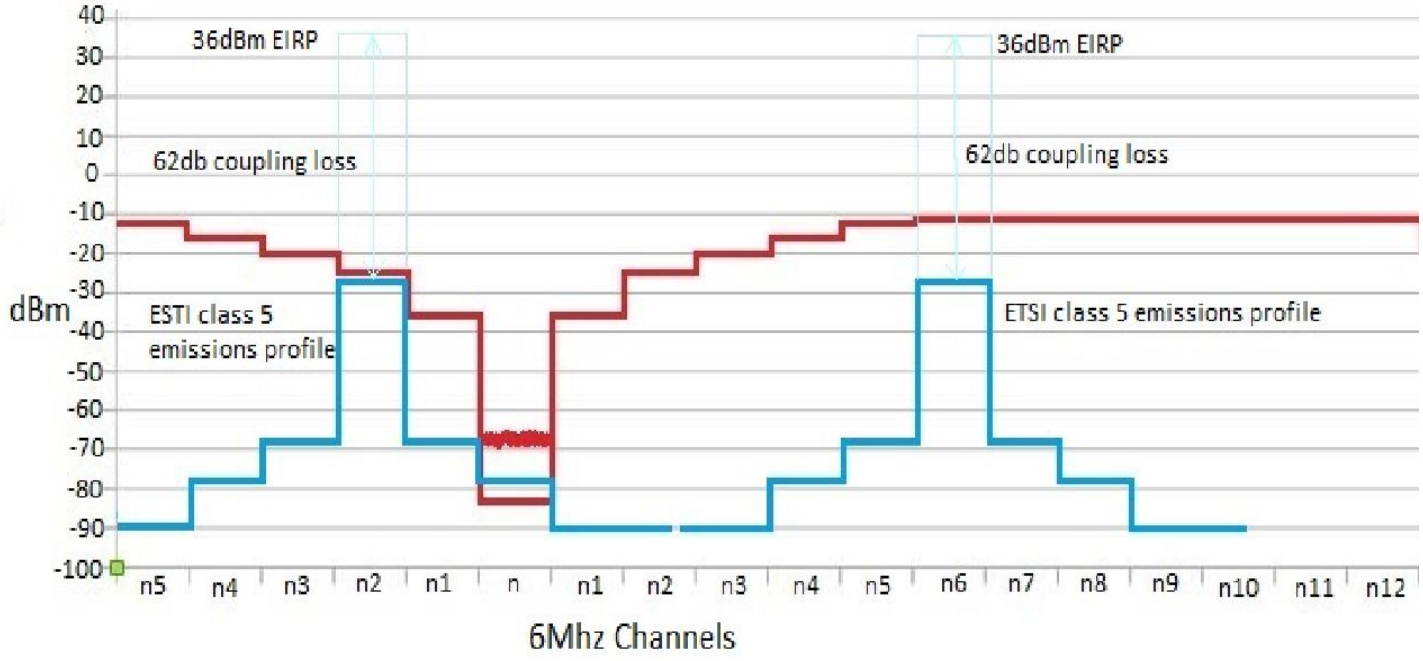
Both devices can operate at full power in channel +/-n2 but cannot operate at higher power despite the clean emissions mask, the coupling loss does not change hence the red line would be crossed.
Both devices could operate in the adjacent channels providing their EIRP is reduced to prevent the red line being crossed at which time their emissions in the co channel would be 25db below that required to cause interference to the ATSC receiver.
The seems to be little need to have such a sharp ACLR, the class 4 device with 20dB less is able to operate in the same channels at the same power levels

Class 4 device operating mode



As shown on the left the class 4 device could operate in channel +/-n2 at 36dBm
It would have to reduce power to operate in the adjacent channel +/-n1
It could operate at a higher power greater than 36dBm at +/-n3 or greater
As shown on the right when we are operating at greater than +/-n5 we can have a very relaxed emission mask.

Class 5 device operating modes



We cannot operate at +/- n2 at 36dBm we need to reduce power
We cannot operate in adjacent channels +/- n1 at any power level
We can operate at +/-n3 at 36dBm
We can operate at greater than +/- n4 at higher power levels.

Proposed Device class operating modes

The maximum power for a TVWS device is determined by it's emission class and the number of channels separating it from an occupied TV channel
These numbers used are to illustrate the concept and are not recommendations, the device class specifications are as per the ETSI table above

nth adjacent channel	Class 1	Class 2	Class 3	Class 4	Class 5
+/- n1	27	27	27	27	Prohibited
+/- n2	38	38	38	38	31
+/- n3	42	42	42	42	42
+/- n4	46	46	46	46	42
+/- n5	50	50	50	50	42

(2) Recommendations and learning from the Cape Town TVWS Trials section 8.6.2.4 page 39
https://www.tenet.ac.za/tvws/recommendations-and-learnings-from-the-cape-town-tv-white-spaces-trial