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Abstract:

Contract owner

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Contractor

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Assignment

Contract owner (CO) asked contractor to develop complex and fully working mobile device to “intelligently” jamm legally transmitted FM signal from Radio Broadcast Station (RBS). Matter of the device should be FM receiver able to receive and decode special code from RBS signal used to trigger-on jamming FM transmitter black box (BB) broadcasting special version of commercial spot to specified area. The BB device must be equipped by uninteruptable power source (UPS) optionally with solar charger. Maximum BB daily working time expected 10-30min est.

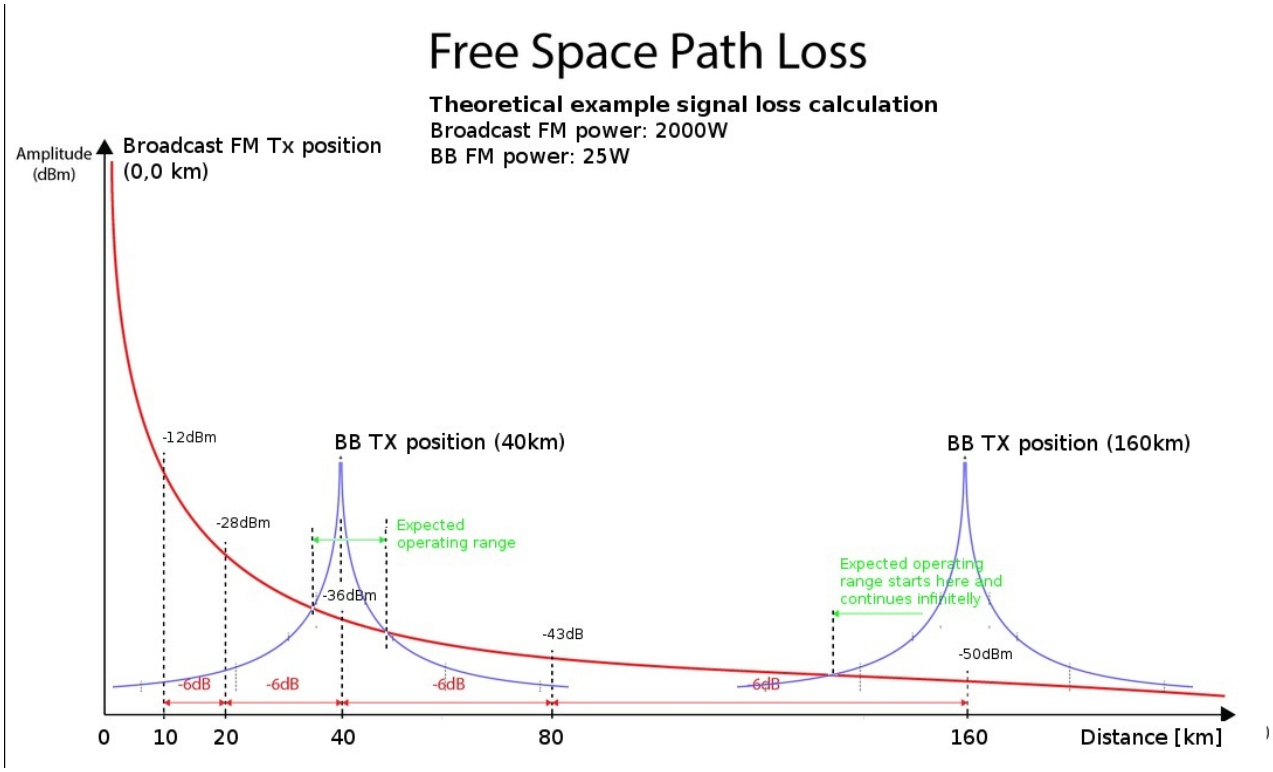
IMPORTANT: Contractor is responsible for BB device development and production only, all legal papers etc to use BB device in selected localities, countries and frequencies are under CO responsibility. Contractor refuses any responsibility from use of the device anywhere. Developed device does not lays under any FCC rules and does not have any oficial license to be used as a professional licensed solution. If this papework necessary, it's not part of this subject and must be solved individually.

2. Simplified theory to understand assignment

To develop such a device able to successfully jamming original FM signal and to “replace original commercial spot” with other, needs to understand problems and issues comming with FM signal modulation. Even contractor is going to try to develop as best solution as it can be in such a short contract time, by physical principles **it's sure that there will be some localities where signal jamming will be unsufficient and where can some noises or tunning jumping from original to jamming signal occurs, all hearable from listeners!! It's under CO responsibility to understand how FM broadcastnig works, and install BB to localities and places with set FM power to minimalize these problems!!**

Frequency modulation (FM) signal uses carrier frequency with small frequency changes modulated by audio signal, instead of so–called Amplitude modulation (AM) which uses direct carrier amplitude modulation. While jamming of AM modulation signal occurs, there is going to be modulating Audio signal mixed both, original and jamming together. Within FM modulation, FM receiver is equipped with special module named PLL (phase locked loop) synchronised by transmitted carrier frequency. Because of this, if FM signal is jammed slightly, it's not noticeable until PLL works and is synchronised OK. Since jamming carrier signal increase to be higher enough in comparation to original FM radio carrier, PLL is going to be locked on jamming signal. If original signal is more or less equal to jamming signal, there are going these noises and issues hearable by listenners occur:

- Audio jumping between both signals, sometimes original Audio hearable, sometimes jamming audio. Hearable audio signal can jump with a hundreds of miliseconds period to seconds
- between jumps strong “cracks” or noises can occur, depends on carrier signal level differrences
- if carrier signals on same level, there can be just very strong noise and cracks hearable continuously with no understable audio. Even if this covers just a small area, it's very annoying and uncomfortable to listenners and CO should plan localities to use BB a way to minimalize listenners in this problematic area. To help plan as much preciously as possible localities to use BB device, contractor prepared calculator and graphic explanation which helps to understand proper planning.

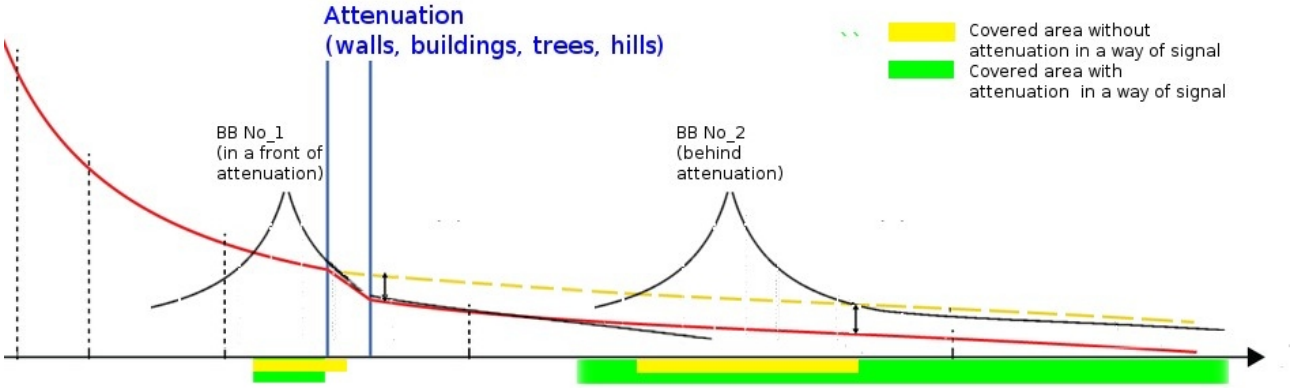


If you have a look at the free space loss graph, there are red signal strenght line (RBS) and blue signal strength lines (BB project). It shows situations where jamming on, usefull areas are green marked. There are these situations:
- As far as you go off the RBS, you get better conditions from the size of the area point of view. But also, area of non-comfortable signal mixing increase. There is only one limit and it's maximum distance from RBS where is possible to receive continuous STEREO FM signal to succesfully decode RBS coding signal to trigger-on BB.
- As close as to the RBS you go, size of usefull area decrease, but on the other hand size of non-comfortable signal mixing decrase as well.

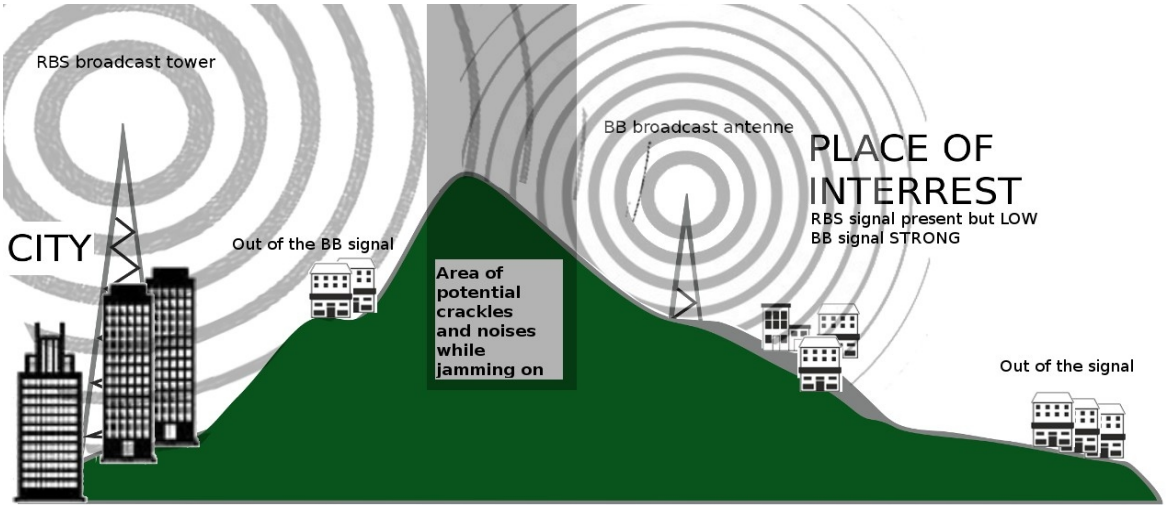
It's best to do test in local conditions, but according to the theory we would expect that "succesfully" working distance for mentioned BB FM power 25W is going to be somewhere between 20km to 100km of RBS with the power of 2kW.

What also has strong influence to the signal distribution is "Fresnell zone". Very simply said, it's an area between transmitter and receiver which must be clear of any possible object to achieve best signal conditions. For an imagination, whole power transmitted on one single direction "occupies more than just a line", most of the power is in a space which looks like this:

Size of the zone can be calculated and is a function of distance and frequency. According to this is clear, that transmitting (and also receiving) antenne suppose to be in some height to get best conditions. If you imagine that receiver side can be at "zero position" because it's houses, cars radios, people just walking on the streets with mobile phone with FM, the transmitter must be much higher to comply conditions at image Basic rule is, keep 50% of energy at least, which is half of the zone. One single solid wall in a trace of a signal can make huge attenuation. This means basically, that there are absolutelly differrent conditions on flat or villiages instead of Central Business Districts (CBD's) where are tall buildings everywhere and close to each other. Also, FM signal on specified FM frequency band (87-108MHz) is strongly attenuated by any material in a way of the signal (and Fresnell zone also). The worstest cases are metallic buildings and industry zones, then concrete buildings, less problematic but still signifficant are stone and brick buildings. Also trees are problems, mountains, etc. Following diagram shows two examples of BB position according to an attenuation object and how obstacles can have negative but also positive influence to planning.



If you have a look closer to the diagram you see, that some situations according to the attenuation are bad, but some can help us. If we install BB before some large building or hill in the direction to the “zone of interest”, it's has bad influence to both signals, RBS and BB which can be good or bad, depends on a situation. But if you install BB behind the building in the direction to the “zone of interest”, it can help us to cover larger space. Person who plans installation should understand how large objects in Fresnell zone can affect spreading of the signal. We can define “theoretically best situation for an installation” which can minimize 1/ hearable crackles and noises outside an area of interest and 2/ best power conditions. Check this “optimal” situation:



Of course, real situations may vary. With low height installed BB transmit antenne, buildings, trees, etc can have influences to the signal and may causes small “islands with bad signal conditios”. There are much more physical factors according to FM signal spreading, but this are basics to understand for proper BB positioning.

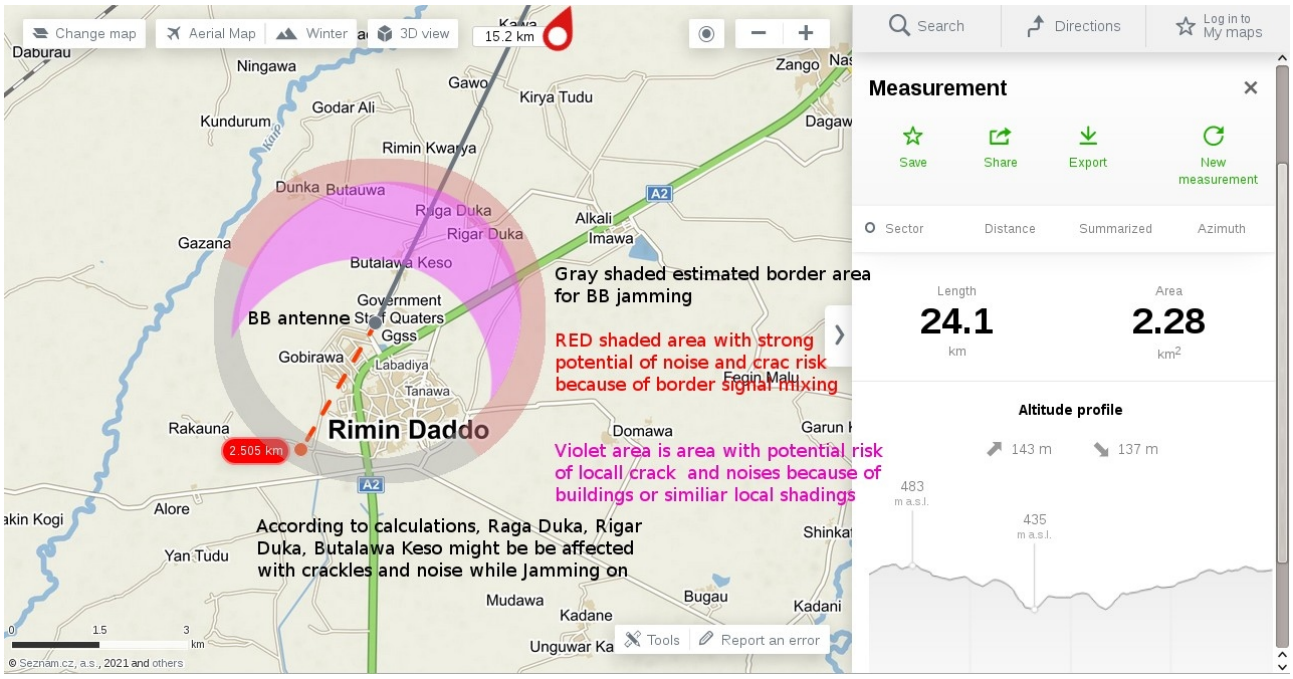
FM signal calculator for free space path loss (availabile in xlsx):

Enter distance from Broadcasting radio tower			
(use max cca 100km)			
BB center distance [km]	**L =**	**21**	**km**
(use max cca 10km)			
BB area coverage (dia)	**d =**	**5**	**km**
BB Tx power	**Pbb =**	**25**	**W**
Expected lowest signal differrence (should be > 0db, >3db is best)			
Worst	**AdiffW =**	**1.4**	**db**
Medium	**AdiffC =**	**2.5**	**db**
Best	**AdiffB =**	**3.4**	**db**
Bellow this h, more than 50% energy loss @ far area border			
Minimum antenna height 2m, nothing in direction close than 200m			
Must correspond to following:			
Critical antenna height	**hc =**	**16**	**m**
If close or bellow, divide Pbb /2 or more			

Note: expected signal difference is calculated for the LOWEST (border) values. Of course, as close you go to the BB transmitter, differece increases because signal strength of BB transmitter increases. So this calculation shows theoretically the worstest values.

Example situation

RBS: 11°57'33.0"N 8°30'34.0"E
Tx power: 2000W
Zone of interrest: **Rimin Daddo community**
Recommended BB distance from RBS: 21km
BB Tx power: 25W
Jamming area diametter: 5km
Calculated average minimum gain difference at the border of the area: +2,5dB



If you have a look on the map, there are marked areas with stronger potential risk of crackles and noise for listenners. While planning it's important to estimate this pattern and minimize affected areas by choosing proper place and, also setting-up proper Tx power. Also, it's possible to use enviromental conditions to preserve some areas of Jamming by attenuating signal in critical directions by houses, hills.. etc. Also using of directional antenna could be usefull, but it's more problematic to use because of it's size and also price.

3. Suggested solution explanation

Contractor find as a usefull (beta) solution to built BB system consisting from modules and installed in one or two handy boxes. Some of the modules are from serial production, some under own developement. Whole system consist from this main blocks:

- FM power omnidirectional antenne
- FM power transmitter 25W
- MP3/WAV player with micro-SD card
- FM stereo receiver
- decoding system able to decode two differrent coding procedures
- decoding system able to properly trigger-on FM power transmitter and play audio spot
- power supply 230V
- UPC system allowing min. 30min of full power operating
- DC solar charge system (optionally)
- electronic protection lock to protect BB from abuse (optionally)

4. BB development

Main development is concentrated to a mainboard module with all decoding and controlling modules, where installed microprocessors are able to controll all modules included, MP3 player and radio receiver. They also support user graphical interface with TFT color touch screen to configure BB and supplementary displays to monitor FM band, power, decoding state etc. Also there will be necessary rebuild production modules to be used within our solution. Whole developement include on-site testing, we expect 3 month est. all together.

5. Expected functionalities

BB device should be able to:

- continuously monitor FM particular band selected by user
- receive and decode trigger signal from spot transmitted by RBS
- shutdown and protect FM receiver from high power carrier wave while transmitting
- enable FM transmitter
- start playing MP3 spot inserted in on a micro SD flash disc
- broadcast it throught FM transmitter on particular band selected by user
- after defined time shutdown transmitter and stop playing
- go to back to idle state
- continuously monitor FM band and wait for next trigger
- all must fully work from internal UPS
- batteries must allow minimal 24hrs monitoring FM band and after that, minimal FM Tx time 30min on max. power

6. User interface, controlling, coding

BB user interface is going to be a couple of manual power switches/buttons, TFT touch screen, LED indicators, etc. Whole system must be able to work with minimum special knowledges and must be designed to be prepared to transmit by trained person within short time period (tens of minutes e.g.) There are going to be just most important values to be set by user on site, but all of them can be pre-set before installation (they can be saved to FLASH memory). Main user parametters necessary to succesfully operate will be like:

- FM monitored frequency
- FM transmit carrier frequency
- FM transmit power
- select proper loaded spot on micro SD flash in MP3 or WAV
- selecting proper spot to play manually or set-up automatical trigger system

If BB device will be installed in separated boxes, there will be simple multi-cable(s) used to interconnect them easilly with low risk of damage device.

7. Notes

- this is a first version of the document, no grammar correction, not finalized yet. Draft only.
- not for publishing, only for internal use.
- all parts of the document belongs contractor until contract with contract owner is signed