FM TRANSMITTER & ANTENNA TECHNICAL PAPER

This document is provided to explain the technical criteria and references how I figured out the distance you can transmit with Low-Power, Non-Licensed Transmitters and feel confident the FCC will not pay you a visit. Never, ever broadcast on the same frequency a licensed Radio Station does or it won't matter, you could be fined.

How I determined approximately 500 feet (160 yards)

Before I get started lets clearly read and understand what the FCC Part 15 maximum field strength is and then look at what a typical FM receiver radio is capable of receiving.

Title 47: Telecommunication, PART 15—RADIO FREQUENCY DEVICES, Subpart C—Intentional Radiators, Radiated Emission Limits as of May 11, 2011 in the Electronic Code Of Federal Regulations states:

(a) Emissions from the intentional radiator shall be confined within a band 200 kHz wide centered on the operating frequency. The 200 kHz band shall lie wholly within the frequency range of 88–108 MHz.

(b) The field strength of any emissions within the permitted 200 kHz band shall not exceed 250 microvolts/meter at 3 meters. The emission limit in this paragraph is based on measurement instrumentation employing an average detector.

For clarification, it does not state how far you can transmit, it states what the maximum emissions measured at 3 meters (approximately 9.8 ft) is. It also states the measurement instrument employs an average detector; wow, how can it be any clearer what the FCC uses to measure it with. Since I don't know exactly what they use, and measuring this stuff is beyond the scope of this paper, I want to give you a general idea of how it might be done because my job often does this on the missiles we build. It's basically a one meter (approximately 3.3 feet) long antenna connected to a devise (Spectrum Analyzer) that measure voltage of the transmitted energy and frequency coming from the source (your antenna). Now, they probably won't stand 3 meters from your antenna so they use calculations to figure out all the details.

I figured out that at about 500 ft. your FM transmitter (broadcasting your Christmas music) should not be heard, or at least so full of noise (static) it cannot be understood. Also, keep in mind, radio waves don't just stop, they fade away and get weaker.

Sensitivity

Just about every modern FM receiver has a "Sensitivity" specification on the device. Some will have SINAD which stands for Signal-to-noise and distortion ratio expressed "microvolts at some dB". Some FM receiver radios just use "Microvolts". Regardless of what they use, we are interested in the "microvolts" they indicate in the Sensitivity.

With SINAD it is always true that a lower SINAD value means worse performance of the system. In a real world example as the received RF signal becomes weaker it becomes progressively lost in the noise and distortion generated by receiver, demodulation and audio output drive circuits.

In our FM band music radio system a Signal, Noise and Distortion level of 12dB SINAD is the maximum acceptable level of noise that will not swamp intelligible music in our audiences FM receiver. A typical example quoted from a JVC FM CD car radio; Receiver Usable Sensitivity was described as 1.0 µV (1.0 microvolts) at 11.3 dB; that is the SINAD.

The example above is stating that the receiver will produce intelligible audio with a signal at its input (Antenna) as low as 1µV (1 microvolt). This next part is where the real meat is.

Distance From Transmitter Antenna

The best source I've found to help explain this, is at Ramsey Electronics. Below is a copy of what they say along with my comments in BOLD parentheses:

The new FCC Part 15 Rules specify a maximum "Field Strength" of your transmitted signal. Since it is unlikely that you have the equipment to carry out accurate field strength measurements in microvolts, it is useful to understand the theory of field strength so that you can understand both what you can expect from such transmitters, and what limits the FCC intends.

(as of May 11, 2011 in the Electronic Code Of Federal Regulations) the rule specifies a maximum of 250 µV per meter, but measured at 3 meters from your antenna. The term, "250µV per meter" means that an accurate field-strength meter with a calibrated and scaled 1-meter antenna may indicate a maximum signal field strength of 250µV.

In all cases **(If everything is perfect)**, the field strength of a signal decreases in direct proportion to the distance away from the antenna. Power decreases by the square of distance: for every doubling in distance, the signal power is quartered, but the field strength voltage is only halved. Using this theory, we can construct a simple chart to show the maximum permitted performance of a non-licensed FM band transmitter. The theoretical figures assume a simple 1 meter receiving antenna in all cases and do not take into consideration that reception can be greatly enhanced with larger, multi-element antennas and preamplifiers on the receiver. (**Uh, Ramsey didn't mention that RECEPTION can be greatly <u>decreased</u> by HOMES, TREES, CRAPPY ANTENNAS and other INTERFERENCE in populated areas, so keep that in mind as well.)**

In the following chart depicts Ramey's field strength theory.

(I want you to just focus on the (FEET and FIELD STRENGTH) columns.)

Distance From YOUR Transmitter Antenna			
METERS	**FEET**	**FIELD STRENGTH (µV)**	**TOTAL AREA RECEIVED**
3	**10**	**250**	
6	**20**	**125**	
12	**39**	**63**	
24	**78**	**31**	
48	**157**	**15**	
96	**315**	**7.5**	
192	**630**	**3.8**	
384	**1260**	**1.9**	
768	**2520**	**.95**	
1536	**5036**	**.5**	

JVC FM Stereo Receiver with Sensitivity 1.0 µV (1.0 microvolts) at 11.3 dB could easily pick up your music, IN A PERFECT ENVIRONMENT

IF EVERYTHING IS PERFECT and YOU ARE COMPLIENT with FCC PART 15

If a Car with a JVC FM Stereo Receiver with a **Sensitivity** of 1.0 µV (1.0 microvolts) at 11.3 dB has a good antenna on the car, then according to Ramsey theory, that JVC FM receiver could easily pick up your Low Power, Non-Licensed FM Transmitter station at 1260 feet (almost 1/4 mile) from your antenna and you would not be in violation of FCC PART 15.

Don't get excited, this would be under perfect conditions; we are not in perfect conditions. In reality, there are lots of reasons why your FM transmitter system should not be able to punch through all the interference in the real world to get that far. Unless you live on flat open land that goes for miles in each direction with no obstacles, you won't get that far, even if you did live out in the open plains, you shouldn't be able to get that far unless you have a perfectly tuned transmitter to antenna mounted perfectly on a pole at least 30 feet tall like a no gain (1/4 Wave Antenna).

500 feet 40% Safety Factor For A Non-Perfect System

It is practically impossible to determine how far you can legally transmit under FCC PART 15. That old Public Notice Dated July 24, 1991 (20 years ago) is pretty much obsolete at best, and although it is available, and it does have the current microvolts listed, the FCC no longer refers that public notice to answer the question of how far can we legally transmit. See the document at the Wiki Understanding FCC Regulations For Low-Power Non-Licensed Transmitters.

Using a conservative 40% estimate (0.40 X 1260=504 feet) is probably a fair reality of your actual ability to get a non perfect legal transmission out to your audience. There are so many reasons why your system won't get to 1260 feet even if you are measured at 9.8 feet (3 meters) to be 250 microvolts which is legal. For a vast number of reasons, (i.e., transmitter antenna loss, coax cable loss, trees, houses, hills, other RF interference from electrical transmission lines and so on) you won't get that far, and if you did, it's because you are transmitting too much power to get past all that junk. Furthermore, you should not attempt to transmit at the maximum allowed because that is risky as well.

Not to discredit Ramsey, but they are trying to sell you on a system that under perfect conditions can legally transmit enough RF for the average car radio to pick your station up at over 1/4 mile. That is simply not realistic.

Realistically, if you can reach over a 1/4 mile then you are not legal. Realistically, if you are legal and using a no gain antenna (in your house), you should not hear your music from your car at 500 feet or even better, less than 500 feet.

Common Sense

FCC Certified Part 15 Low Power, Un-licensed Transmitters are designed to be extremely weak. Why? It's not because they are transmitting at the legal max. It's because they are transmitting way below the legal limit. Why? Because if a Whole House rig is interfering with a next door neighbor and the FCC caught wind of it, that company will be paying a bunch of fines and in a boat load of legal battles. The customer base is going to be filing class action suits against them because they are also getting fined by the FCC.

Those Belkin IPod's, Delphi XM SKYFI's and other Commercially Off The Self FM gizmos are designed not to interfere with other peoples radios. The only way to do that is make sure they don't go much more than 30 to 100 feet. That's just plain common sense.

The FCC knows that if a certain RF energy measured at a predetermined distance you are legal and you won't be covering much area at that measured power. It is impossible to actually know how far, there are just too many variables.

With knowledge of what the FCC is really interested in (what's coming from your antenna at about 9.8 feet) you can use good judgment from what I've put together in this document to stay safe. If you want no music to be intelligible at approximately 200 feet, then that's good.

And if you can get it a little farther that's fine also, just don't hear it past 500 feet and you should be safe.

Written by:

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