VHF ANTENNA SYSTEMS AND RECEPTION

ANALYSIS OF FCC RULES AND REGULATIONS

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Mark J. Colombo

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On my honor as a University student, on this assignment I have neither given nor received unauthorized aid as defined by the Honor Guidelines for Thesis-Related Assignments in the Undergraduate Thesis Manual.

Signed ____

Approved ____ Date _____________
Benjamin Cohen, Department of Science, Technology, and Society

Approved ____ Date _____________
Stephen G. Wilson, Department of Electrical and Computer Engineering

Introduction

On June 12, 2009, the United States took one of the final steps in its long road from analog to digital transmissions of over-the-air broadcast stations. After more than 20 years of work on transmission standards and equipment, more than 10 years of equipment installation and replacement, and more than a year and a half of wall to wall advertising and a coupon program to help the process along, analog transmissions ended and digital transmissions became the sole form of broadcasting. However, all did not go as smoothly as one might assume from all those years of work and preparation. Issues arose on transition day and lingered afterward with regard to loss of signals by viewers for many different reasons.

The goal of this project is to understand what caused these issues and what solutions to on-going problems can be devised to ensure the continued success and survival of over-the-air broadcasting. Since there are many other countries which plan to make similar transitions to digital broadcasting such as Canada in August 2011, such a study of the transition itself would ensure that they can take lessons from the experience of the broadcasters in the United States to make their own transitions go more smoothly. Simultaneously, this project will focus on a technical problem with the transition that has yet to be resolved; specifically, the poor design of many indoor VHF (very high frequency) antennas. This project will involve the construction and then testing of various VHF antenna designs in real world, ideal, and simulated conditions. This will be accomplished with both professional analysis tools and consumer receivers in order to determine which design is the superior choice in attempting to receive VHF broadcasts.

While primarily intended to benefit the broadcast industry, the benefits of this project can also impact other industries and applications. The military has access to a significant amount of VHF spectrum and improved compact antenna designs would make their equipment smaller and easier to handle. FM radio operates on the VHF band and a superior antenna design could improve reception in those radio receivers. The NWS (National Weather Service) weather radios operate in a narrow section of the VHF spectrum and could be made more reliable through use of improved antenna designs. Clearly, VHF antenna design is an important subject area across several industries that is thus worthy of additional study and attention.

Background

Digital television was conceived as a way to produce a broadcast equivalent of the Japanese analog HDTV (high definition television) system in the United States (Hart, 2010). Broadcasters originally proposed that the US digital television system operate only on the UHF (ultra high frequency) band, but commercial interests wanted access to the more desirable UHF spectrum, and thus the VHF bands remained available as part of the broadcast spectrum (Hart, 2010). This decision was not made completely without technical considerations for broadcast; in 1994, the FCC (Federal Communications Commission) conducted experiments on channel 6 in Charlotte, NC and found performance on that lower VHF frequency to be acceptable with their outdoor antenna testing (Sgrignoli, 1999). However, no testing of that signal was conducted indoors, and it is unclear whether or not testing was conducted during poor weather or in the presence of consumer electronic devices, both of which could have revealed significant problems.

Prior to the transition, the FCC conducted so-called “channel elections” to determine how the channels would be allotted in the post-transition era. Stations which retained their existing digital channels would be given priority, while those who relocated would have to work around existing ones (Eatherson, 2006). For stations with channels outside the “core” channels 2-51, existing coverage could not be preserved and these stations had to start from scratch. Any which had to return to a VHF channel were often left with severely depressed power levels. Due to observed poor performance (Lung, 2004), a stigma had developed surrounding the lower VHF channels 2 through 6. For this reason, the FCC allowed stations would have otherwise been forced to a lower VHF frequency to relocate to other frequencies (Martin, 2005), and some of them also ended up on upper VHF channels at depressed power levels as well.

Once the channel elections were settled, the push toward the final transition ensued. Congress passed the Deficit Reduction Act (2005) which contained provisions for a $40 off coupon program for coupon-eligible converter boxes (CECBs) to allow analog televisions to receive digital television signals, as well as a provision setting the transition date as February 17, 2009. At the same time the coupon program was being organized, stations began a blitz of advertising for the upcoming transition and CECB program. One thing these extensive advertisements did not cover, however, was the need for an appropriate antenna, with many treating the box as all that was required to receive digital television signals. In early February 2009, the transition was delayed until June 12 of that year due to the coupon program having run out of money (Miller, 2010).

Though many in the government and the industry would claim the transition was generally “smooth,” it was not without issues. Many of the converter boxes would not properly erase outdated channel plans from their memories, causing stations which had relocated to different channels to become unavailable to viewers. This led the FCC to issue a bulletin advising that the so-called “double rescan” would assist with this issue (Eggerton, 2009). In addition, despite the 18 months of advertising and other measures, there was still a small minority of people who were unprepared and left scrambling for coupons and/or converter boxes (Hart, 2010). The largest issue to arise was that many viewers experienced significant issues with stations which had relocated to the VHF band, and for these, solutions have been varied and with mixed success (Lung, 2009).

Non-technical Project

In setting up the digital transition, many regulatory issues arose and were settled by the FCC. For example, the channel election process was complicated and yet completely accepted by the various broadcast stations in the United States. Even today, regulations on power levels limit the viability of VHF stations and place limits on other aspects of digital broadcasting in the post-transition world. The STS portion of this project aims to discover what the impacts of various FCC regulations have had on the digital transition as well as the continuing role off those regulations on broadcasting today in an attempt to improve those regulations and provide insight on how to make digital transitions by other countries smoother than that of the United States.

This analysis will delve into the records of the FCC and determine what justifications are given for various rules which were put into effect over the years. The project will focus on regulations regarding the transition itself, such as channel elections and rules on transitioning after the date was delayed in Congress, but a special focus will be on regulations pertaining to VHF power levels and how they compare to real world observations. Other portions of the project will analyze programming content, carriage on cable and satellite, and other areas to determine if these regulations can be adjusted to improve service to the public and the continued competitiveness of over-the-air broadcasting. The specific analysis used for each set of regulations will vary. For example, an analysis of programming content regulations would examine the ratings of programming mandated by regulation versus alternate programming that could air in that time slot. An analysis of VHF power and other signal-related regulations would investigate real world studies of VHF broadcast station interference levels in order to determine where appropriate limits lie. Some of the noted subject areas may not be feasible if an objective measure cannot be determined or necessary data is unavailable, but those areas alone would be effective in proposing reforms for a significant amount of FCC regulations.

When finished, this project will provide a set of recommendations for ways to improve FCC regulations either through its own rule making process or through Congressional action. A number of technical recommendations regarding VHF power levels and other signal characteristics will aid in improving reception among viewers who may have lost some of their channels due to the transition, many of whom are lower income (Smith, 2009). In addition, alterations to other regulations which are outdated or overly strict could be made to help stations be able to draw in viewers and better compete with the growing popularity of subscription television channels. Once met, these goals would help to ensure that broadcast television remains freely available for as long as possible for the largest number of people.

Technical Project

The goal of the technical portion of this project is to test VHF antenna designs to determine which provides the best performance. Improvements in consumer antenna design could prove to be a key component of successful VHF reception. At present, most indoor VHF antennas consist of rabbit ear style dipole antennas, which FitzGerrell (1979) among others have shown to have very poor performance. In addition, Turney (2007) has demonstrated that walls can attenuate VHF signals significantly more so than UHF signals, making improved VHF antenna design essential for capturing as much of that reduced signal as possible. Since there are too many broadcasters to relocate all of them to UHF frequencies, some will have to remain on VHF in the future. This project will ensure that VHF remains a viable band for over-the-air broadcasting and that antenna design can allow for all channels to be received successfully.

In the project, several antennas will be designed and built, including several common existing designs as well as newer designs and designs not commonly used in the VHF band, such as helix (Dobbins, 2001) or fractal antennas (Vinoy, 2001). Testing will take place in three phases. In the first phase, the antennas will be modeled with software designed to determine the characteristics of various antenna designs, such as gain and front-to-back ratio. In the second phase, the antennas will be tested outdoors with line of sight to a VHF broadcast station. The antennas will be hooked to a spectrum analyzer to view the resulting waveform, as well as to a consumer digital television receiver to determine if the signal is adequate for decoding. In the final phase, the antennas will be tested in various indoor locations. Once again the antennas will be attached to both a spectrum analyzer and a consumer digital receiver. This last phase will be used to determine the performance of these antennas in real world environments, and will be key to determining which is the superior design.

At the conclusion of testing, the various test results will be compared and a design chosen as the type with superior performance based on figures including gain, rejection of alternate signal reflections, and actual reception as noted by the testing with the consumer receiver. Several broadcast industry representatives have expressed interest in this project, with one even offering corporate sponsorship if required, and as such this project has the potential to redefine how consumer television antennas are designed and built if a superior design is developed. The impacts extend not only to the broadcasters, but also to companies which develop antenna and receiver products, offer data services on digital television bandwidth, and develop mobile digital equipment. Even outside the broadcast industry, other users such as the military use many VHF frequencies for various purposes and these groups could also make use of improved antenna designs.

Conclusion

From the advent of broadcasting through the present day, antennas have been necessary to ensure a transmission completes its journey from one point to another. Due to ineffective designs of indoor antennas and limitations of digital broadcasting, VHF has gone from the frequency band on which all broadcasters wanted to operate to the frequency band from which most broadcasters would like to flee. It is important to understand what impacts FCC regulations had on the the transition to digital broadcasting as well as the impacts those regulations continue to have today and the lessons learned from the transition, as well as technical solutions to the various problems that arise in these matters. This project will have far-reaching ramifications on several major industries and should be seriously considered in order to provide benefits and knowledge to these industries and to the world.

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Some examples of antenna systems are also given in order to show their performance and orientate the user in selecting the configuration that best suits the requirements. In particular Â§ 6.4 and Â§ 7.2 give the analytical procedure to calculate the overall radiation pattern of an antenna system.Â 1.1 Reference frames In the Radio Regulations, the horizontal angle of the â€œbeamâ€ of an antenna (the â€œbeam tiltâ€) is specified in degrees relative to the horizontal; a downward tilt being a negative angle. Beam azimuth is specified in degrees measured clockwise from true north.Â This is a typical situation for VHF and UHF antenna systems, where the radiating elements (panels, Yagi, etc.) are considered as point sources with similar or dissimilar radiation patterns oriented in different directions. The new communication systems and newly introduced applications operating at frequencies in the ultra-high frequency (UHF) and super-high frequency (SFH) bands (Table 1.1) set strict requirements for the antenna in terms of size and efficiency. The portability and mobility of wireless technology demands compact and handheld devices with small enough size to be easily carried, of light weight and with low cost. Dipole and monopole antennas were the two most practically used antennas types for wireless communication systems in the early stage of their development.Â Additionally, facilities used for the analysis, fabrication and measurement of the proposed antennas are described. 2.1 A. NTENNA. VHF, UHF and Microwave Antennas - II: Microstrip Antennas â€“ Introduction, Features, Advantages and Limitations, Rectangular Patch Antennas â€“ Geometry and Parameters, Characteristics of Microstrip Antennas. Impact of Different Parameters on Characteristics, Reflector Antennas â€“ Introduction, Flar Sheet and Corner Reflectors, Paraboloidal Reflectors â€“ Geometry, Pattern Characteristics, Feed Methods, Reflector Types â€“ Related Features, Illustrative Problems.Â In reception, an antenna intercepts some of the power of an electromagnetic wave in order to produce a tiny voltage at its terminals, that is applied to a receiver to be amplified. Antennas are essential components of all equipment that uses radio.Â Transmission and reception antennas can be used interchangeably. In the USA the Federal Communications Commission (FCC) will issue a VHF operatorsâ€™ license (Operators Permit) upon payment of a fee but there is no test of competence or exam, as there is in most other parts of the world. Any operator on commercial vessels must have a VHF license as does anyone operating an SSB also.Â Although the regulations do not apply to most leisure craft it is important to have a basic understanding of the system and voluntarily carry selected systems with GMDSS capability. In simple terms the objectives of GMDSS are to improve the effectiveness of a distress call and to increase the chance of a distress call being received anywhere in the world. Given this complexity, antenna measurement and analysis will be more successful if you use an experienced and accredited antenna laboratory equipped to handle the tests, standards, and their nuances. This article is the second of a two-part analysis of antenna theory and design for a remote-keyless-entry (RKE) application. The first part of this article, Small Loop Antennas: Part 1â€”Simulations and Applied Theory, explains the complexity of antenna analysis, presents several simulation tests, discusses test results, and compares the benefits and limitations of short-loop or open-loop antenna de...Â Please refer to official FCC rules and regulations for compliance. B.2. General Requirements.