Part 5 Application

Question 7

Exhibit Detailing Program of Research for Part 5 Application

a. The complete program of research and experimentation proposed including description of equipment and theory of operation.

This is a program of research and experimentation of radio at the 2200m and 1750m wavelengths. This program is expected to run for a 5 year period. Research into the propagation of radio at 2200m and 1750m, suitability of this band for one- and two-way automatic (computer controlled) and aural communication, and the effects of the solar sunspot cycle, weather, season, time of day, radiated power and antenna height upon this communication. Modern narrowband signaling methods will be tested and optimized for suitability at LF. This communication will be through a radio beacon operated between 135.7 and 139 kHz and between 160 and 190 kHz using CW Morse code for aural reception, slow Morse code for automatic reception (QRSS), low baud rate phase shift keying for automatic reception as well as narrowband voice transmissions in the single-sideband suppressed carrier mode. (Voice transmissions are to be restricted to the 160-190 kHz band.) Both one- and two-way communication (two-way with other Part-5 license holders and foreign amateur radio operators who are authorized to use the 2200 meter band) will be attempted as well as two-communications with stations operating under Part 15 of the FCC rules in the 160-190 kHz band.

The transmitters and other equipment used for this experiment are and will be built by owner/operators Robert J. Raide (Penn Yan, NY) and Warren H. Ziegler(Wayland, MA). The applicants for this license are the owners/operators of the experimental stations. The transmitter frequency will be determined by a quartz crystal and operated at LF through division of the crystal frequency or direct digital synthesis. The transmitter is a class-D design using power MOSFETs. Operation will be either automatic (computer controlled) or hand keying for CW Morse code and computer generated low speed Morse and frequency/phase shift keying as well as narrow-band voice transmissions.

The antenna will be an electrically short, top loaded monopole (see attached diagram). At these frequencies the efficiency of electrically short antennas is typically 1% or less (example efficiency calculation attached).

b. The specific objectives sought to be accomplished.

Objectives to be accomplished are:

• Study and proof of effective communication in this band using stated techniques.
• Optimization of modern narrowband signaling techniques for long distance low frequency propagation.
• Study of propagation and suitability of this band for one- and two-way communication.
• Study of effects of solar cycle, weather, season, time of day, radiated power, and antenna height upon this communication.

The proposed program of research into two-way narrowband signaling techniques at LF **CANNOT** be achieved by any other route. The Part 15 rules permitting one watt into a 15 meter antenna in the 160-190 kHz band is **NOT** a substitute for the proposed experimental allocation for the following reason:

Due to the extremely short antenna (15 meters maximum) the electrical efficiency of a Part 15 antenna is less than .1%. One watt into a 15 meter antenna yields an e.r.p. of less than 1 milliwatt. I am requesting an e.r.p. of 10 watts which is more than 4 orders of magnitude greater. Greater signal strength is essential to permitting two-way communication and overcoming high ambient noise levels. The higher e.r.p. will permit the study of more marginal propagation modes and spanning greater distances than would be possible with the sub-milliwatt e.r.p.

c. How the program of experimentation has a reasonable promise of contribution to the development, extension, expansion or utilization of the radio art, or is along line not already investigated. Modern narrowband signaling techniques have not been studied in depth for application to the low frequency range. Research that had been done in radio at the beginning of the last century was consulted, as most of this had been initially at low frequencies before it was discovered that shortwaves were the route to go for long distance communications. There is a lack of information about long distance propagation at LF, i.e. in the 100 kHz-200 kHz region. There is a lot of information on VLF where work has continued for submarine communications and a lot of work at MF to HF for the broadcasting communities, so to some extent there is a gap in our knowledge at LF. This program will test both aural and automatic signaling techniques, and detail their effectiveness and how these techniques are influenced by sunspot cycle, weather, season, time of day, radiated power, and antenna height.

The results of this program will be made available to the public (for free) and to the FCC in hopes that the data may be used to further understand operation in this band and might perhaps be used by the FCC in any future consideration of uses for this band.

ERP Calculation

Assumptions:
Transmitter power output 2500 watts; Antenna vertical monopole 90 feet high with a 300 foot long top loading wire (sloping to 40 feet at the ends); Wavelength=2200m; Antenna Current: I = 7 amps

For a top loaded vertical the radiated power P_{rad} is given by:

$P_{rad} = 160 \bullet \pi^2 I^2 H_{eff}^2/\lambda^2$

Where I= antenna current; H_{eff} is the effective height of the antenna; λ is the wavelength

$H_{eff} = H_{actual}\,(2C_h+C_v)/\{2(C_h+C_v)\}$ C_h and C_v are the capacitance of the horizontal and vertical sections of the antenna respectively

$C_h = 90\text{m} \bullet 5\text{pF/m} = 450\text{pF}$; $C_v = 27\text{m} \bullet 6\text{pF/m} = 162\text{pF}$

Since in this case the top loading wire slopes slightly we use C_{slope} instead of C_h
$C_{slope} = C_h \sin\alpha$; where α is the angle from horizontal to the sloping horizontal antenna

For a 300' long wire which is 90' high at the center and 40' at the ends, $\alpha = 70^o$

$C_{slope} = 450 \text{ Sin}(70^o) = 450\ .94 = 423\text{pF}$

$H_{actual} = 27\text{m}$ (90')

Using $C_{slope} = 423$ pF instead of C_h @ 450pF,

$H_{eff} = 27(2 \bullet 423 + 162)/\{2(423+162)\} = 23.3$ m (sloping top, $\alpha = 70^o$)

$P = 160\ \pi^2 I^2 H_{eff}^2/\lambda^2$

For an antenna current of 7 amps I = 7

$P_{rad} = 160 \cdot 3.14^2 (7)^2 23.3^2 / 2200^2 = 8.7$ Watts

Efficiency = $100 \cdot P_{rad}/P_{out} = 100 \cdot 8.7/2500 = 0.348\%$