FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

APPROVED BY OMB
3060-0065
Expires 12/31/95

APPLICATION FOR NEW OR MODIFIED RADIO STATION AUTHORIZATION UNDER PART 5 OF FCC RULES - EXPERIMENTAL RADIO SERVICE (OTHER THAN BROADCAST)

1. Applicant's Name and Post Office address (Street address, city, state, and ZIP Code. See Instruction No. 4)

Dr. T.S. Rappaport
Mobile & Portable Radio Research Group, Virginia Tech
340 University City Blvd
Pointe West Commons, Suite 1
Blacksburg VA 24061-0350

DO NOT WRITE IN THIS BLOCK
File No.
4721-EX-MR-95

2(a). Application for (check only one box)

☐ New station ☑ Modification of existing authorization

2(b). For Modification indicate below:
File No: Call Sign: KFZXCT

3. Application for modification indicate whether change is an addition or replacement of (check all that apply)

☑ FREQUENCY ☑ EMISSION ☐ POWER ☐ LOCATION

☐ OTHER PARTICULARS (describe below or in attached EXHIBIT No. _____)

4. Particulars of Operation (see instruction below)

Frequency (state whether ~~kHz~~ or MHz)	POWER			EMISSION	MODULATING SIGNAL	NECESSARY BANDWIDTH (KHz)
(A) MHz	(B)	(C)	(D)	(E)	(F)	(G)
800-950	10 W	100 W	Peak	See 1. & 2. Below		
1800-2500	10 W	100 W	Peak	"		
3800-4200	10 W	100 W	Peak	"		
5700-6500	10 W	100 W	Peak	"		
5800-9200	10 W	100 W	Peak	"		
17.8-18.5 GHz	10 W	100 W	Peak	"		
26-27.99 GHz	10 W	100 W	Peak	"		

(A) List each frequency or frequency band separately. (If more space is required, attach as EXHIBIT No._____)
(B) Insert maximum R.F. output power at the transmitter terminals. Specify units.
(C) Insert maximum effective radiated power from the antenna (If pulsed emission, specify peak power).
(D) Insert "MEAN" or "PEAK" (See definitions in Part 5).
(E) List each type of emission separately for each frequency. (See Section 2.201 of FCC Rules.)
(F) Insert as appropriate for the type of modulation:
(1) the maximum speed of keying in bauds;
(2) maximum audio modulating frequency;
(3) frequency deviation of carrier;
(4) pulse duration and repetition rate.
For complex emissions, describe in detail in the space provided below.
(G) Describe how the necessary bandwidth was determined in space provided below.

1. Spread spectrum, chip rate = 240 MHz max. (240 MHz), Bandwidth = 480 MHz max
2. FM: 50 KHz Bandwidth max

5(a). Proposed location of transmitter and transmitting antenna (check only one box)

☐ FIXED/BASE ☒ MOBILE ☐ BASE AND MOBILE

5(b). If permanently located at a fixed location, give below:			5(d). If mobile, describe the exact area of operation
State	County	City or Town	Virginia Tech Campus Pointe West Commons (MPRG Office/Lab Rosslyn, VA area, Roanoke, VA area Washington DC area.
Number and street (or other indication of location)			

5(c). Enter geographical coordiantes exact to the nearest second		5(e). Enter geographical coordinates of the approximate center of proposed area of operation (mobile applications)	
North Latitude	West Longitude	North Latitude	West Longitude
° ' "	° ' "	37 ° ~~37~~ 13 ' 48 "	80 ° 26 ' 24 "

(Lat/Long For VA Tech Campus and P

6. Is a directional antenna (other than radar) used?
If "YES", give the following information: ☑ YES ☐ NO
(a) Width of beam in degrees at the half-power point _____ SEE EXHIBIT No. 1
(b) Orientation in horizontal plane _____ (c) Orientation in vertical plane _____

7. Is this authorization to be used for fulfilling the requirement of a government contract with an agency of the United States Government? ☑ YES ☑ NO
If "YES", attach as EXHIBIT No. _____, a narrative statement describing the government project, agency and contact number.

8. Is this authorization to be used for the exclusive purpose of developing radio equipment for export to be employe by stations under the jurisdiction of a foreign government?
☐ YES ☑ NO
If "YES", attach as EXHIBIT No. _____, the following information: Provide the contract number and the name of the foreign government concerned.

9. Is this authorization to be used for providing communications essential to a research project? (The radio communi cation is not the objective of the research project).
☑ YES ☐ NO
If "YES", attach as EXHIBIT No. 1, a narrative statement provding the following information:
(a) A description of the nature of the research project being conducted.
(b) A showing that the communications facilities requested are necessary for the research project involved.
(c) A showing that existing communications facilities are inadequate.

10. If all the answers to Items 7, 8, and 9, are "NO", attach as EXHIBIT No. _____, a narrative statement describi in detail the following:
(a) The complete program of research and experimentation proposed including description of equipment and theory of operation.
(b) The specific objectives sought to be accomplished.
(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.

11(a). Give an estimate of the length of time that will be required to complete the program of experimentation propc in this application. 2 years
(b) If less than 2 years, give the length of time in months that the authorization requested in this application will be required.

12. Would a Commission grant of this application come within Section 1.1307 of the FCC Rules, such that it may hav significant environmental impact? ☐ YES ☑ NO
If you answer "YES", submit an Environmental Assessment required by Section 1.1311.

13. List below transmitting equipment to be installed (if experimental, so state):

MANUFACTURER	TYPE	NO. OF UNI
HP 83630A	Synthesizer } Spread Spectrum system	
FUJITSU 10W	Power Amp }	
HP 83630A	→ FM System	

14. Is the equipment listed in Item 13 capable of station identification pursuant to Section 5.152? ☐ YES ☑ NO

15. Will the antenna extend more than 6 meters above the ground, or if mounted on an existing building, will it extend more than 6 meters above the building, or will the proposed antenna be mounted on an existing structure other than a building? ☐ YES ☑ NO

If "YES", give the following (see instruction 9):

(a) Overall height above ground to tip of antenna is _____ meters.

(b) Elevation of ground at antenna site above mean sea level is _____ meters.

(c) Distance to nearest aircraft landing area is _____ kilometers.

(d) List any natural formations of existing man-made structures (hills, trees, water tanks, towers, etc.) which, in the opinion of the applicant, would tend to shield the antenna from aircraft and thereby minimize the aeronautical hazard of the antenna.

(e) Submit as EXHIBIT No. _____ a vertical profile sketch of total structure including supporting building, if any, giving heights in meters above ground for all significant features. Clearly indicate existing portion, noting particulars of aviation obstruction lighting already available.

16. Applicant is: *(Check only one box)*

☐ INDIVIDUAL ☐ ASSOCIATION ☐ PARTNERSHIP ☐ CORPORATION

☑ OTHER (describe below)

Research University – Virginia Tech

17. Is applicant a foreign government or a representative of a foreign government? ☐ YES ☑ NO

18. Has applicant or any party to this application had any FCC station license or permit revoked or had any application for permit, license or renewal denied by this Commission? ☐ YES ☑ NO

If "YES", attach as EXHIBIT No. _____ a statement giving call sign of license or permit revoked and relate circumstances.

19. Will applicant be owner and operator of the station? ☑ YES ☐ NO

20. Give name, title, and telephone number (include area code) of person who can best handle inquiries pertaining to this application.

Dr. T.S. Rappaport, Professor (703) 231-2971

21. APPLICANT ANTI-DRUG ABUSE CERTIFICATION:

By checking "YES", the applicant certifies that, in the case of an individual applicant, he or she is not subject to denial of federal benefits, that includes FCC benefits, pursuant to Section 5301 of the Anti- Drug Abuse Act of 1988, 21 U.S.C. 862, or, in the case of a non- individual applicant (e.g., corporation, partnership, or other unincorporated association), no party to the applicant is subject to a denial of federal benefits, that includes FCC benefits, pursuant to that section. For the definition of "party" for these purposes, see 47 CFR 1.2002(b). ☑ YES ☐ NO

22. List below all exhibits in numerical sequence and the item number of form requiring the exhibit identified.

EXHIBIT NUMBER	ITEM NO. OF FORM	EXHIBIT NUMBER	ITEM NO. OF FORM	EXHIBIT NUMBER	ITEM NO. OF FORM
1	8				

23. **CERTIFICATION:**

Attention: Read this certification carefully before signing this application.

THE APPLICANT CERTIFIES THAT:

(a) Copies of FCC Rule Parts 2 and 5 are on hand; and

(b) Adequate financial appropriations have been made to carry on the program of experimentation which wil be conducted by qualified personnel; and

(c) All operations will be on an experimental basis in accordance with Part 5 and other applicable rules, and w be conducted in such a manner and at such a time as to preclude harmful interference to any authorized station; and

(d) Grant of the authorization requested herein will not be construed as a finding on the part of the Commiss
(1) that the frequencies and other technical parameters specified in the authorization are the best suited for the proposed program of experimentation, and
(2) that the applicant will be authorized to operate on any basis other than experimental, and
(3) that the Commission is obligated by the results of the experimental program to make provision in its ru including its table of frequency allocations for applicant's type of operation on a regularly licensed bas

APPLICANT CERTIFIES FURTHER THAT:

(e) All the statements in the application and attached exhibits are true, complete and correct to the best of the applicant's knowledge; and

(f) The applicant is willing to finance and conduct the experimental program with full knowledge and understanding of the above limitations; and

(g) The applicant waives any claim to the use of any particular frequency or of the electromagnetic spectrum against the regulatory power of the USA.

Signed and dated this 10th day of April, 19 9

Name of Applicant Dr. T.S. Rappaport
(must correspond with name given on page 1)

By Theodore S Rappaport
(print) *(signature)*

Title Professor

Check appropriate classification:

☐ Individual applicant ☐ Member of applicant partnership

☑ Authorized employee ☐ Office of applicant corporation or association

WILLFUL FALSE STATEMENTS MADE ON THIS FORM ARE PUNISHABLE BY FINE AND/OR IMPRISONMENT (U.S. Code, Ti 18 Section 1001), AND/OR REVOCATION OF ANY STATION LICENSE OR CONSTRUCTION PERMIT (U.S. Code, Title 47, Section 312(a)(1), AND/OR FORFEITURE (U.S. Code, Title 47, Section 503).

NOTIFICATION TO INDIVIDUALS UNDER PRIVACY ACT OF 1974
AND THE PAPERWORK REDUCTION ACT OF 1980

Information requested through this form is authorized by the Communications Act of 1934, as amended, and speci by Section 308 therein. The information will be used by Federal Communications Commission staff to determine eligibility for issuing authorizations in the use of the frequency spectrum and to effect the provisions of regula responsibilities rendered the Commission by the Act. Information requested by this form will be available to the public unless otherwise requested pursuant to 47 CFR 0.459 of the FCC Rules and Regulations. Your response is re to obtain this authorization.

THE FOREGOING NOTICE IS REQUIRED BY THE PRIVACY ACT OF 1974, P.L. 93-579, DECEMBER 31, 1974, 5 U.S.C. 552a(e)(AND THE PAPERWORK REDUCTION ACT OF 1980, P.L. 96-511, DECEMBER 11, 1980, 44 U.S.C. 3507.

EXHIBIT No. 1
Description of the RF Communications Research Projects at the Mobile and Portable Radio Research Group
Virginia Tech, Blacksburg, VA

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1. Propagation Measurement and Prediction at MPRG

For the past five years, MPRG has been developing propagation prediction tools and channel measurement techniques for wireless communications. Channel measurements using a channel sounding system provide information which is vital to testing and validating propagation models. The current system is capable of measuring the power delay profile of an RF channel up to 6 GHz and can perform omnidirectional measurements or angle-of-arrival (AOA) measurements. Future uses of the measurement system include antenna polarization diversity research and digital signal processing (DSP) baseband modulation research.

2. Spread Spectrum Measurement System Description

In order to measure and predict the effects of multipath propagation, researchers at MPRG use a spread spectrum sliding correlator channel sounding system. The system uses transmitter and receiver sections as shown in Figure 1. (Figure 1 shows the system configured for measurements at 6 GHz; wideband measurements at the other bands listed on the station modification application will also be conducted.)

The transmitter uses an HP8360 signal sweeper to produce a carrier frequency. This carrier is mixed with a pseudo noise (PN) sequence produced by a ten-stage, 1023-chip PN sequence generator. The rate at which the PN sequence generator is clocked (i.e. the chip rate) determines the spread of the carrier and the minimum bandwidth of the bandpass filter. The current system clocks the PN sequence generator at 10, 20, 50, or 100 MHz, depending upon the width of the channel to be measured.; the 100 MHz chip rate corresponds to a channel bandwidth of 200 MHz. A 240 MHz chip rate has been proposed which will make the system capable of measuring a wideband RF channel with a 480 MHz bandwidth.

The signal power out of the transmitter bandpass filter is -15 dBm. Two cascaded amplifiers provide 55 dB of gain, producing a maximum of 10 W at the antenna terminals minus any waveguide losses. Lower power levels are achieved by inserting attenuation with the step attenuator, or by removing the 10 W power amplifier. The transmitter uses a biconical antenna with 3 dB gain and oriented to have vertical polarization.

The receiver uses either a biconical antenna for omnidirectional measurements or a horn antenna (10^{o} horizontal by 30^{o} vertical beamwidth, 3 dB gain) for AOA measurements. A bandpass filter identical to that in the transmitter is used in the receiver, followed by two low-noise amplifiers providing 40 dB gain. The received signal is mixed with a PN sequence which is identical to the transmitter PN sequence, but is clocked at a slightly slower rate. A TEK 2782 spectrum analyzer set to zero-span at the carrier frequency acts as a receiver and correlator. The vertical axis output of the spectrum analyzer is displayed on a TEK 11402 sampling oscilloscope, creating a plot of the power delay profile of the channel being measured. The scope is triggered

by a second mixer and a second PN sequence generator which is synchronized with the PN sequence generator in the transmitter (the correlation of the two receiver PN sequence generators produces the trigger pulse).

To measure the power delay profile of a channel, the transmitter and receiver are placed at separate points within a geographical area (outdoor measurements) or building (indoor measurements). The receiver's second PN sequence generator and the transmitter's PN sequence generator are synchronized before measurements are made.

An unobstructed line-of-sight (LOS) component, if it exists, appears as the first peak on the oscilloscope. Multipath components appear on the scope as peaks following the LOS peak. Factors such as antenna orientation and antenna polarization affect the strength of each component. The delay seen on the scope can be related to the actual propagation and multipath delay by a proportionality constant (slide factor).

The power delay profile displayed on the scope is saved by a data acquisition system. Measurements can be taken and recorded over a distance of a few wavelengths, and a three-dimensional plot can be produced showing the power delay profile versus distance travelled.

3. Adaptive Array Antenna Testbed

Researchers at MPRG are also developing and implementing adaptive array antenna systems and algorithms. The adaptive antenna testbed is a system designed to allow researchers to study adaptive antenna arrays, direction finding techniques, and associated digital receiver technologies. The system currently consists of a four-element linear array of monopoles. The signals are amplified and downconverted from a 2050 MHz RF frequency to a 24 kHz IF frequency where the signals from each element are sampled. The signals are split into in-phase (I) and quadrature (Q) channels using Digital Downconversion techniques. The digital complex baseband signals for each branch are constructed from these I and Q signals.

Currently the system uses a Constant Modulus Algorithm (CMA) (a blind adaptive algorithm) to adjust the weights and phases of the complex baseband digital signals from each branch to give the maximum signal-to-noise-and-interference ratio after the signals from each element are summed. In this way, the system forms an effective antenna beam pattern which is a maximum in the direction of the desired signal and forms nulls in the directions of interference.

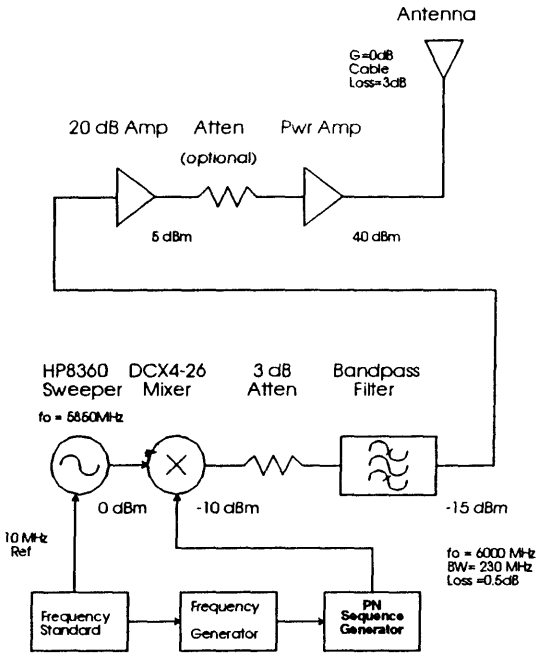
The IF and baseband portions of the system are currently implemented using three DSP processing boards mounted in an IBM compatible PC. The target signals currently used are CW, however in the future, we would like to demonstrate applicability of this technology to AMPS (Advanced Mobile Phone System) by using 30 kHz FM voice signals.

4. Cellular Transmitter Development

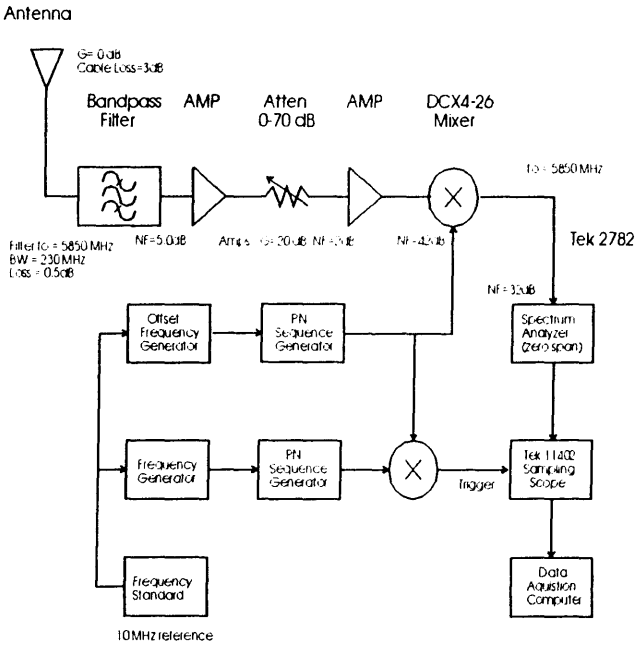
MPRG is developing an FM transmitter design which will be used to transmit baseband signals for research purposes. The first generation transmitter will transmit in the AMPS frequency band (824 MHz - 894 MHz) for research involving the analog standard. The transmitter currently produces a frequency modulated intermediate frequency (IF) at 72 MHz. The IF is multiplied and mixed with a CW signal synthesized by a phase-locked loop, producing an FM signal in the AMPS band with a maximum bandwidth of 30 KHz. One application of the transmitter will be to act as a narrowband interferer for the adaptive antenna system.

Spread Spectrum Channel Sounding System for Measuring Wideband Mobile Radio Channels

Figure 1.



6 GHz Transmitter



6 GHz Receiver

Mobile and Portable Radio Research Group
Virginia Tech

Virginia Tech
VIRGINIA POLYTECHNIC INSTITUTE
AND STATE UNIVERSITY

The Bradley Department of Electrical Engineering

Mobile and Portable Radio Research Group
840 University City Blvd.
Pointe West Commons, Suite 1, Blacksburg, Virginia 24061-0350
(703) 231-2970 Fax: (703) 231-2968

April 12, 1995

Kim Baum
FCC Experimental License Branch
2000 M St., Suite 230
Washington, DC 20554

Dear Kim:

Enclosed is our application for renewal and modification of existing authorization. We are requesting a fee waiver since MPRG is a research group at Virginia Tech, a state university. Our RF work is described within Exhibit 1 attached to the enclosed Form 442. If you have any questions, please call me at (703) 231-2965. Thanks for your help in expediting this process!

Sincerely,

Bill Newhall

Bill Newhall

enclosure