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.

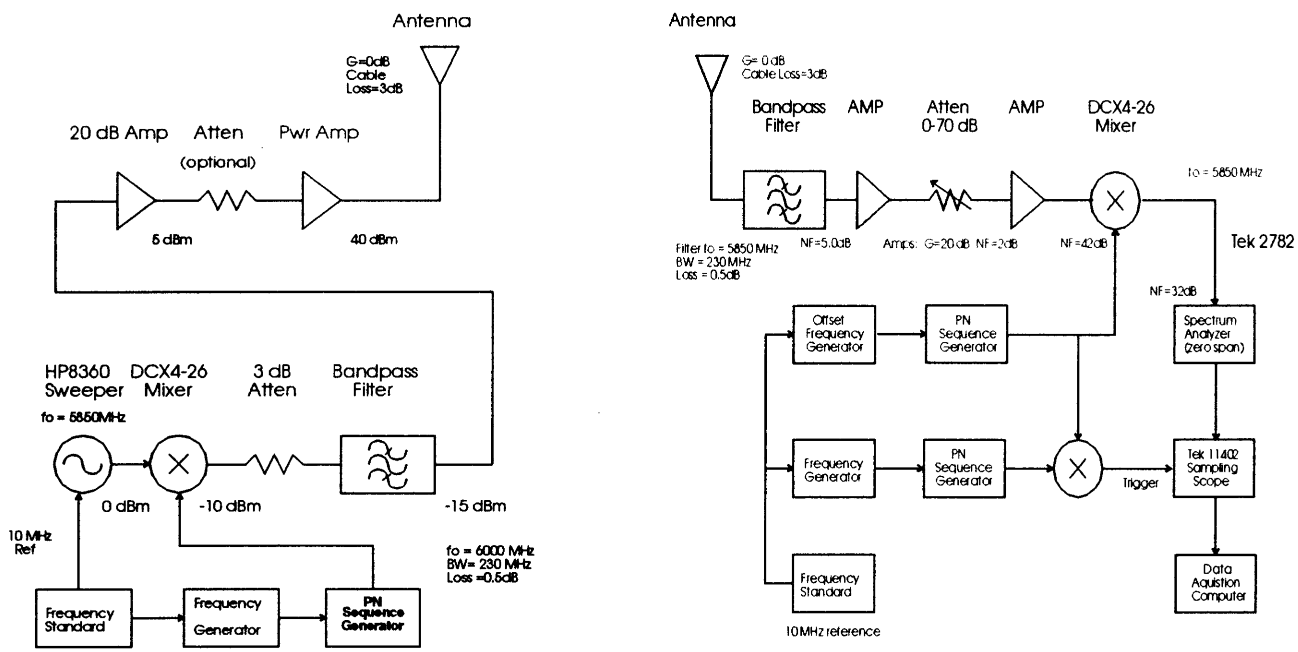
The IF and baseband portions of the system are currently implemented using three DSP processing boards mounted in an IBM compatible PC. The target signals currently used are CW, however in the future, we would like to demonstrate applicability of this technology to AMPS (Advanced Mobile Phone System)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

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