"MODULATING SIGNAL DESCRIPTION

Exhibit 2.1 Channel Sounding for RF Modulated Backscatter

RF modulated backscatter (RFMB) has traditionally been used only for very low cost and low data rate transmitters with either no batteries or batteries that must have extremely long lifetimes. RFMB is used for so-called “long-range” (<20m) RF tags. Applications include labels for large shipping containers, electronic shelf labels, and automated vehicle tolling. The purpose of the proposed experiment is to develop models for the large- and small-scale multipath fading in the RFMB channel. Such models will facilitate improved communication system design.

RFMB operation is illustrated in Figure 4 and explained as follows. An off-board source (the interrogator) transmits an interrogation waveform, which can be a CW wave or a frequency-hopped waveform. The interrogation waveform propagates to the RF tag that uses RFMB and reflects off of the tag antenna. A simple diode switch across the terminals of the antenna modulates the *impedance* of the antenna, thereby changing the reflection coefficient of the antenna with time. When the switch is in one state, the antenna reflects and when the switch is in another state, the antenna absorbs. The reflection or backscattered signal from the RF tag is therefore pulsed, creating an on-off keyed modulated signal. This is how an RF tag can transmit digital data without a power amplifier. Of course, the unmodulated wave from the interrogator reflects off of other objects in the environment, but the reflection from the tag is only the reflection that is pulsed. If the diode switching function is simply a periodic square wave, then the backscattered signal is amplitude modulated by a periodic square wave. The interrogator receiver can detect the presence of the backscattered signal by tuning a narrow filter to the frequency which is the carrier frequency plus the pulse repetition frequency, i.e. the first sideband.

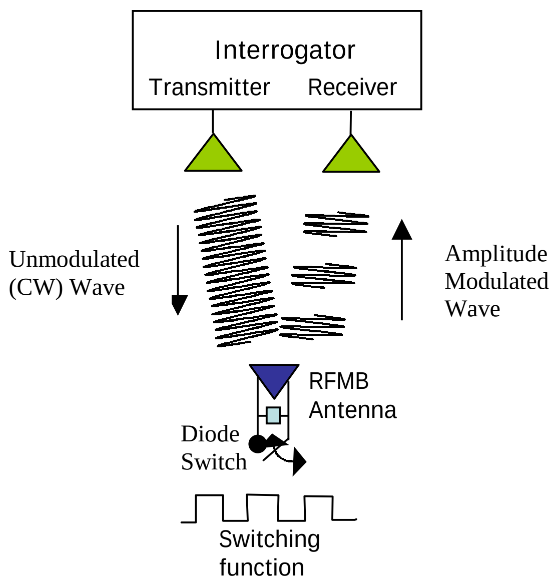

Figure 4. Illustration of RF Modulated Backscatter (RFMB)

We wish to transmit CW interrogation waveforms for the purpose of channel sounding, specifically, to measure the fading characteristics of the RFMB signal. Because of the two-way nature of this link (the interrogation waveform propagating to the tag and then reflecting back to the interrogator), we expect the two-way fading to be the product of typical one-way fades. As the product of two faded channel gains the RFMB channel gain can have very deep fades, and we want to capture those fades to get an accurate estimate of the fading distribution. This is the main reason why we are requesting a transmit power that exceeds the "ANY" category in the Part 15 regulations.

The measurement setup is shown in Fig. 5. For our reflection antenna, we will use the nearly omnidirectional antenna on the electronic shelf tag (EST) from NCR's DecisioNet™ system. The EST is modified to allow the antenna to be switched continuously by an HP33120A function generator at a rate of 25 KHz with a 50 % duty cycle. The EST will be attached to the side of a T-shaped fixture made of plastic. The **unmodulated (CW)** RF carrier (i.e. the interrogator signal) will be transmitted by a patch antenna (ANP-C-116) in the suspended ceiling, indicated by Antenna 1 in Fig. 7. The patch antenna has right hand circular polarization and a peak gain of 4 dBi. Antenna patterns are omnidirectional in azimuth and hemispherical in elevation as shown in Fig. 6, in which the contour scale is 5 dB per division. The peak power delivered to the transmit antenna will be 16 dBm, giving an EIRP of **20 dBm (0.577 V/m @ 3m).**

At this power level, a person would have to put their body within 13 mm of the source for at least 6 minutes to exceed the ANSI threshold for harmful exposure.

An active patch antenna, indicated by Antenna 2 in the figure, with a pattern similar to that of Antenna 1, will be used to receive the backscattered signal. The active antenna includes the low-noise amplifier (LNA) HP INA-10386. Its output signal will go to a modification of the DecisioNet ceiling base station (CBS), which includes amplifiers, a mixer, and an eighth-order filter and which produces I and Q outputs. The local oscillator (LO) for the mixer will be detuned by 1 KHz, in order to avoid signal cancellation and to get IF conversion, and the I output at 26 KHz will be monitored on an audio spectrum analyzer. A computer will controll all instruments through GPIB and RS-232C interfaces and collect data for analysis.

In the Form 442, we describe two "modulations" associated with this experiment, one for the "downlink" or interrogator transmitted signal and one for the "uplink" or backscattered signal. The downlink is the unmodulated segment of RFMB and the uplink is the modulated segment. The uplink signal is only a reflected signal, which is why it is described as having such a low EIRP and the "power applied to the terminals" is left as "not applicable" (N/A).

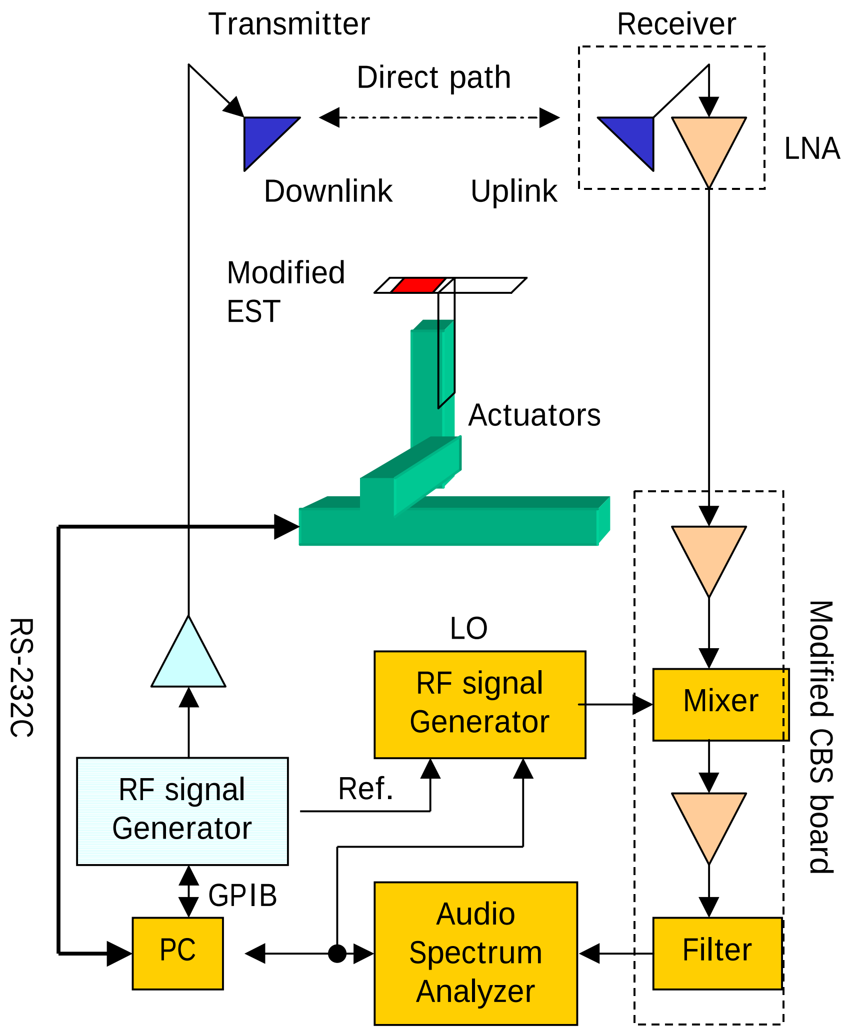

Figure 5. The setup for measuring the fading characteristics of the modulated backscatter link at 2.45 GHz

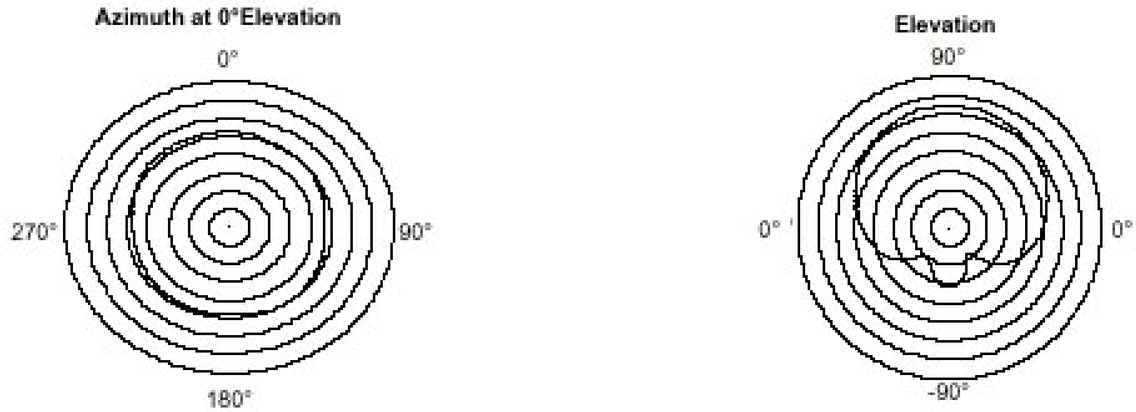

Figure 6. Representative azimuth and elevation patterns for the patch antennas that will be used as the transmit and receive antennas (at the top of the diagram) in the previous figure. The EST is the reflection antenna on the RF tag, and is not used for active transmission.