Understanding Backscatter Radio Propagation through New Radio Link Budgets

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UHF and microwave backscatter radio systems for radio frequency identification (RFID) and sensors are growing rapidly because transponders in these systems can exchange information with little- or no-power at distances of several meters. Though the concept of backscatter radio is straightforward – a backscatter transponder (or RF tag) communicates with an interrogator (or reader) by modulating the waves scattered from its antenna by changing the antenna load – a thorough understanding of the propagation mechanisms pertinent to backscatter radio is needed for successful system design. This presentation will examine the four link budgets required for backscatter radio with an emphasis on how small-scale fading influences radio link design. Each parameter of the link budgets will be discussed in detail and demonstrated through an example of a typical RFID portal system operating at 915 MHz (J. D. Griffin and G. D. Durgin,"Complete Link Budgets for Backscatter Radio and RFID Systems," *Antennas and Propagation Magazine*, April, 2009).

The need for new link budgets specific to backscatter radio and RFID systems arises because of their substantial differences with conventional radio systems. The first difference is that the power available to the RF tag is severely limited and precludes the use of conventional RF devices and signaling techniques on the RF tag. Instead, all of the system complexity must be included in the interrogating device, or RF tag reader, to reduce tag power consumption and cost. Second, since a backscatter RF tag communicates by modulating the waves scattered from its antenna, the complete radio propagation channel is composed of two cascaded channels, or radio links - the forward *power-up link* that affects the power received by the RF tag from the reader transmitter and the *backscatter link* that governs the modulated backscatter signal received from the RF tag. Because of the two-fold nature of this propagation channel, a single radio link budget is not adequate for backscatter radio design; instead, four link budgets are required – the power-up radio link budget that describes the power available to the RF tag and three backscatter link budgets that describe the modulated backscattered power received by an RF tag reader in the monostatic and bistatic antenna configurations. These radio link budgets account for polarization mismatches between the reader transmitter, reader receiver, and the RF tag antennas; the effect of an impedance mismatch between the RF tag antenna and integrated circuit on the power coupled into the RF tag and the modulated power scattered back to the reader receiver; multipath fading for monostatic and bistatic reader antenna configurations; the reduction in RF tag antenna gain when the tag is attached to an object; and losses caused by obstructions to the line-of-sight path in the channel. Proper application of these link budgets will result in successful backscatter radio system design while reducing cost and design time.