The Power Delay Profile versus Eigenvalue Distribution of Resonant Electromagnetic Environments

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The power delay profile (PDP) of a communications channel is derived from the impulse response, typically emphasizing the multipath nature of the channel. The PDP has proven widely useful for optimizing RF communications systems. In highly resonant environments, such as certain indoor applications, the eigenvalue distribution proposed here offers an alternative model of the channel based on the eigenmodes of the environment, rather than multipath reflections. The close relationship of the eigenvalue decomposition to the electromagnetics underlying the channel characteristics offers physical insight distinct from the PDP. The two models are, of course, strongly related.

Here, we compute and compare both the PDP and eigenvalue distribution of an impulse response ensemble measured in a reverberation chamber. The PDP is computed via the average of impulse response magnitude squared, as commonly defined. The eigenvalue distribution is computed by "harmonic inversion", a frequency analysis algorithm that assumes the impulse response is a linear superposition of individual eigenmode responses. (Mandelshtam and Taylor, 1997) The PDP emphasizes time domain channel characteristics such as the mean delay and RMS delay spread. In contrast, the eigenvalue distribution emphasizes frequency domain features such as wavelength, bands of high and low SNR, and energy storage.

The PDP will remain a more useful model than the eigenvalue distribution for many applications, especially for modeling moderate numbers of multipath reflections. The eigenvalue distribution may offer a simpler model, with clearer physical insight, when the numer of reflections is very high. An unloaded reverberation chamber is the prototype environment where the number of reflections is high, and where our model was developed. We conclude with observations about the range of Q's that an environment must have for the eigenmode distribution to be useful in comparison to the PDP.