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OPTIMUM AND SUB-OPTIMUM DETECTION OF PHYSICS-BASED ULTRA-WIDEBAND SIGNALS —A TUTORIAL REVIEW

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Abstract. This paper gives a tutorial review of physics-based ultra-wideband signals and their optimum and sub-optimum detection. A balanced treatment of theoretical results and practical implementations is attempted.

Keywords. Ultra-wideband, Physics-based signals, detection

1 Introduction

Modern communication theory originated from the attempts of communication engineers to understand what they were doing in the most general terms. The limit of digital wireless communication networks depends primarily on four basic laws and their underlying theories, which attributed respectively to: Maxwell and Hertz, Shannon, Moore, and Metcalfe [1]. The first laws are laws of nature, while the last two are laws of behavior. The order is in the sequence of their discovery and their importance. As the field of wireless communications has matured, the emphasis and immediate relevance have shifted gradually downward in the list. Without an appreciation for Maxwell and Hertz's theories, there would be no controlled wireless propagation of electromagnetic waves. Without an understanding of Shannon's theories, efficient use of the spectrum through sophisticated signal processing could not have been achieved. Ultra-wideband (UWB) is experiencing this shift, probably from the first two laws, while the narrowband communication has shifted to the last two laws.Although often considered as a recent breakthrough in wireless communications, UWB has actually experienced well over 40 years of technological developments. The physical cornerstone for understanding UWB pulse propagation was established by Summerfield a century ago (1901) when he attacked the diffraction of time-domain pulse by a perfectly conducting wedge. In fact one may reasonably argue that UWB actually had its origins in the spark gap transmission design of Marconi and