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In the present work, noncoherent receivers for both frequency–nonselective and frequency–selective possibly time–variant channels are considered. $\underline{M}$–ary differential phase–shift keying (MDPSK) and $\underline{M}$–ary differential amplitude/phase–shift keying (MDAPSK) modulation, which both enable noncoherent demodulation, are employed.

The first part of the present work is devoted to noncoherent receivers for frequency–nonselective channels. Since the main field of application of such receivers is mobile communication, we keep receiver complexity as low as possible and focus on simple decision–feedback techniques, i.e., so–called decision–feedback differential detection (DF–DD) schemes. For derivation of these schemes three different approaches are considered. Namely, we distinguish between multiple–symbol detection (MSD) based DF–DD, linear prediction based DF–DD, and DF–DD based on nonlinear noise prediction.

MSD–based DF–DD is derived from optimum maximum–likelihood block detection and thus, it may serve as a benchmark for other DF–DD schemes. However, this scheme degrades if the actual channel statistics do not coincide with the statistics assumed for receiver optimization. This problem is circumvented by DF–DD based on linear prediction since here a simple adaptive implementation using the recursive least–squares (RLS) algorithm is possible at the expense of a higher receiver complexity. On the other hand, DF–DD based on nonlinear noise prediction offers only a performance gain compared to conventional differential detection (DD) for transmission over the additive white Gaussian noise (AWGN) channel, but, in contrast to MSD–based DF–DD optimized for AWGN, it does not degrade under fading, i.e., a simple and robust receiver results.

In the second part of this work, noncoherent receivers for frequency–selective channels are regarded. As in the classical coherent case, we distinguish between sequence estimation, decision–feedback equalization, and linear equalization. Five noncoherent sequence estimation (NSE) schemes are presented and compared. The NSE scheme proposed by Colavolpe and Raheli (CR–NSE) turns out to provide the best performance. In particular, a modified version of the original CR–NSE scheme, which allows to generate the reference symbol necessary for branch metric calculation recursively, is well suited for implementation. The considered noncoherent DFE (NDFE) scheme is derived directly from NSE and yields a significant performance gain (more than 4 dB) over all previously proposed NDFE schemes. The investigated noncoherent linear equalization (NLE) techniques consist of a linear filter and a decision–feedback differential detector. For filter optimization, two different criteria are employed. The first criterion leads to the minimization of the variance of intersymbol interference (ISI) in the equalizer filter output signal, whereas the second criterion leads to the minimization of the total error, which consists of ISI and noise.

For all regarded equalizers efficient noncoherent adaptive algorithms, which have a similar convergence speed as conventional coherent adaptive algorithms, are provided for channel estimation and filter adjustment.

The power efficiency of all discussed noncoherent receivers increases as the size of the observation window employed for estimation of the transmitted symbols increases. At the same time the robustness against phase variations decreases. Thus, a trade–off between power efficiency for channels with constant phase and sensitivity to phase variations exists.

Also, this work shows that properly designed noncoherent receivers can always approach the power efficiency of their coherent counterparts if the observation window is made sufficiently large. Especially for NDFE and NLE this is a new result since all previously reported schemes suffer from a large loss in performance compared to coherent equalizers.