The aim of this paper is to investigate the recently developed mixed-analog-to-digital converter (ADC) architecture for frequency-selective channels. Multi-carrier techniques, such as orthogonal frequency division multiplexing, are employed to handle inter-symbol interference. A frequency-domain equalizer is designed for mitigating the inter-carrier interference introduced by the nonlinearity of one-bit quantization. For static single-input-multiple-output (SIMO) channels, a closed-form expression of the generalized mutual information (GMI) is derived, and based on which the linear frequency-domain equalizer is optimized. The analysis is then extended to ergodic time-varying SIMO channels with estimated channel state information, where numerically tight lower and upper bounds of the GMI are derived. The analytical framework is naturally applicable to the multi-user scenario, for both static and time-varying channels. Extensive numerical studies reveal that the mixed-ADC architecture with a small proportion of high-resolution ADCs does achieve a dominant portion of the achievable rate of ideal conventional architecture, and that it remarkably improves the performance as compared with one-bit massive multiple-input-multiple-output.