A Theoretical Comparison of the Visual, Aural, or Meter Reception of Pulsed Signals in the Presence of Noise

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Abstract

The present paper examines theoretically the relative sensitivity of the detection of signal pulses in the presence of noise, (a) by observation of an oscilloscope, (b) by aural perception, in which one listens to the fundamental or a low harmonic of the pulse repetition frequency (PRF), (c) and by a meter. The metering scheme may be either aperiodic, where the rectified current is fed directly to a meter with a long time-constant, or periodic, where the rectified current is sent through an audio-filter tuned to the PRF, given a supplementary rectification, and then passed through the meter. The dependence of the sensitivities of the different methods on various relevant parameters is studied in some detail. These parameters include the width and the shape of the IF response, the pulse length, the PRF, and in aural or meter reception, the duration of the gate, the width of the audio-filter, and/or the time constant of the meter. The descriptive survey of the results is given in Part I and the mathematical analysis in Part II. Among the more important results are (I): The optimum IF filter is the conjugate of the Fourier transform of the pulse, not merely for visual reception, as was previously known, but also for aural or meter reception as well. (II): For very weak signals the linear detector requires only about 5 percent more input signal power than does the quadratic to achieve the same minimum detectable signal (same final signal-to-noise ratio). (III): The aperiodic meter has the advantage of not requiring knowledge of the PRF, and has potentially great sensitivity if spurious fluctuations in gain can be balanced out. (IV): Meter methods can be made more sensitive than the oscilloscope if long time-constants are available. Gating is also necessary. (V): Although the best IF filter is the Fourier transform of the pulse, the best pulse is not the Fourier transform of the filter in aural reception (though it is in vi- sual), for the best results in meter or audio-detection are obtained by using long pulses. In visual work, the pulse length is immaterial, to a first approximation. Curves are given showing the power required to achieve a given signal-to-noise ratio as a function of pulse length, IF filter width, the PRF, gating time, and audio-filter width, in some cases when the pulse and filter are not matched (i.e., are not related as Fourier transforms). Some numerical estimates of aural and meter performance relative to visual are also essayed.

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