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NASA TECH BRIEF

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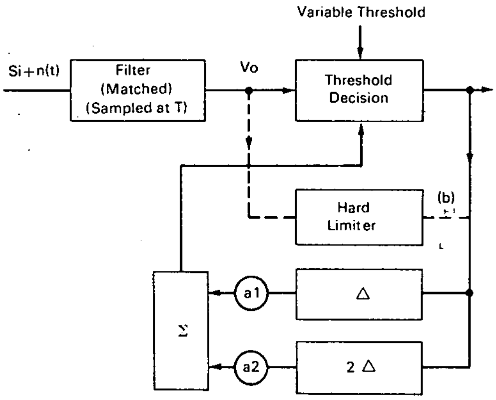
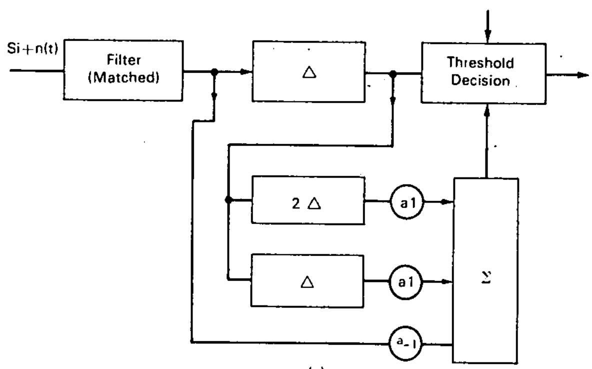
PCM Bit Detection with Correction for Intersymbol Interference



(a)



(c)

Bandwidth is at a premium in most communication systems, with at least some parts of the communication link insufficiently wide to give accurate reproduction of the transmitted signal in the presence of intersymbol interference or Gaussian additive noise. While previous systems have been used to largely overcome such interference, they have suffered from the disadvantage of matched filter systems requiring change whenever the bandwidth changes.

In the present system the received signal is filtered by an optimum filter; in the case of PCM bits this is an "integrate and dump" filter. The output of this filter is a set of samples at the end of the PCM bit. These samples are sent to a threshold decision circuit. If the sample voltage exceeds the threshold voltage V_i, the decision is that a $+A$ bit has been received. If the sample is below V_i, the decision is that $-A$ has been received. Here the correction for intersymbol interference is done by operating on the threshold voltage V_i. The basic idea behind this system is that if the channel's characteristics are known, the interference caused by a known bit in the past can be predicted exactly. In other words, if it is known that the previous bit was a $+A$ or a $-A$ and the channel has a known αT the contribution of this previous bit at the present sampling time can be calculated. Therefore the effect of this interference can be corrected, when making the decision, by raising or lowering the value of the threshold V_i correspondingly.

The system shown in the figure corrects for interference caused by two past bits. If the amount of interference at the threshold element at the sampling time is a_1 due to the previous pulse and a_2 is the interference due to the pulse previous to that, the threshold voltage has to be adjusted by $\pm a_1 \pm a_2$ (depending on the previous decisions).

The system in (a) uses the two previous decisions for setting the present threshold. Under certain conditions this may lead to rapid deterioration of the system and propagation of errors. If the last decision

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was in error the voltage a_1 will have the opposite polarity and the threshold V_i for the present decision will be moved in the wrong direction increasing the probability of error for this bit. However, it will be shown that as long as the probability of error is less than 0.1, this is not a serious problem because the probability of errors propagating will be negligible.

The system shown in figure (b) is very similar to figure (a). The only difference is that instead of using constant correction voltages $\pm a_1$ and $\pm a_2$ that are determined by the previous decision, voltages a_1V_0, a_2V_0 proportional to the filter's output are used for correction purposes. This reduces the probability of error propagation. The hard limiter is introduced to protect the system against high peaks of noise. If the limiter is not used, high peaks of noise may result in values of a V_0 that are very large and bias the decision circuit excessively. The limiter ensures that the correction voltage will never exceed the value corresponding to the signal in the absence of noise.

The system in figure (c) is an extension of the system shown in figure (b). The additional delay in front of the decision circuit enables the detector to incorporate into the correction the effect of the next bit. If the transmission is over a channel that has dispersive delay, it may happen that part of the energy due to the next bit arrives earlier and affects the present decision. This type of interference is considered to be minimal in the case under consideration.

Note:

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