

Simplified theory of NRZ, duo-binary, and PR-4

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NRZ

NRZ is the baseline signal. It is big but gets attenuated and has ISI added by the channel. The ISI can be corrected by equalization.



duo-binary, aka PR-1

Duo-binary uses a $(1+D)$ partial response which is similar to the channel attenuation and should need only minor amounts of equalization. This comes at a cost: the response is really $(1+D)/2$, since it involves averaging over 2 bit times. This means the basic signal will be only half the size of an NRZ signal. Its better spectral response partially offsets this but without maximum likelihood detection it will not be as good as NRZ.



PR-4

PR-4 is similar to duo-binary but adds a $(1-D)$ to get a total response of $(1-D^2)$. The $(1-D)$ characteristic is usually due to an intrinsic high pass characteristic of the channel or transmitter. If PR-4 is used in 10GBASE KR the transmitter will need to have a $(1-D)/2$ filter. This implies another 2:1 signal loss, this time without a better fit to the channel.



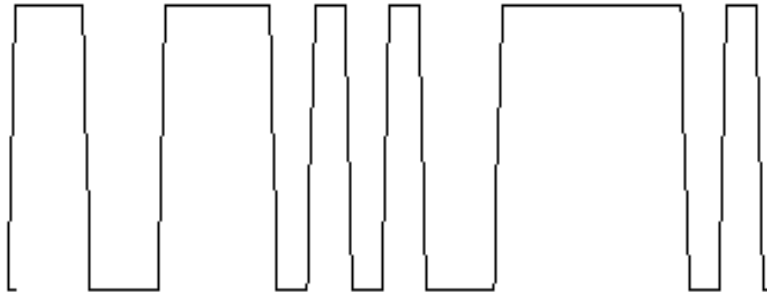
The next slide shows this in graphical form

It show ideal, unequalized data without channel loss

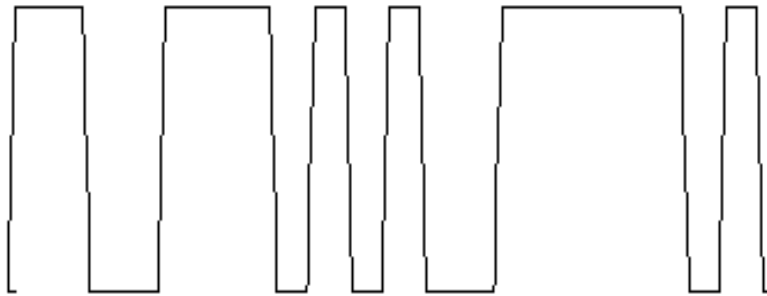
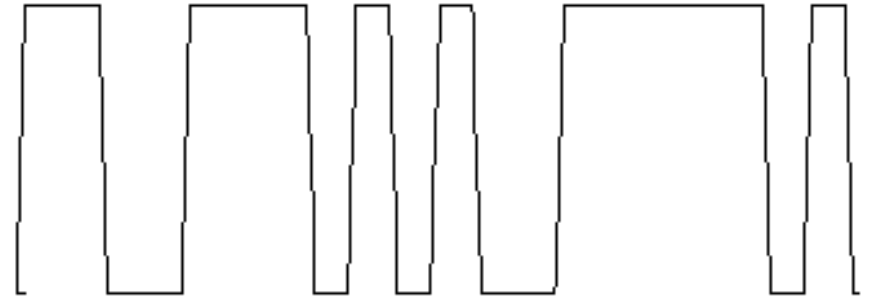


Transmitted

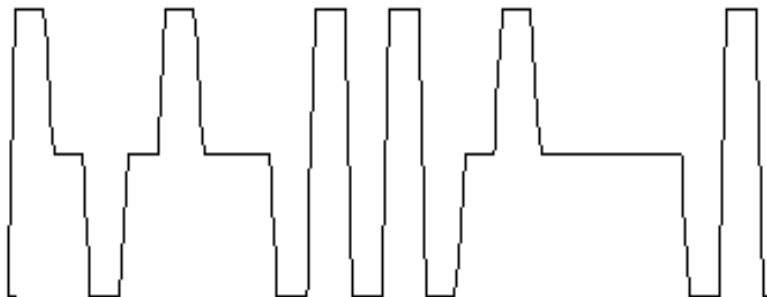
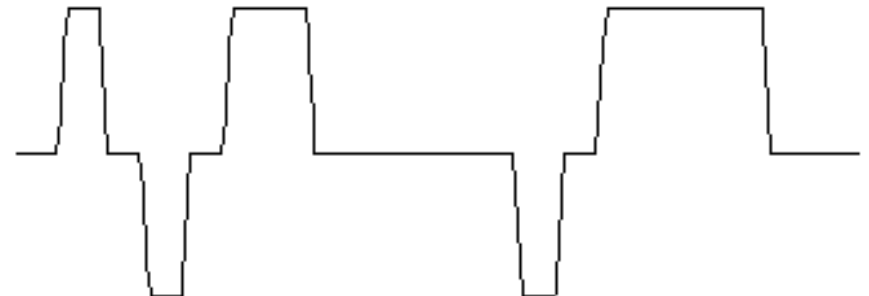
Received



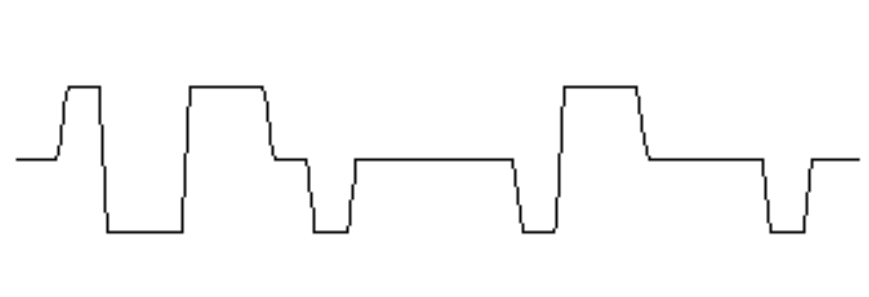
NRZ



PR1



PR4



Notes:

- Although the transmitted data is the same, PR1 has only half the amplitude available for its received EYE as NRZ has.
- Although PR4 transmitted signal has much less energy than that transmitted for NRZ or PR1, its energy at high frequencies, which contribute most to crosstalk, is just as great.
- The PR4 received EYE is similar to a PR1 received EYE, but it is only half as big.
- The PR4 received EYE differs from the PR1 received EYE in that it can have transitions from positive to negative or negative to positive as well as transitions between positive or negative and zero. This will add uncorrectable jitter.



Conclusions:

I expect that:

- NRZ will generally work better than duo-binary but not by much.
- Duo-binary will work much better than PR-4.

