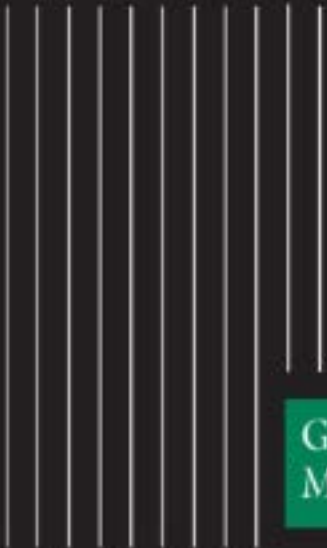


DATA AND COMPUTER COMMUNICATIONS

NETWORKING AND
INTERNETWORKING



Gurdeep S. Hura
Mukesh Singhal

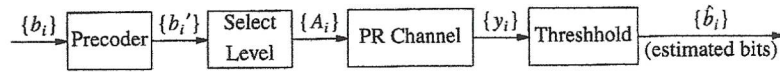


FIGURE 25.12 Precoding for a PR channel.

TABLE 25.1 Example of Precoding for Duobinary PR.

$\{b_i\}$:	1	0	0	1	1	1	0	0	1	0
$\{b'_i\}$:	0	1	1	1	0	1	0	0	1	1
$\{A_i\}$:	-1	1	1	1	-1	1	-1	-1	1	1
$\{y_i\}$:	0	2	2	0	0	0	-2	-2	0	2

performance of a particular PR scheme depends on the channel characteristics, as well as the type of detector used at the receiver. We now describe a simple suboptimal detection strategy.

Precoding

Consider the received signal sample Eq. (25.27) with duobinary signalling. If the receiver has correctly decoded the symbol A_{k-1} , then in the absence of noise A_k can be decoded by subtracting A_{k-1} from the received sample y_k . If an error occurs, however, then subtracting the preceding symbol estimate from the received sample will cause the error to propagate to successive detected symbols. To avoid this problem, the transmitted levels can be **precoded** in such a way as to compensate for the intersymbol interference introduced by the overall partial response.

We first illustrate precoding for duobinary PR. The sequence of operations is illustrated in Fig. 25.12. Let $\{b_k\}$ denote the sequence of source bits where $b_k \in \{0, 1\}$. This sequence is transformed to the sequence $\{b'_k\}$ by the operation

$$b'_k = b_k \oplus b'_{k-1} \quad (25.33)$$

where $\oplus$ denotes modulo 2 addition (exclusive OR). The sequence $\{b'_k\}$ is mapped to the sequence of binary transmitted signal levels $\{A_k\}$ according to

$$A_k = 2b'_k - 1 \quad (25.34)$$

That is, $b'_k = 0$ ($b_k = 1$) is mapped to the transmitted level $A_k = -1$ ($A_k = 1$). In the absence of noise, the received symbol is then

$$y_k = A_k + A_{k-1} = 2(b'_k + b'_{k-1} - 1) \quad (25.35)$$

and combining Eqs. (25.33) and (25.35) gives

$$b_k = \left(\frac{1}{2} y_k + 1 \right) \bmod 2 \quad (25.36)$$

That is, if $y_k = \pm 2$, then $b_k = 0$, and if $y_k = 0$, then $b_k = 1$. Precoding, therefore, enables the detector to make *symbol-by-symbol* decisions that do not depend on previous decisions. Table 25.1 shows a sequence of transmitted bits $\{b_i\}$, precoded bits $\{b'_i\}$, transmitted signal levels $\{A_i\}$, and received samples $\{y_i\}$.

interference,
complexity
signal levels for
estimated. The

Duality	$X(t) \leftrightarrow x(\omega)$
Shift	$e^{j\alpha t} x(t) \leftrightarrow X(\omega - \alpha)$
Differentiation	$\frac{d^n x(t)}{dt^n} \leftrightarrow (j\omega)^n X(\omega)$
Integration	$\int_{-\infty}^t x(\rho) d\rho \leftrightarrow \frac{X(\omega)}{j\omega}$
Multiplication	$x(t)y(t) \leftrightarrow X(\omega) \oplus Y(\omega)$
Convolution	$x(t) \oplus y(t) \leftrightarrow X(\omega)Y(\omega)$

Useful Transforms

$x(t)$	$X(\omega)$
$e^{-bt}, t > 0$	$\frac{1}{b + j\omega}$
$\cos(\omega_c t + \psi)$	$\pi[\delta(\omega - \omega_c)e^{j\psi} + \delta(\omega + \omega_c)e^{-j\psi}]$
$\sin(\omega_c t + \psi)$	$\frac{\pi}{j}[\delta(\omega - \omega_c)e^{j\psi} - \delta(\omega + \omega_c)e^{-j\psi}]$
1	$2\pi\delta(\omega)$
$\delta(t)$	1
1, $t > 0$	$\frac{1}{j\omega}$
$\frac{1}{\sqrt{2\pi}} e^{-t^2/2}$	$e^{-\omega^2/2}$
$t, t > 0$	$\left(\frac{1}{j\omega}\right)^2$
$t^2, t > 0$	$\frac{2}{(j\omega)^3}$

A.2 THEOREMS, IDENTITIES, AND EXPANSIONS**Parseval's Theorem**

$$\int_{-\infty}^{\infty} x(t)y(t) dt = \frac{1}{2\pi} \int_{-\infty}^{\infty} X(\omega)Y^*(\omega) d\omega$$

$$\int_{-\infty}^{\infty} |x(t)|^2 dt = \frac{1}{2\pi} \int_{-\infty}^{\infty} |X(\omega)|^2 d\omega$$

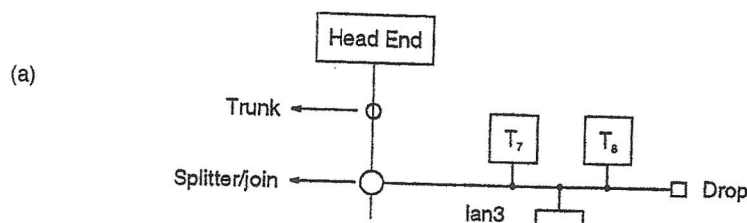


Figure 7.18 Baseband (bidirectional) or single-channel broadband.

is a bidirectional communication system (signals travel in both directions) and uses only one cable.

In baseband LAN transmission, the signal is directly impressed onto the underlying media in binary form via **Manchester encoding**. In this encoding scheme, logic 1 is described by low-to-high transition while logic 0 is described by high-to-low transition and, as such, it does not require any extra clock pulse for synchronization. This type of encoding is very popular with Ethernet LANs, IEEE 802.3 for baseband coaxial cable, and twisted-pair CSMA/CS bus LANs, and also for shielded twisted-pair bus LAN (MIL-STD 1553B). Another encoding technique which is equally popular and widely used is **differential Manchester encoding**. In this encoding scheme, transition is always defined at the center of each interval of the pulse in such a way that logic 1 will be represented by no transition at a pulse boundary while logic 0 will be represented by a transition at the pulse boundary. This scheme is widely used in IEEE 802.5 LANs using shielded twisted pair. It is simple and very inexpensive, as the layout of the cable is very simple. The only problem with baseband LANs is that these LANs offer a limited capacity over a limited distance. Other encoding schemes defined for digital signals include **non-return-to-zero-level (NRZ-L)** (high level for logic 0 and low level for logic 1), **non-return-to-zero-inverted (NRZI)** (logic 0 is represented by no transition at the beginning of an interval while logic 1 is represented by transition at the beginning of an interval), **bipolar with 8 zeros substitution (B8ZS)**, **high density bipolar 3 zeros (HDB3)**, **bipolar-AMI (alternate mark inversion)**, etc. The NRZ code usually is used for generating or identifying the digital signals of terminals and devices and is used in digital magnetic recording. The encoding scheme bipolar-AMI is a form of multilevel binary representation and is useful for error detection.

The baseband-based LANs may use any cable (coaxial, twisted-pair, etc.), and no modulation is required due to its support for only a very short distance (typically a few kilometers). It uses 50- Ω cable and supports multiple lines. For multiple access to the channel, it uses time division multiplexing (TDM). It does not divide the bandwidth for data communication but instead allocates the entire bandwidth to the channel, thus offering higher data rates. Only one piece of data can be transmitted at a time. The access method to a baseband system (usually Ethernet) is usually provided by a device known as a **transceiver**. This device receives the data from the node and defines the packets for transmitting over the bus. The packet contains a source address, destination address, user's data, and some control information. These LANs can only handle the data and are cheap and very simple. The shielded twisted pair offers more capacity than twisted-pair baseband, but it is more expensive. An unshielded twisted pair may allow the users to use the existing wiring system (telephone wiring, etc.). A general bus topology for baseband or single-channel broadband LANs is shown in Figure 7.18.

Some of the vendors of baseband LANs include Datapoint Corporation (Texas), Starnet Data Systems (Colorado), and Xerox Corporation (Connecticut). Typically, the baseband LANs from different vendors include the following specifications: