## REVIEW II

EE4367 Telecom. Switching \& Transmission
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## REVIEW (Terminology)

$\square$ Added-channel framing
$\square$ Added-digit framing
$\square$ Asynchronous transmission
$\square$ Asynchronous network
$\square$ Baseband
$\square$ Baud rate
$\square$ Binary N-Zero Substitution (B3ZS, B6ZS, B8ZS)
$\square$ Bipolar coding
$\square$ Blocking
$\square$ Blocking probability
$\square$ Channel associated signaling (CAS)
$\square$ Common-channel signaling

## REVIEW (Terminology)

$\square$ Crosstalk
$\square$ Crossbar switch
$\square$ Circuit switching, TS, STS, TST
$\square$ ESS
$\square$ Extended superframe format
$\square$ Frame
$\square$ Frame alignment
$\square$ Gaussian noise

- HDB3
$\square$ Inband signaling
$\square$ Intersymbol interference


## REVIEW (Terminology)

$\square$ Multilevel Signaling
$\square$ Multiplexing
Nonblocking
$\square$ Nyquist rate
$\square$ Parity
$\square$ Pulse shaping
$\square$ Reframing time
$\square$ Robbed bit signaling

- Symbol rate (baud rate)
$\square$ Synchronous transmission
- TDM
$\square$ Time Division Switching
$\square$ White noise

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## Twisted Pair

$\square$ A twisted pair consists of two wires that are twisted together to reduce the susceptibility to interference.

$\square$ The two-wire system is susceptible to crosstalk and noise since the multiple wires are bundled together.

## Error Performance

$\square$ Polar Signaling

$$
P(\text { error })=Q\left(\frac{A}{\sigma}\right) \quad \text { Power }=\mathrm{A}^{2}
$$

A $\rightarrow$ Peak amplitude (Volts)
$\sigma \rightarrow$ noise rms amplitude (Volts)
$\square$ On-Off Signaling

$$
P(\text { error })=Q\left(\frac{A}{2 \sigma}\right) \quad \text { Power }=\mathrm{A}^{2} / 2
$$

$\square$ Bipolar Signaling
$P($ error $)=1.5 Q\left(\frac{A}{2 \sigma}\right)$
Power $=A^{2} / 2$
$\mathrm{SNR}=$ Power $/ \sigma^{2}$

## Performance Monitoring

$\square$ Redundancy Checks
$\square$ Parity Bits are inserted into DS3 and DS4 signals for the purpose of monitoring the channel error rate.
$\square$ The following equation relates the parity error rate (PER) to the channel probability of error or bit error rate (BER)
$\mathrm{PER}=\sum_{i=1}^{N}\binom{N}{i} p^{i}(1-p)^{N-i} \quad$ (i odd) $\quad \begin{aligned} & \mathrm{N}=\text { number of bits over which parity is generated } \\ & \mathrm{p}=\mathrm{BER} \text { assuming independent errors }\end{aligned}$
$\square$ Cyclic redundancy check (CRC) codes are also incorporated into a number of transmission systems as a means of monitoring BERs and validating framing acquisition.
$\square$ Examples of CRC use: Extended superframe (ESF) on T1 lines
CRCER $=1-(1-p)^{N} \quad \begin{aligned} & \mathrm{N}=\text { length of CRC field (including CRC bits) } \\ & \mathrm{p}=\mathrm{BER} \text { assuming independent errors }\end{aligned}$

## Error Performance

$\square$ Example 1:
(a) Polar binary pulses are received with peak amplitude $\mathrm{A}=1 \mathrm{mV}$. The system noise rms amplitude is 192.3 mV . Optimum detection is used and 1 and 0 are equally likely. Find the bit error rate (probability of error).
(b) Find the error probability for (i) the on-off case and (ii) the bipolar case if the same pulses in part (a) are used but their amplitudes are adjusted so that the transmitted power is the same as in part (a).
$\square$ Example 2: A T1 transmission system uses 22-gauge cable between repeaters and is operating with a $10^{-6}$ error rate. What design changes are needed to reduce the error rate to $10^{-8}$ without increasing the power from the repeaters.
$\square$ Attenuation of 22 -gauge cable is $5 \mathrm{~dB} / \mathrm{kft}$ at 1 MHz

## Example

$\square$ Design an STS switch for 128 primary TDM signals of 30 voice channel per input (E1 signal). Blocking should be less than 0.002 and the loading (channel utilization) is 0.2 per channel. How many time slot interchange modules are needed? What is the complexity of the switch?
$\square \mathrm{N}=128, \mathrm{c}=30$ (number of voice channel per primary line)
$\square \mathrm{B}=0.002$ (maximum), $\mathrm{p}=0.2$ (channel utilization)

- $p^{\prime}=p / \beta, \beta=k / N$
$\square B=\left(1-\left(1-p^{\prime}\right)^{2}\right)^{k}$
$\square$ Complexity $=\mathrm{N}_{\mathrm{x}}+(\mathrm{NBX}+\mathrm{NBT}) / 100=10,228$
$\square N_{x}=2^{*} 128^{*} 41=10,496$
- $\mathrm{NBx}=2 * 41 * 30^{*} 7=17,220$
- $\mathrm{NBT}=41 * 30 * 8+41 * 30 * 5=15,990$


## Binary N-zero Substitution (BNZS)

$\square$ Bipolar signaling has several advantages: (1) its spectrum has a dc null. (2) its bandwidth is not excessive. (3) it has single-error-detection capability. This is a due to the fact that if a single detection error is made, it will violate the alternating pulse rule.
$\square$ Disadvantages of bipolar signaling: it requires twice as much power ( 3 dB ) as a polar signal. It is not transparent, i.e, we need a minimum density of 1 's in the source to maintain timing at the regenerative repeaters. Low density of pulses increases timing jitter.
$\square$ Solution: Binary N-zero substitution (BNZS) augments a basic bipolar code by replacing all trings of N 0 's with a special $N$-length code containing several pulses that purposely produce bipolar violations.

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## BNZS Line Codes

$\square$ High Density Bipolar (HDB) coding is an example of BNZS coding format. It is used in E1 primary digital signal.
$\square$ HDB coding replaces strings of four 0's with sequences containing a bipolar violation in the last bit position. Since this coding format precludes strings of 0 's greater than three, it is refereed to as HDB3 coding.


000 V and B 00 V , where $\mathrm{B}=1$ conforms to the
bipolar rule and $\mathrm{V}=1$ violates the bipolar rule. The choice of sequence 000 V or B 00 V is made in such a way that consecutive V pulses alternate signs in order to maintain the dc null in PSD.
$\cdot \mathrm{B} 00 \mathrm{~V}$ is used when there is an even number of 1's following the last special sequence
$\cdot 000 \mathrm{~V}$ is used where there is an odd number of 1's following the last sequence.

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## B3ZS Line Code

$\square$ B3ZS Algorithm (as used DS-3 signal interface): Each string of three 0's in the source data is encoded with either 00 v or BOV.


