## REVIEW (Terminology)

$\square$ Polar signaling
$\square$ Baud rate (symbol rate)
$\square$ Bipolar signaling (coding)
$\square$ Central office
$\square$ Circuit switching
$\square$ C-message weighting
$\square$ Common-channel signaling, Inband signaling
Companding
$\square$ Crosstalk, far-end crosstalk (FEXT), near-end crosstalk
$\square \mathrm{dBm}$, dBrnC, dBrnC0
$\square$ Delta modulation, slope overload
$\square$ DTMF Signaling
$\square$ Echo, echo canceller, echo suppressor, talker echo, listener echo

## REVIEW (Terminology)

$\square$ Multiplexing, FDM, TDM

- Full-duplex, half-duplex
$\square$ Gaussian noise
- HDB3

Hybrid, two-wire circuit, four-wire circuit

- ITU
$\square$ Line code, NRZ, RZ
LATA
- Modem

Multi-frequency signaling
$\square$ Nyquist rate
$\square$ Power spectral density

- PAM, PCM
$\square$ Quantization noise
$\square$ Regeneration, repeater
$\square$ Robbed bit signaling

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## REVIEW (Terminology)

$\square$ Tandem office, Trunk
$\square$ On-off signaling
$\square$ T1 carrier system
$\square$ DS0, DS1, DS2, DS3
$\square$ Error performance, PER, CRCER
$\square$ SQR, SNR

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## Decibel Questions

$\square$ There are three networks in series. The first network has a gain of 19 dB , the second a loss of 23 dB , the third a gain of 11 dB . The output of the third network is +23 dBm . What is the input to the first network in mW ?

## Transmission

$\square$ What are the three basic impairments (not echo or singing) we have to deal with regarding the voice channel?

## Noise Power Levels

$\square$ Relationships between various noise measurements

$$
\begin{aligned}
& \text { Y dBrn=X dBm+90dB } \\
& \text { Y dBrnC }=X \mathrm{dBrn}-2 \mathrm{~dB}
\end{aligned}
$$

$\square$ Example: An idle-channel noise power measurement of 21 dBrn occurs at a -7 dB TLP. Express the noise power of this measurement in $\mathrm{dBrn0}$ and determine what power measurement this noise would produce at another point in the circuit that is designated as a -2 dB TLP.
$\square \mathrm{dBrn0}=\mathrm{dBrn}-(\mathrm{TLP} \mathrm{dB})$ or dBrn=dBrn0+(TLP dB)

## Voice Digitization

$\square S Q R=10.8+20 \log _{10}(\mathrm{v} / \mathrm{q}), \mathrm{v} \rightarrow$ rms amplitude of the input
$\square$ For a sinewave input $v^{2}=A^{2} / 2, S Q R=7.78+20 \log _{10}(A / q)$
$\square \mathrm{q}=2 \mathrm{~A}_{\max } / 2^{\mathrm{n}} \rightarrow \mathrm{SQR}=1.76+6.02 \mathrm{n}+20 \log _{10}\left(\mathrm{~A} / \mathrm{A}_{\max }\right)$
$\square$ Dynamic Range $=20 \log _{10}\left(\mathrm{~V}_{\text {max }} / \mathrm{V}_{\text {min }}\right)$
$\square$ Example: If two bits per sample are added to a PCM bit stream, how much can the dynamic range be increased if the quantization intervals are adjusted to improve the SQR by 3 dB ?

## PSD of Line Codes

$\square$ Example: The duobinary line coding (proposed by Lender) is also like bipolar, but requires only half the bandwidth of bipolar. In this code

- A "0" is transmitted by no pulse,
- A " 1 " is transmitted by a pulse $f(t)$ or $-f(t)$ using the following rule:
- A " 1 " is encoded by the same pulse as that used for the previous " 1 ", if there is even number of " 0 " $s$ between them.
- It is encoded by a pulse of opposite polarity if there is an odd number of 0 's between them.
- The number 0 is considered an even number.
a) Using the half-width pulse $f(t)$, sketch the duobinary signal $y(t)$ for an input sequence 11010010101110001
b) Determine $\mathrm{R}_{0}$ for this code if " 0 " and " 1 " are equally likely.

