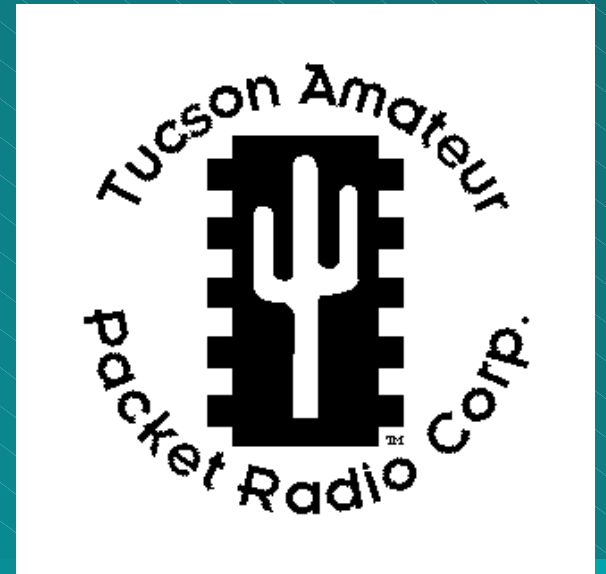


Spread Spectrum an Overview

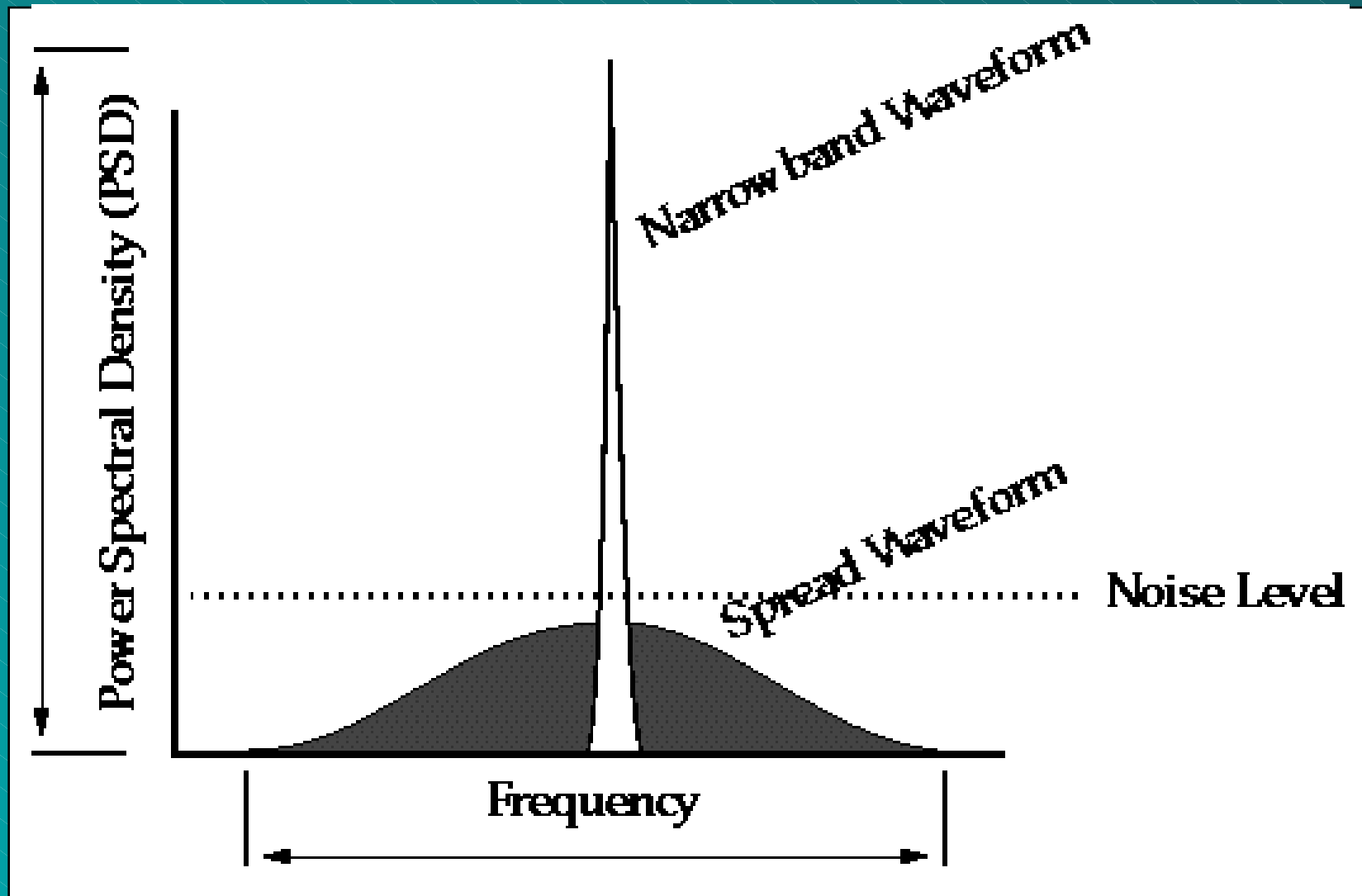
*By: Greg Jones, WD5IVD
President, TAPR*



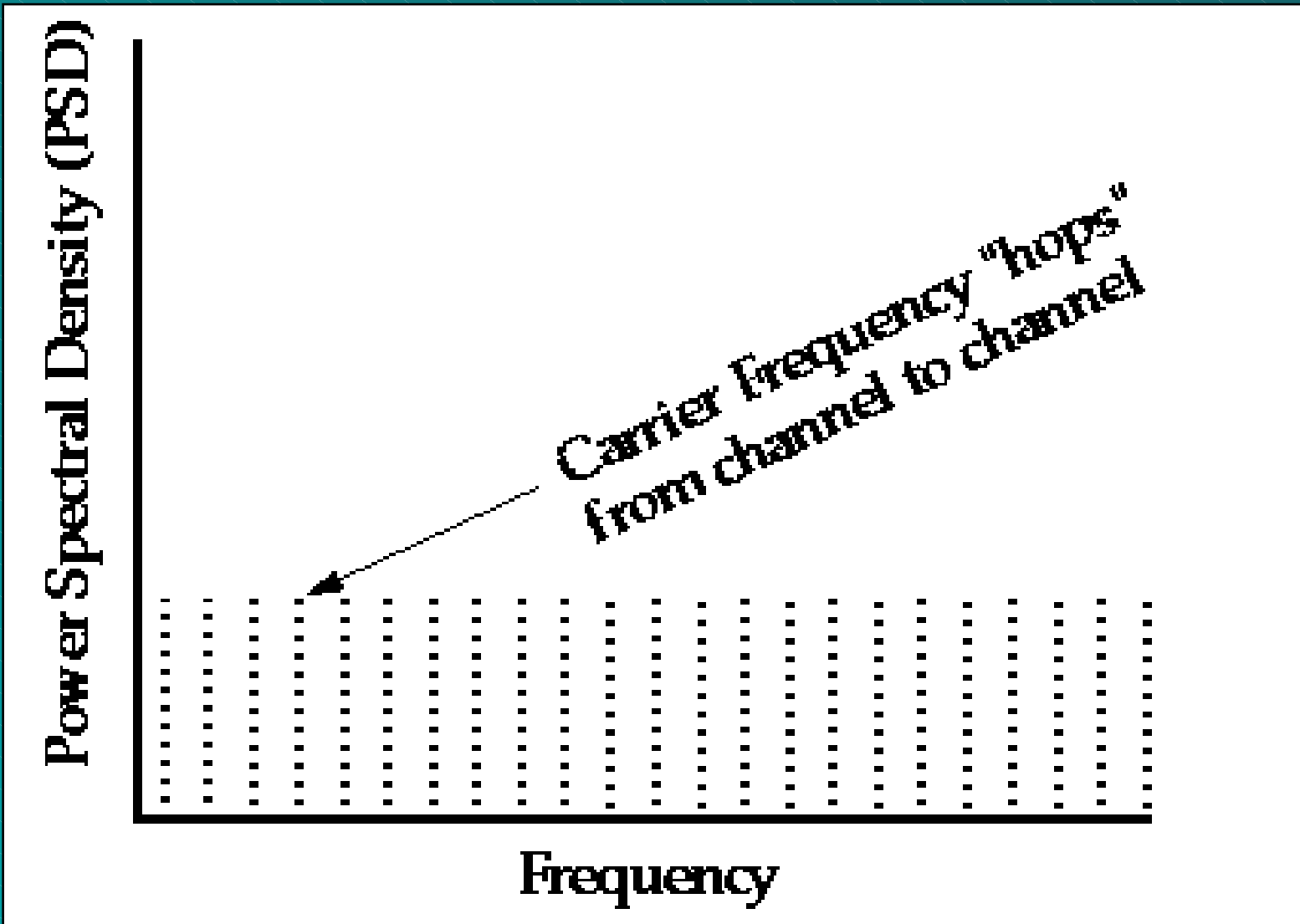
What is Spread Spectrum ?

- **Modulation Scheme**
 - Frequency Hopping
 - Direct Sequence
 - Hybrid Systems
- **Method to modulating the signal in such a way as to increase performance by allowing a higher resistance to interference.**
 - Noise
 - Other Signals
 - etc

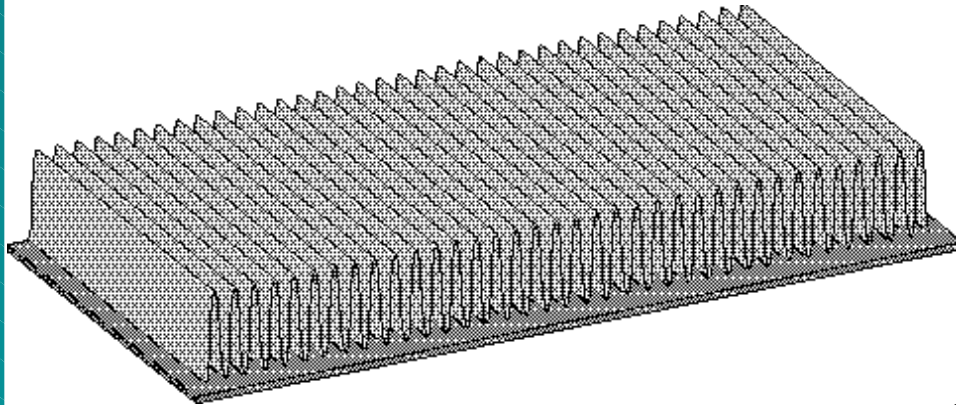
Direct Sequence (DS)



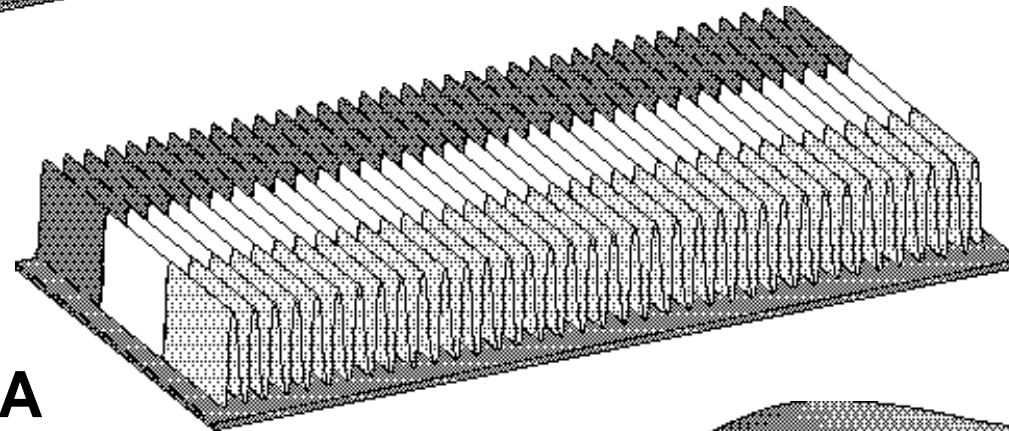
Frequency Hopping (FH)



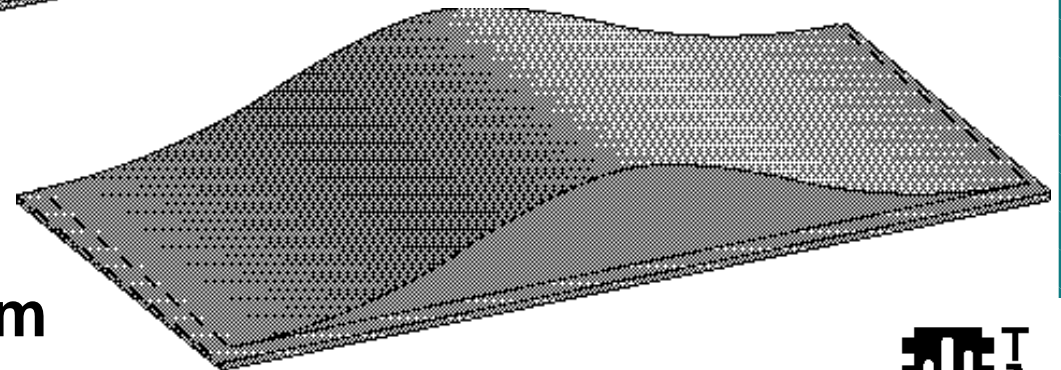
FDMA / TDMA / SS



FDMA

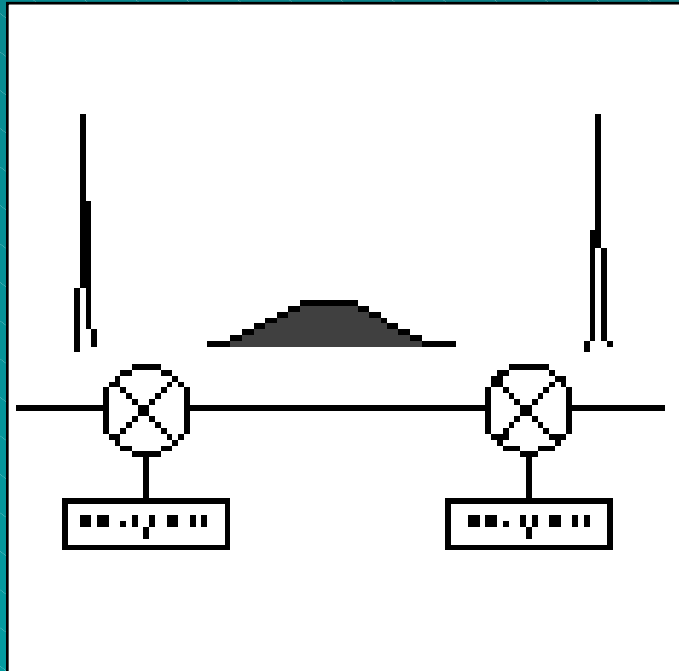


TDMA



Spread Spectrum

How does Spread Spectrum Work ?



- Takes a signal and spreads it into a wide band signal using a P/N sequence
- The receiver then recovers (collapses) the wide band signal using the same P/N sequence
- The wide band signal is recovered and all other signals not matching the P/N sequence are converted to wide band signals
- Thus, the receiver can use sophisticated filters to reject all other signals outside the narrow window of the recovered signal.

History of Spread Spectrum

- **Started in the 20's with the advent of RADAR**
 - enhanced ranging and resolution
- **Early military usage was to combat jamming**
 - reliable communications in an intentional jamming environment
- **1959 - John Costas, K2EN paper**
- **1970's - GPS (Global Positioning System)**
- **1981 - First Amateur Radio Usage**
- **1985 - Part 15 devices**
 - Not to avoid jamming, but for its interference resistance and shared communications properties
- **1995 - RM-8737 SS Rules Change**



Amateur Experimentation

- 1980 - AMRAD
- 1981 - First Amateur STA
- 1985 - R&O Docket 81-414
 - SS was established as a mode in amateur radio
- 1989 - Glen Elmore, N6GN
- 1993 - Robert Buass, K6KGS - STA
- 1995 - TAPR
- 1996 - RM-8737 & TAPR STA



Poisson, Shannon, and the Radio Amateur

- **1959 - John Costas, K2EN paper**
 - Spread Spectrum was the best usage of the bands
 - FDMA wastes spectrum utilization
 - bandwidth is one dimension in a multidimensional situation
 - proposed that spread spectrum would be best used in the amateur bands due to the type of on and off communications used. Thus allowing the utmost utilization of the bands.
 - J.P. Costas, “Poisson, Shannon, and the Radio Amateur.” Proc IRE, vol 47, no 12, pp 2058-2068. Dec 1959.



What is the Capacity of a Channel ?

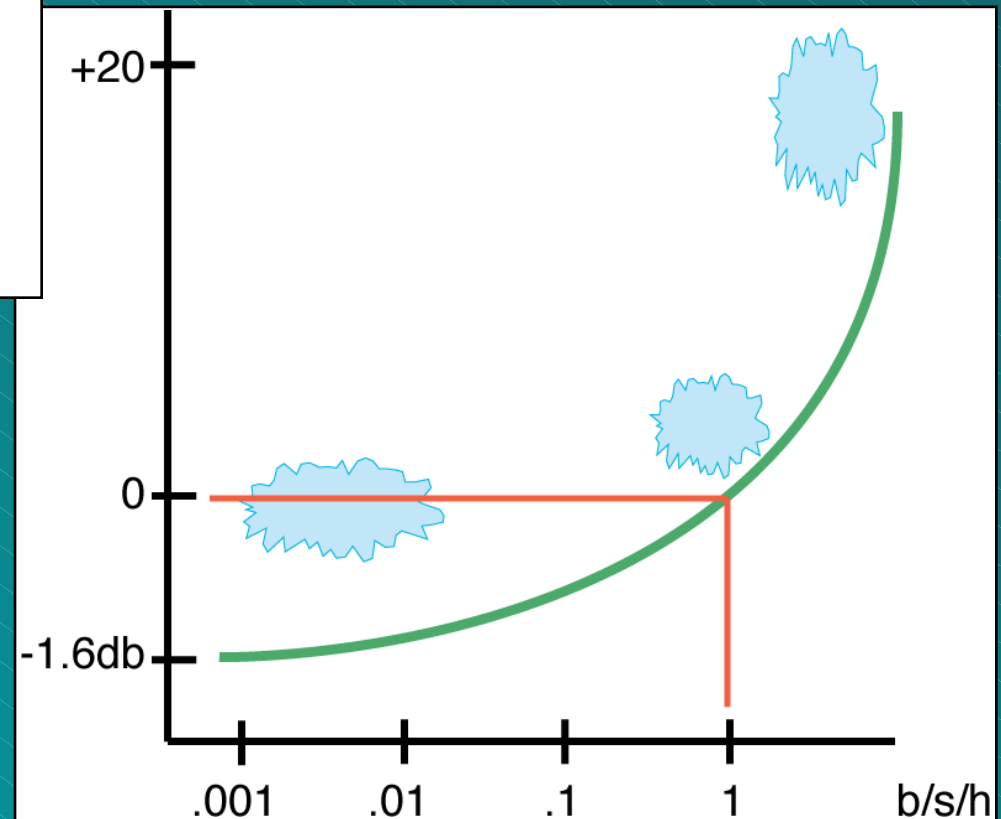
- Claude Shannon - 1949 – Bell System Tech Journal

$$C = B \log_2 (1 + S/N)$$

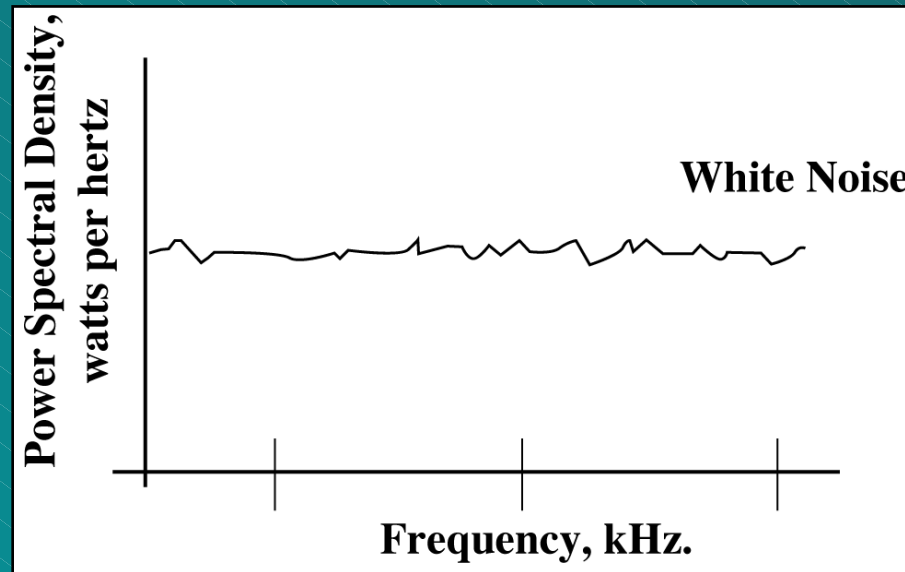
↑ bits/sec
Hz

↑ Hz

↑ signal to noise



Power Spectral Density

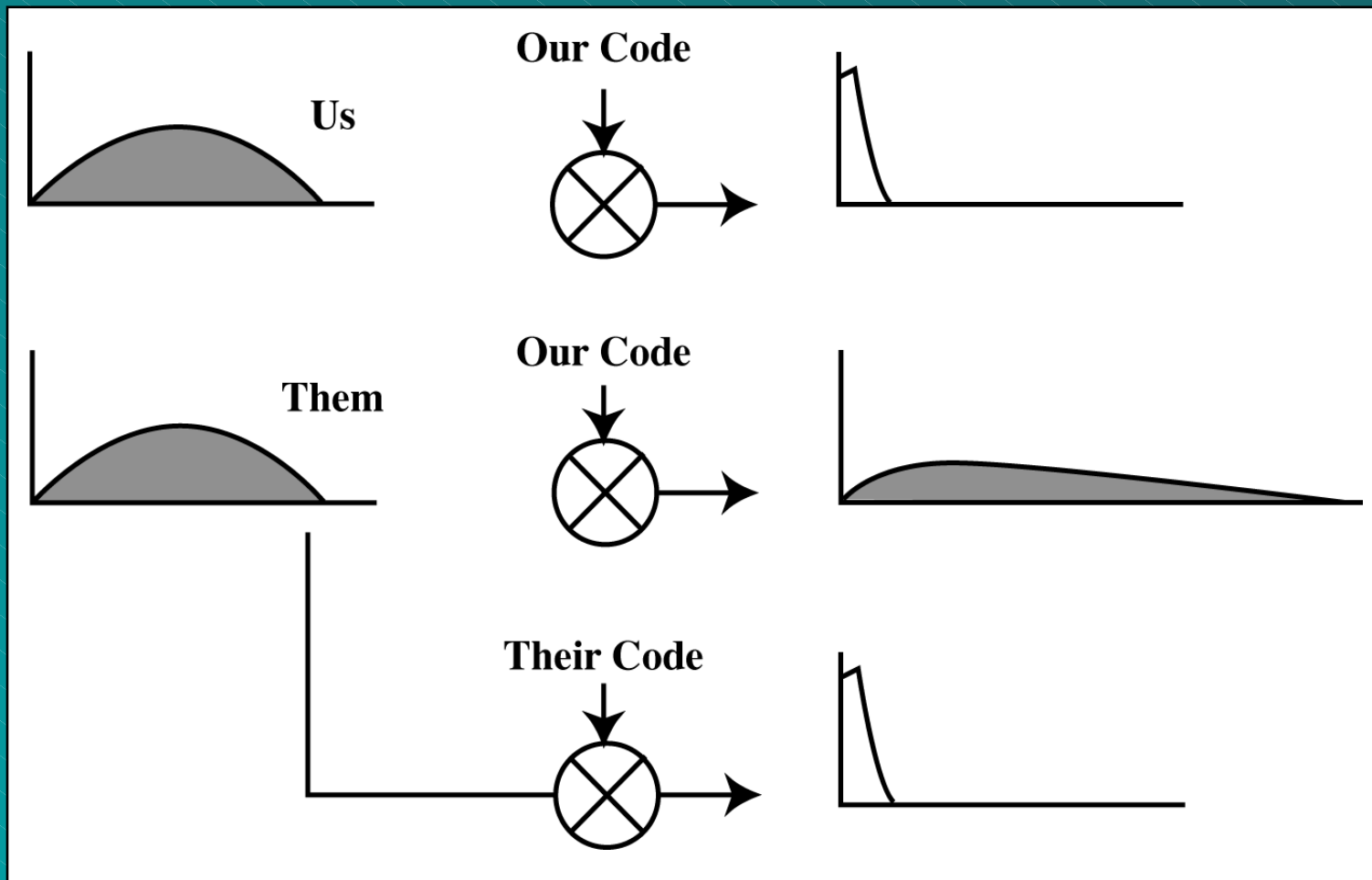


Let $N_0 = 1 \text{ } \mu\text{W} / \text{Hz}$

$B = 1,000 \text{ Hz}$

then $P = B \cdot N_0 = 1 \text{ mW}$ is the 1 kHz BW

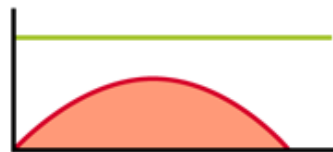
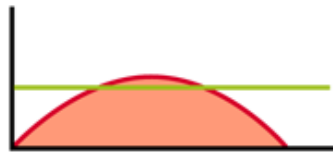
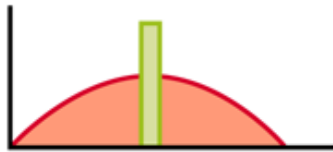
Orthogonal Codes



$$0 = \int_0^t s_1(t) s_2(t) dt \quad \Rightarrow \text{Orthogonal}$$

Orthogonal Codes

The Problem



S/N
is same

OK

OK

Not OK

Processing Gain

$$P_g = 10 \log (F_{\text{spread}} / F_{\text{nbs}})$$

Correlation



REF



Corr = + 10

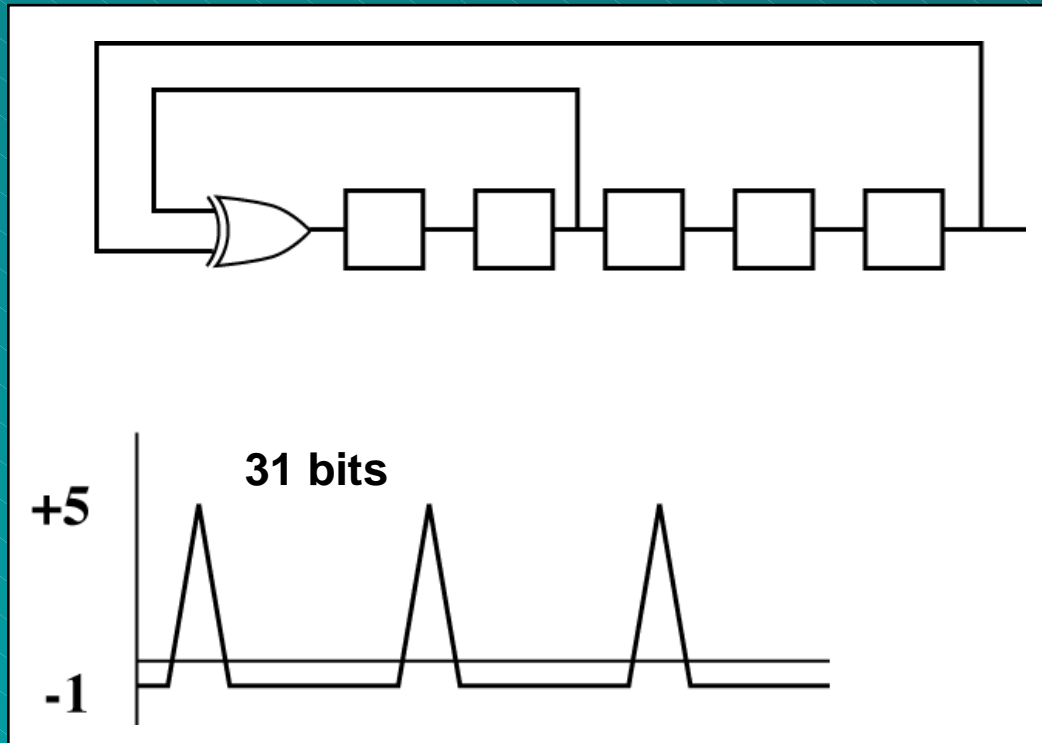


Corr = -10



Corr = 7 - 3 = +4

Pseudo Random Binary Sequence



$$2^5 - 1 = 31 \text{ bits}$$

Benefits of Spread Spectrum

- **Reduced Cost**
 - reduced cost of transmitter, receiver
- **Improved Communications of Radiolocation Performance**
 - resistance to: interference, multi-path fading.
 - using correction ability to add performance
- **Expanded Capabilities**
 - higher data rates at a price that amateurs are willing to purchase
 - combination of voice and data in the same bands
 - ability to operate CD-quality audio through repeaters, where FM system now would be noisy.
 - and much more!



Benefits of Spread Spectrum

- **Improved Spectrum Utilization**
 - allow for the utilization not occupation of many amateur bands
 - spectrum coordination becomes spectrum mgmt of codes and center frequencies

- **Use of Power Control and Error Correction**
 - milli-watts work, 1-2 watts really gets good performance
 - antennas under part 97 buys a lot of performance
 - error correction and coding methods allow higher S/N performance of the system. (i.e. Karn, 1996 Dayton talk)



Unlicensed Spread Spectrum - Part 15

- 1985, the FCC open three bands for unlicensed uses based on a set of regulations designed to minimize interference and encourage inter-operability.
- Since 1985, some 130 companies produce equipment under Part 15 and some 3 million devices have been sold -- with 900Mhz being the most popular of the three bands.
- These devices include:
 - cordless phones
 - utility readers
 - wireless LANs
 - wireless audio speakers
 - home security systems
 - medical monitoring devices, etc



Wireless LANs

- Operates on 900Mhz, 2.4Ghz, and 5.7Ghz
- Speeds up to 5.3Mbps, although many are in the 1 to 2 Mbps range
- Uses direct-sequence (DS) or freq-hopping (FH)
- 802.11 standard coming
 - peer-to-peer style, low power, low range



RM-8737

- **Remove restrictions on P/N sequences and codes**
 - would allow part 15 equipment and the use of better codes
 - the three currently defined are not very good
- **Allow brief test transmissions under 97.305(b)**
- **Allow communications to other countries that allow SS**
- **Remove 97.311(b), regarding harmful interference -- already covered in ITU Radio Regulations and in commission definitions and interpretations generally**
- **Add automatic power control to any radios over 1 watt**
- **Identification remains narrow bands, but gets a lot of comments for adding other methods which are of better spectral efficiency.**



TAPR's STA

- **Asks for a combination of RM-8737 and Buass' STA**
 - Removal of restrictions of codes
 - Asks for 50Mhz and up operations in order to carry out grounded testing in different areas of the US
- **Goal is:**
 - 1. Examine near/far effect with existing amateur sites
 - 2. Examine issues regarding collocation with amateur sites
 - 3. Examine price/performance issues for data systems
 - 4. Generally increase activity in the amateur bands in the usage of Spread Spectrum



The Future (Uses Now and Later)

- TAPR plans on making Part 15 radios available for Part 97 usage under STA
- Phil Karn and Tom Clark are looking at ranging solutions for P3D using Spread Spectrum
- PANSAT (NPGS) '97 - '98 ?
- SS Digital Radios to break 1200/9600 baud log jam
- SS Voice radios to allow more operations on already congested bands



How to contact TAPR

tapr@tapr.org

Spread Spectrum SIG

send e-mail listserv@tapr.org

subscribe ss yourname call

<http://www.tapr.org>

<http://www.tapr.org/ss>

Voice: (817) 383-0000

Fax: (817) 566-2544

Packet Status Register

