

Design and characterization of an MFSK-based Transmitter /Receiver for Ultrasonic Communication Through Metallic Structure

Presented by:

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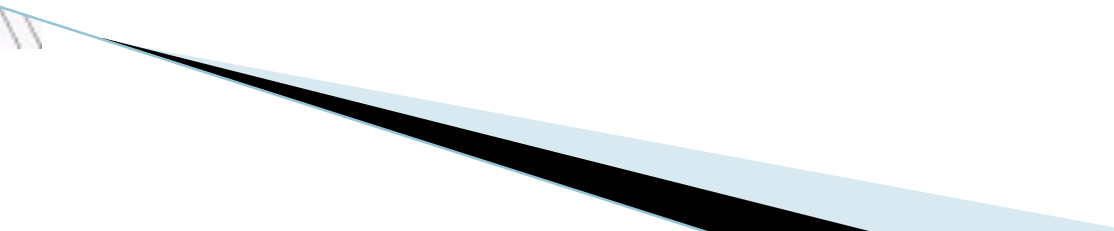
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Communication Systems

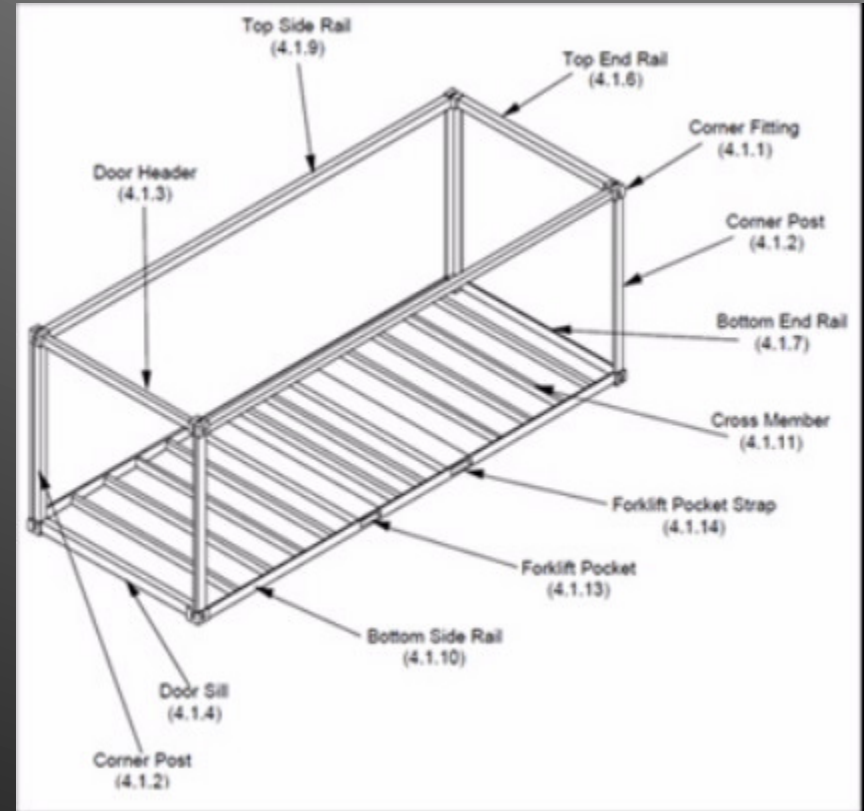
Electronics and Communication Engineering

MNNIT Allahabad

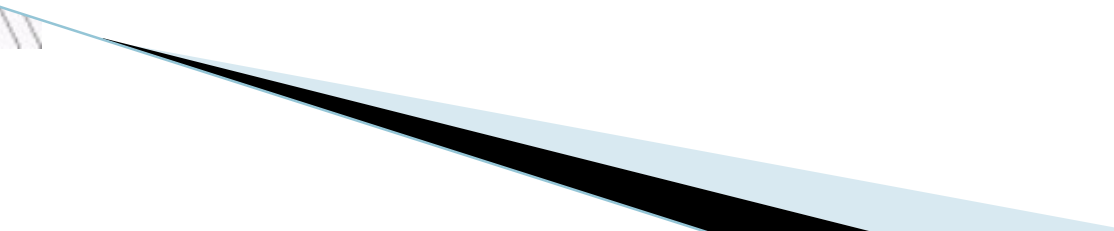
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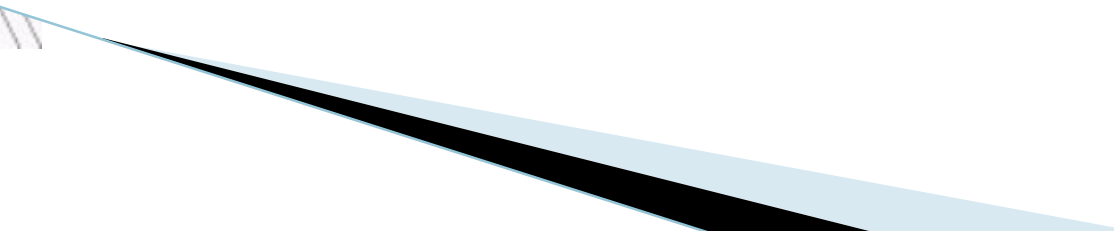
Transmission to and from devices inside metal enclosure



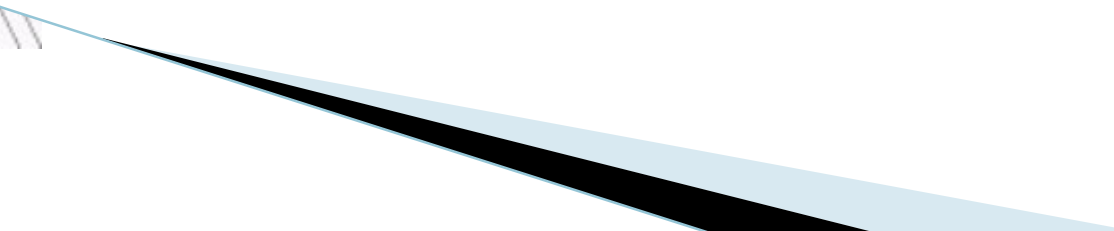
Cont...

- ▶ RF communication is not possible
 - ▶ Ultrasound-a promising alternative
 - ▶ Wireless communication through corner post
 - ▶ Two case studies
 - a) Communication within a container
 - b) Communication between stacked containers..
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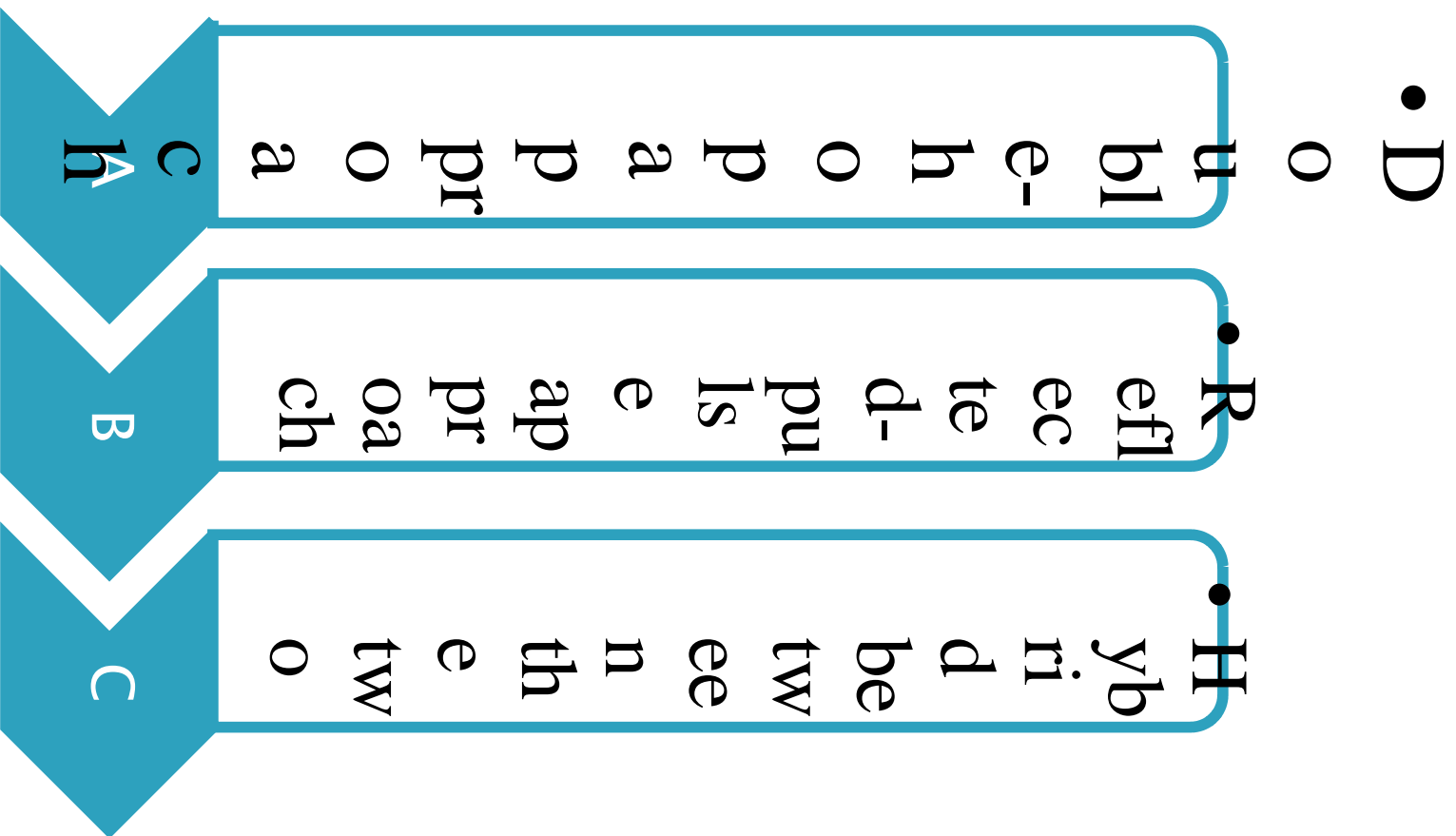
Initial studies on ultrasonic communication

- ▶ Underwater ultrasonic communication using single tone FSK
 - ▶ Short range communication through air using QPSK
 - ▶ Ultrasonic Communication through pipes ,including copper , galvanized and PVC(Oak Ridge National Laboratory,1993)
 - ▶ Communication through metal gas pipeline , steel wall using DPSK and QAM
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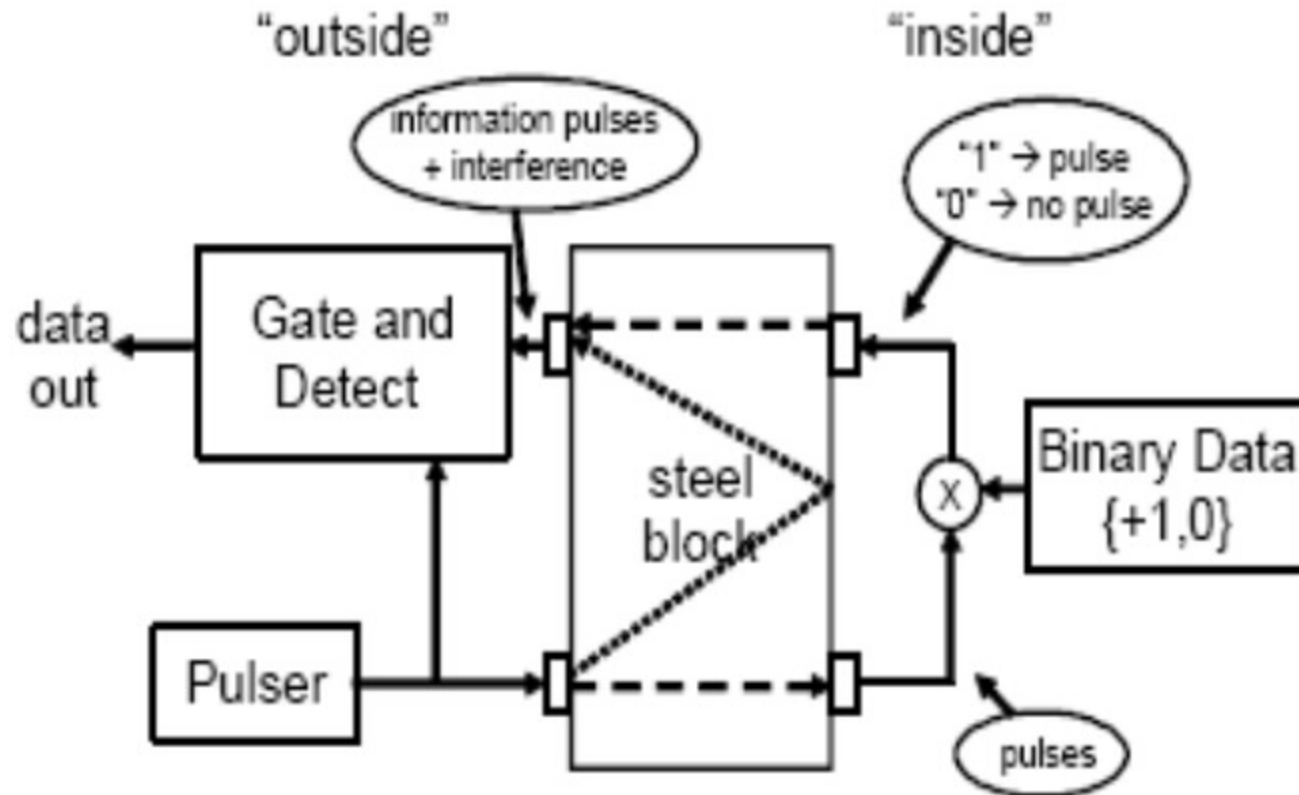
Limitation of those studies

- ▶ One way communication
 - ▶ No communication through stacked containers
 - ▶ No communication from inside to outside of a container
 - ▶ Did not proceed to system prototyping stage
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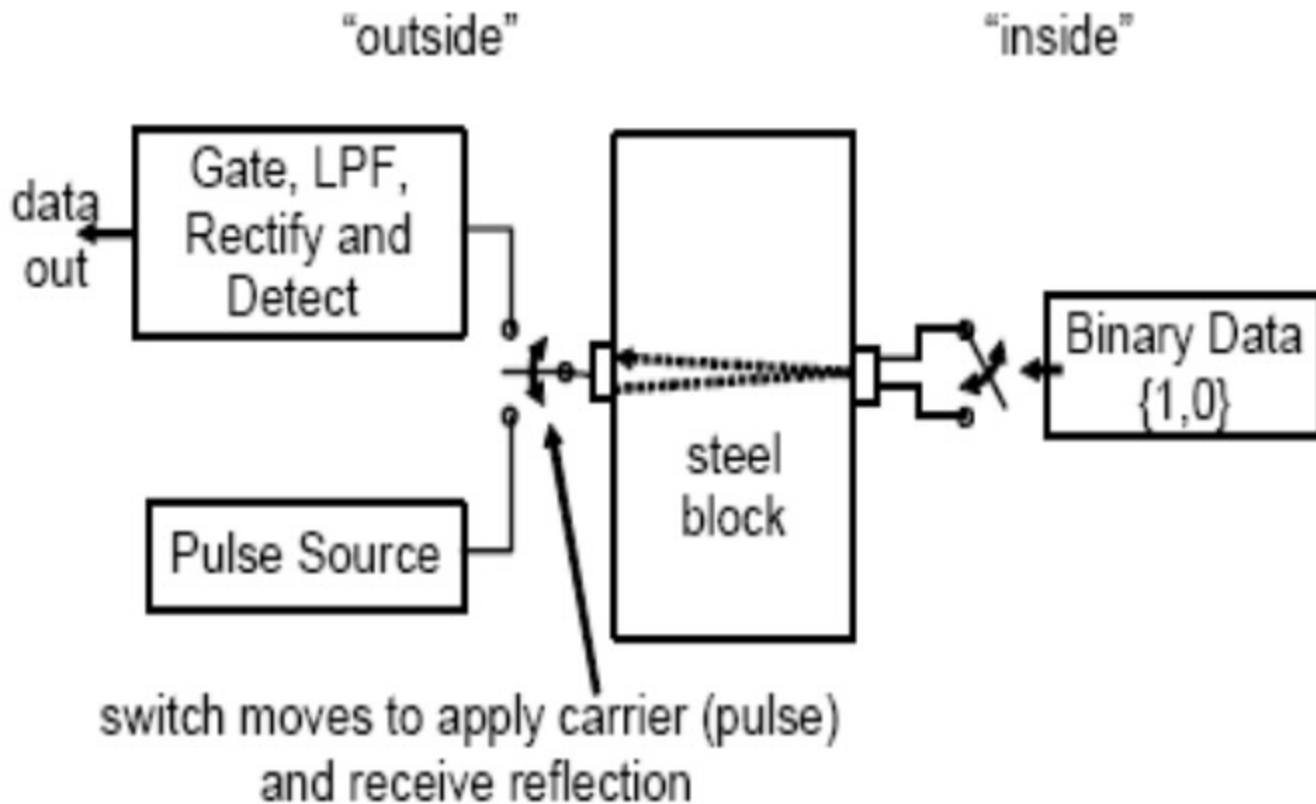
Ultrasonic communication techniques through metal blocks



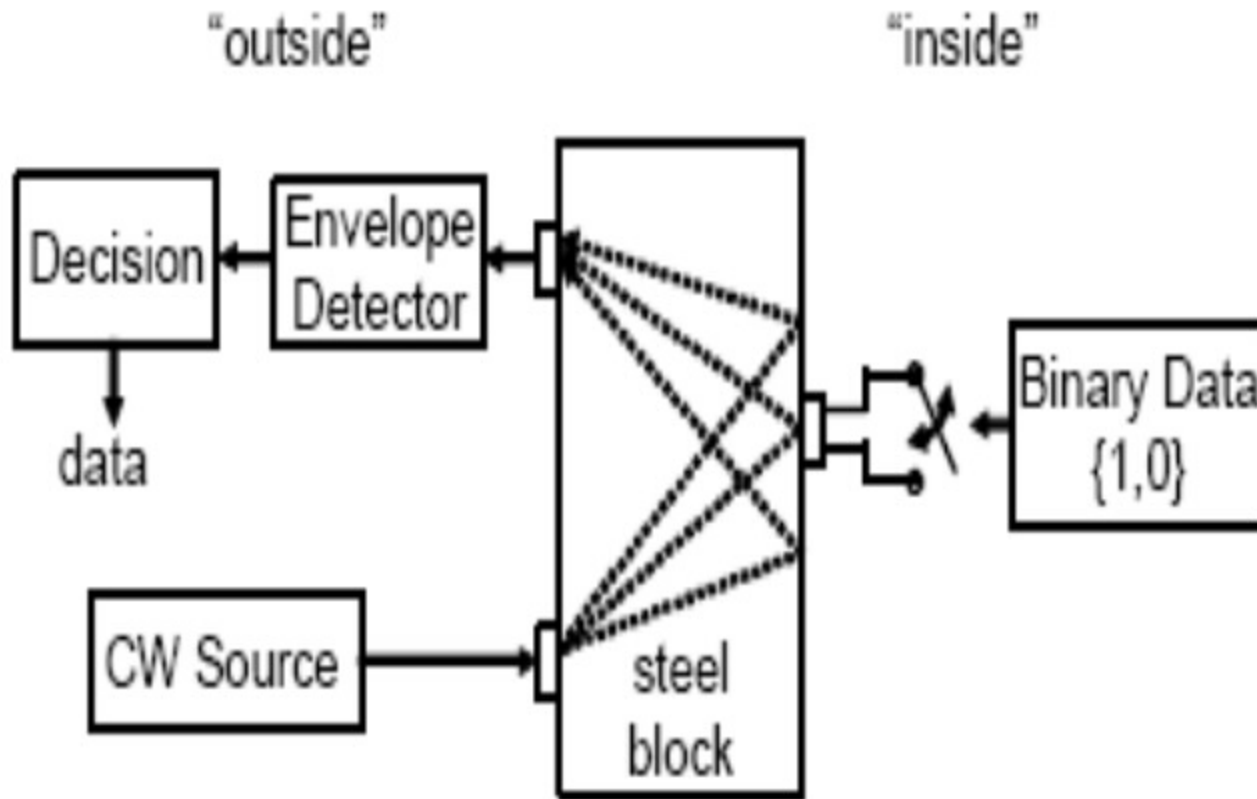
A. Double-hop approach



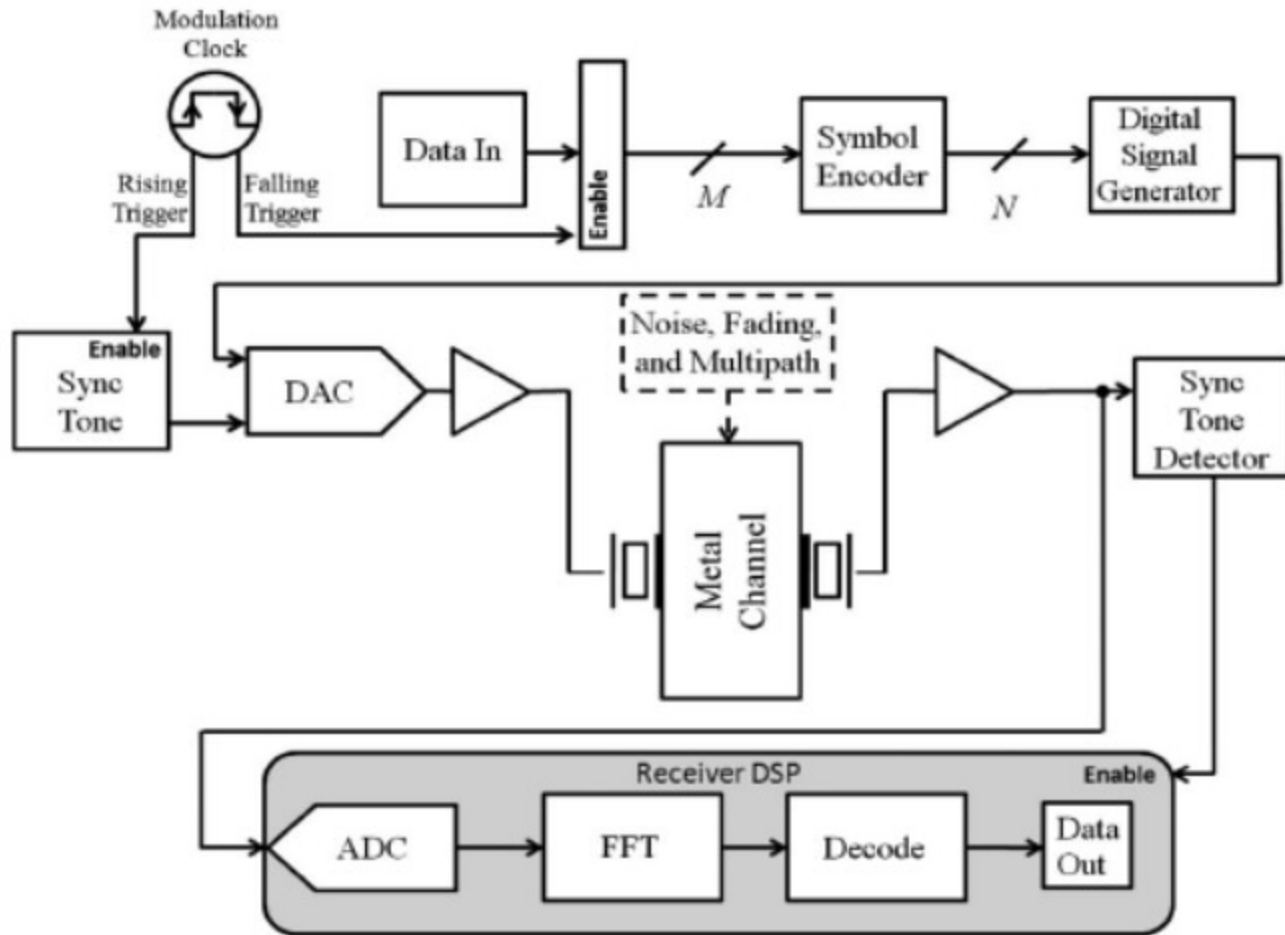
B. Reflected-pulse approach



C. Hybrid between the two

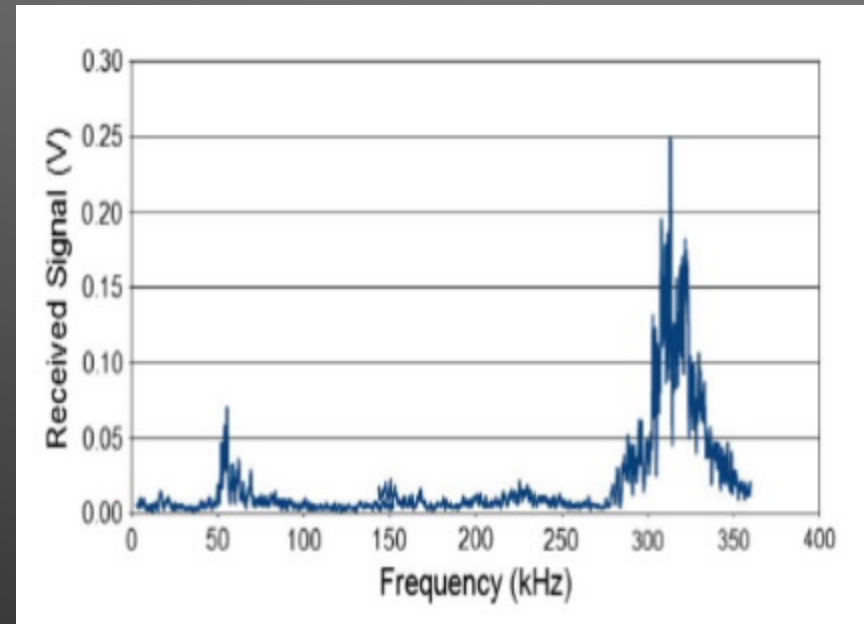


Modelling approach of transmitter and receiver



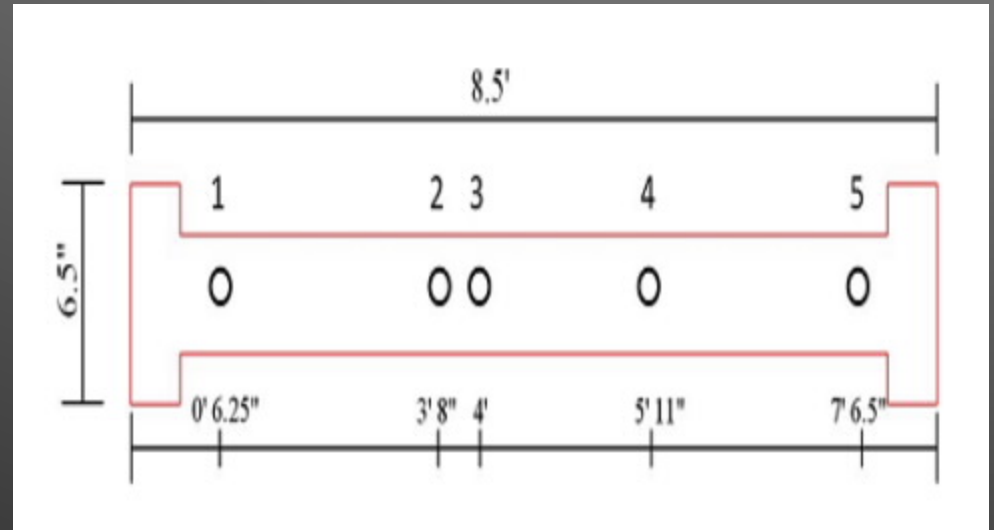
A. Ultrasonic transducer

- ▶ Transformation of energy
- ▶ Piezoelectric material

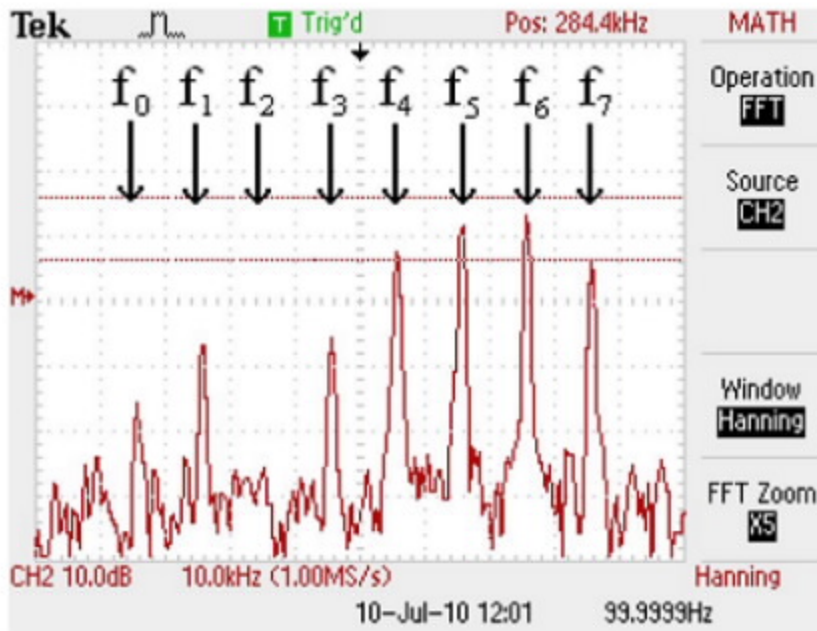


B. Channel evaluation

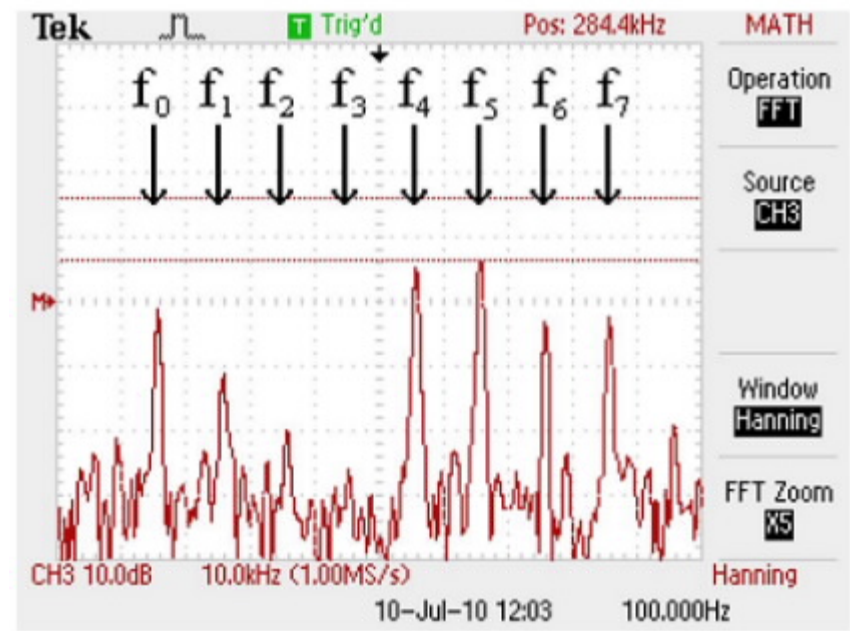
- ▶ Multipath of different wave modes
- ▶ Constructive and destructive interference
- ▶ Some frequencies can be attenuated



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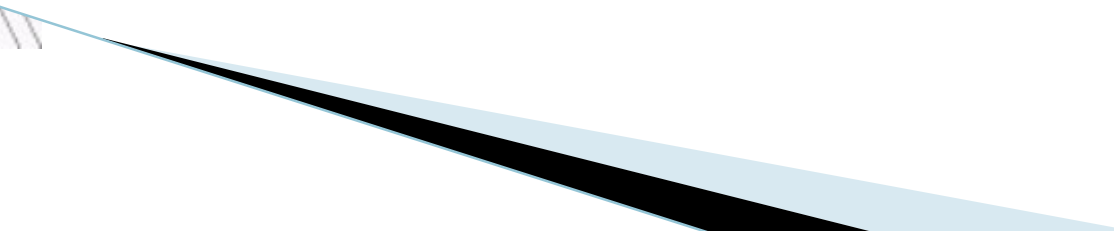


Receiving transducer 1

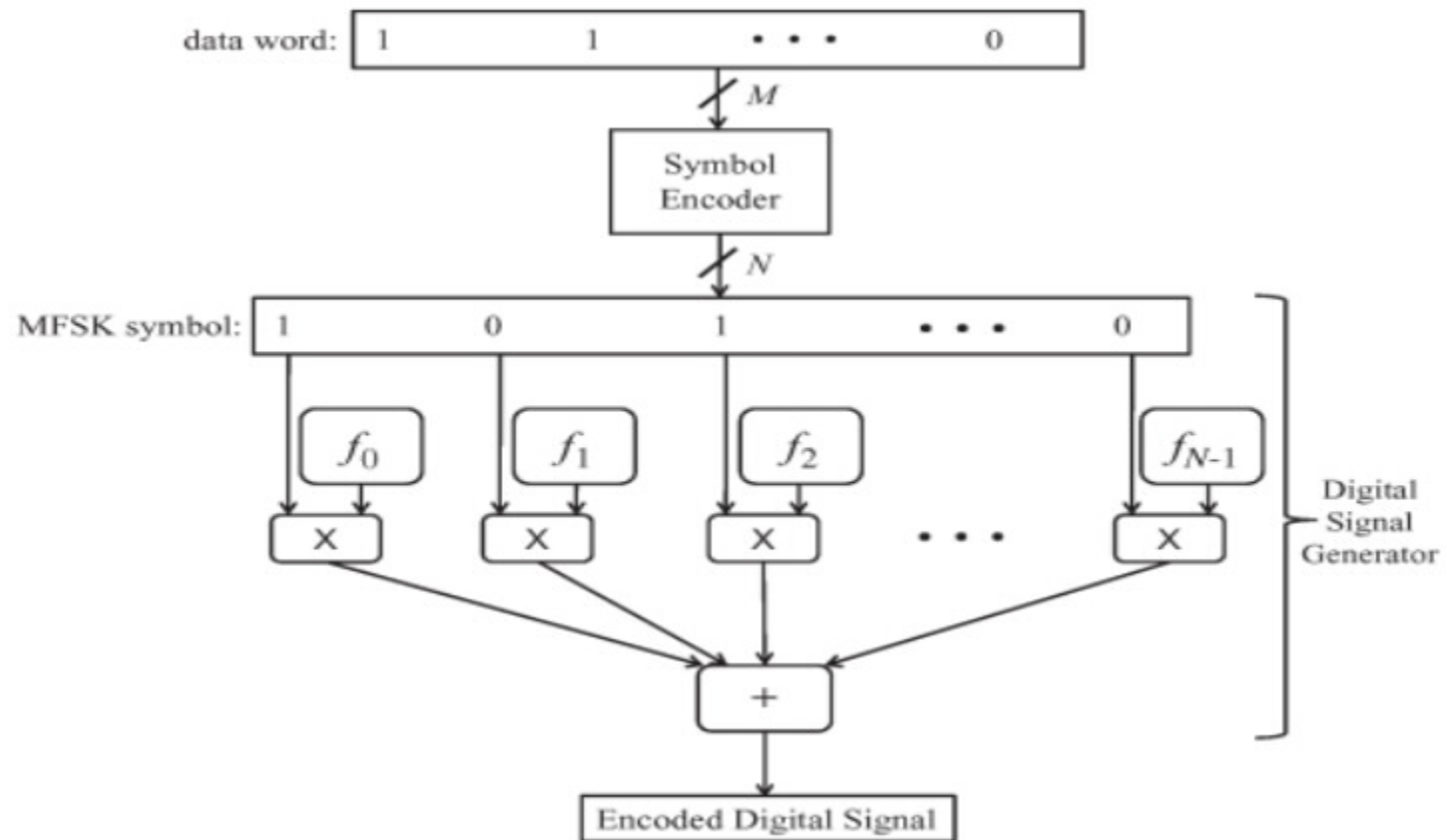


Receiving transducer 2

C. Modulation approach: MFSK

- ▶ MFSK is known to be well suited for fading channels
 - ▶ Two reasons for fading
 1. Multipath effects
 2. Multiples wave travelling in different velocities
 - ▶ For a pool of N tones , maximum of N symbols can be encoded
- 

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- ▶ Here always $Q < M < N$

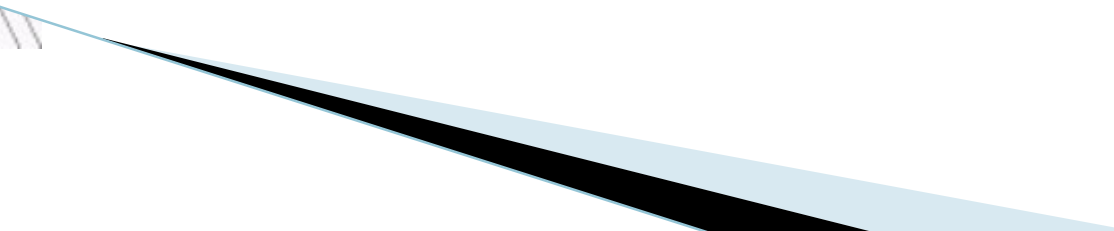
Let $N=23, Q=8$

Total symbol set = $nCq = 490314$

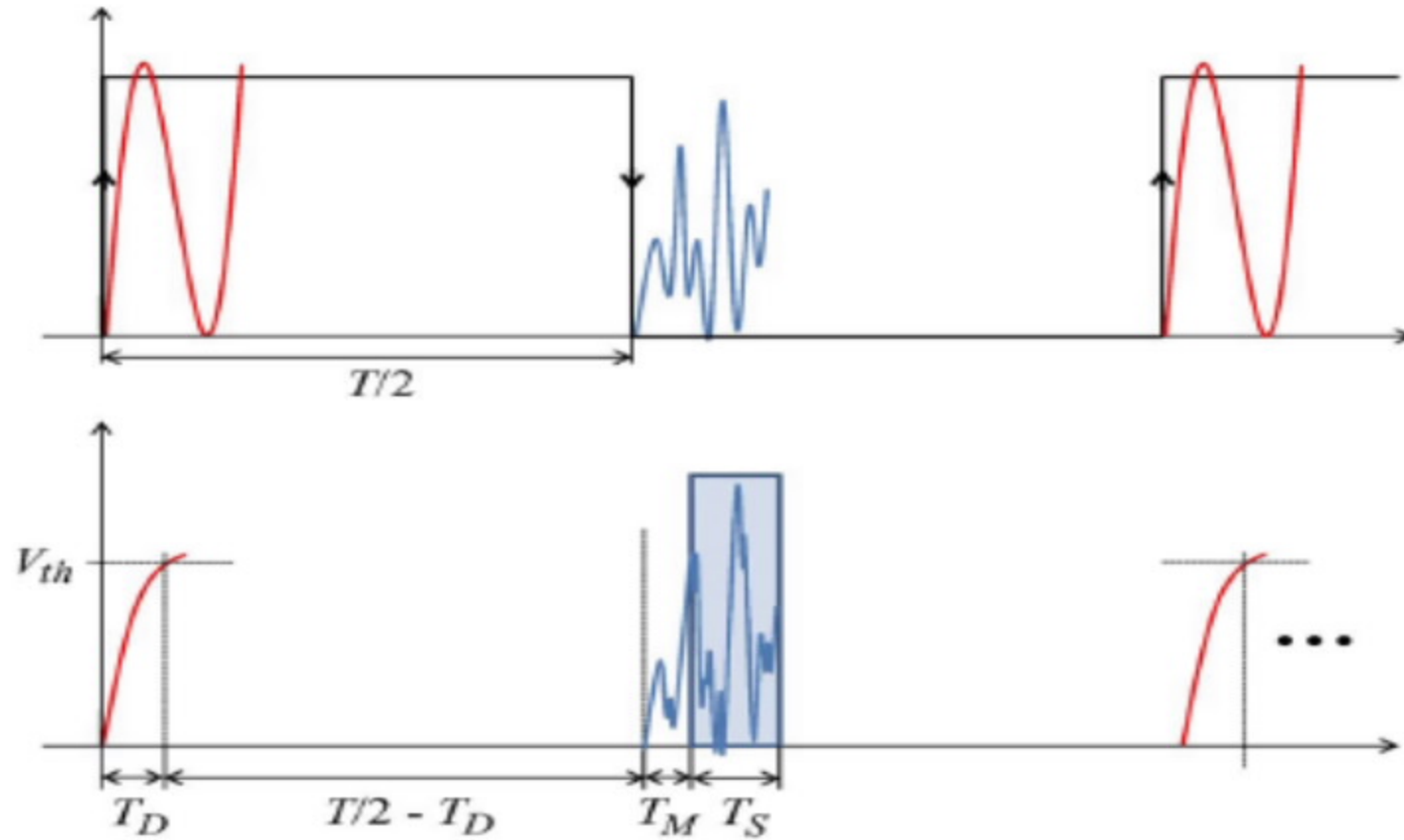
For $M=18$

Total no of combinations = $2^{18} = 262144$

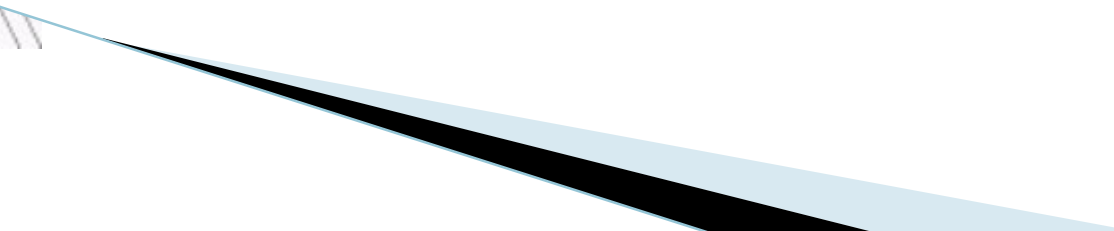
System Designing

- ▶ Transmitter side: a signal generator and an amplifier circuit
 - ▶ Receiver side: an amplifier circuit and a DSP chip
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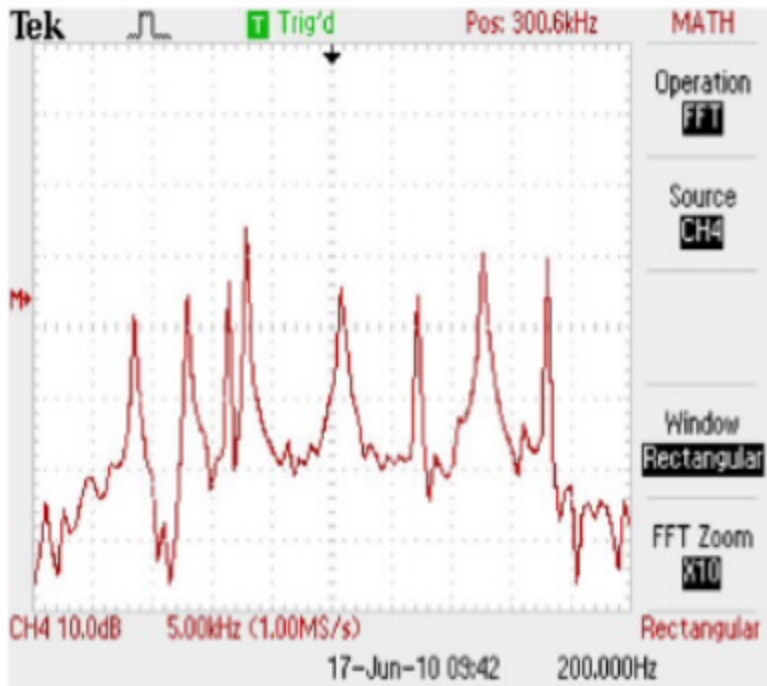
Timing diagram for synchronization



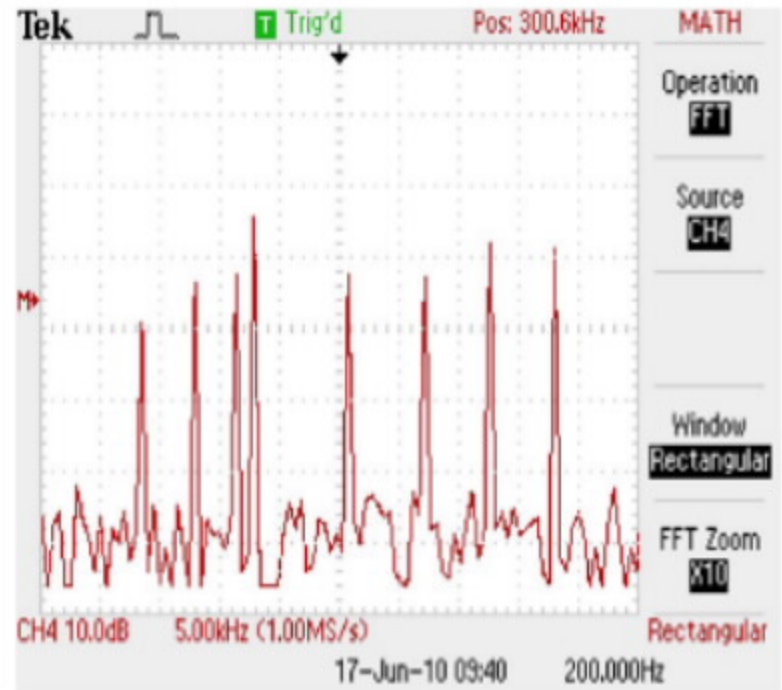
Sampling approach

- ▶ Bandpass sampling
 - ▶ Reduced power consumption
 - ▶ Need of coherency
 - ▶ Increasing of spectral resolution
- 

Contd...



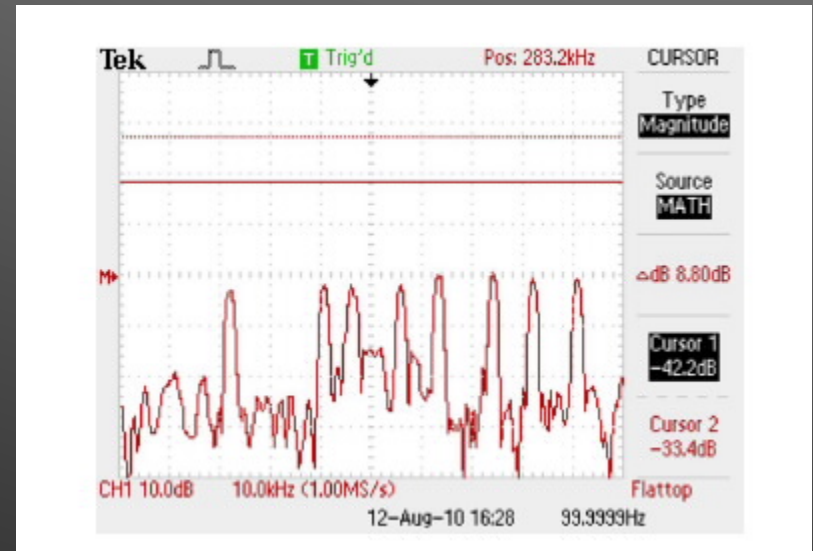
Non-coherent signal



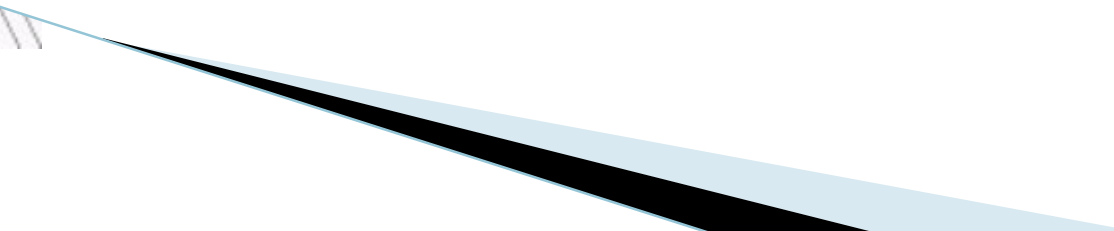
Coherent signal

Equalization

- ▶ To mitigate the effect of multipath propagation
- ▶ Flatten the magnitudes of frequencies
- ▶ Increase number of coherently received tones



Conclusion

- ▶ These design has the ability to reliably encode and transmit 18 bits of data per modulated MFSK symbol
 - ▶ Inexpensive transducers can transmit and receive ultrasonic signals with high SNR and low transmit power
 - ▶ With undersampling technique sampling speed is reduced
 - ▶ Handshaking can be performed for accurate base tone selection
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Thank You