Phobia Glossary (from the Los Angeles Times)

Authorities say a seemingly endless variety of objects or phenomenon can trigger phobias. Most of them – like fear of heights, or fear of water – do not incapacitate an individual. Others do. Some phobias are unique to individuals; most others have appeared frequently enough to have been given a name. Below is a list of medically recognized phobias, with their Latin or Greek names presented first, followed by their English translation.

- ARACHNEPHOBIA – Fear of Spiders.
- AMAXOPHOBIA or HAMAXOPHOBIA – Fear of vehicles.
- ANDROPHOBIA – Fear of Males.
- AUTOPHOBIA – Fear of Self.
- AUTOMYSOPHOBIA – Fear of being dirty.
- BELONEPHOBIA – Fear of pins.
- BROMIDOSIPHOBIA or
- OSPHRESIOPHOBIA or OSMOPHOBIA – Fear of odors.
- CYNOPHOBIA – Fear of dogs.
- ENTOMOPHOBIA – Fear of Insects.
- ERGASIOPHOBIA or PONOPHOBIA – Fear of work.
- GAMOPHOBIA – Fear of marriage.
- GEPHYROPHOBIA – Fear of crossing a bridge.
- GRAPHOPHOBIA – Fear of writing.
- GYNEPHOBIA – Fear of women.
  HELIOPHOBIA – Fear of sun.
- HODCPHOBIA – Fear of traveling.
- HYGROPHOBIA – Fear of dampness.
- HYPNOPHOBIA – Fear of sleep.
- ICHTHYOPHOBIA – Fear of fish.
- MYSOPHOBIA or RHYPOPHOBIA – Fear of dirt.
- OMBROPHOBIA – Fear of rain.
- PANPHOBIA – Fear of everything.
- PENIAPHOBIA – Fear of poverty.
- PHARMACOPHOBIA – Fear of drugs.
- PHOBOPHOBIA – Fear of phobias.
- SIDERODROMOPHONIA – Fear of trains.
- SPECTRAPHOBIA – Fear of ***Fourier Transforms***.
- VACCINOPHOBIA – Fear of vaccination.

Orthogonal Frequency Division Multiplexing
OFDM

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Software Defined Radio: October 27 2008

OFDM

- OFDM also known as
  Multi-Carrier or Multi-Tone Modulation
- DAB-OFDM
  Digital Audio Broadcasting
- DVD-OFDM
  Digital Video Broadcasting
- ADSL-OFDM
  Asynchronous Digital Subscriber Line
- Wireless Local Area Network
  IEEE-802.11a, IEEE-802.11g
  ETSI BRAN (Hyperlan/2)

IEEE 802 Standards Committee

LOCAL AREA NETWORK	*(LAN)*
METROPOLATIN AREA NETWORK	*(MAN)*
PERSONAL AREA NETWORK	**(PAN)**

Wired:
- **802.3: Ethernet**
- **802.17: Packet Ring**

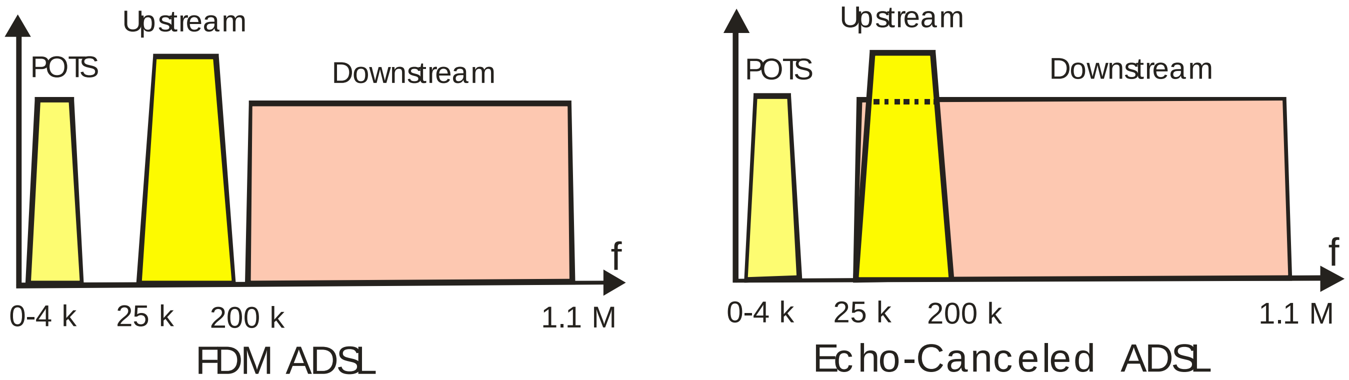
Wireless:
- **802.11: Wireless LAN**
- **802.15: Wireless PAN (Bluetooth)**
- **802.16: Wireless MAN**

Vehicular Mobility:
- **802.20: Wireless (new)**

OFDM Systems

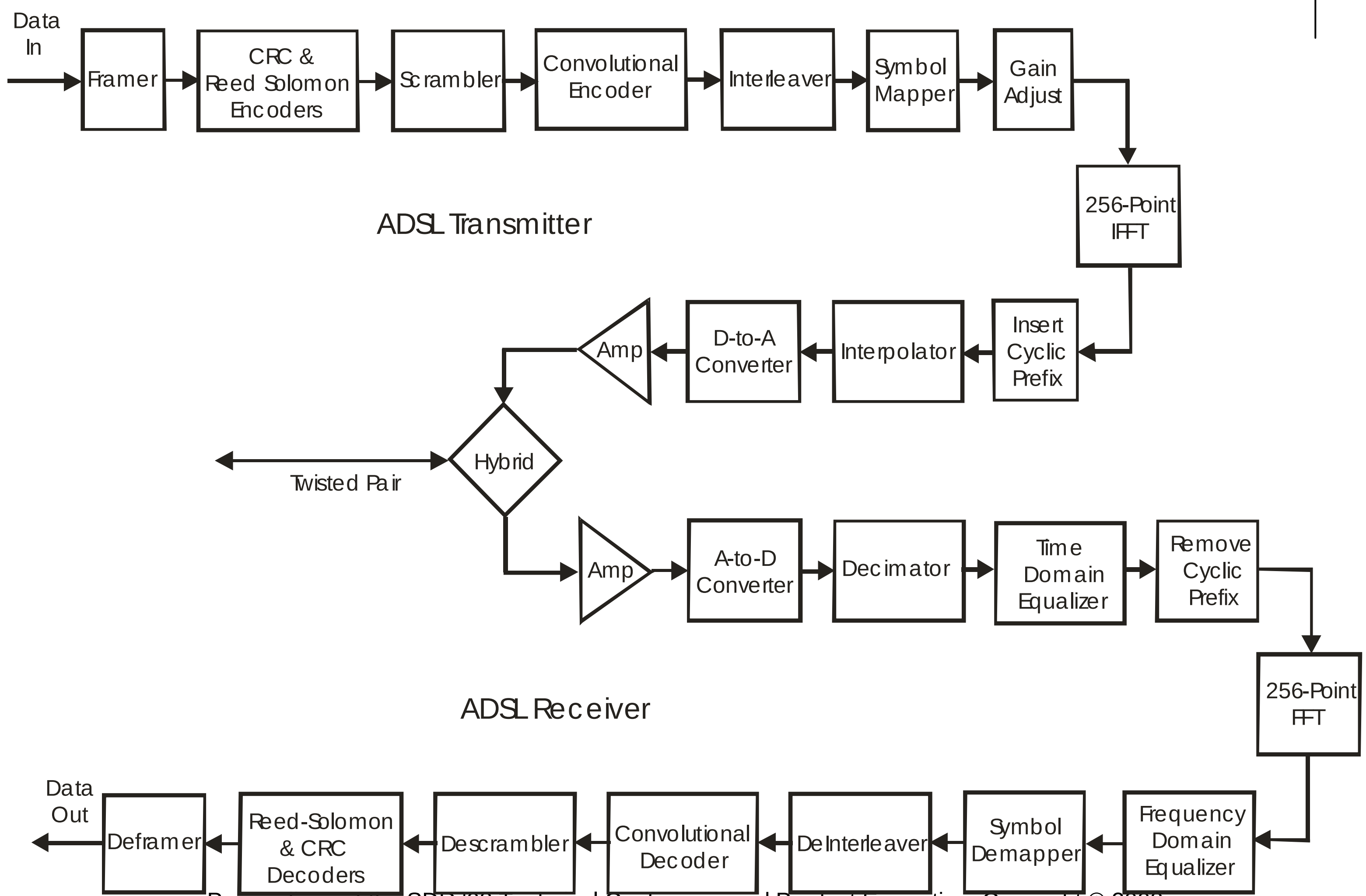
System	Transform Size	Number Carriers	Channel Spacing kHz	Bandwidth MHz	Sample Rate MHz	Symbol Duration μsec	Data Rate Mbits/s
HyperLAN/2	64	52 4	312.5	16.25	20	3.2 0.8	6-54
802.11a	64	52 4	312.5	16.56	20	3.2 0.8	6-54
802.11g 802.16.3							
DVB-T	2048 1024	1712 842	4.464	7.643	9.174	224	0.68-14.92
DAB	2048 8192	1536	1.00	1.536	2.048	24/48/96 msec	3.072
ADSL	256 (down) 64 (up)	36-127 7-28	4.3125	1.104	1.104	231.9	0.64-8.192

ADSL
(Asymmetric Digital Subscriber Line)

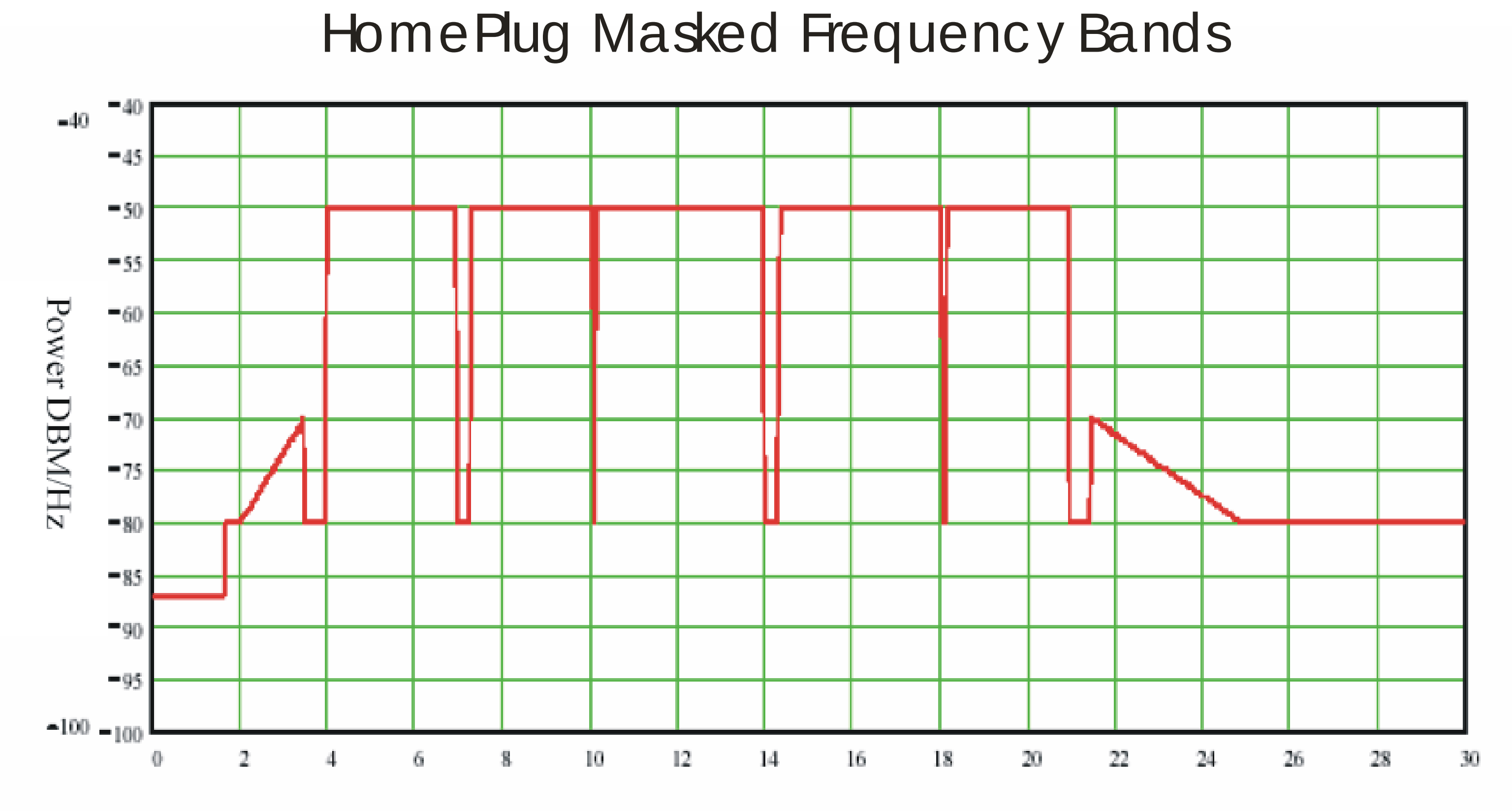


Data Rate	Wire Gauge	Distance
1.5 or 2.0 Mbps	24 AWG (0.5 mm)	18,000 ft (5.5 km)
1.5 or 2.0 Mbps	26 AWG (0.4 mm)	15,000 ft (4.6 km)
6.1Mbps	24 AWG (0.5 mm)	12,000 ft (3.7 km)
6.1Mbps	26 AWG (0.4 mm)	9,000 ft (2.7 km)

ADSL Modulator & Demodulator



HomePlug: Communications on Power Line

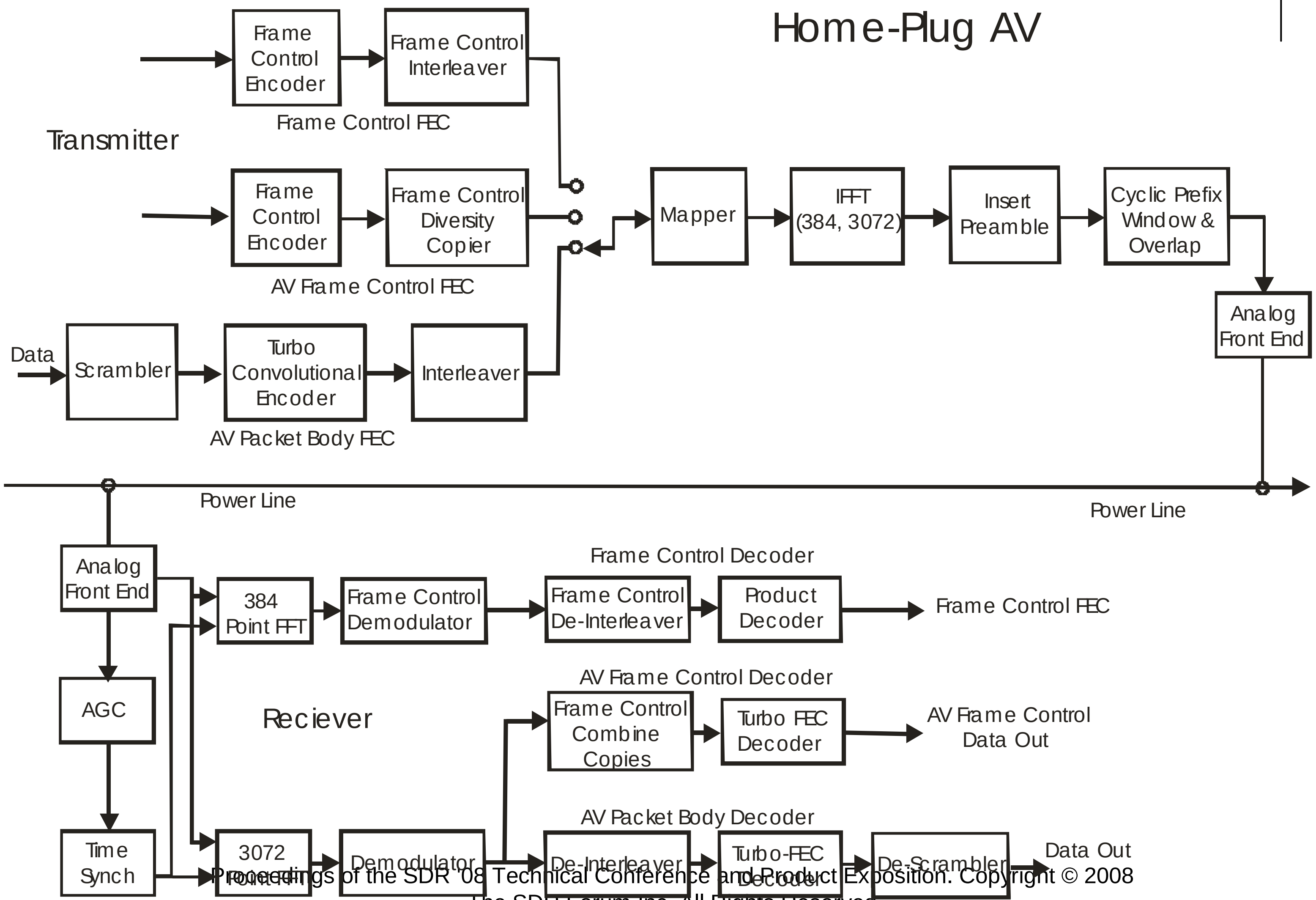


HomePlug 1.0 Operates in Frequency Band Spanning 4.49 to 20.7 MHz

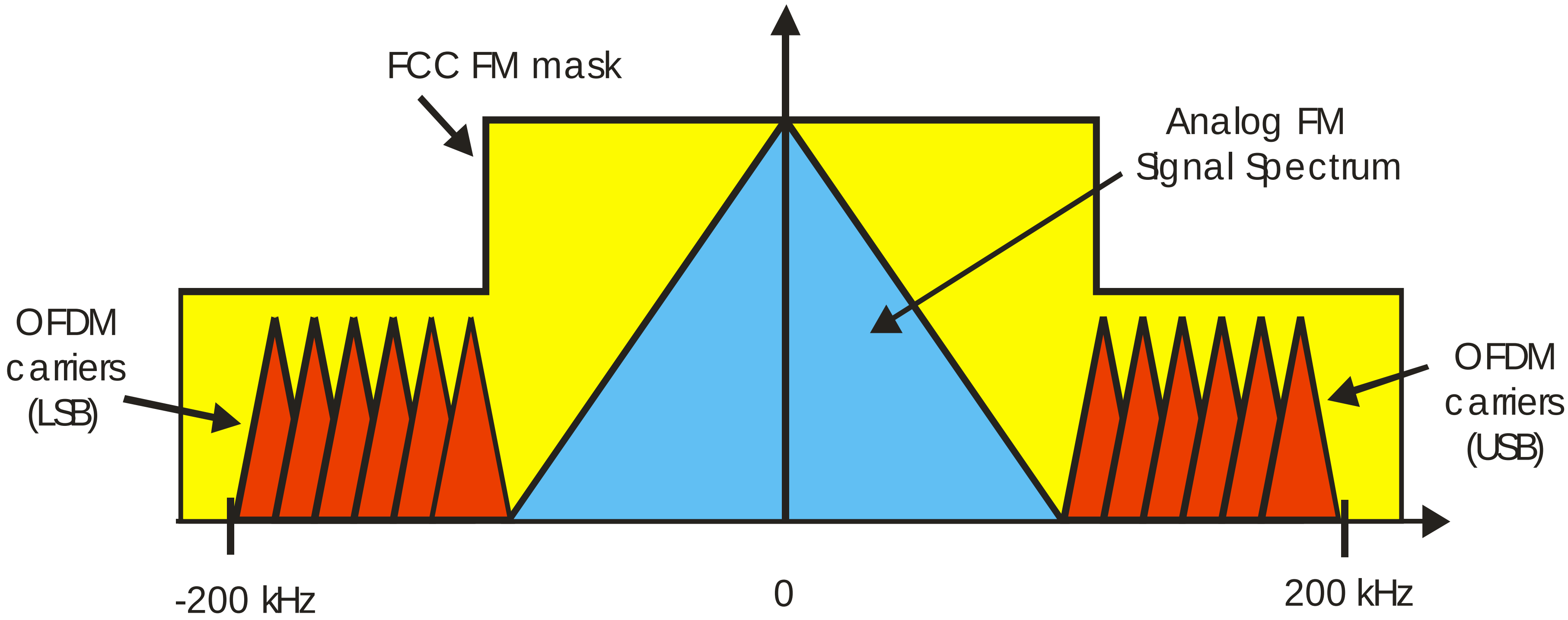
OFDM Splits this Band in 128 Evenly Spaced Sub-Carriers (126.6 kHz Wide)

8-Sub-Carriers Spanning 40, 30, 20, and 17 Meter Ham Radio Band Are Masked

HomePlug Modulator and Demodulator



HD (High Definition Radio)
IBOC (In-Band- On Carrier)



FM-Band OFDM Spectral Overlay

WHY OFDM?

- What wave shape passes through a Linear Time Invariant Channel Without Distortion?

  (Scaled Sums of Derivatives and Delays)
- Square waves? NO!
- Triangle Waves? NO!
- SINC Functions? NO!

- Sine waves? YES ! ! ! !

  The Only one ! ! !

OFDM Advantages

- Efficiently Deals With Multi-path Fading
- Efficiently Deals With Channel Delay Spread
- Enhanced Channel Capacity
- Adaptively Modifies Modulation Density
- Robustness to Narrowband Interference

OFDM Concerns

- OFDM Sensitive to

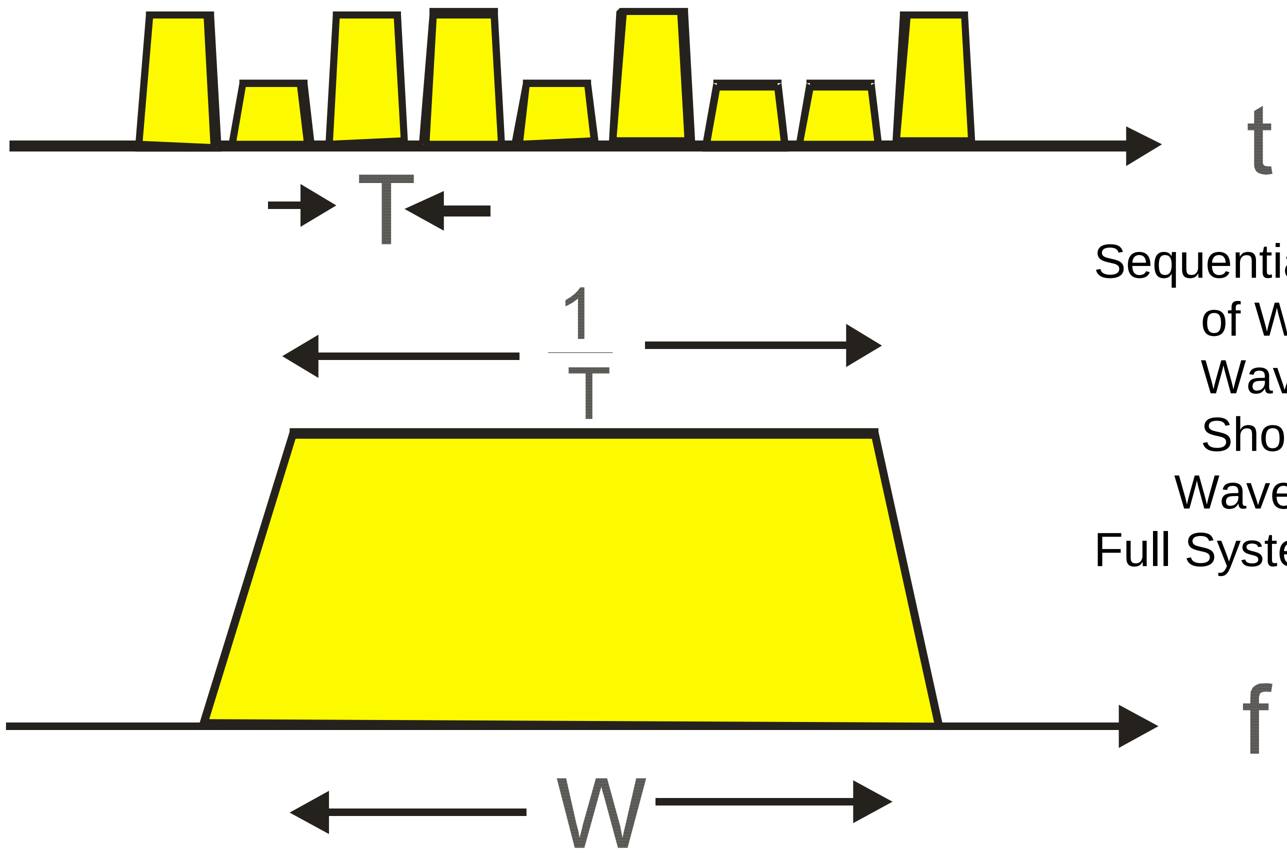
  Small Carrier Frequency Offsets
- OFDM Exhibits

  High Peak to Average Power Ratio
- OFDM Sensitive to

  High Frequency Phase Noise
- OFDM Sensitive to

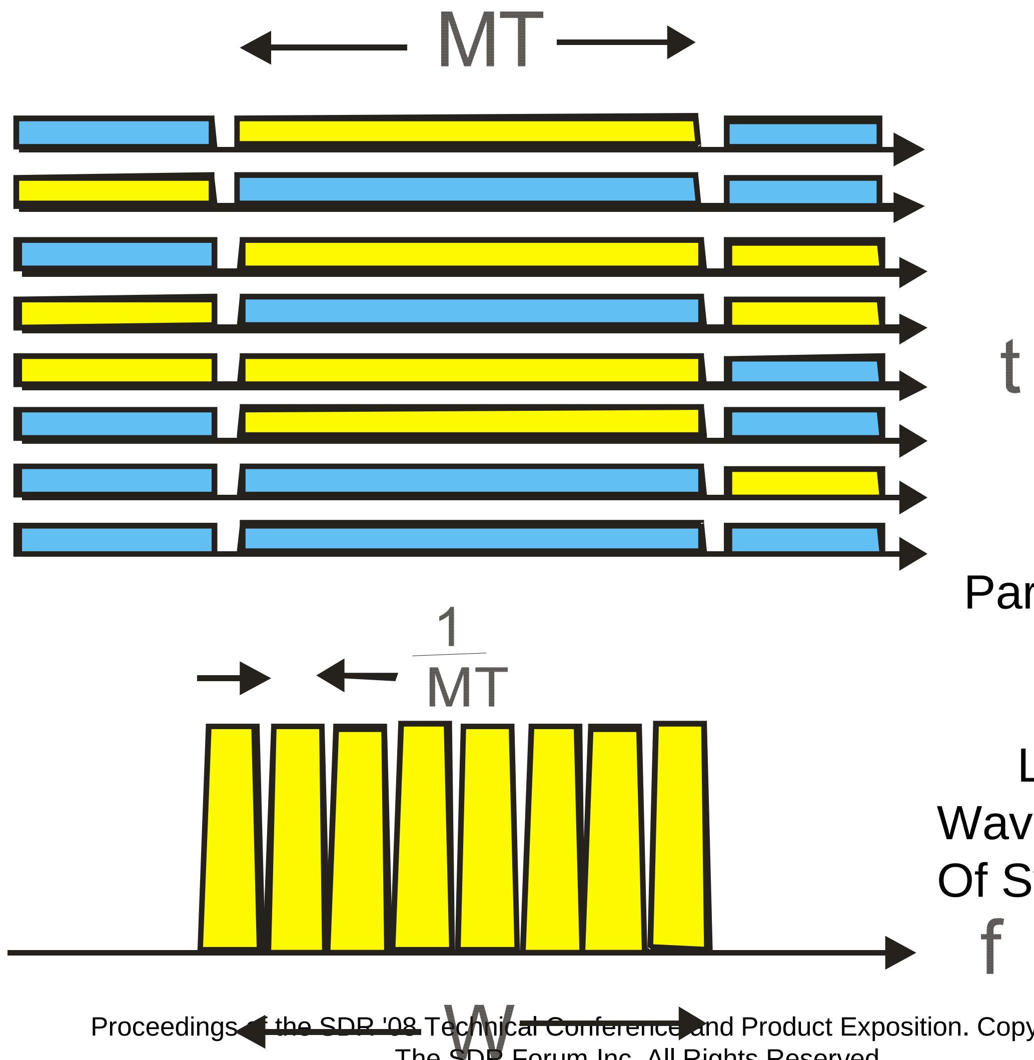
  Sampling Clock Offsets

Single Carrier System



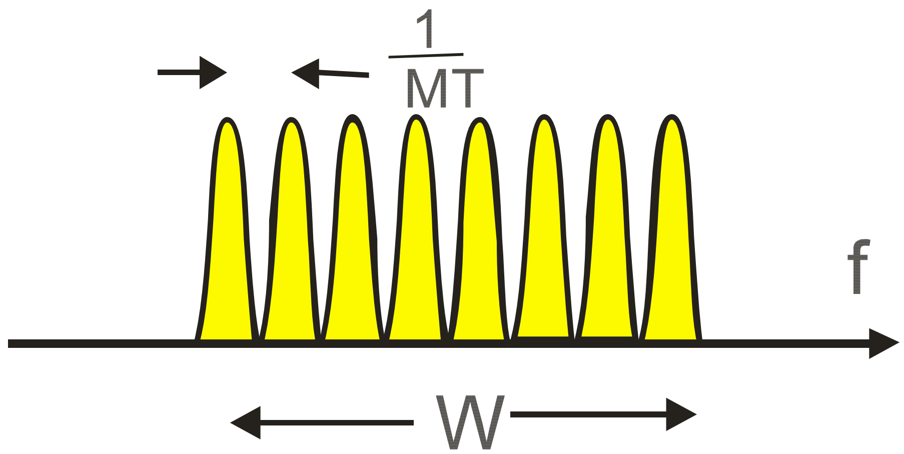
Sequential Transmission
of Waveforms
Waveforms are
Short Duration T
Waveforms Occupy
Full System Bandwidth 1/T

Multi-Carrier System



Parallel Transmission
of Waveforms
Waveforms are
Long Duration MT
Waveforms Occupy 1/M th
Of System Bandwidth 1/T

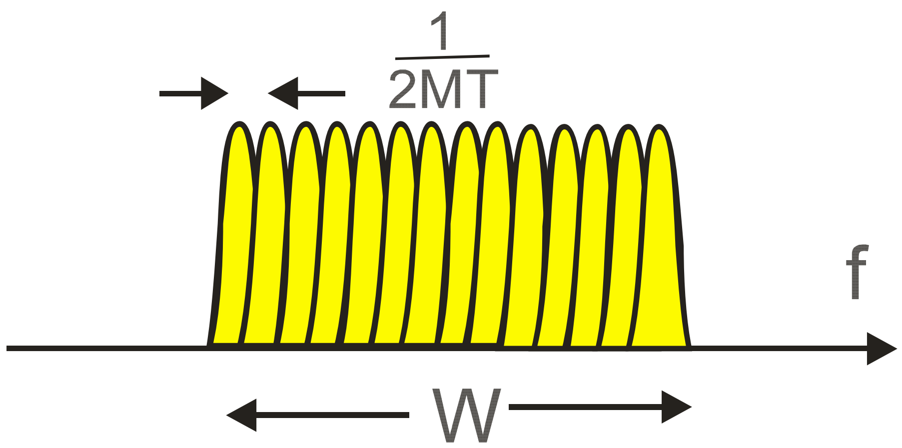
OFDM: Dense Multichannel System



Conventional Multichannel System

Non Overlapping Adjacent Channels.

Channels separated by More
Than Their Two Sided bandwidth

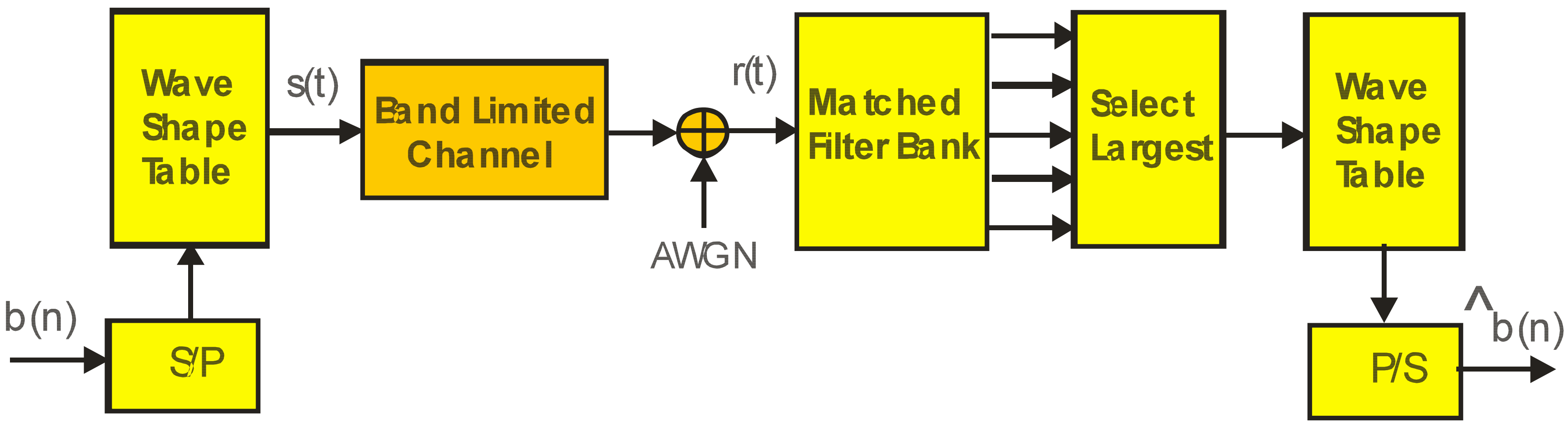


OFDM Multichannel System

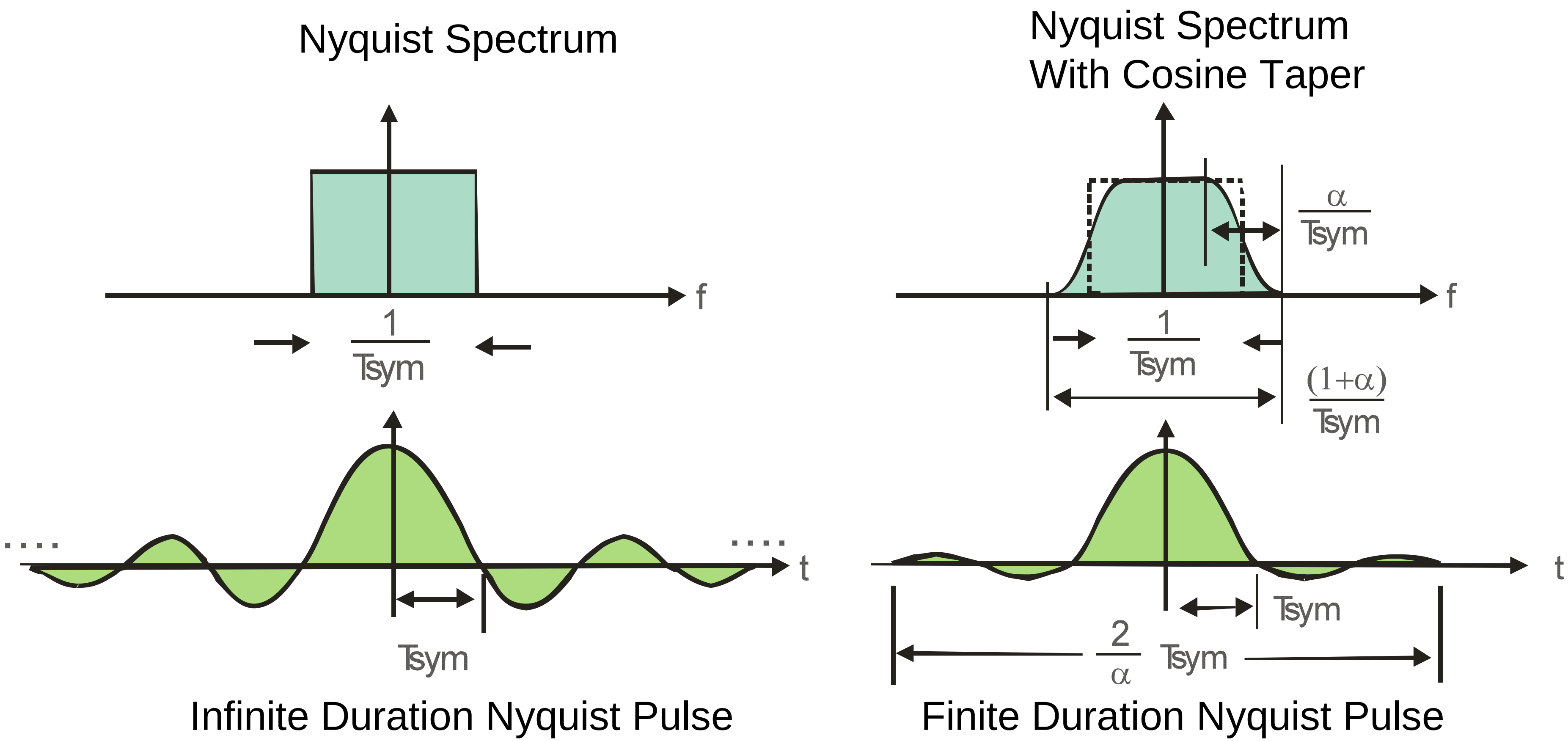
50% Overlap of Adjacent Channels
Available bandwidth is Used Twice

Channels separated by Half
Their Two Sided bandwidth

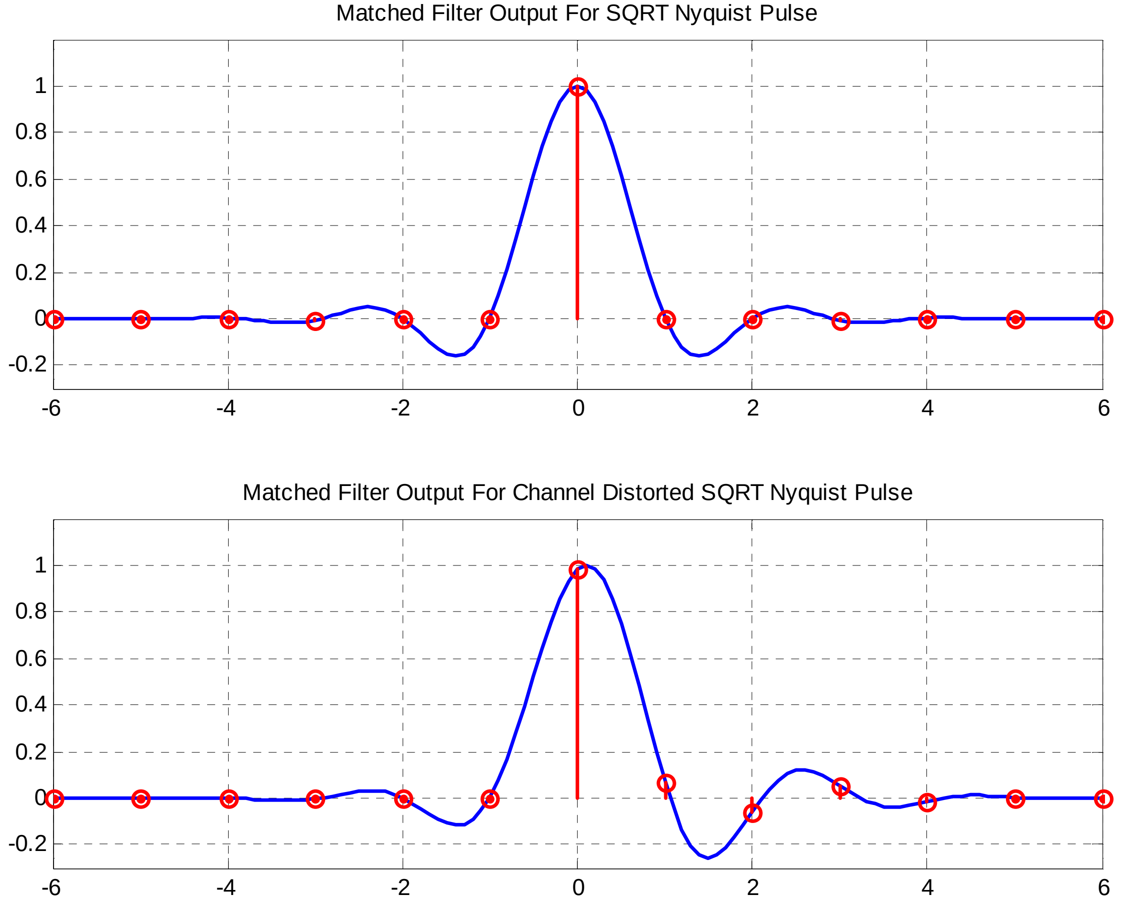
Standard Digital Communication System



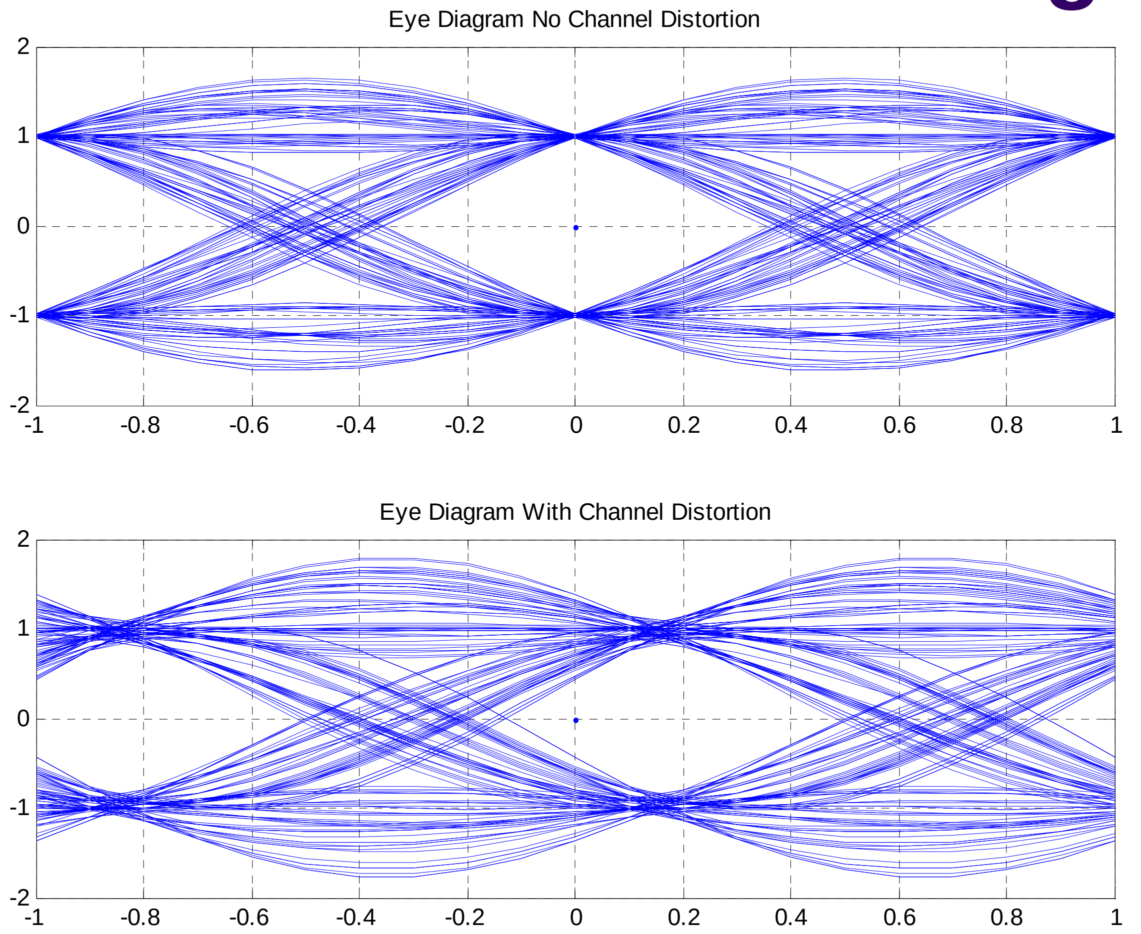
Bandlimited Channel



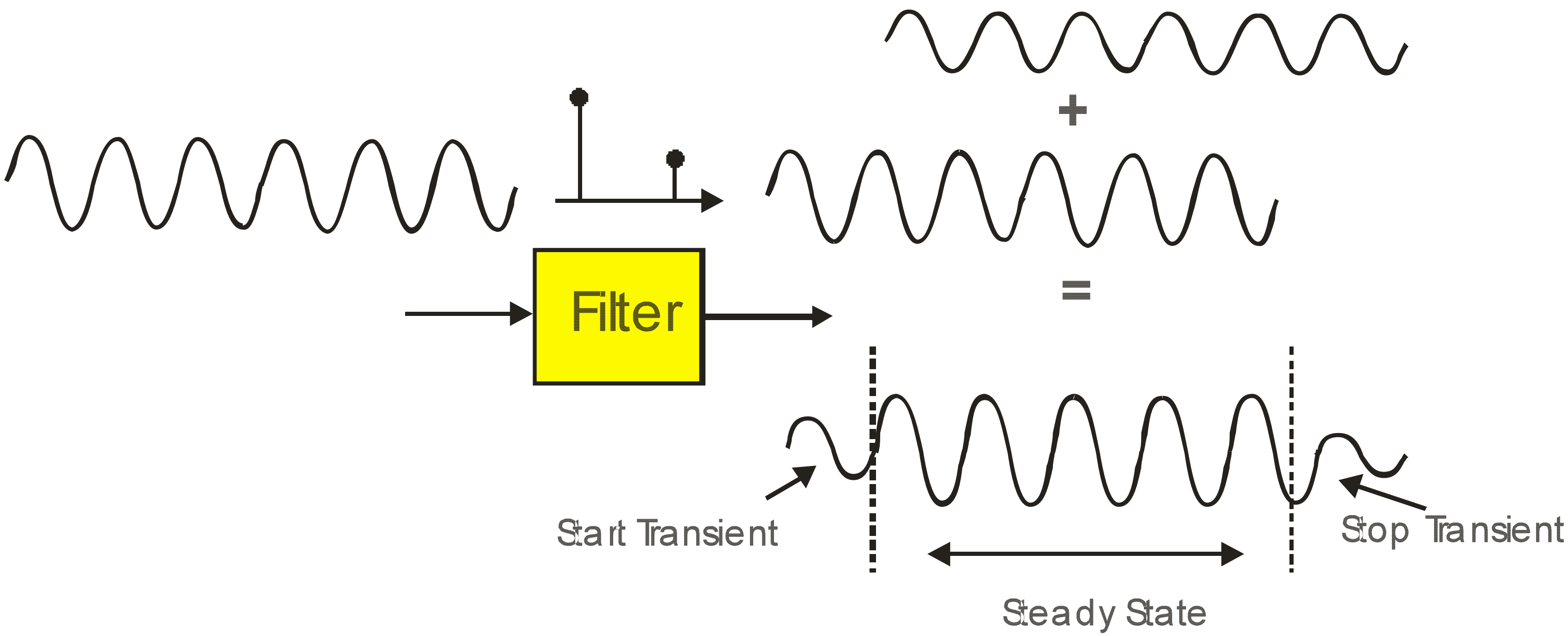
Channel Distortion
Modifies Received Wave Shape



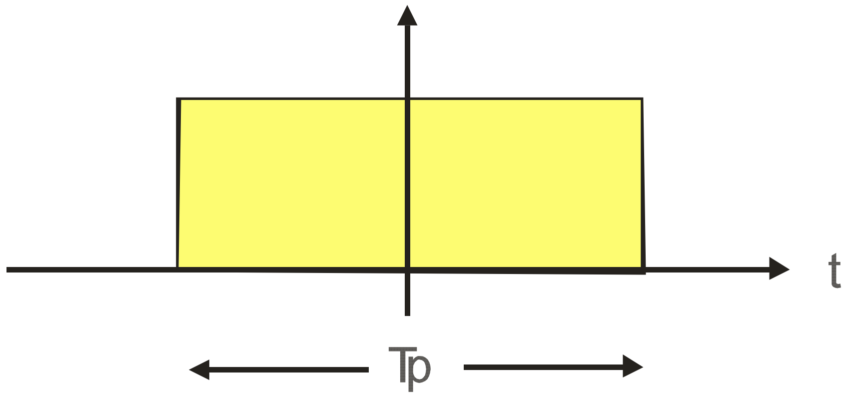
Inter Symbol Interference (ISI) Due to Channel Distorted Signal



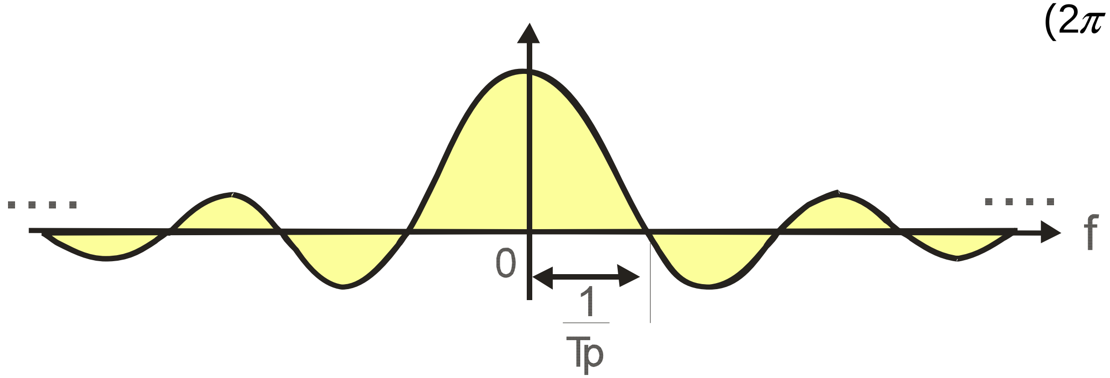
Steady State Response of a Filter to a Sine Wave is a Sine Wave



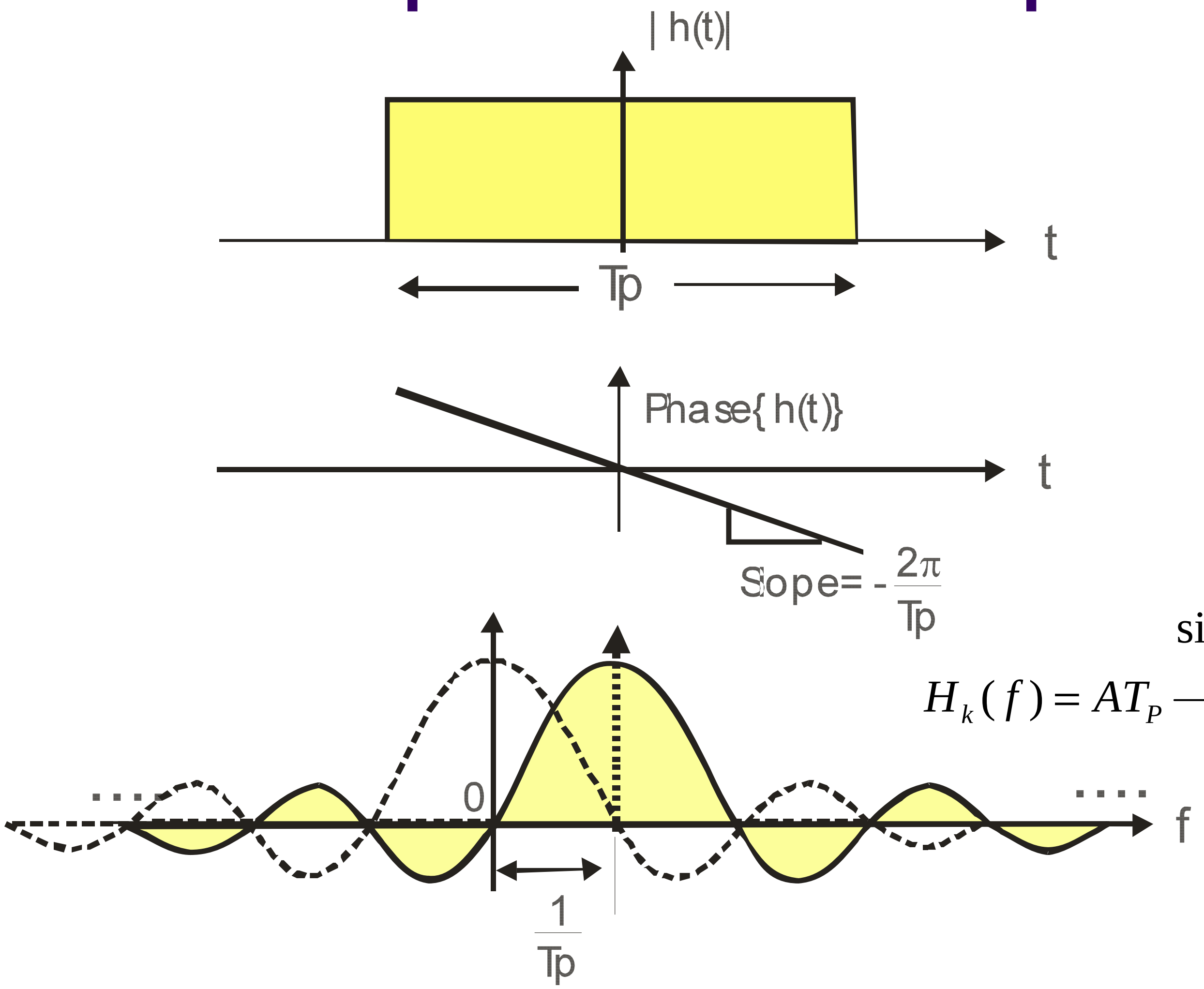
Rectangle Pulse: DC Centered Spectrum with Equally Spaced Zeros



$$H_0(f) = AT_P \frac{\sin(2\pi f \frac{T_P}{2})}{(2\pi f \frac{T_P}{2})}$$

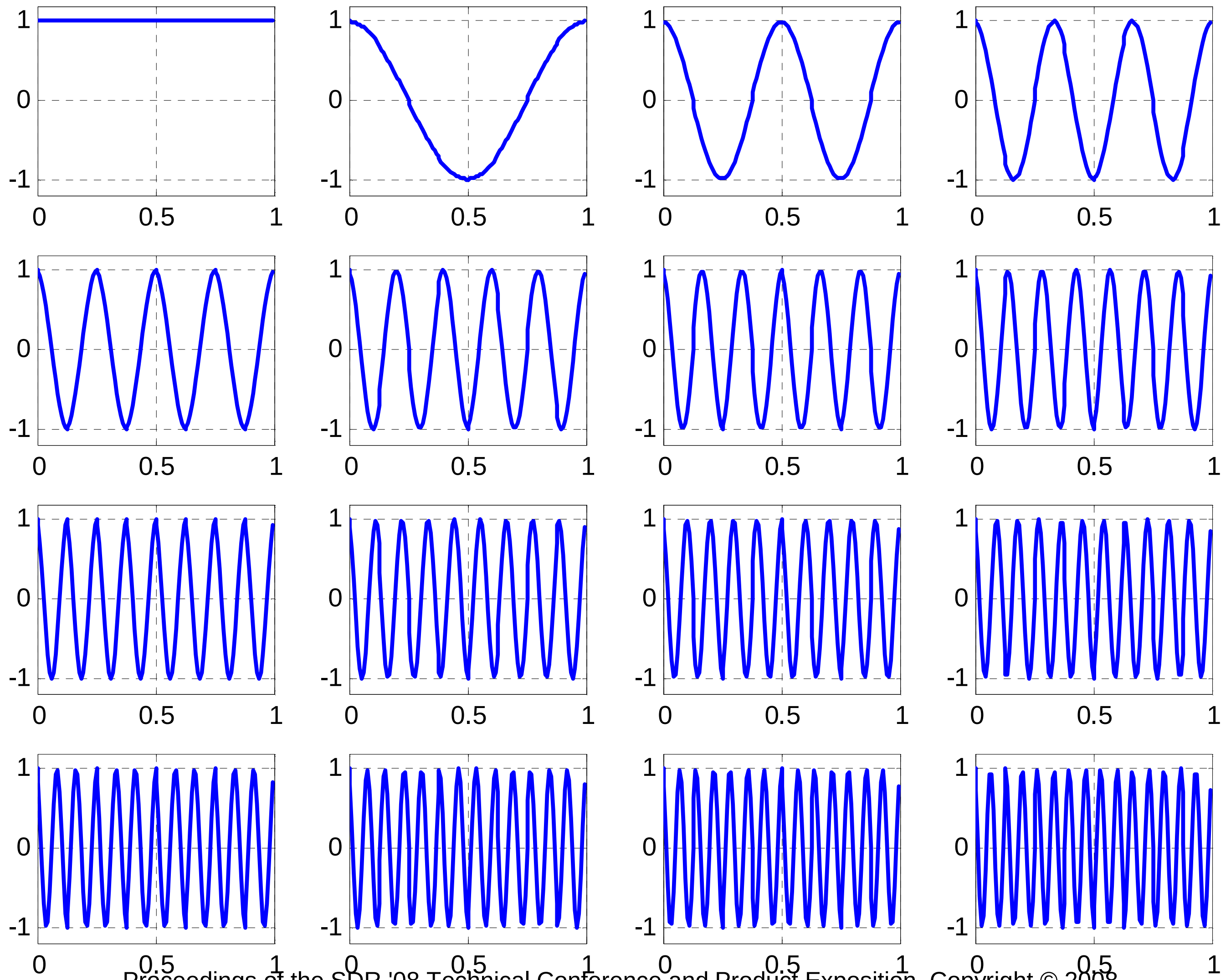


Shift Spectrum with Linear Phase on DC Pulse: Move Spectrum to First Spectral Zero

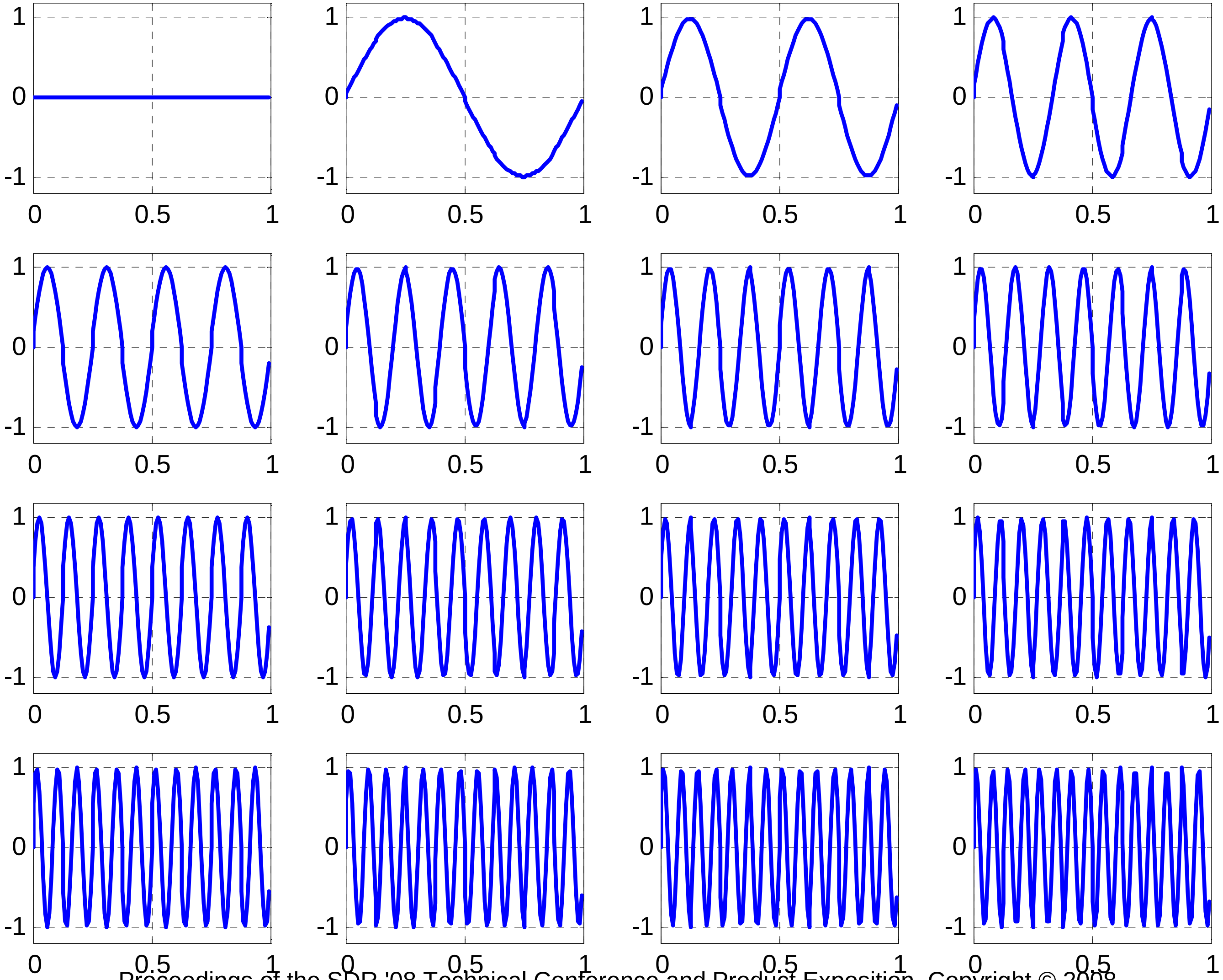


$$H_k(f) = AT_P \frac{\sin(2\pi(f - k\frac{1}{T_p})\frac{T_P}{2})}{(2\pi(f - k\frac{1}{T_p})\frac{T_P}{2})}$$

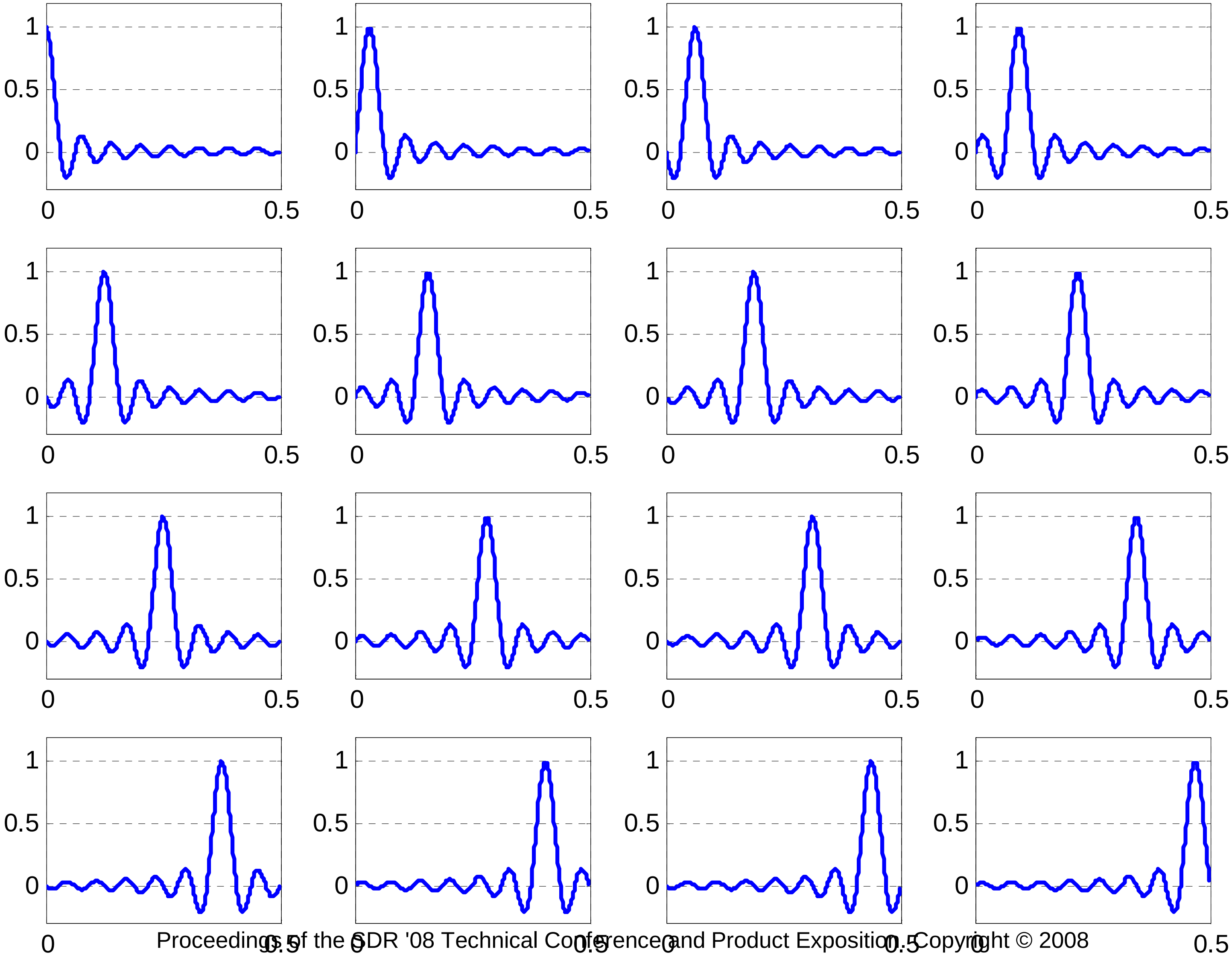
Real Part of Complex Exponential Time Series: Integer Number of Cycles per Interval



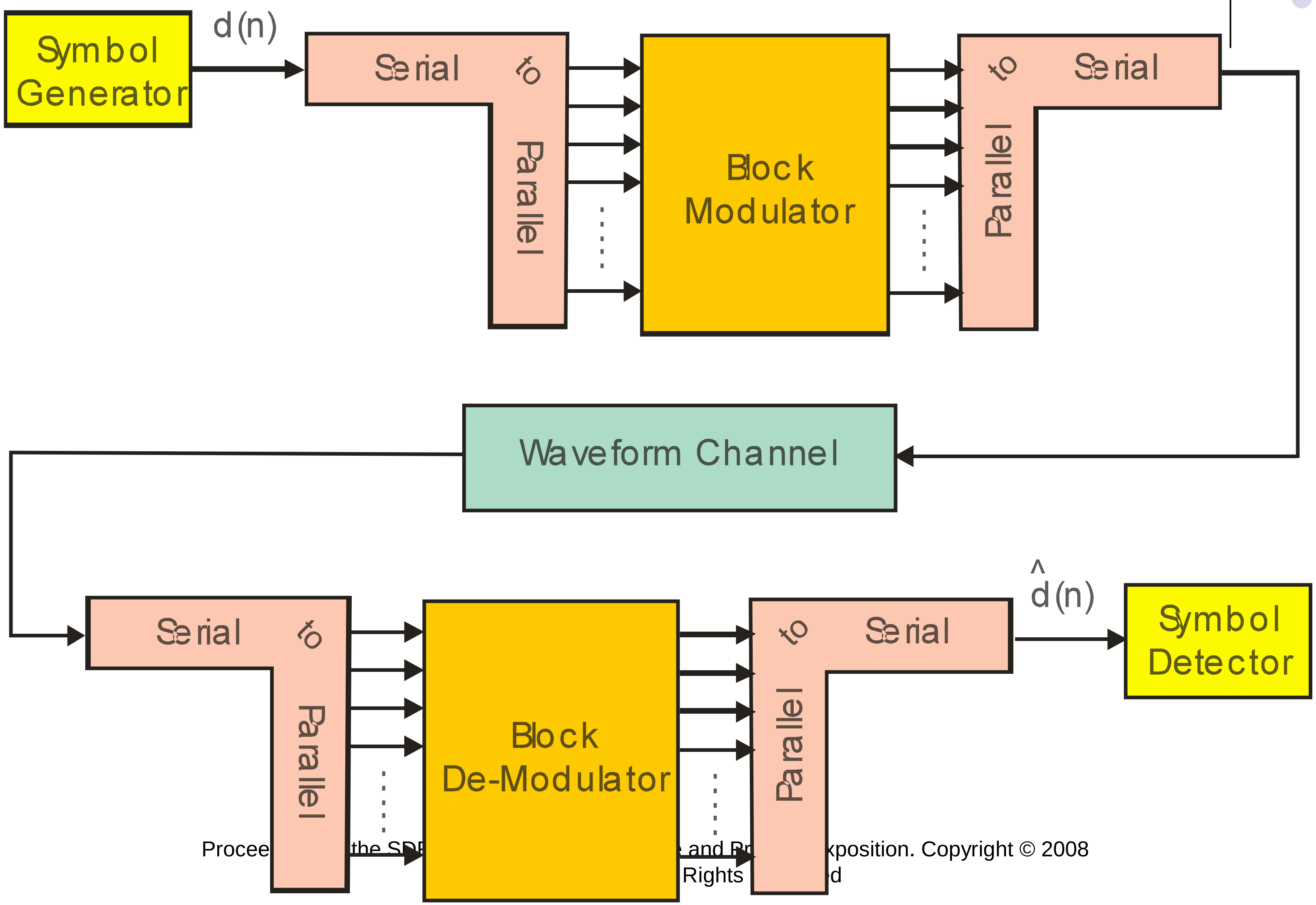
Imaginary Part of Complex Exponential Time Series: Integer Number of Cycles per Interval



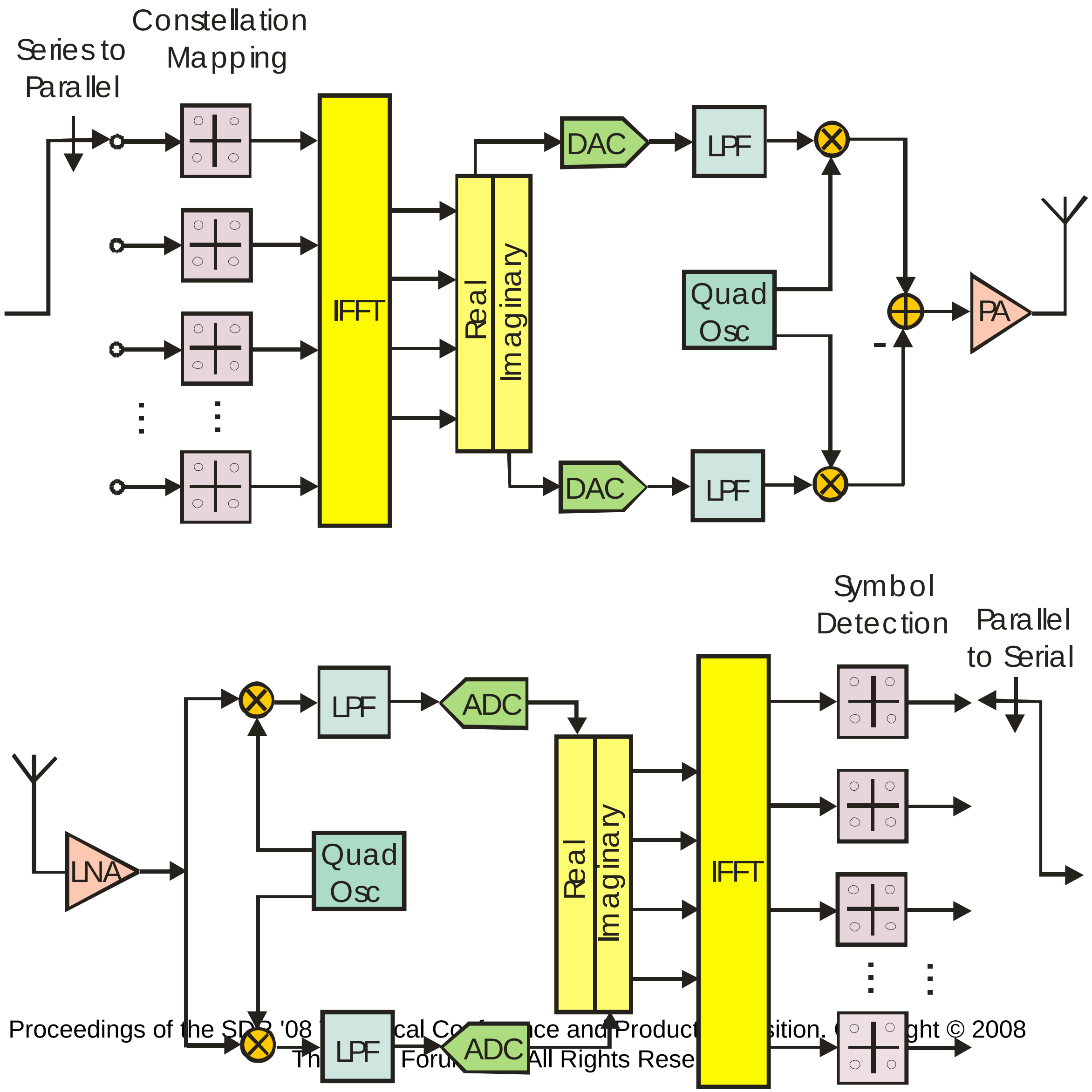
Spectra Of Complex Exponential Time Series: Integer Number of Cycles per Interval



OFDM is a Block Process

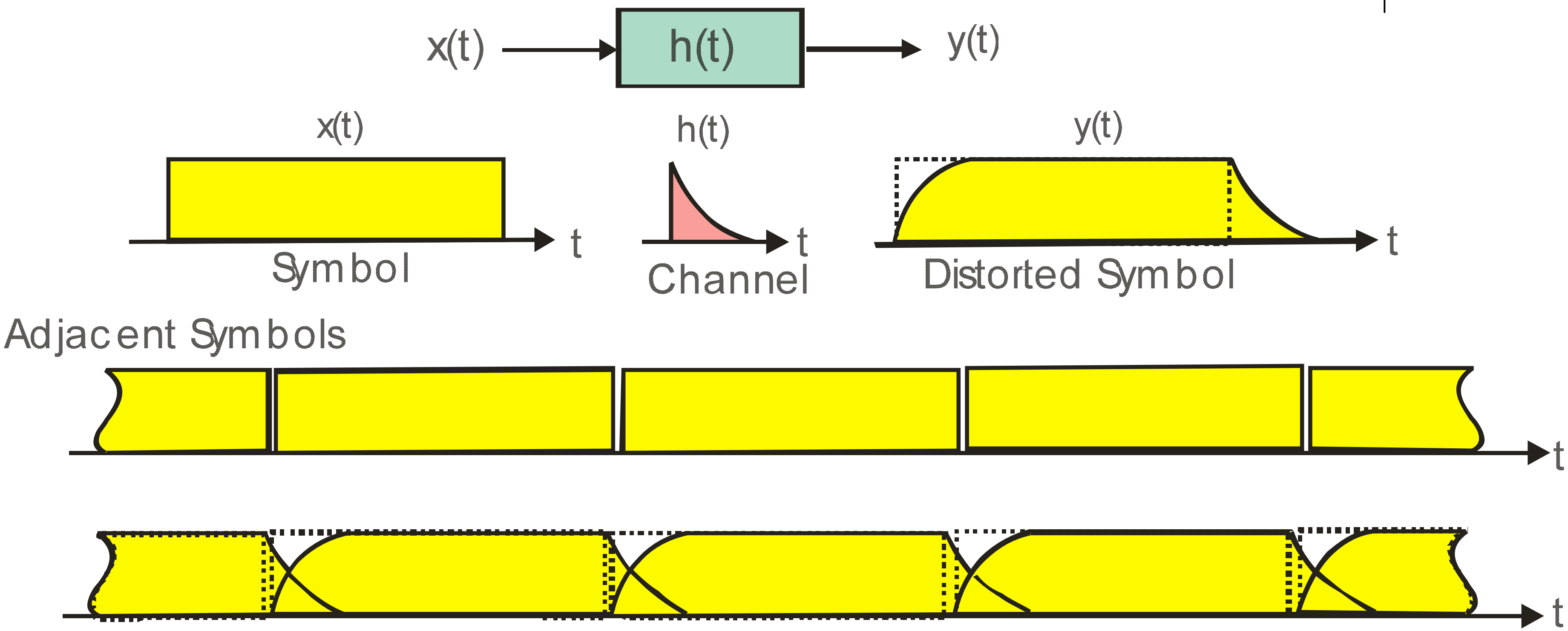


OFDM
Modulator and Demodulator

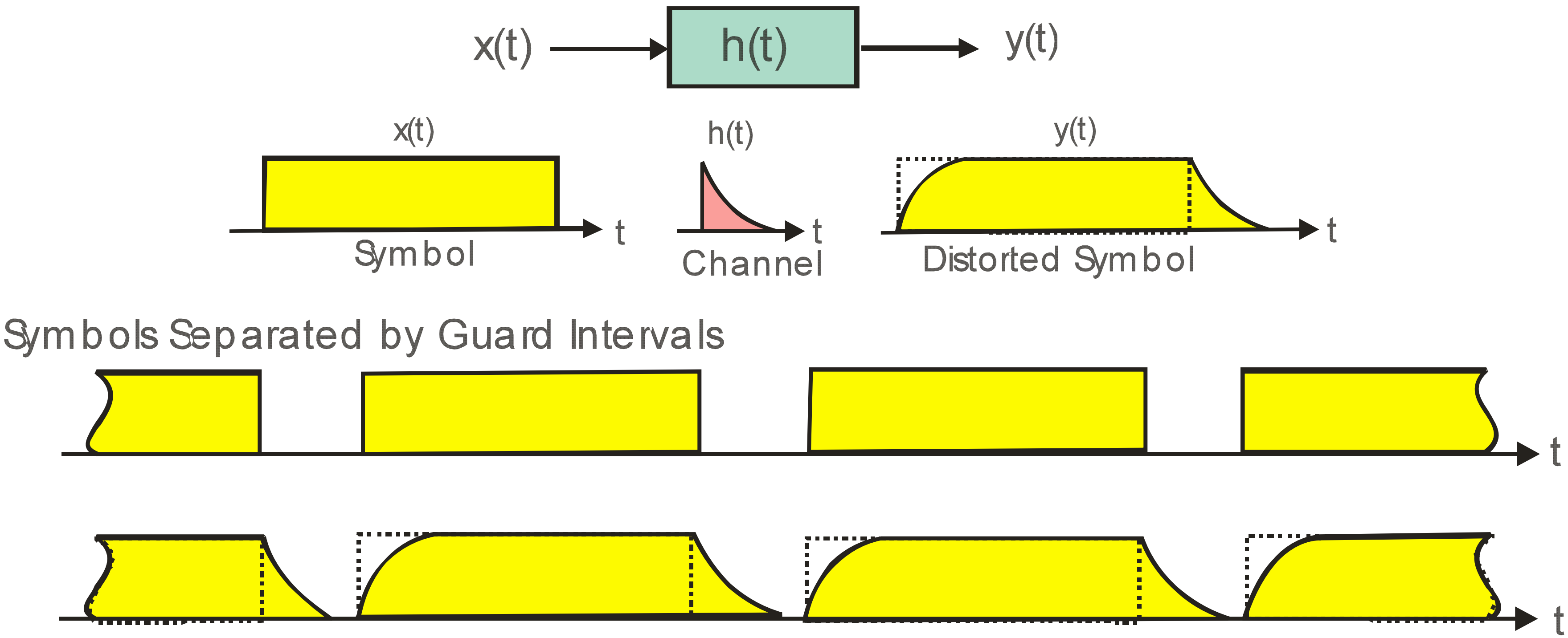


Adjacent Symbol Interference (ASI)

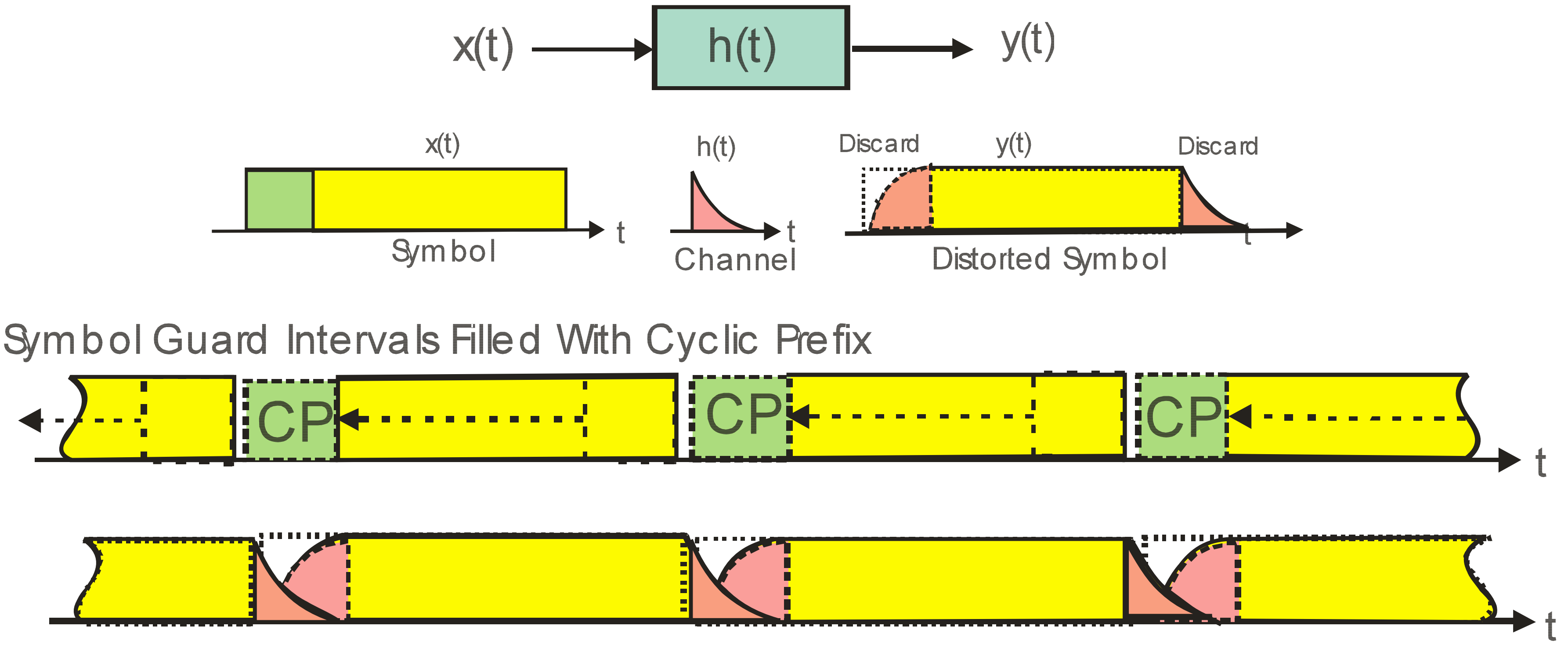
Symbol Smearing Due to Channel



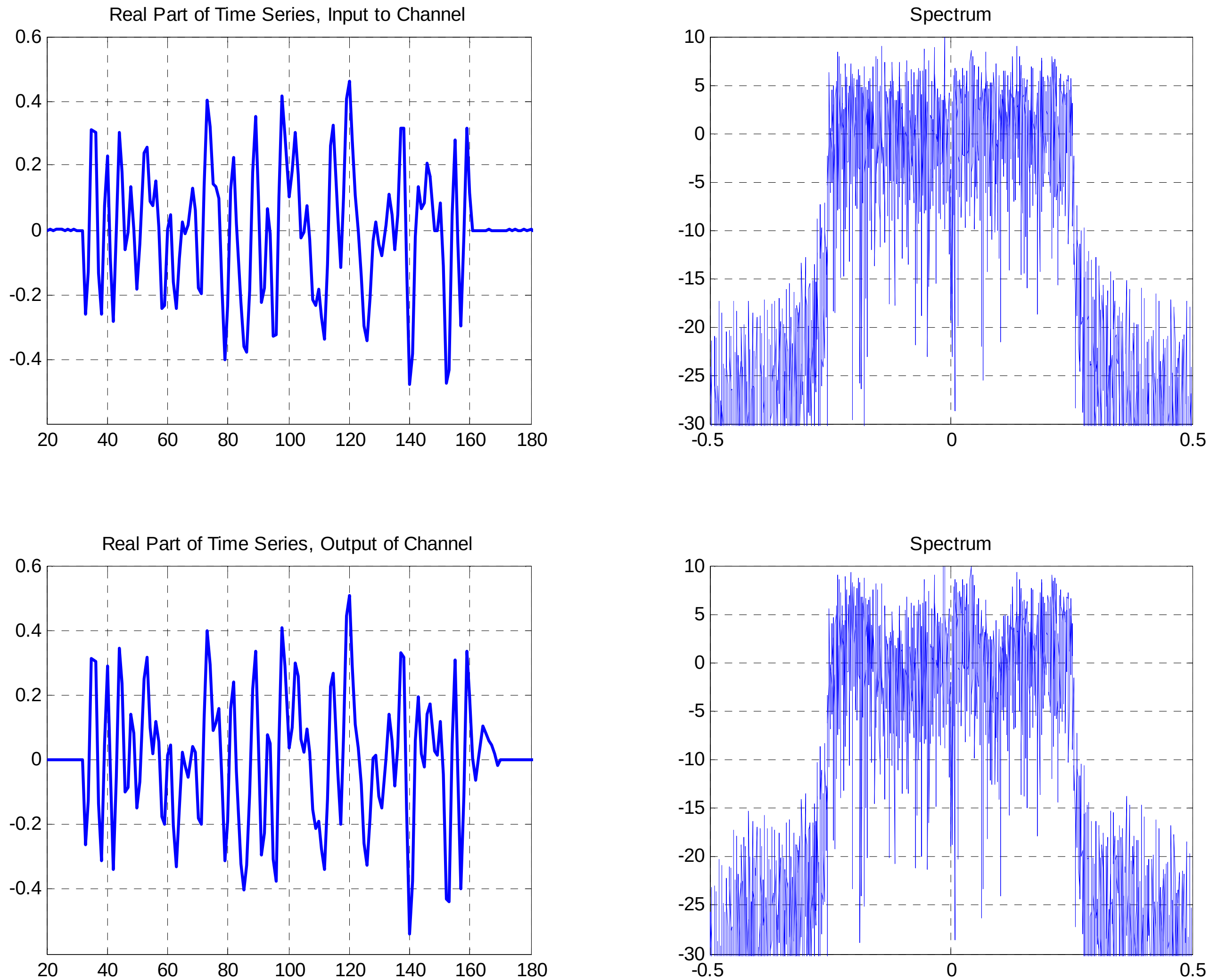
Guard Interval Inserted Between Adjacent Symbols to Suppress ASI



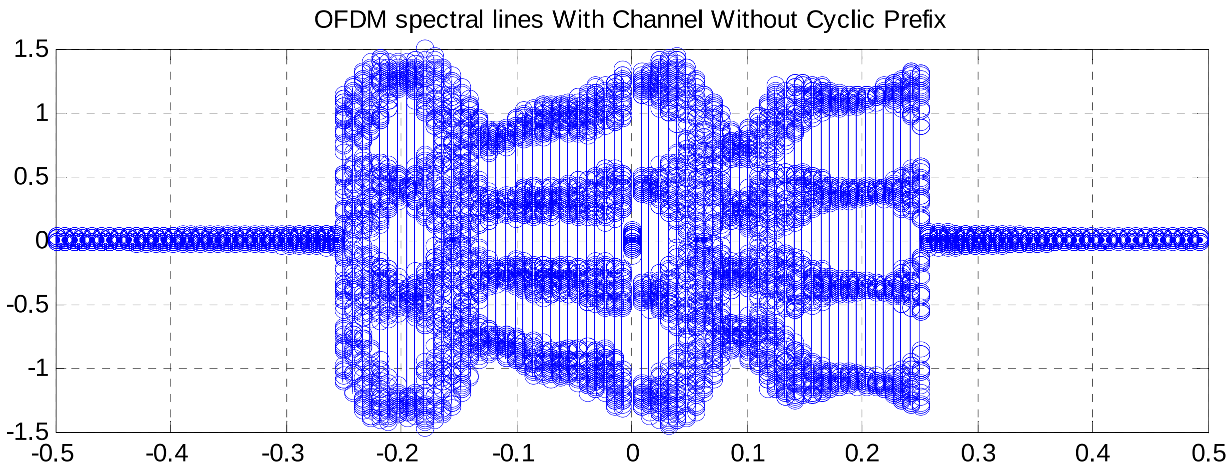
Cyclic Prefix Inserted in Guard Interval to Suppress Adjacent Channel Interference (ACI)

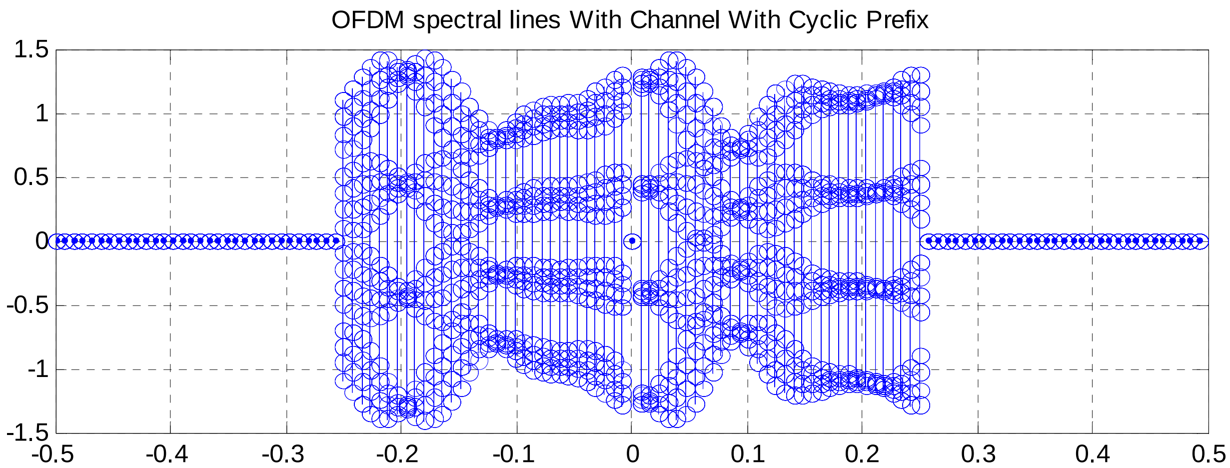


OFDM Symbol: Time and Spectra Channel Input and Output

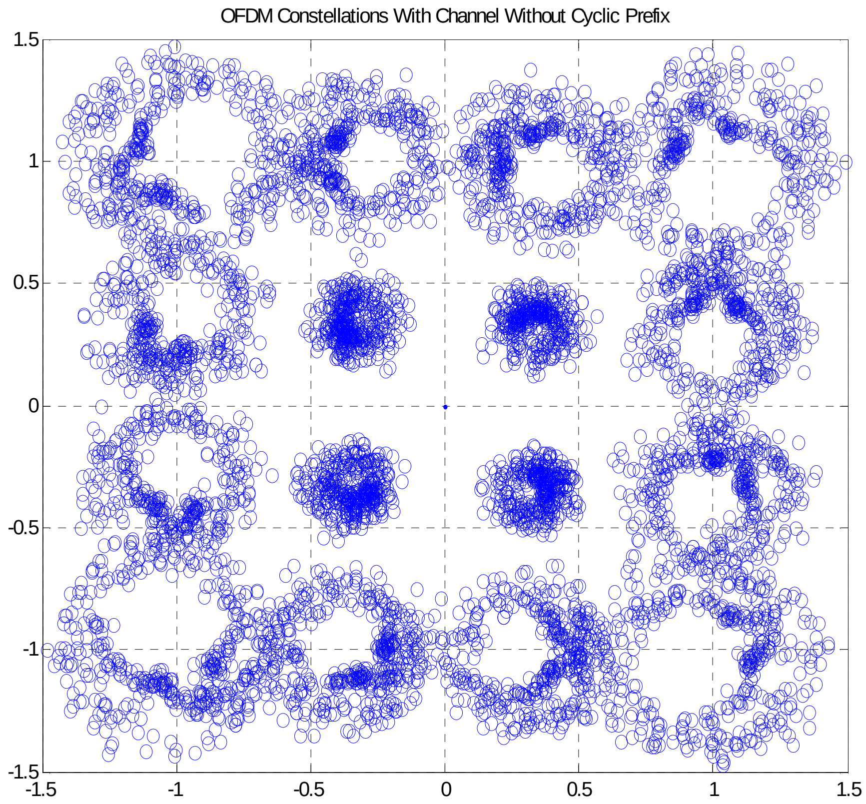


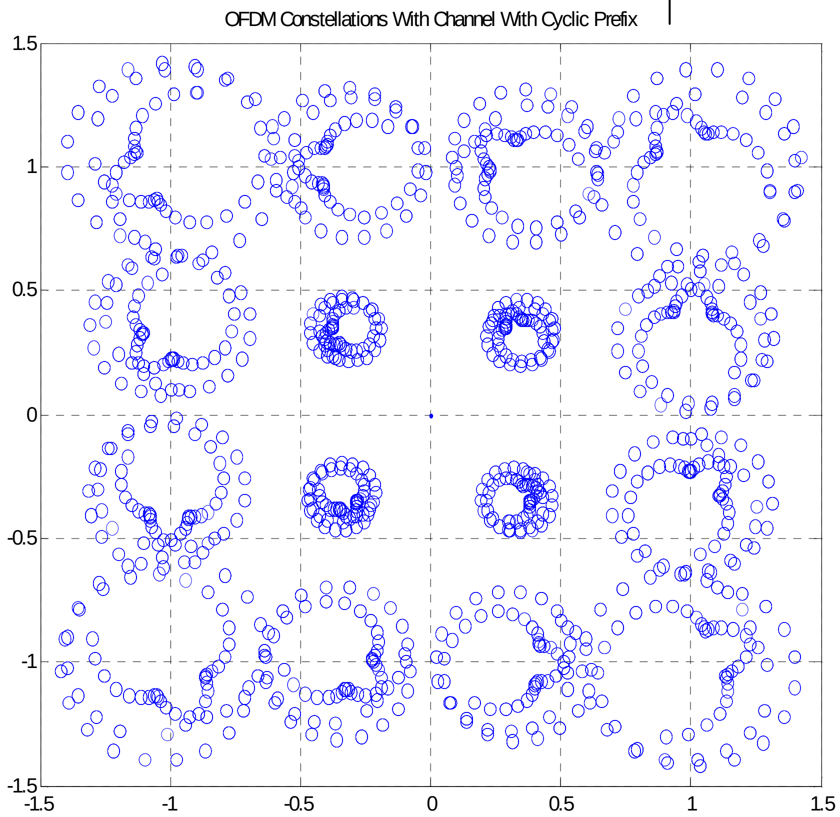
OFDM Spectra
Without and with Cyclic Prefix



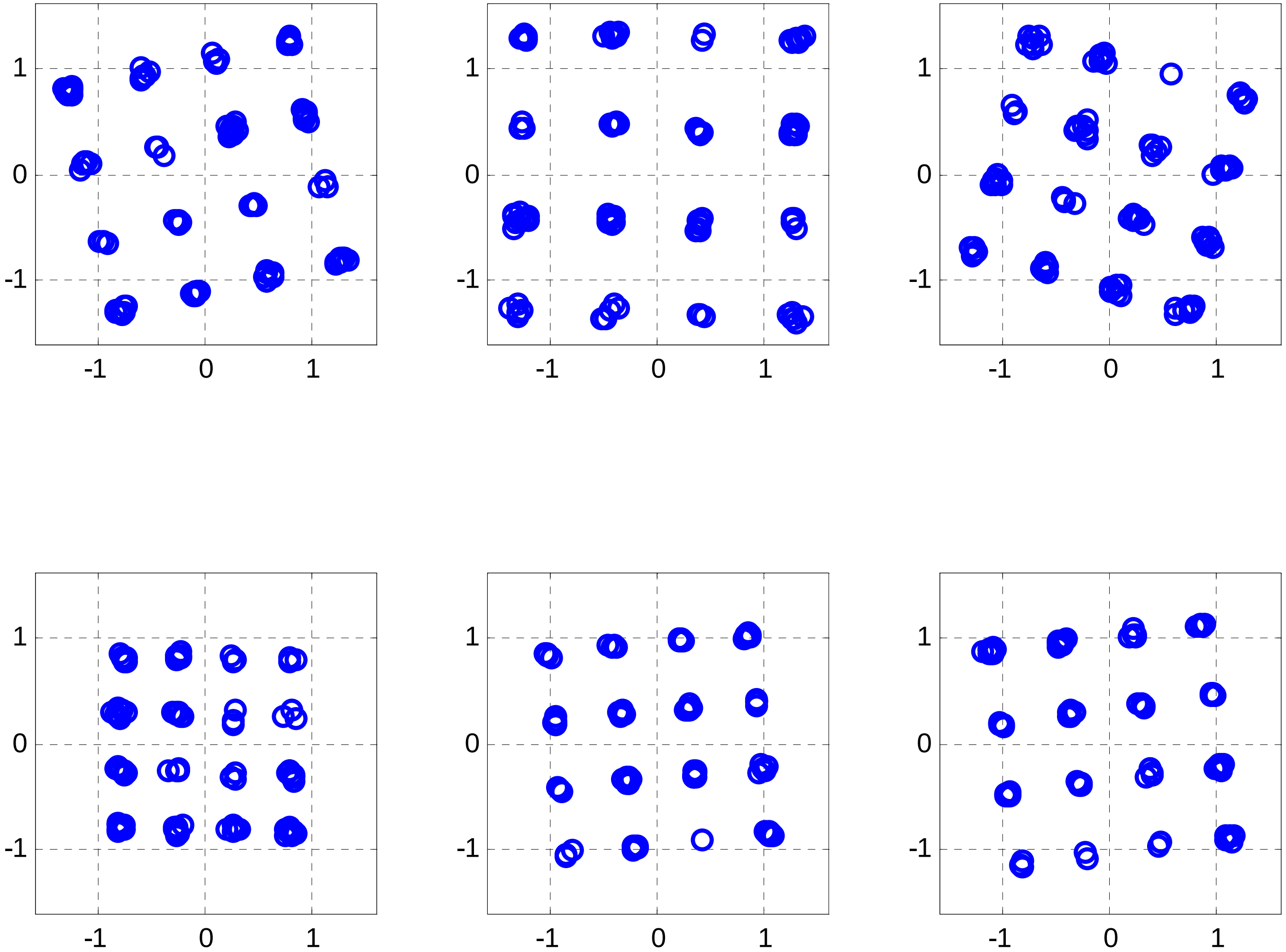


Overlaid Constellations , All Frequencies, Without and With Cyclic Prefix



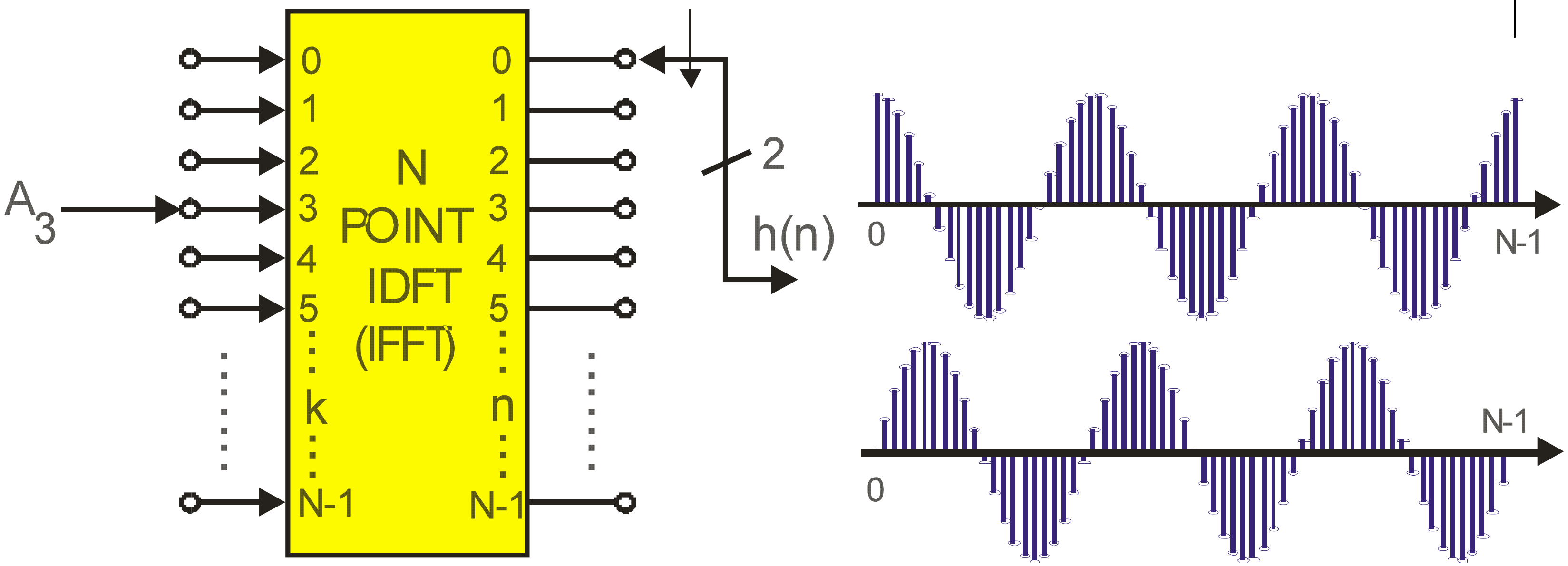


Constellations: Different OFDM Bins Without Cyclic Prefix



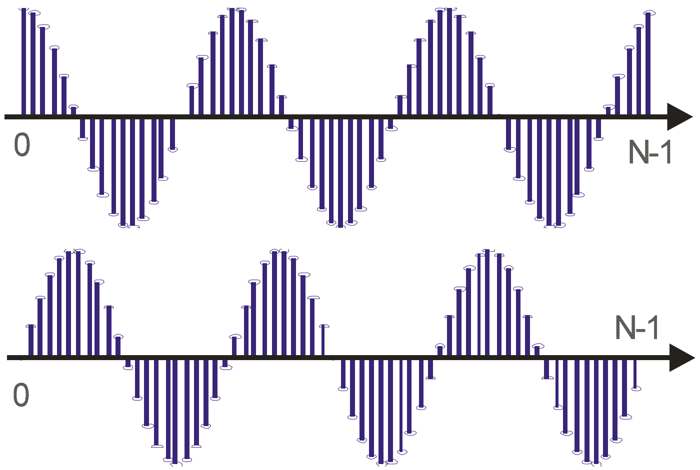
Constellations: Different OFDM Bins With Cyclic Prefix

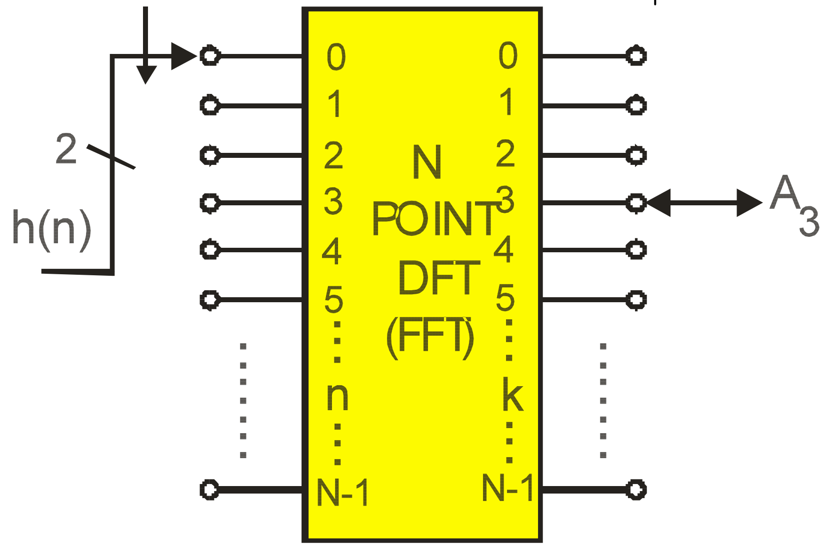
DFT (FFT) as Signal Generator for Complex Sinusoids



$$h(n) = \frac{1}{N} \sum_{n=0}^{N-1} H(k)\, e^{j\frac{2\pi}{N}nk} \quad : \quad n = 0,1,2,\ldots, N-1$$

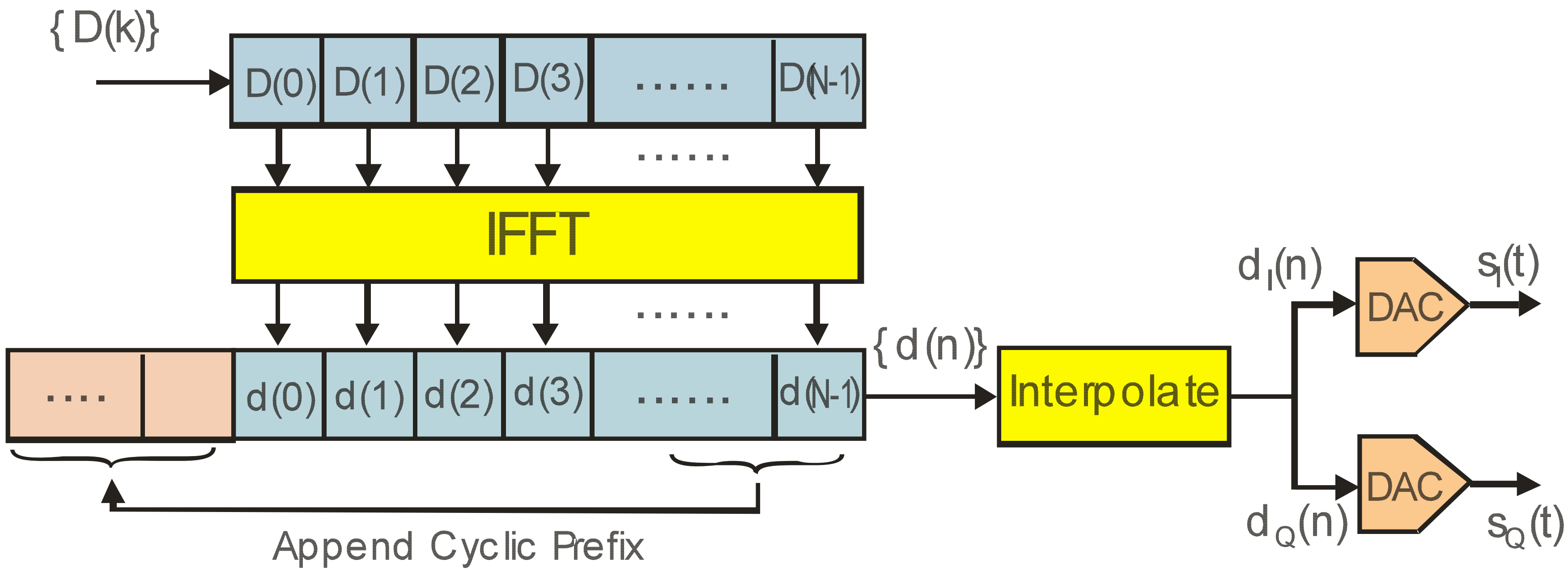
DFT (FFT) As Signal Analyzer for Complex Sinusoids



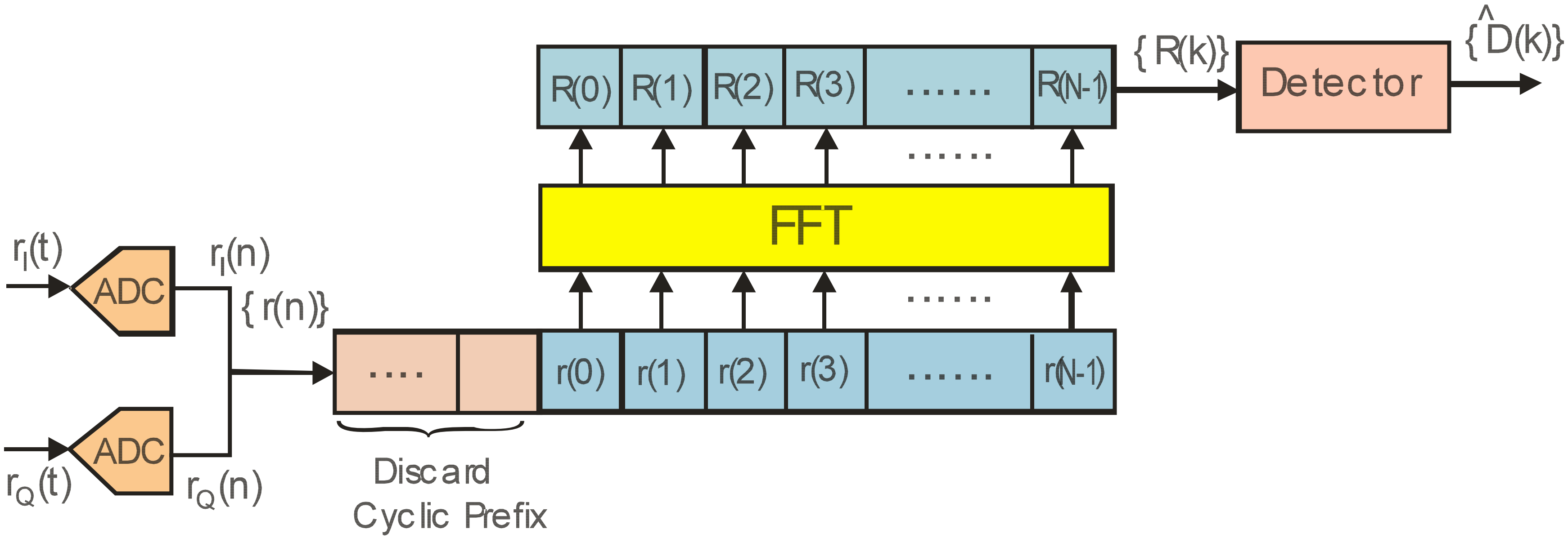


$$H(k) = \sum_{n=0}^{N-1} h(n)\, e^{-j\frac{2\pi}{N}nk} \quad : \quad k = 0, 1, 2, \ldots, N-1$$

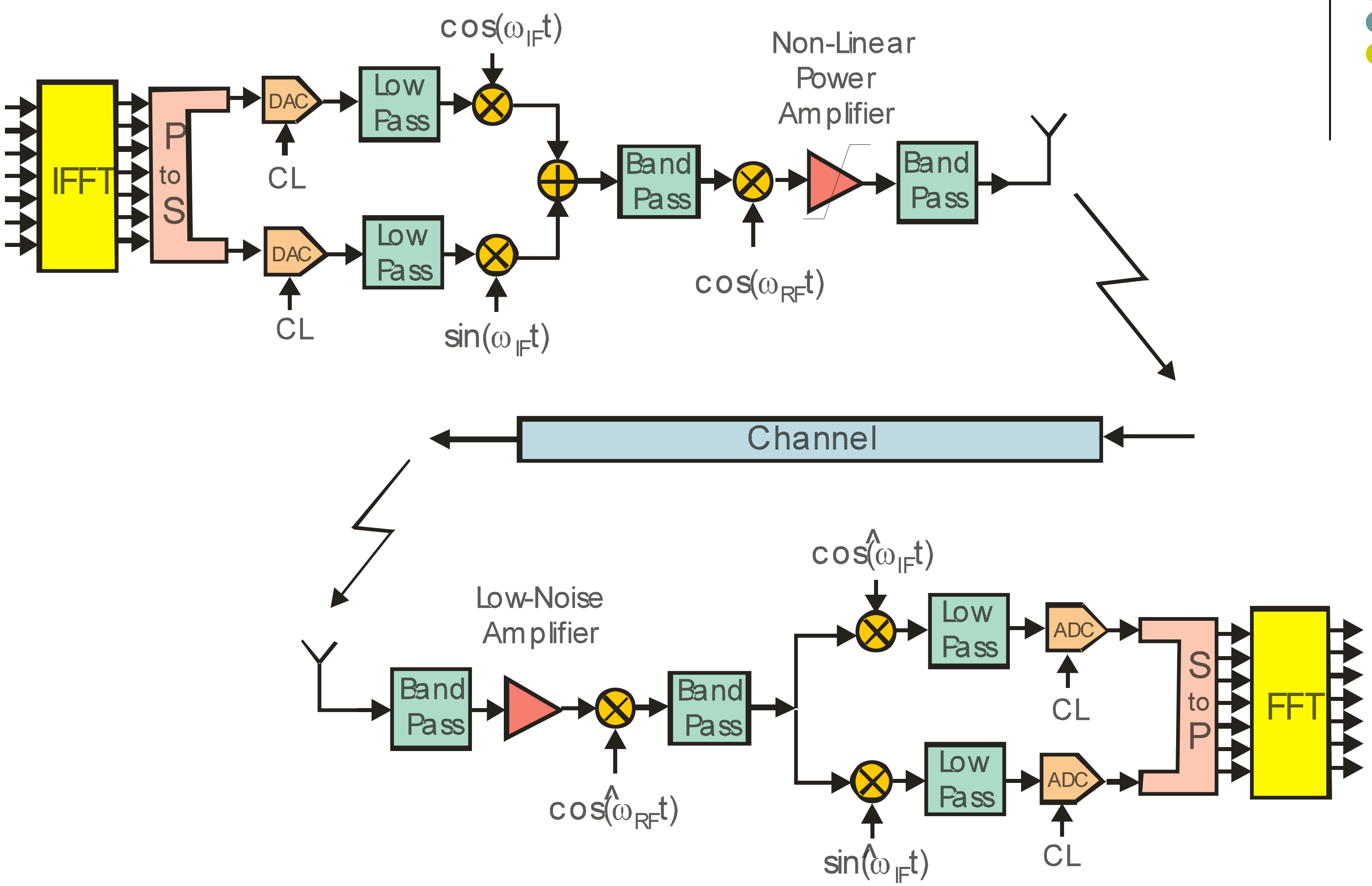
OFDM Modulation With IFFT and Interpolator



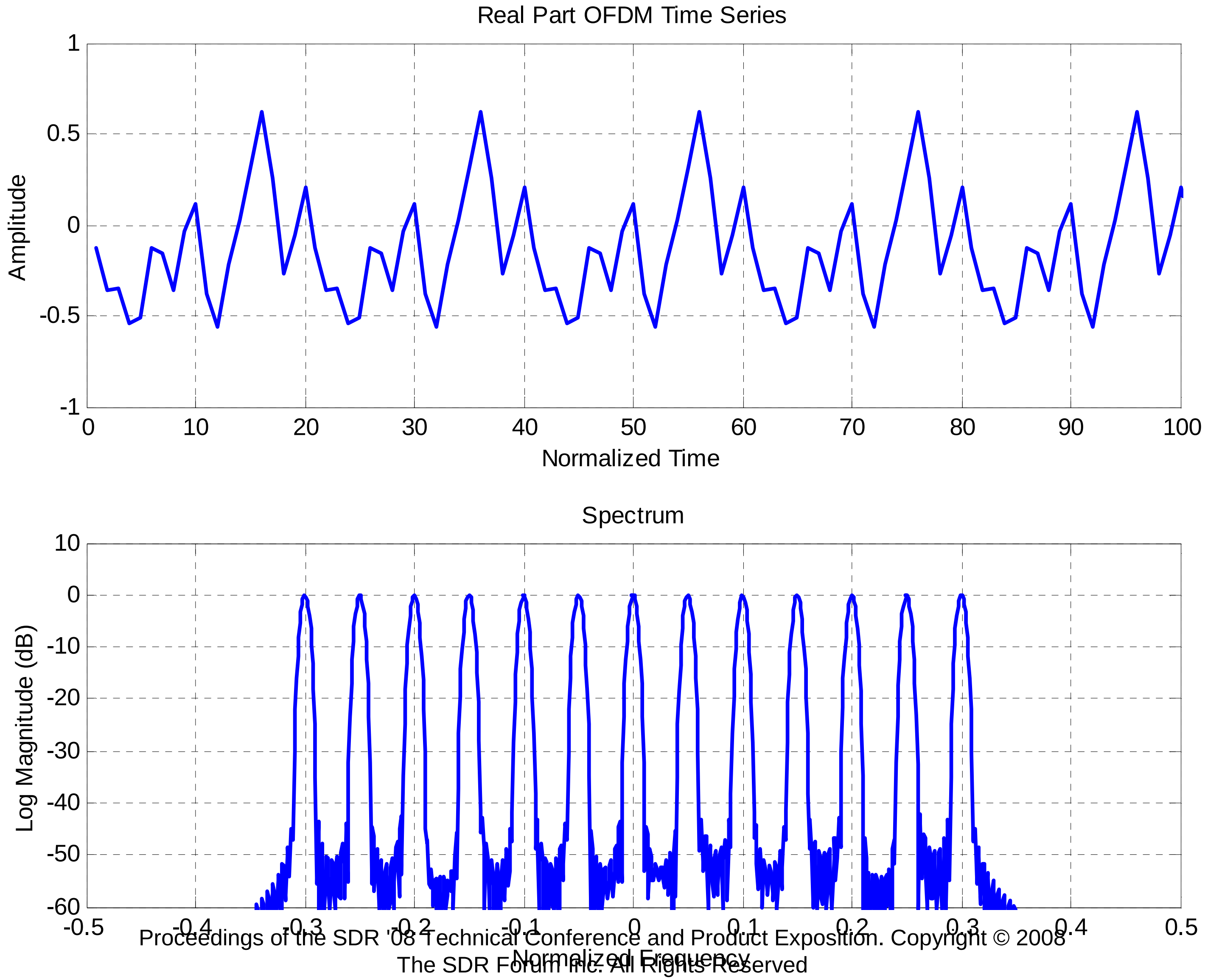
OFDM Demodulation With FFT



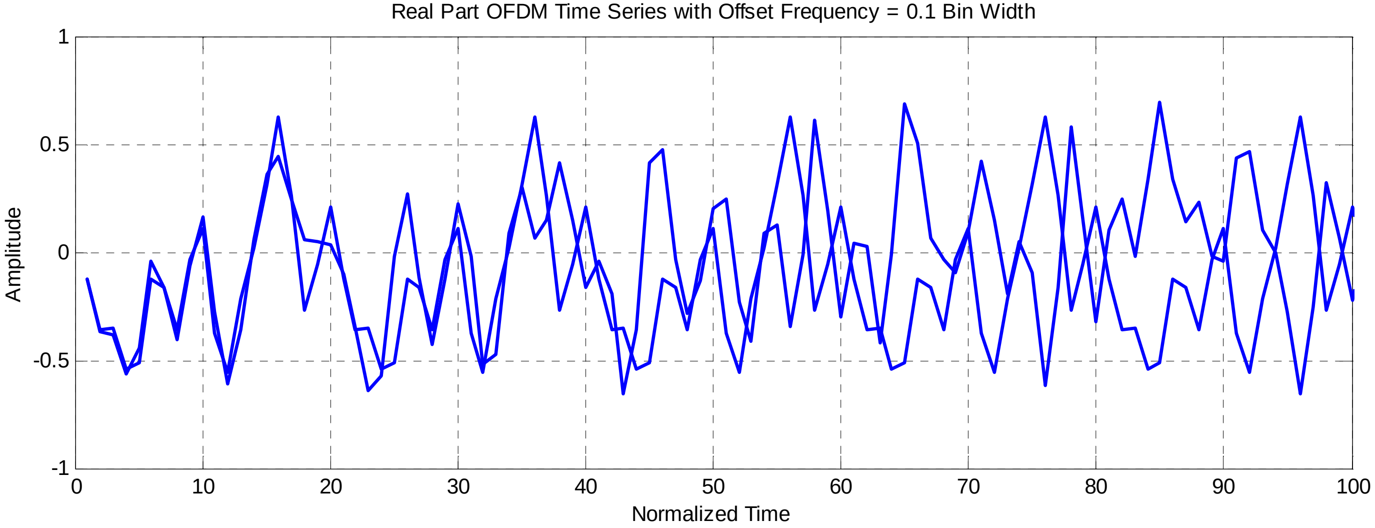
OFDM Transceiver

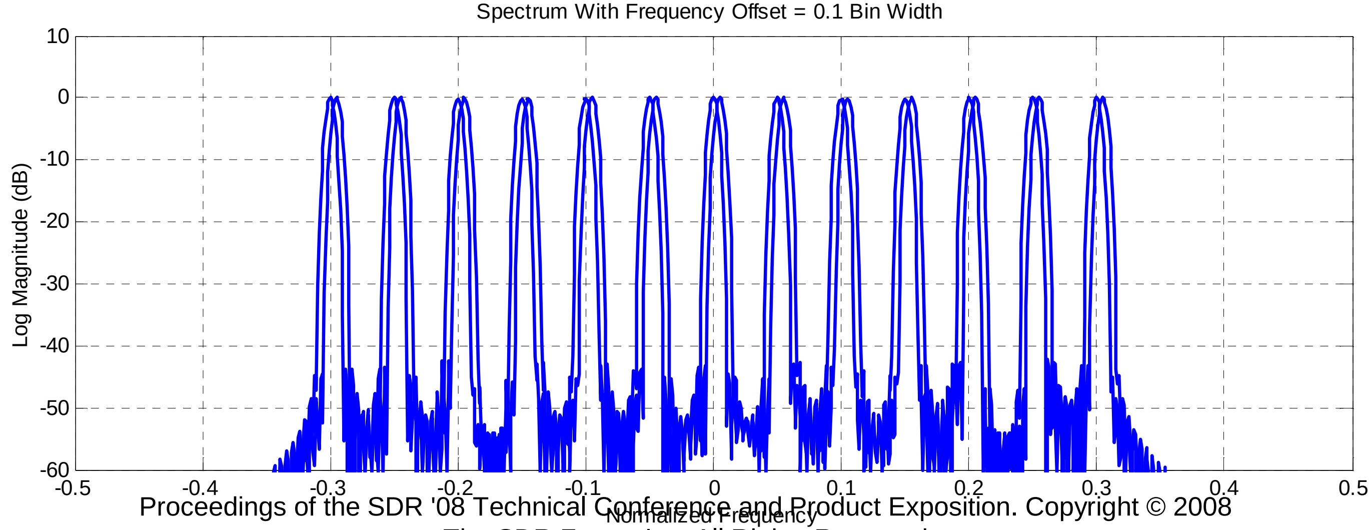


Time and Spectra of Sparse OFDM Symbol

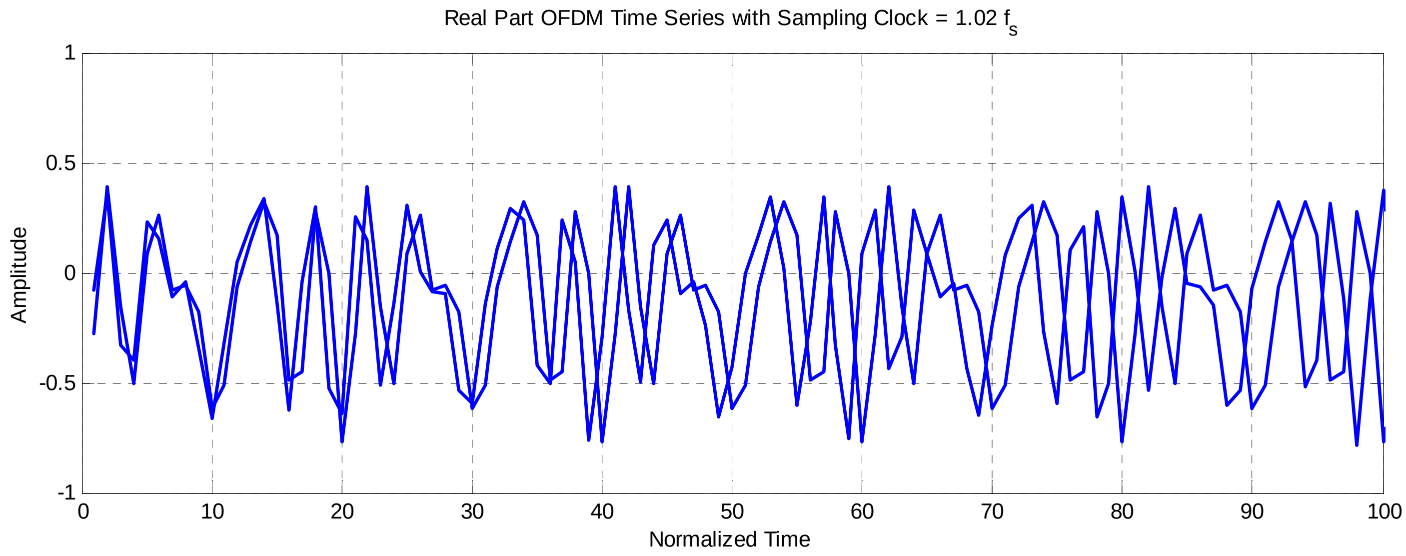


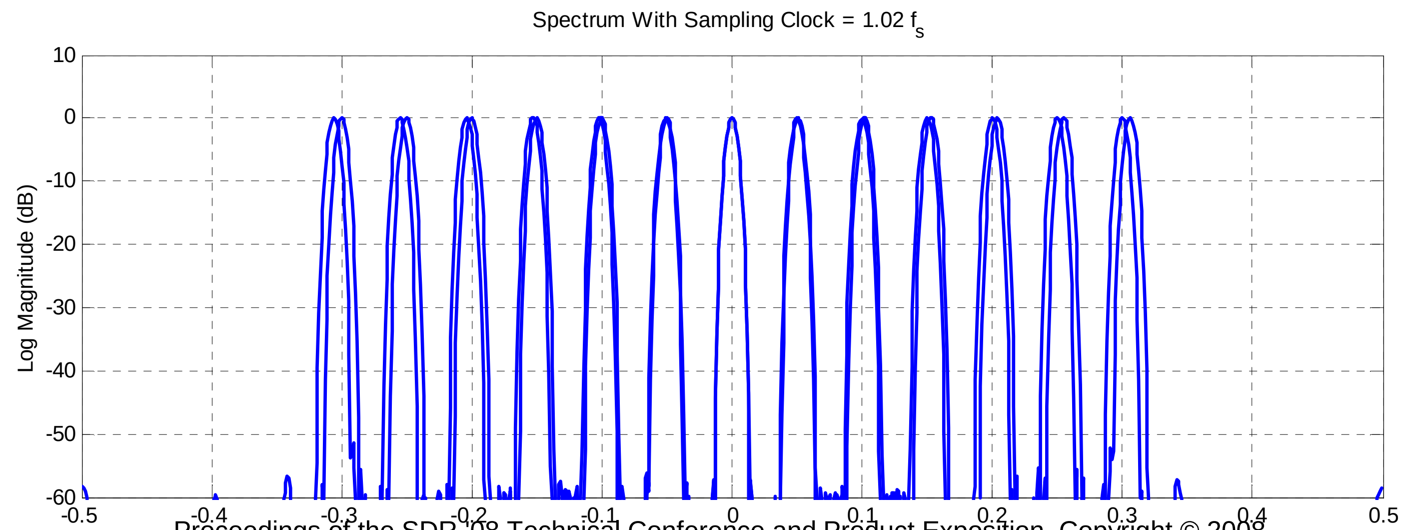
Time and Spectra With Frequency Offset = 0.1 Bin



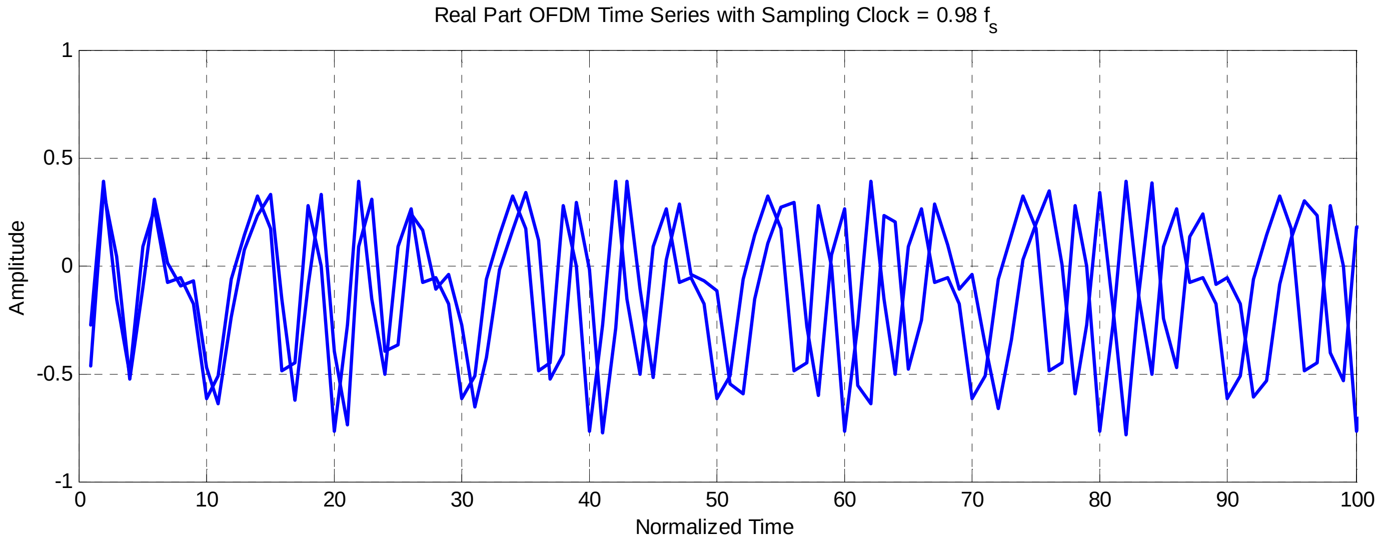


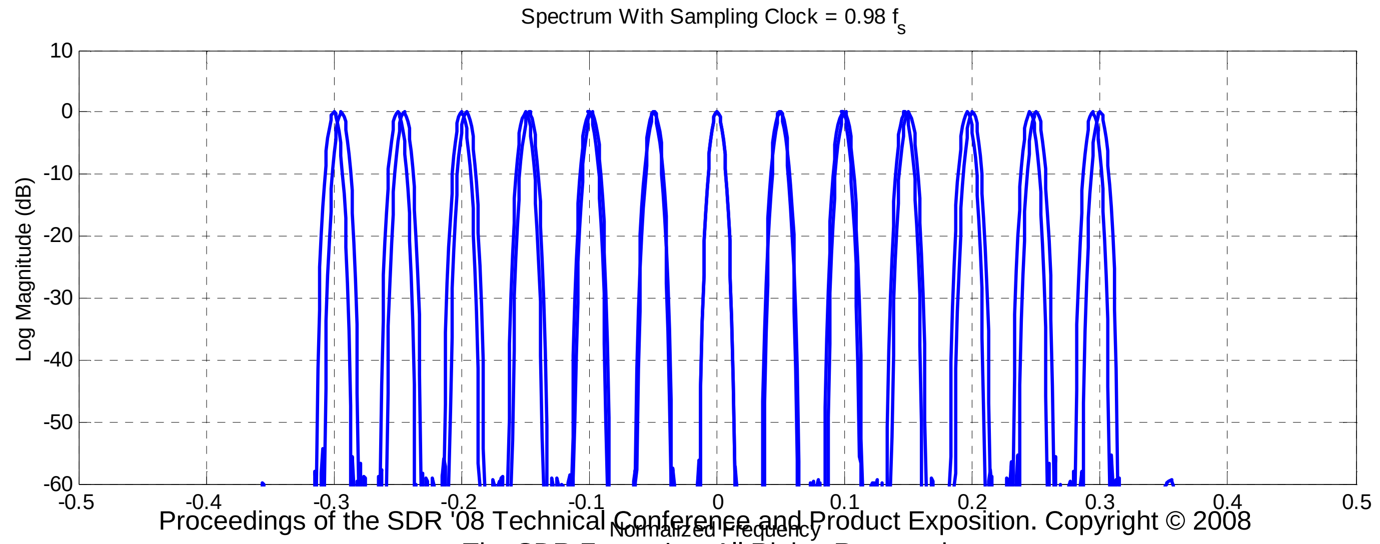
Time and Spectra With Sample Clock Offset = 1.02 f_s



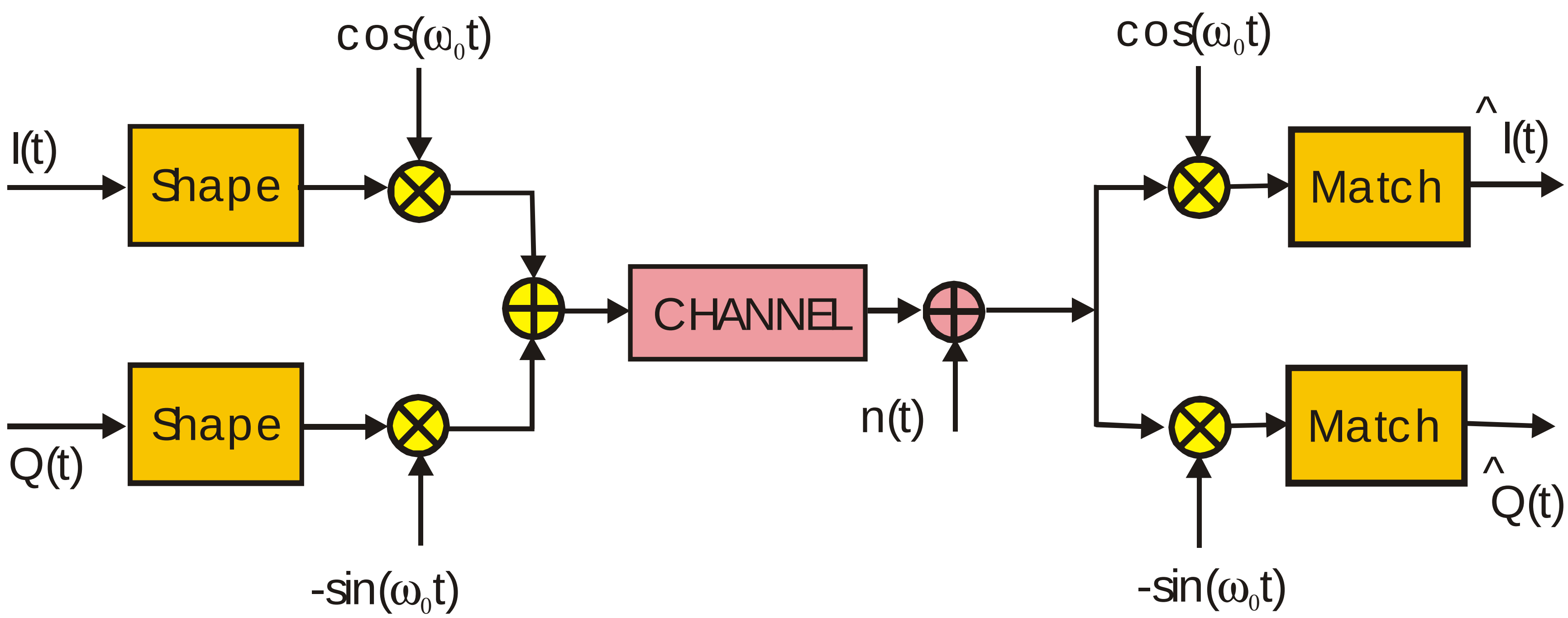


Time and Spectra With Sample Clock Offset = 0.98 f_s

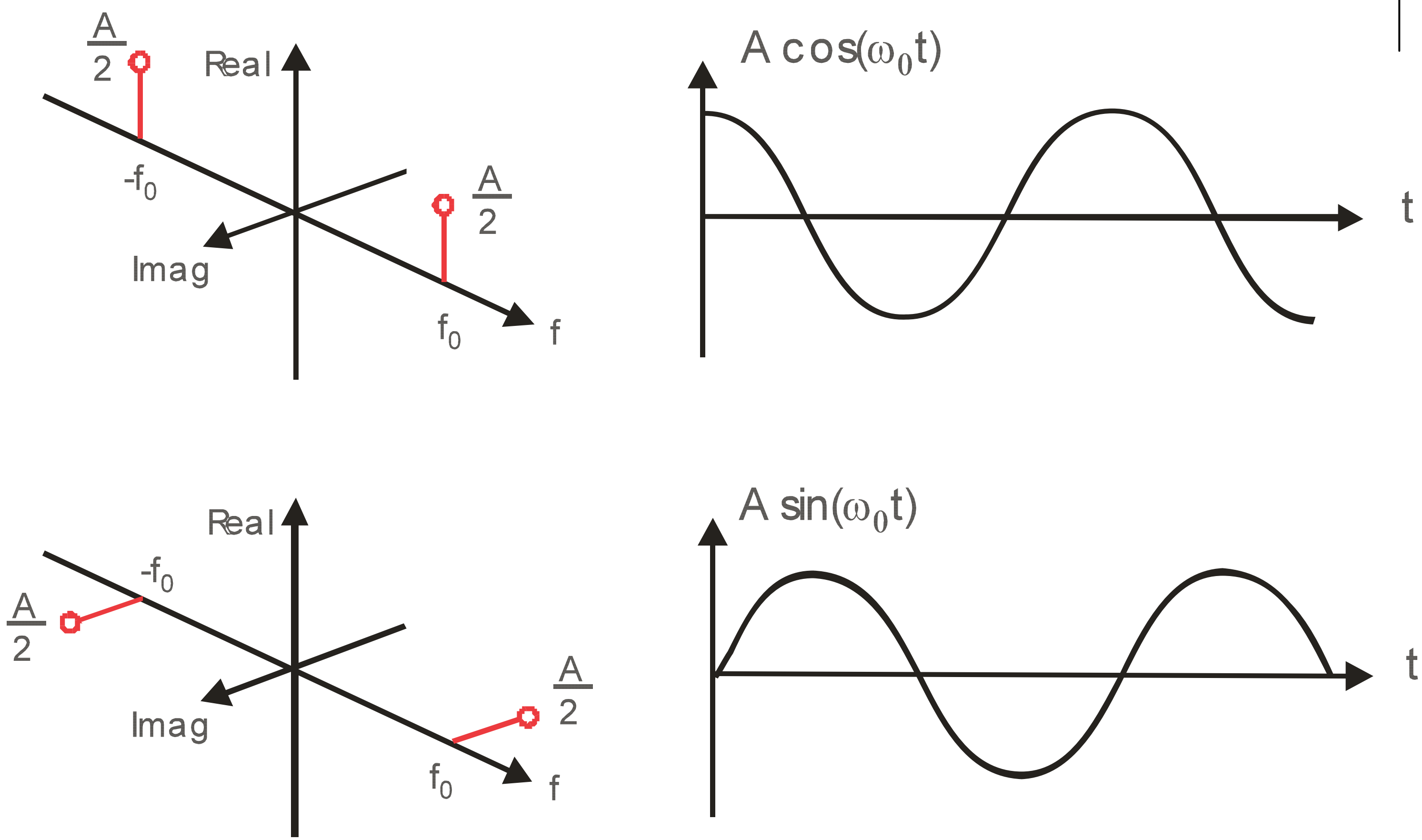




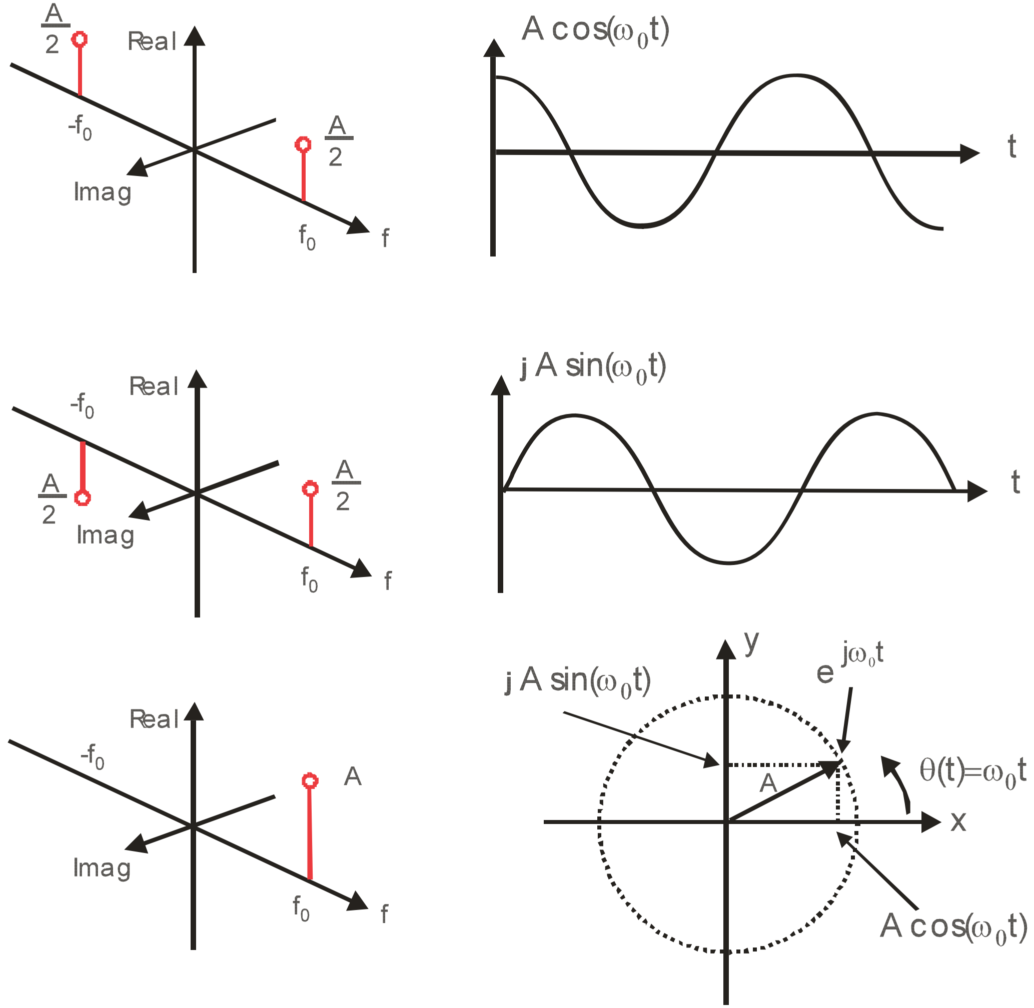
Ideal I-Q Up and Down Conversion



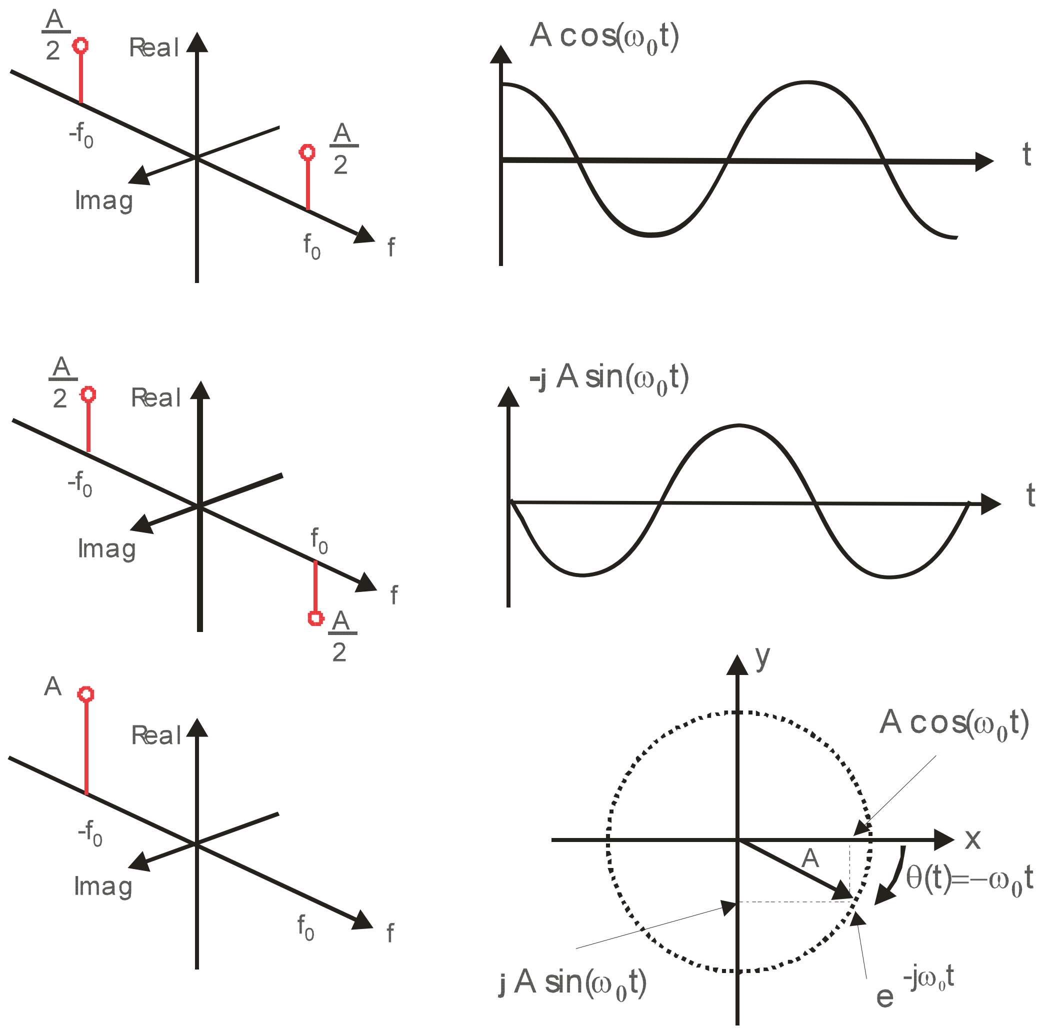
Spectral and Time Description of Real Sinusoids



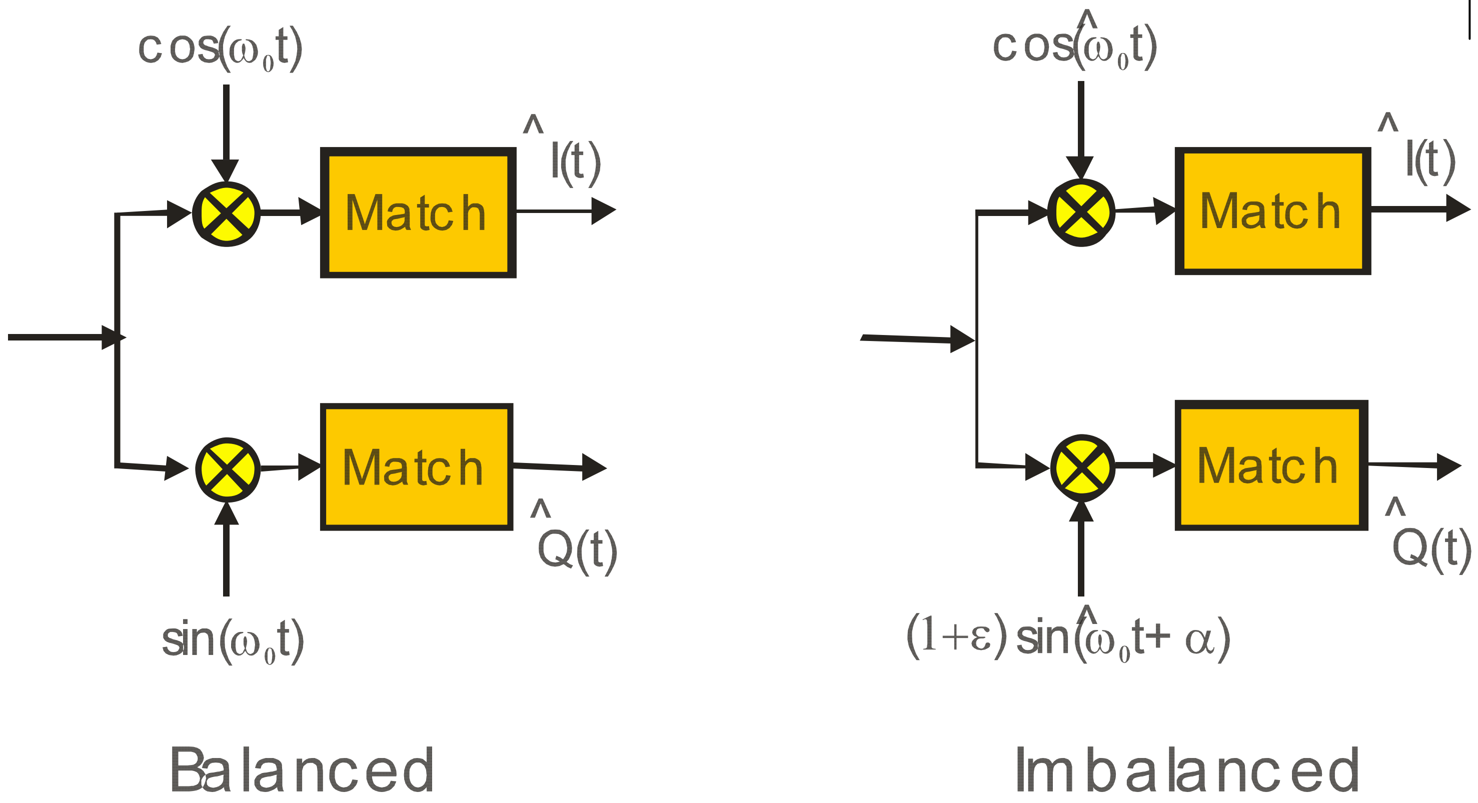
Complex Sinusoids-I



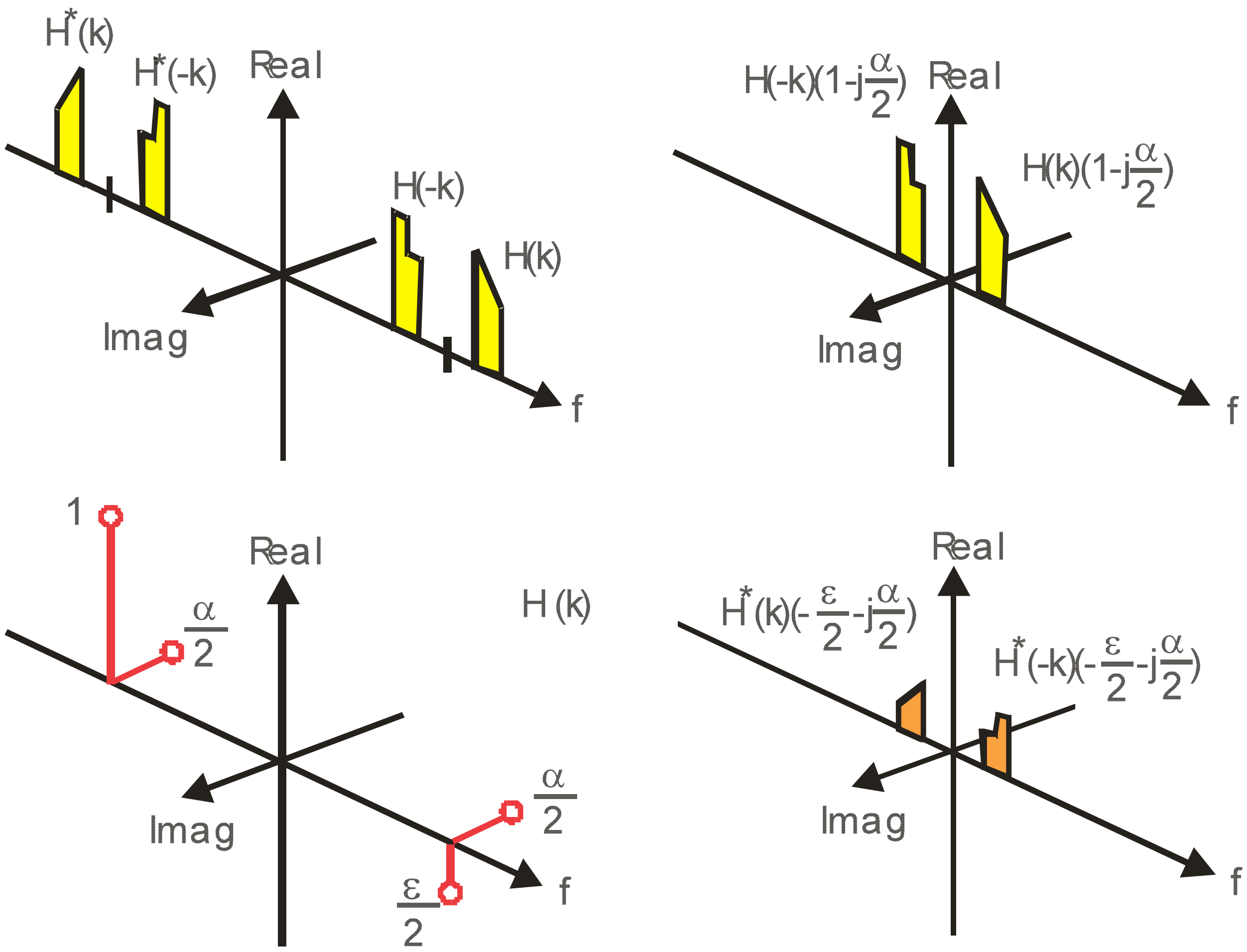
Complex Sinusoids-II



Gain and Phase Imbalance in I-Q Mixers



Line Spectral Images Due to I-Q Mismatch

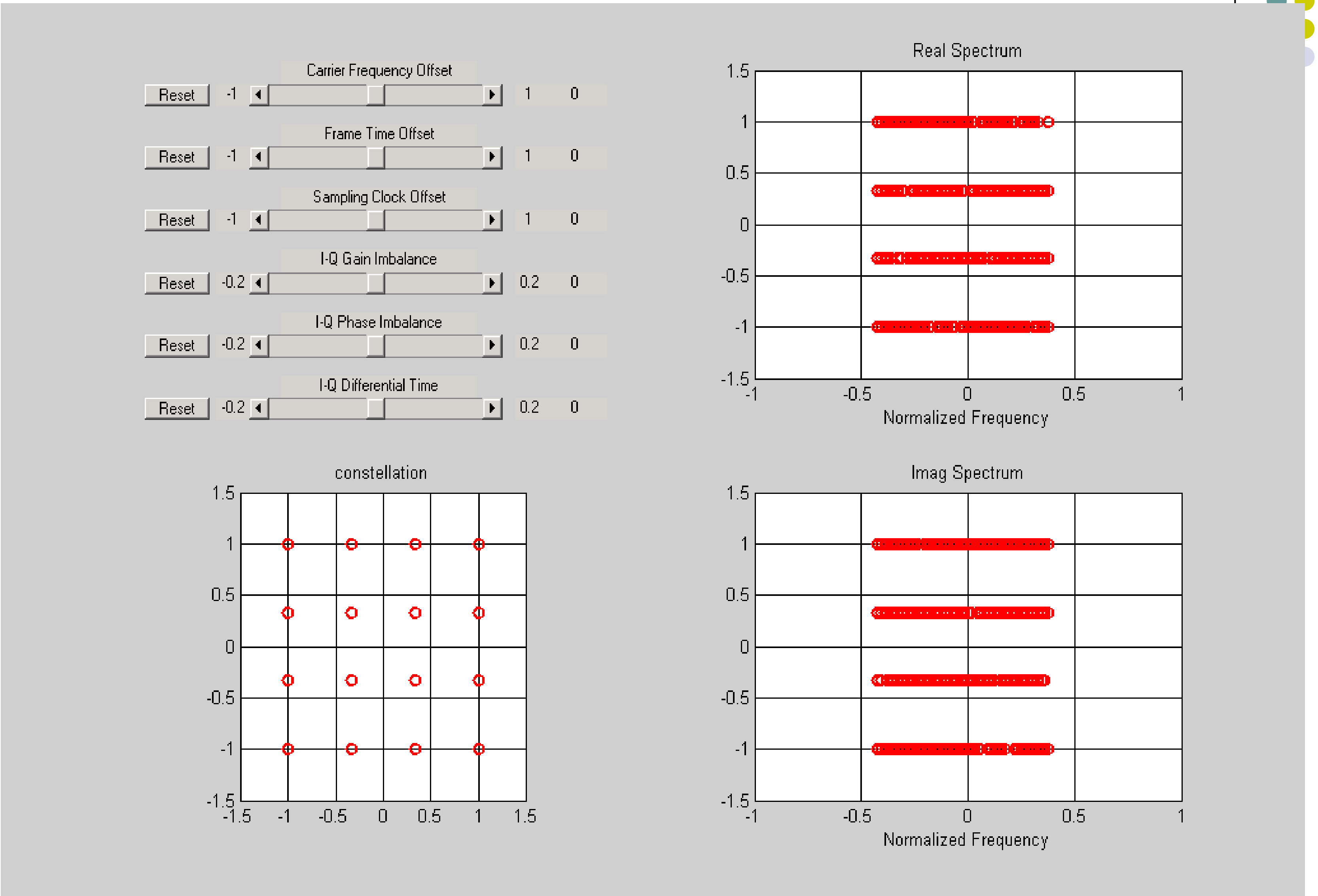


Coupling Between Positive and Negative FFT Indices Due to I-Q Imbalance and First Order Correction Mechanism

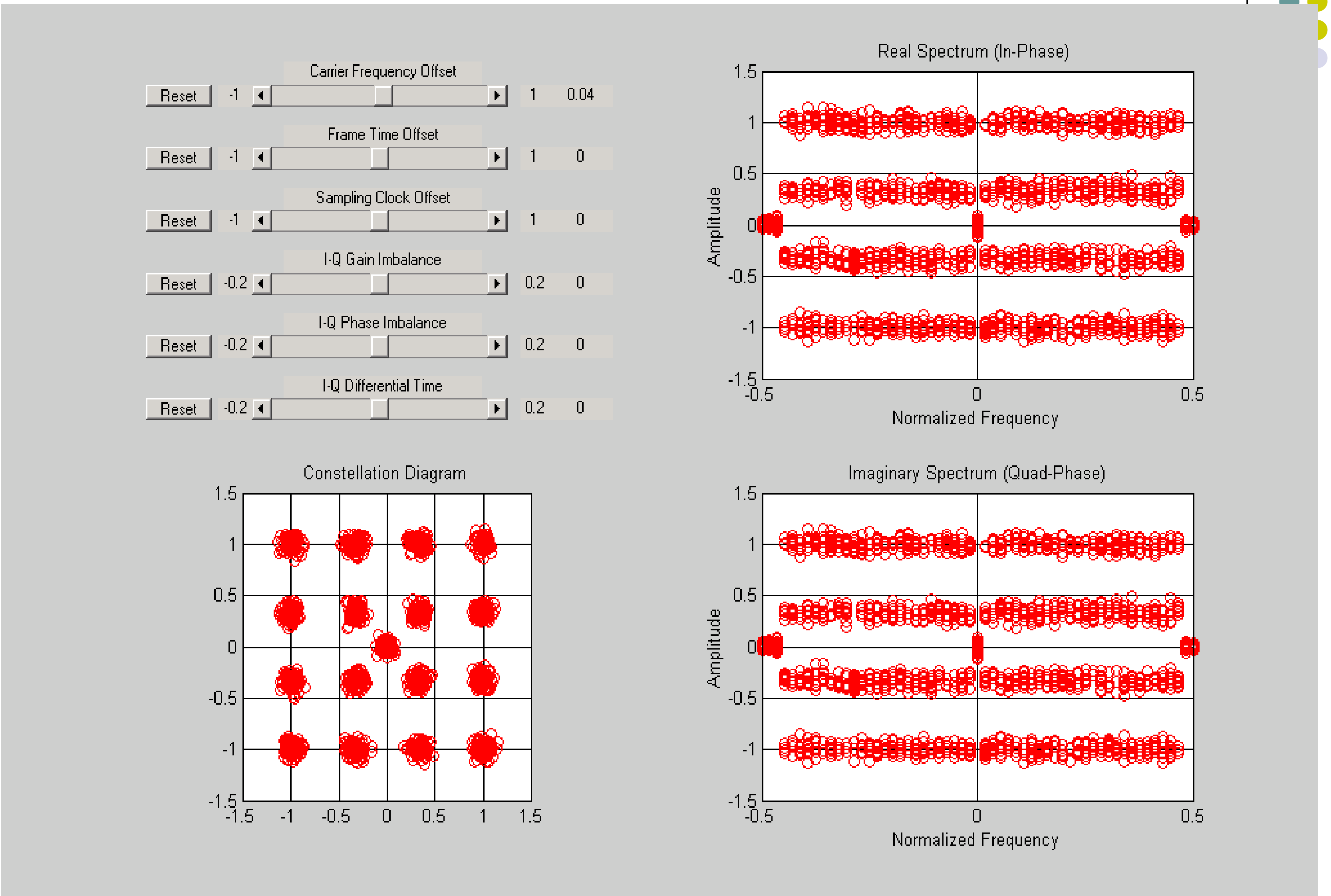
$$\begin{bmatrix} G(k) \\ G(-k) \end{bmatrix} = \begin{bmatrix} (1-j\frac{\alpha}{2}) & (-\frac{\varepsilon}{2}-j\frac{\alpha}{2}) \\ (-\frac{\varepsilon}{2}-j\frac{\alpha}{2}) & (1-j\frac{\alpha}{2}) \end{bmatrix} \begin{bmatrix} H(k) \\ H(-k) \end{bmatrix}$$

$$\begin{bmatrix} H(k) \\ H(-k) \end{bmatrix} \cong \begin{bmatrix} (1+j\frac{\alpha}{2}) & (+\frac{\varepsilon}{2}+j\frac{\alpha}{2}) \\ (+\frac{\varepsilon}{2}+j\frac{\alpha}{2}) & (1+j\frac{\alpha}{2}) \end{bmatrix} \begin{bmatrix} G(k) \\ G(-k) \end{bmatrix}$$

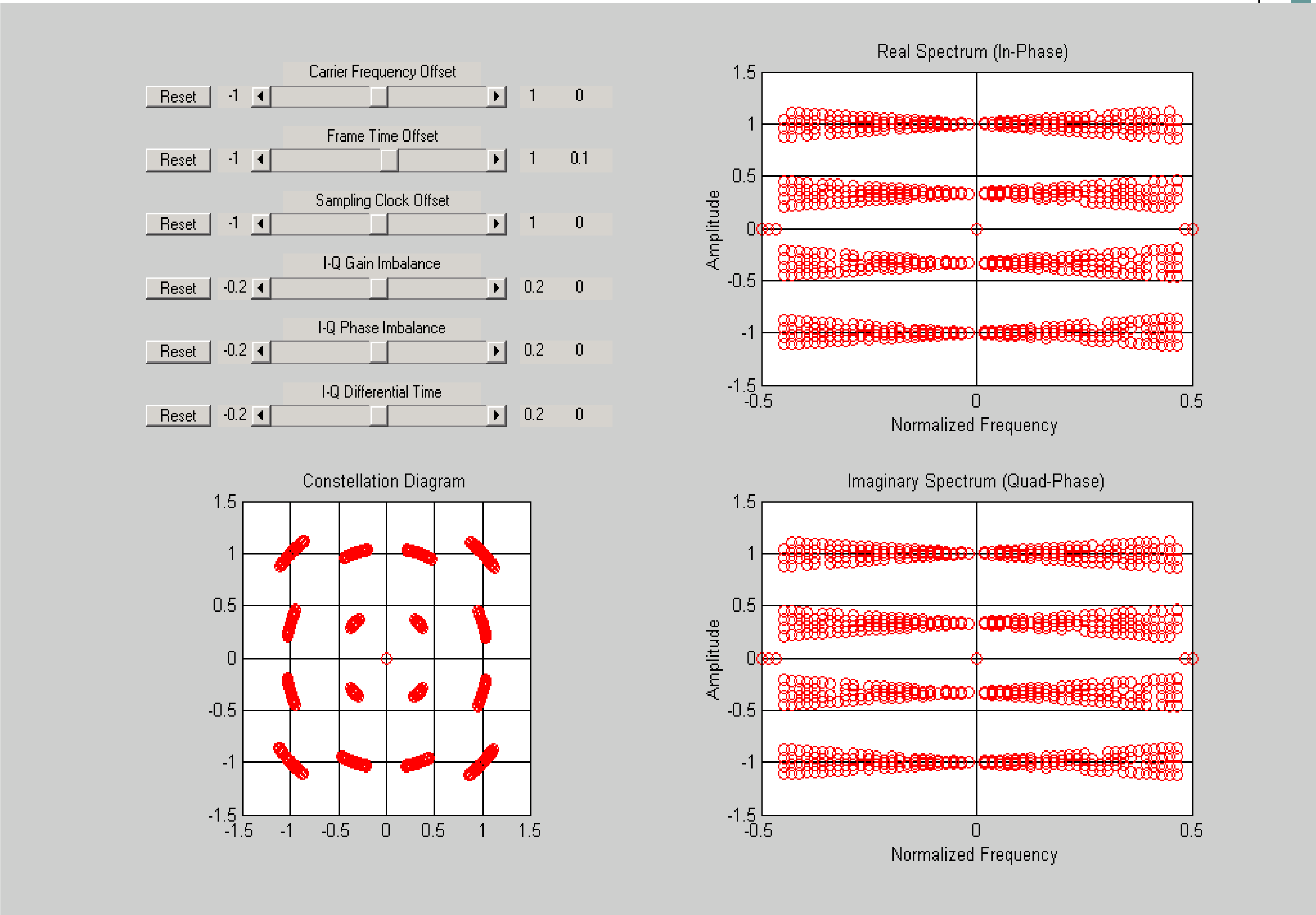
Test Bench: Demonstration of Receiver I-Q Imbalances, Carrier Offset, and Timing Offset



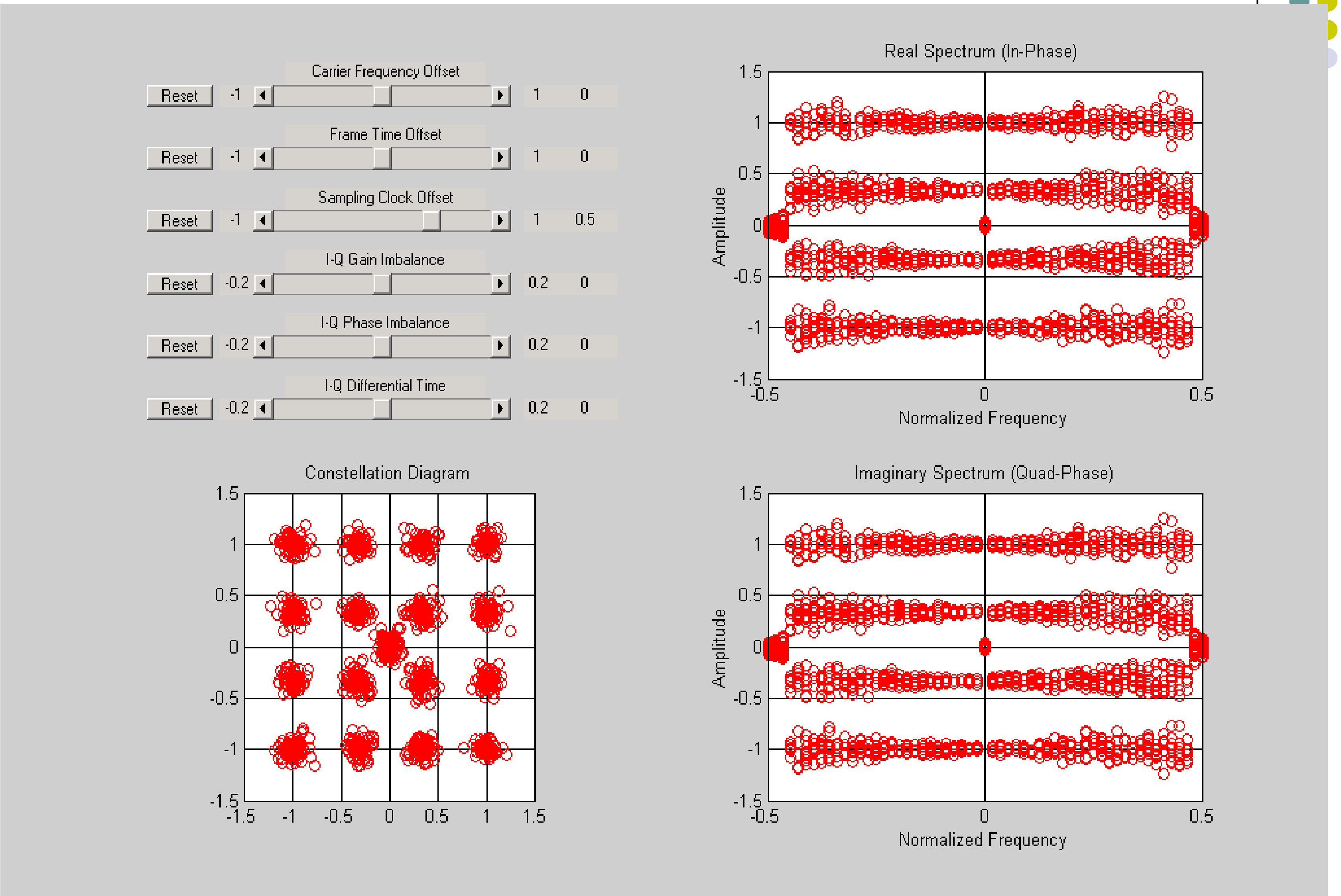
Carrier Offset: 4% of FFT Bin Width



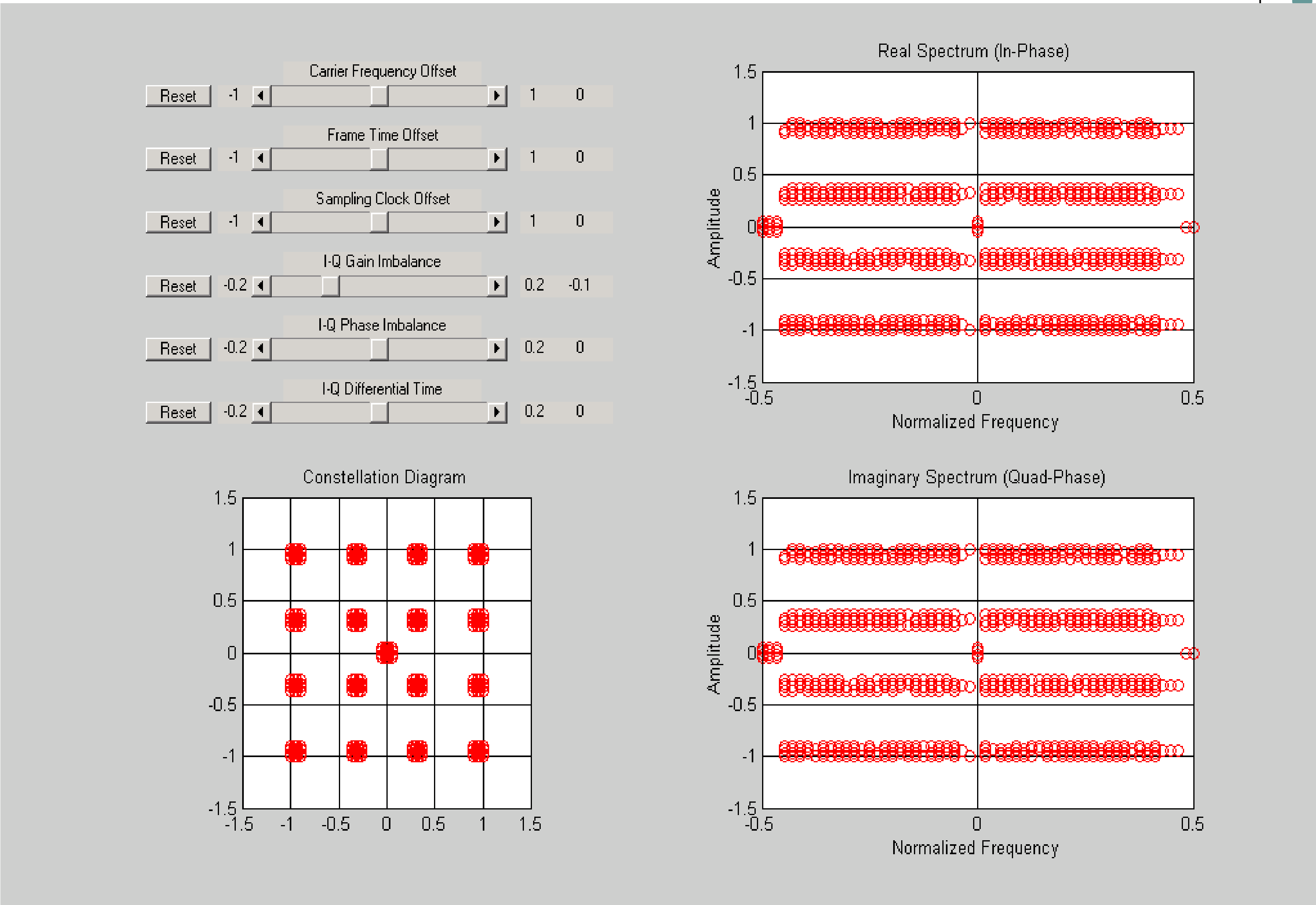
Timing Offset: 10% of Sampling Time Period



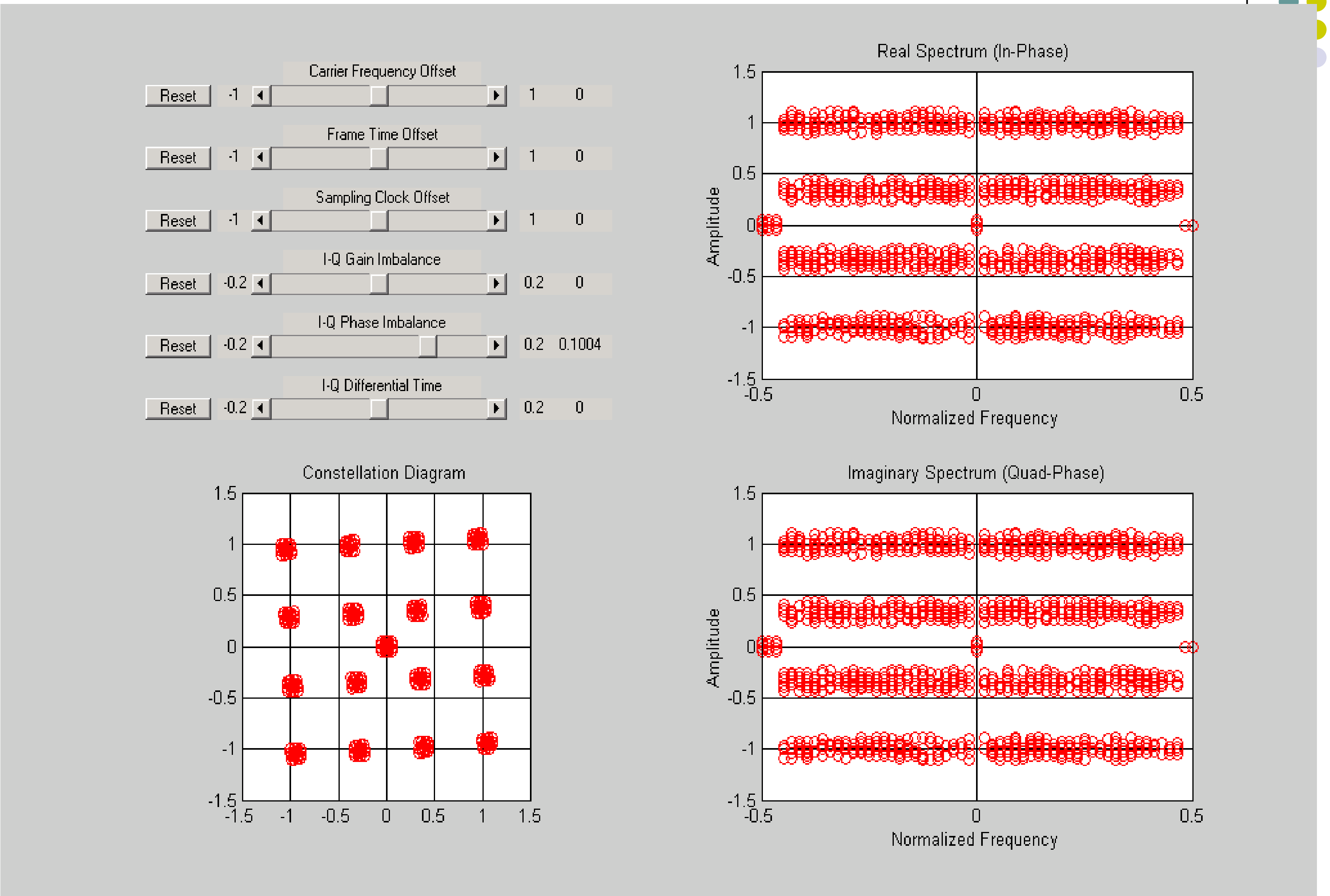
Timing Clock Offset: 5% of Sampling Time Period per Frame



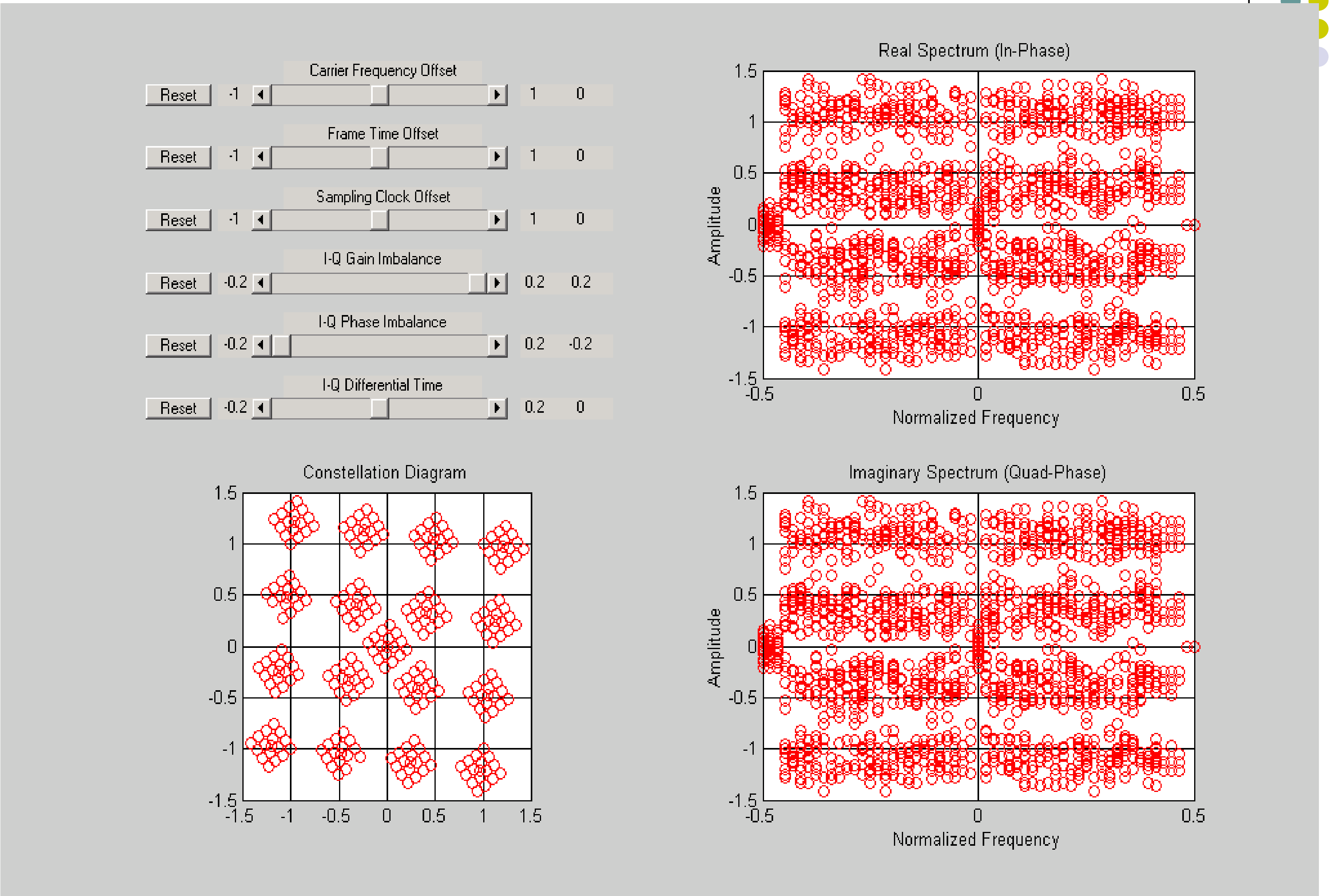
Gain Imbalance: 10% Error



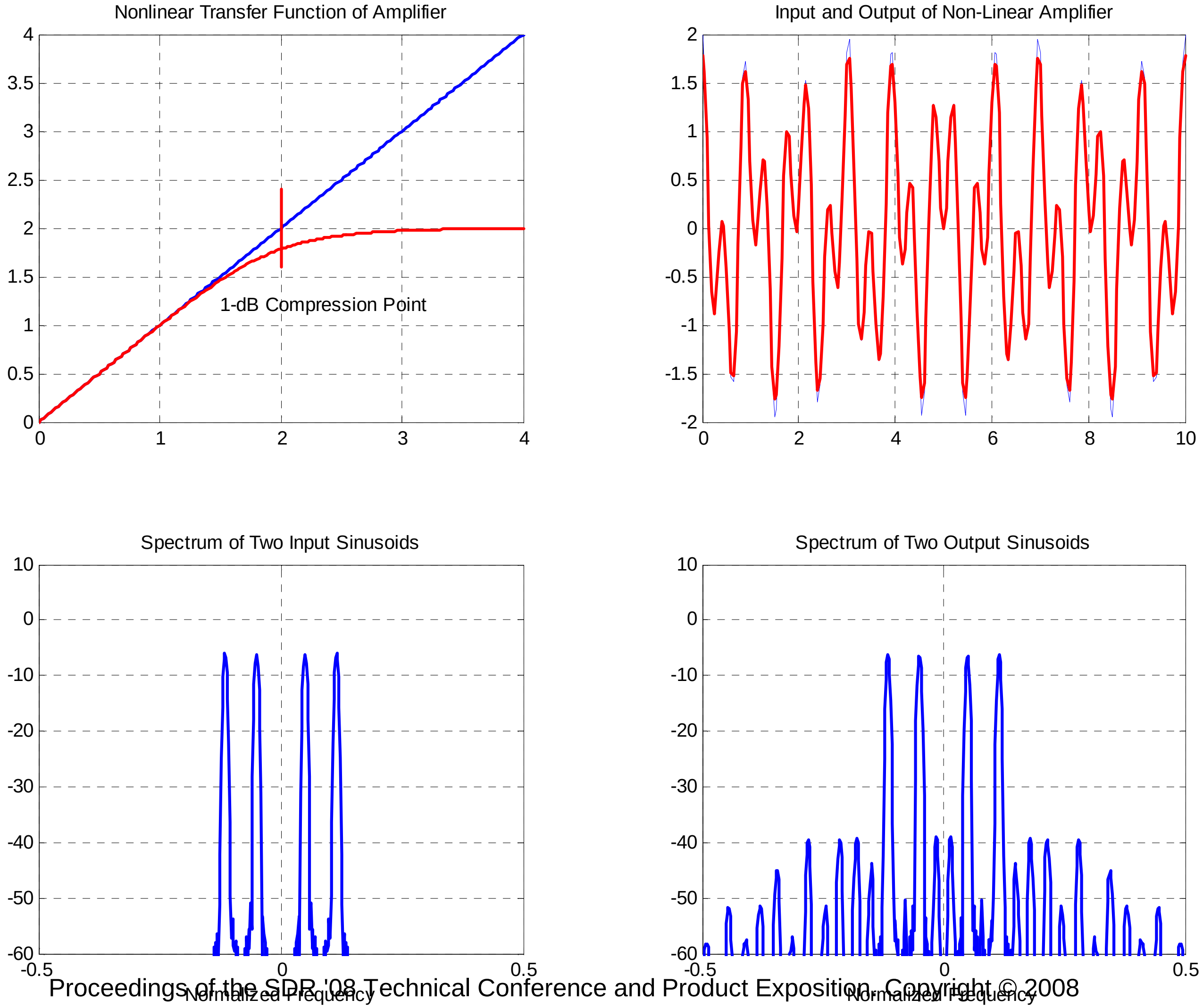
Phase Imbalance: 0.1 Radian Error



I-Q Mixer Imbalance; 20% Gain, 0.2 Radians

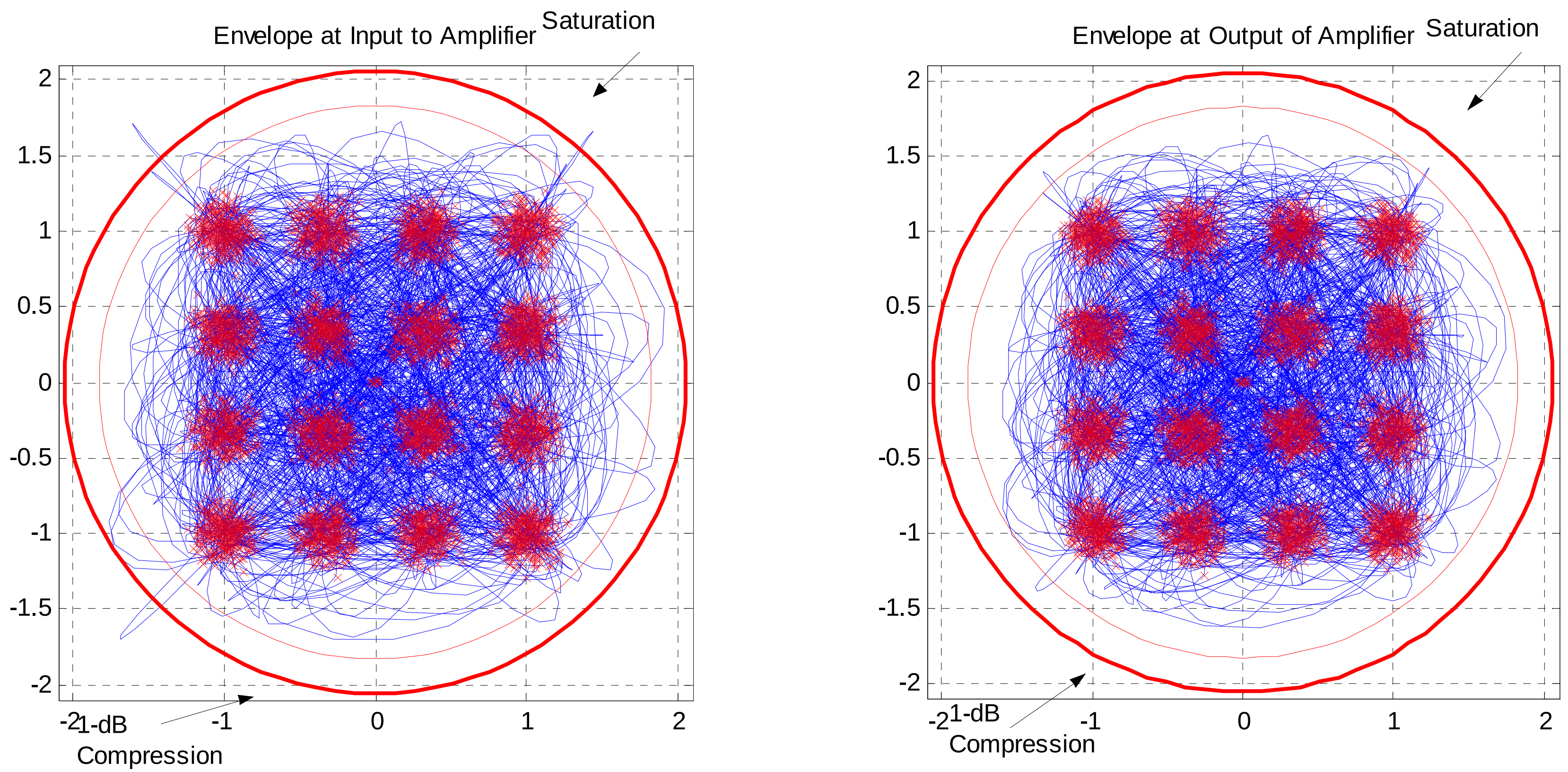


Power Amplifier Non-Linearity

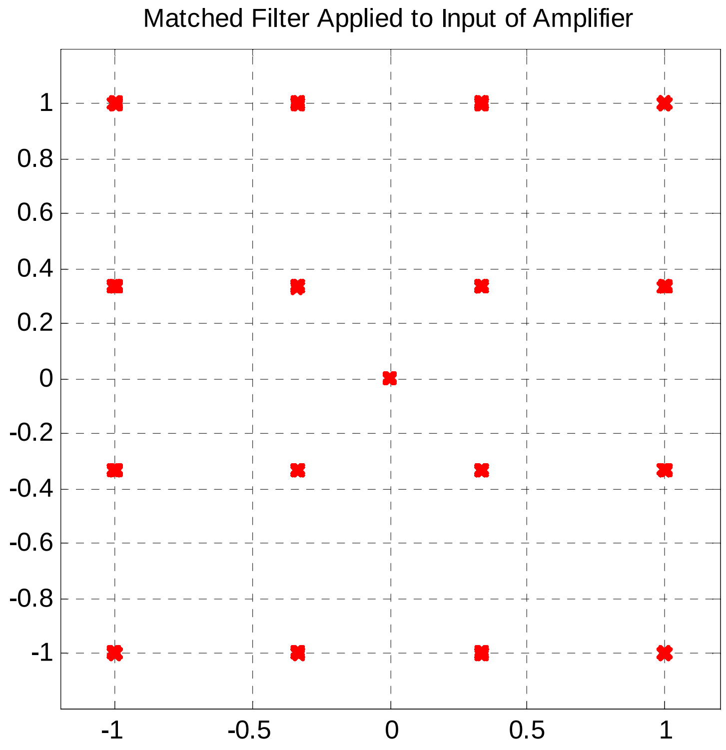


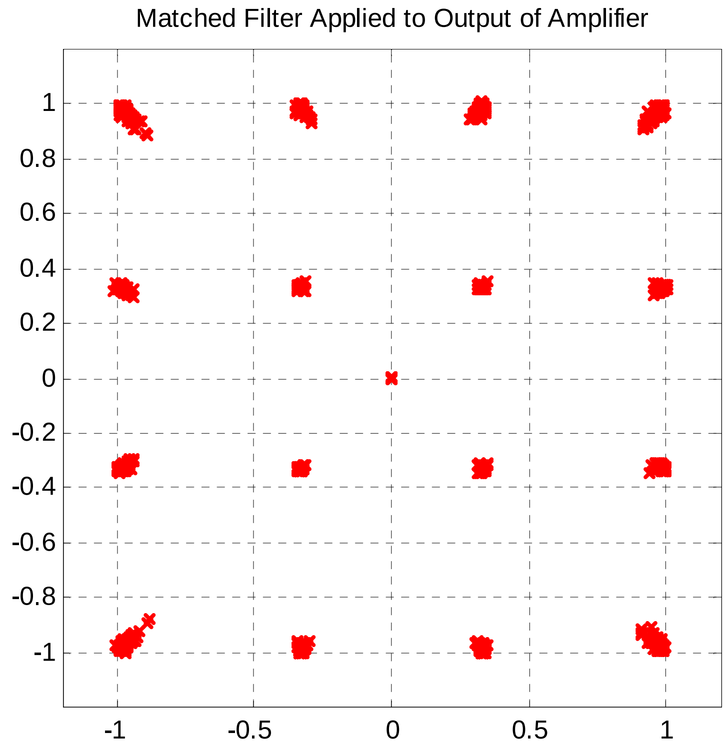
16-QAM Input and Output Envelopes. Saturation and 1-dB Compression Circles

Saturation at 2-Times RMS Signal Level

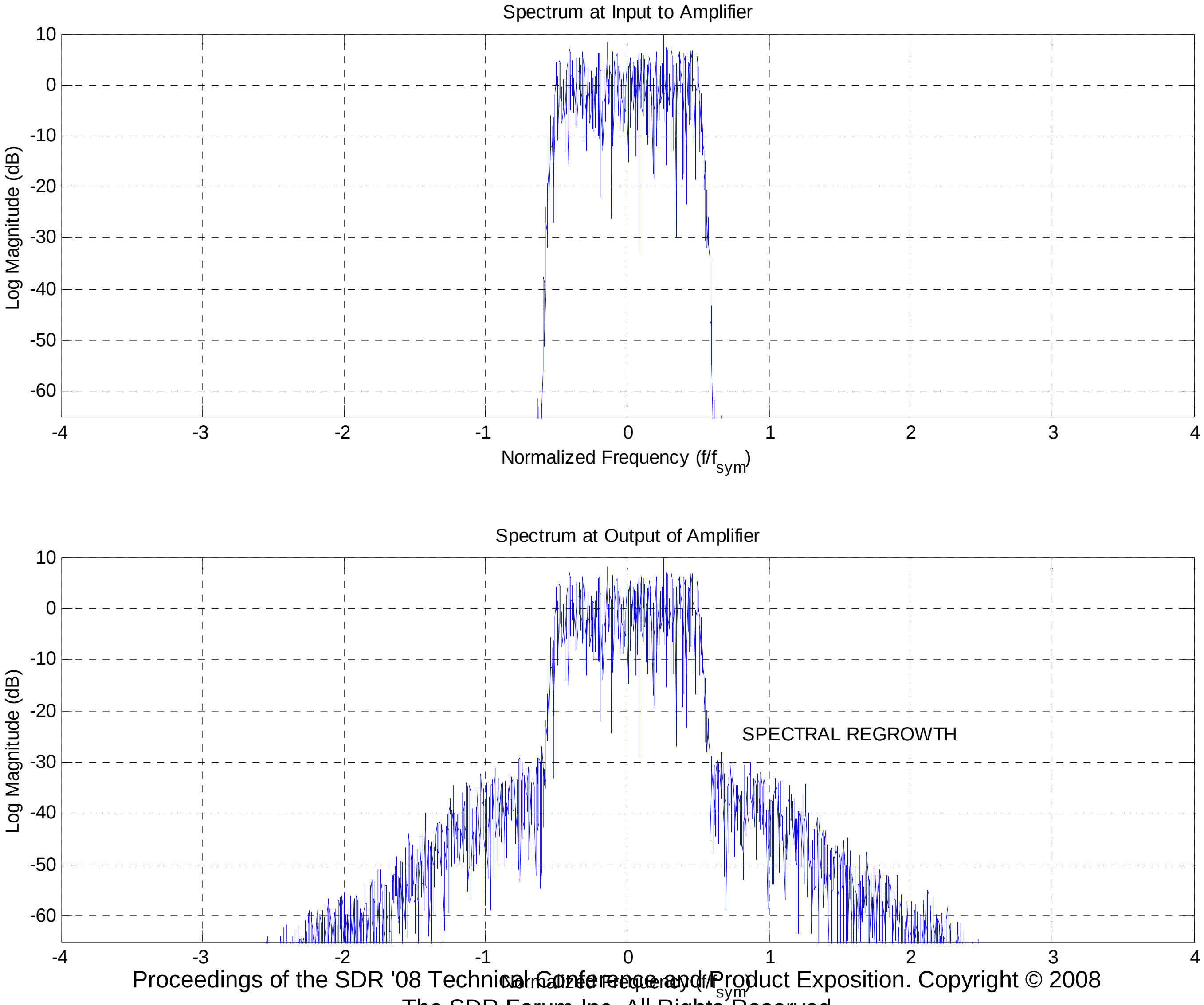


Limiting Amplifier Effect on Received QAM Constellation

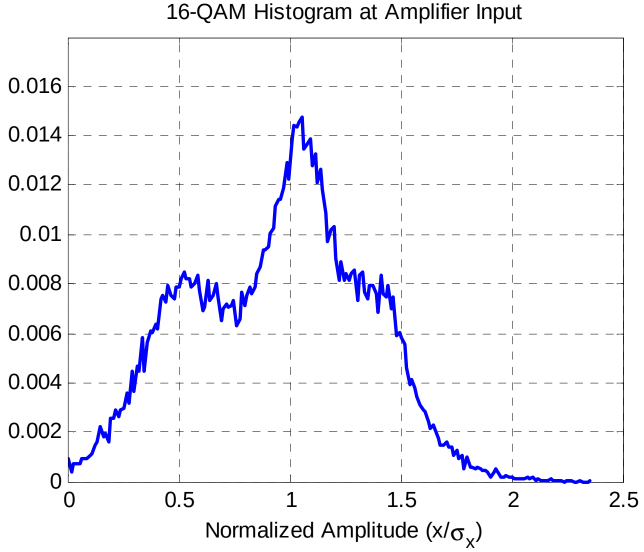


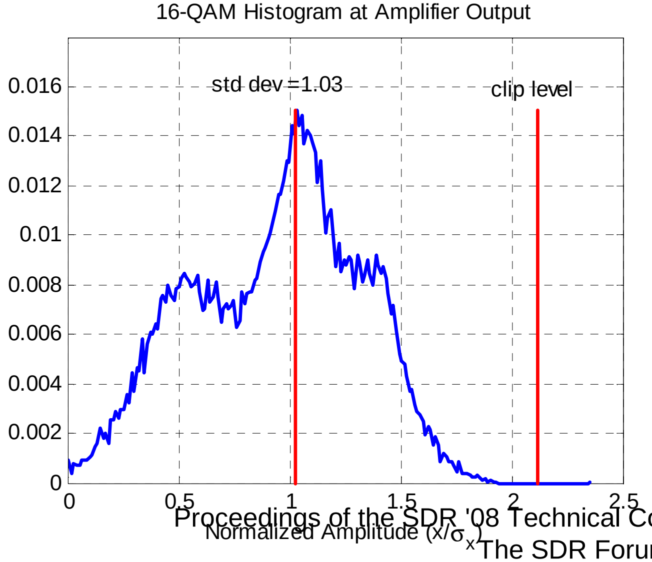


Limiting Amplifier Effect on Signal Spectra



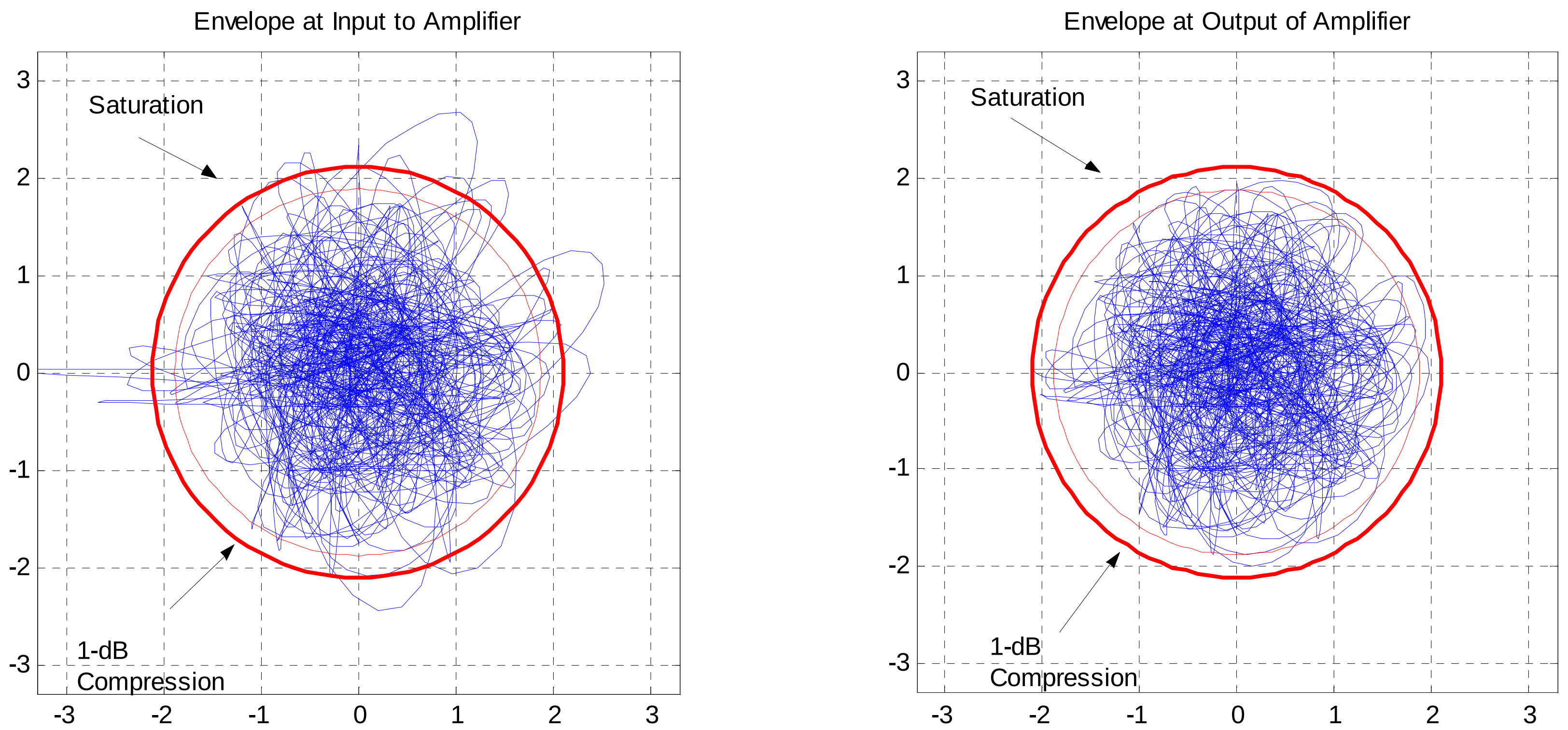
16-QAM (α=0.2) Envelope Statistics



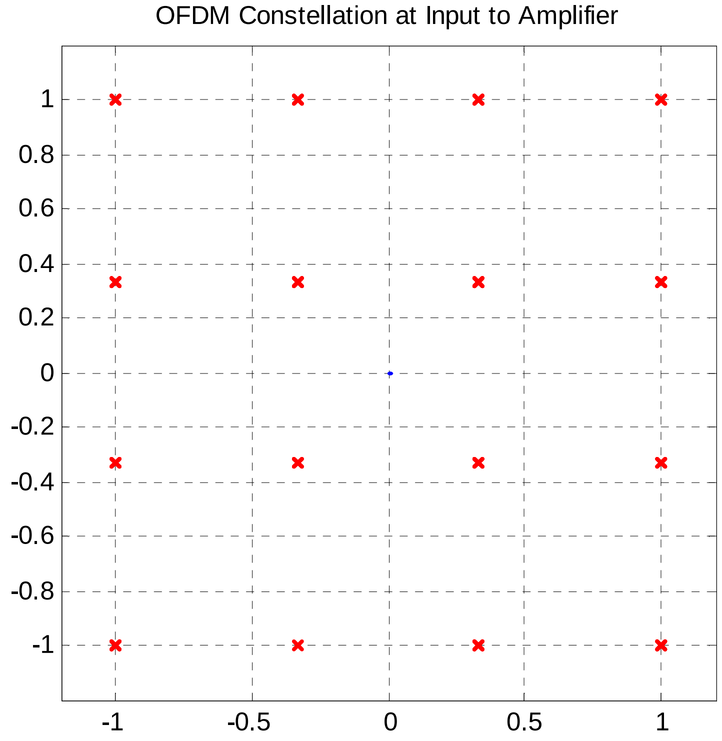


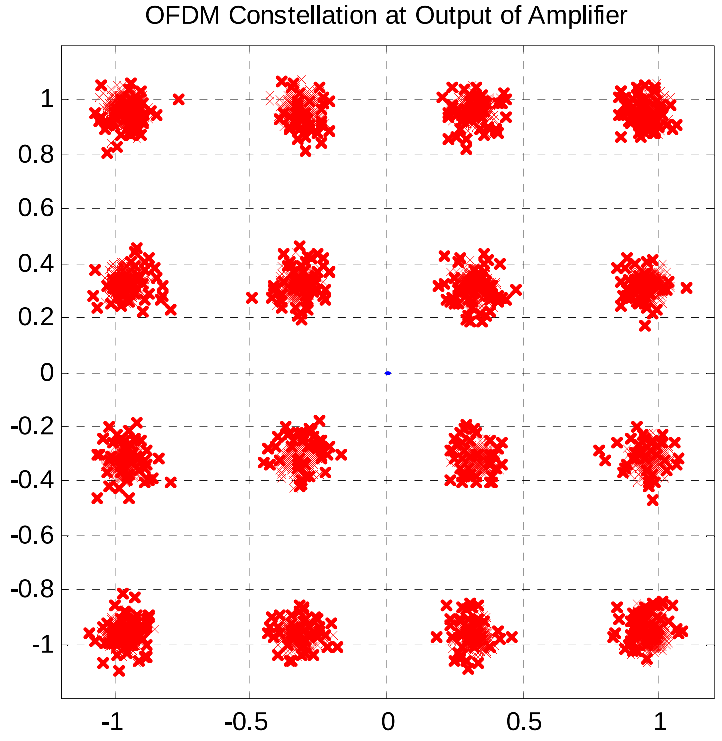
OFDM Input and Output Envelopes: Saturation and 1-dB Compression Circles

Saturation at 2-Times RMS Signal Level

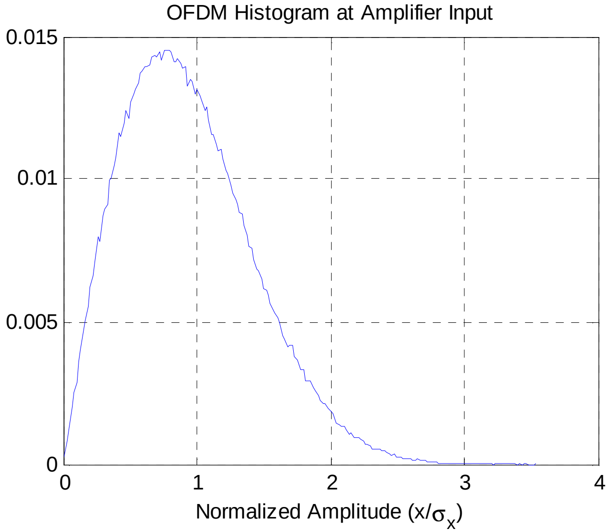


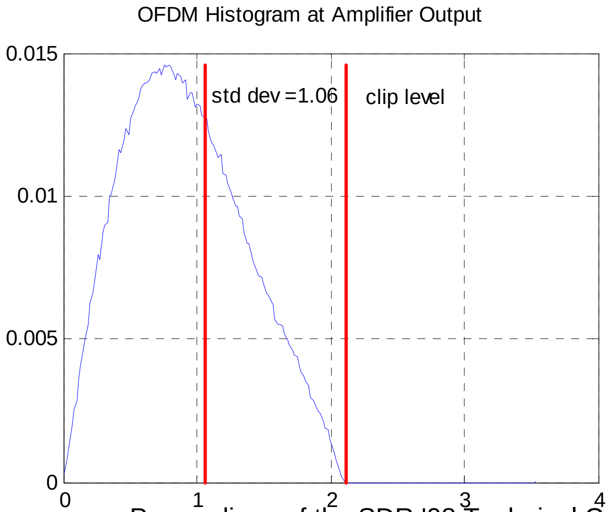
Limiting Amplifier Effect on OFDM Constellation



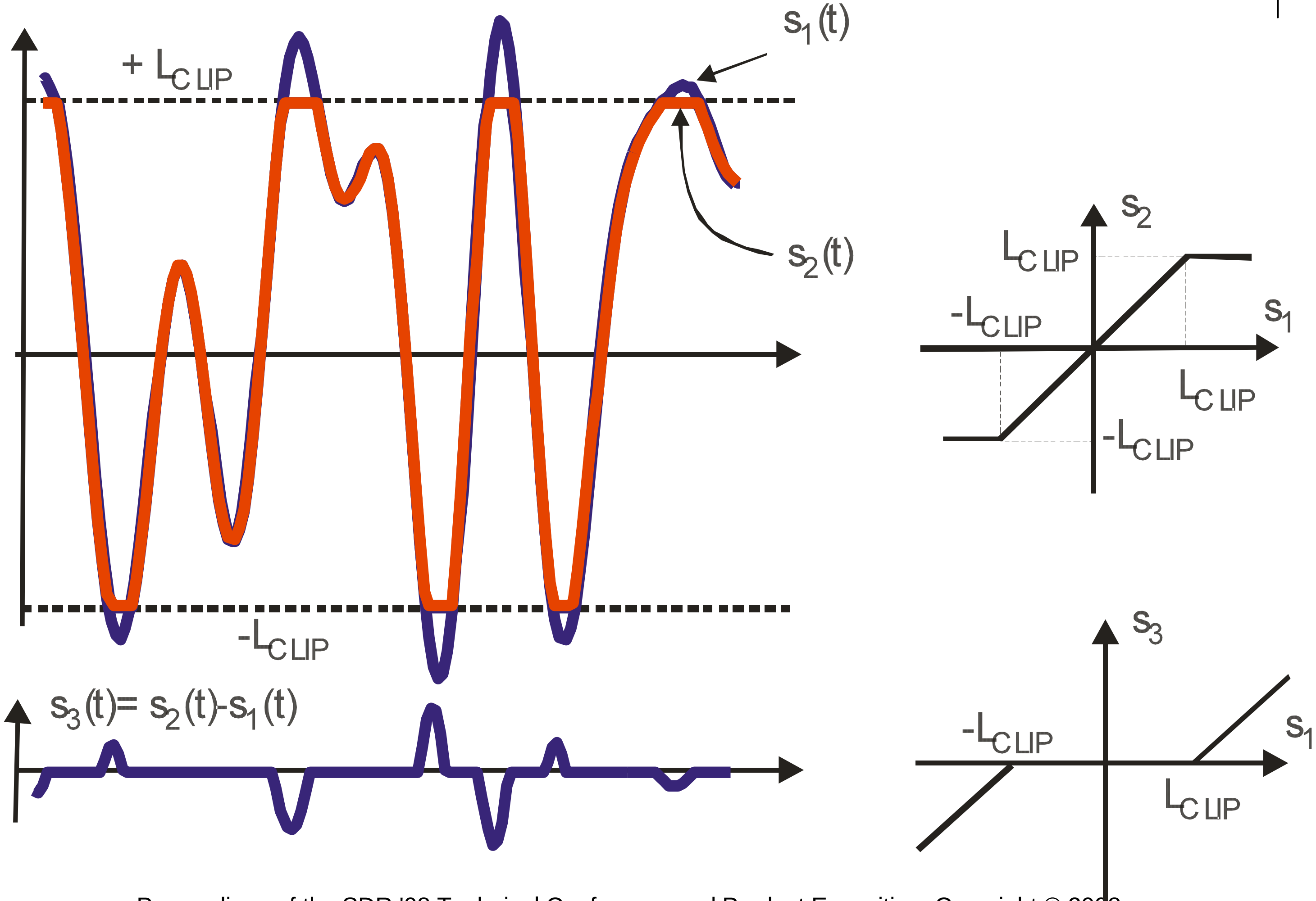


OFDM Envelope Statistics



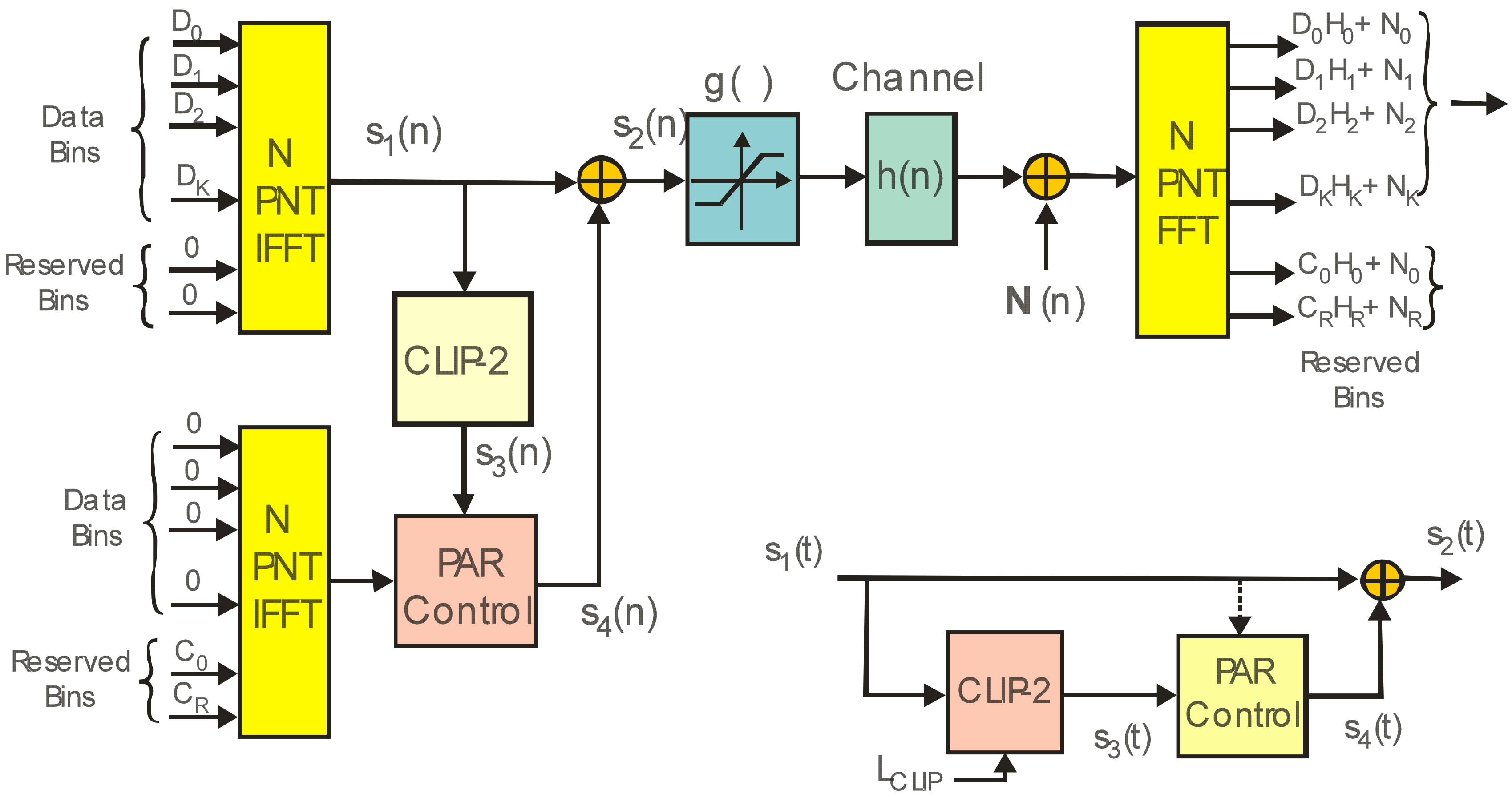


Clipping

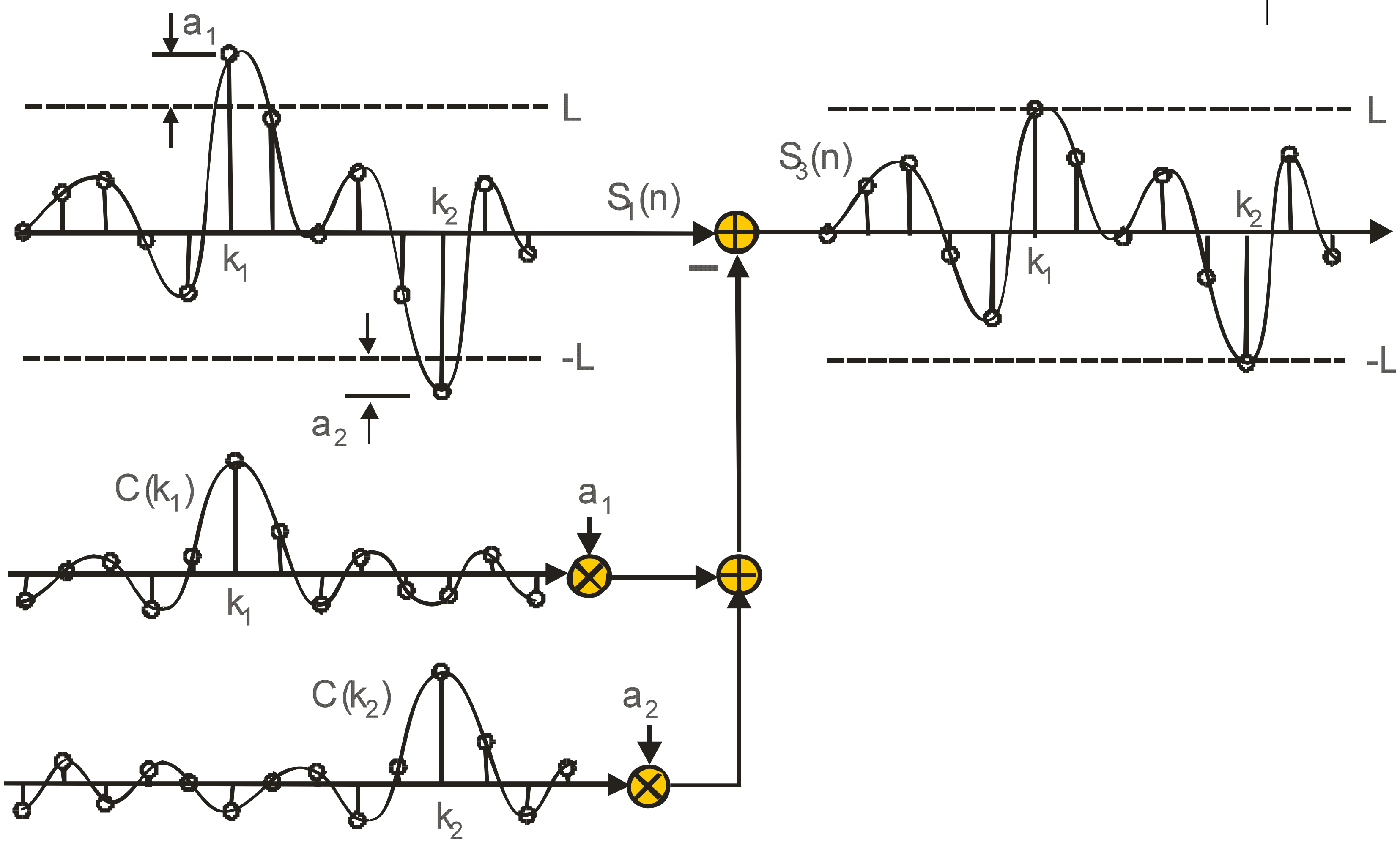


$s_1(t)$
$+L_{CLIP}$
$s_2(t)$
$-L_{CLIP}$
$s_3(t) = s_2(t) - s_1(t)$
s_2
L_{CLIP}
$-L_{CLIP}$
s_1
L_{CLIP}
$-L_{CLIP}$
s_3
$-L_{CLIP}$
s_1
L_{CLIP}

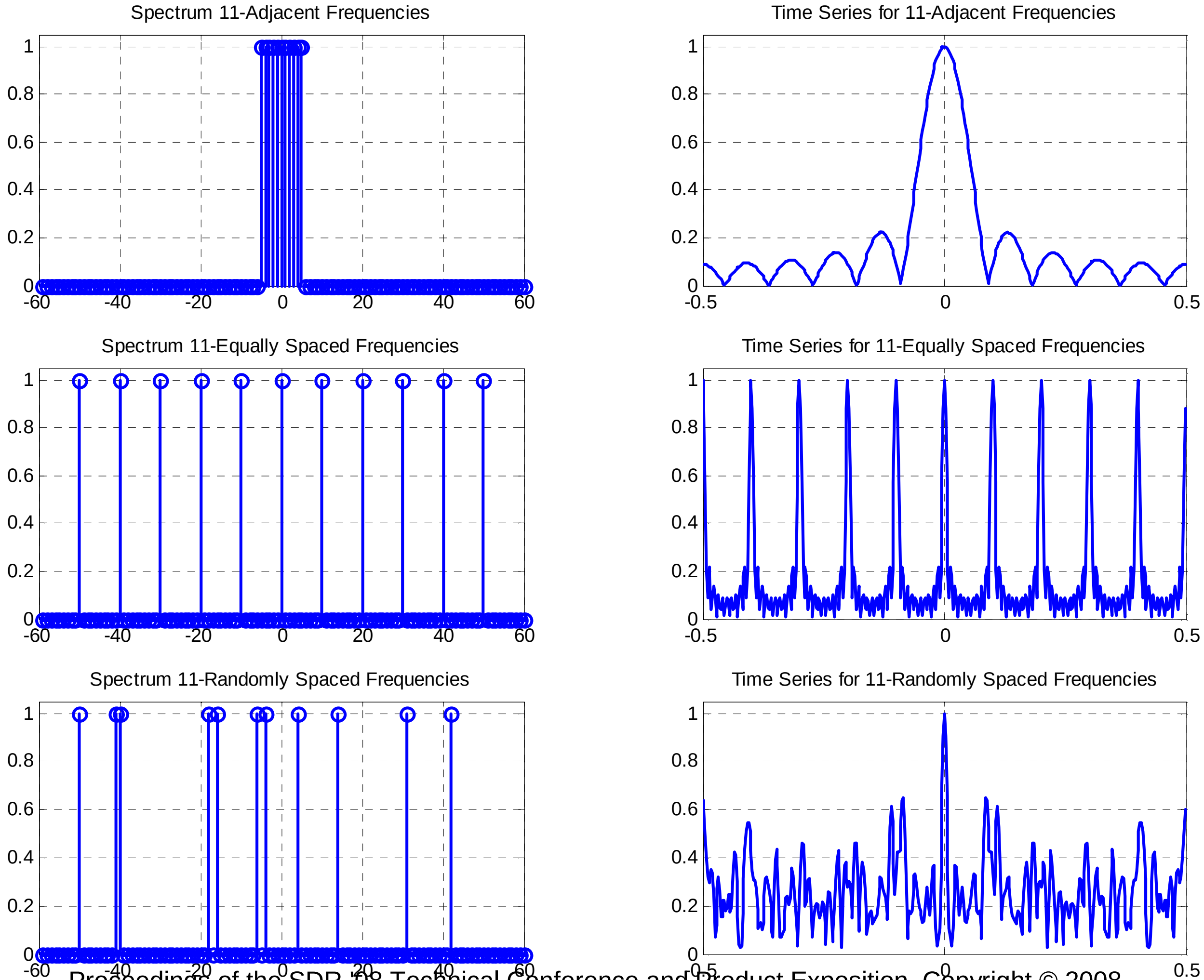
Smart Clipping



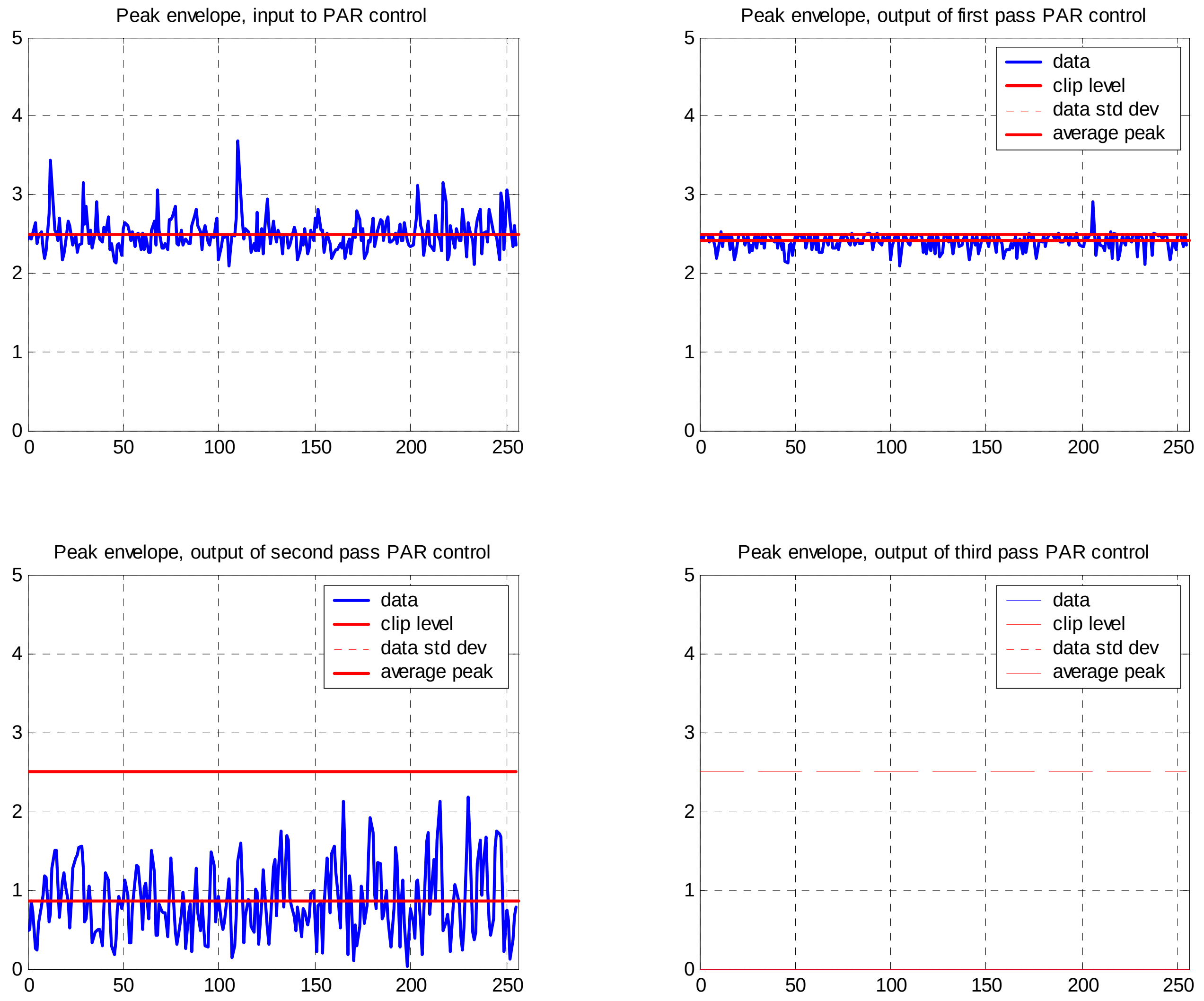
Reserve Frequency Bins Form Clipping Pulses



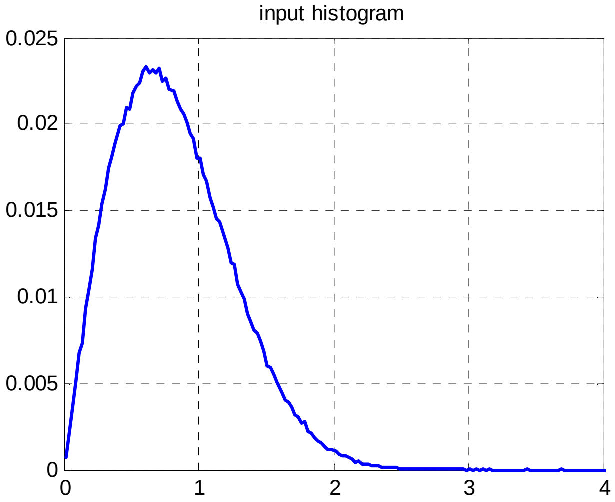
Selecting Reserve Frequency Bins

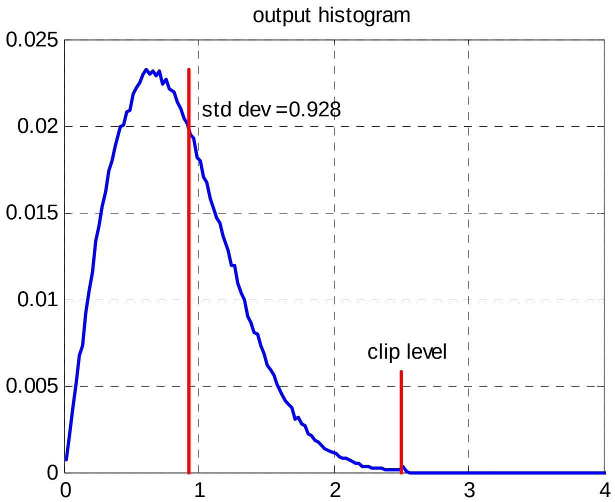


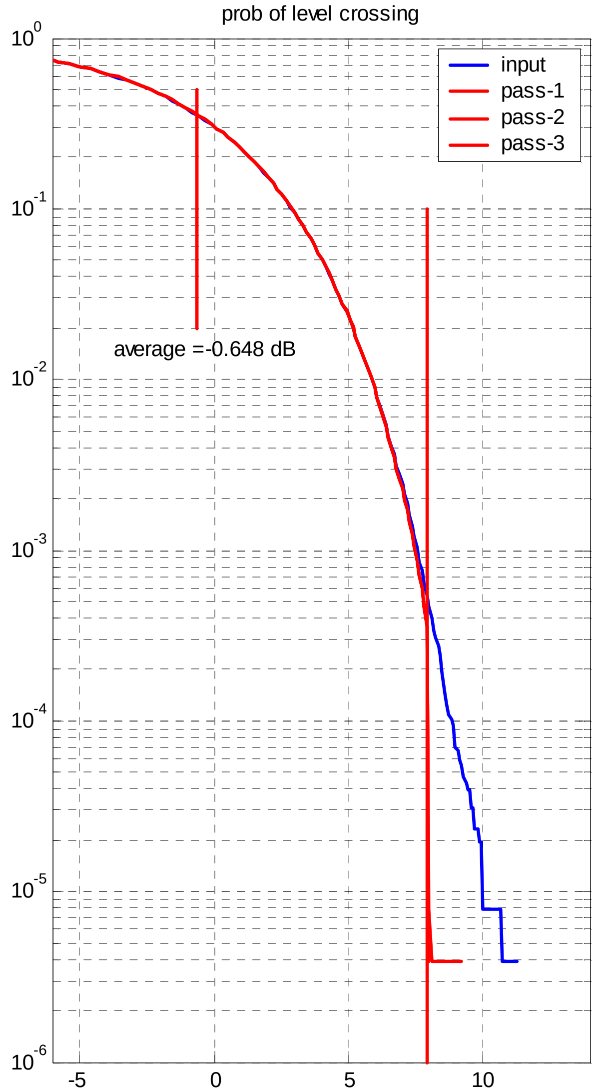
Reserve Bin Canceller Clipping at 2.5 σ (8 dB)



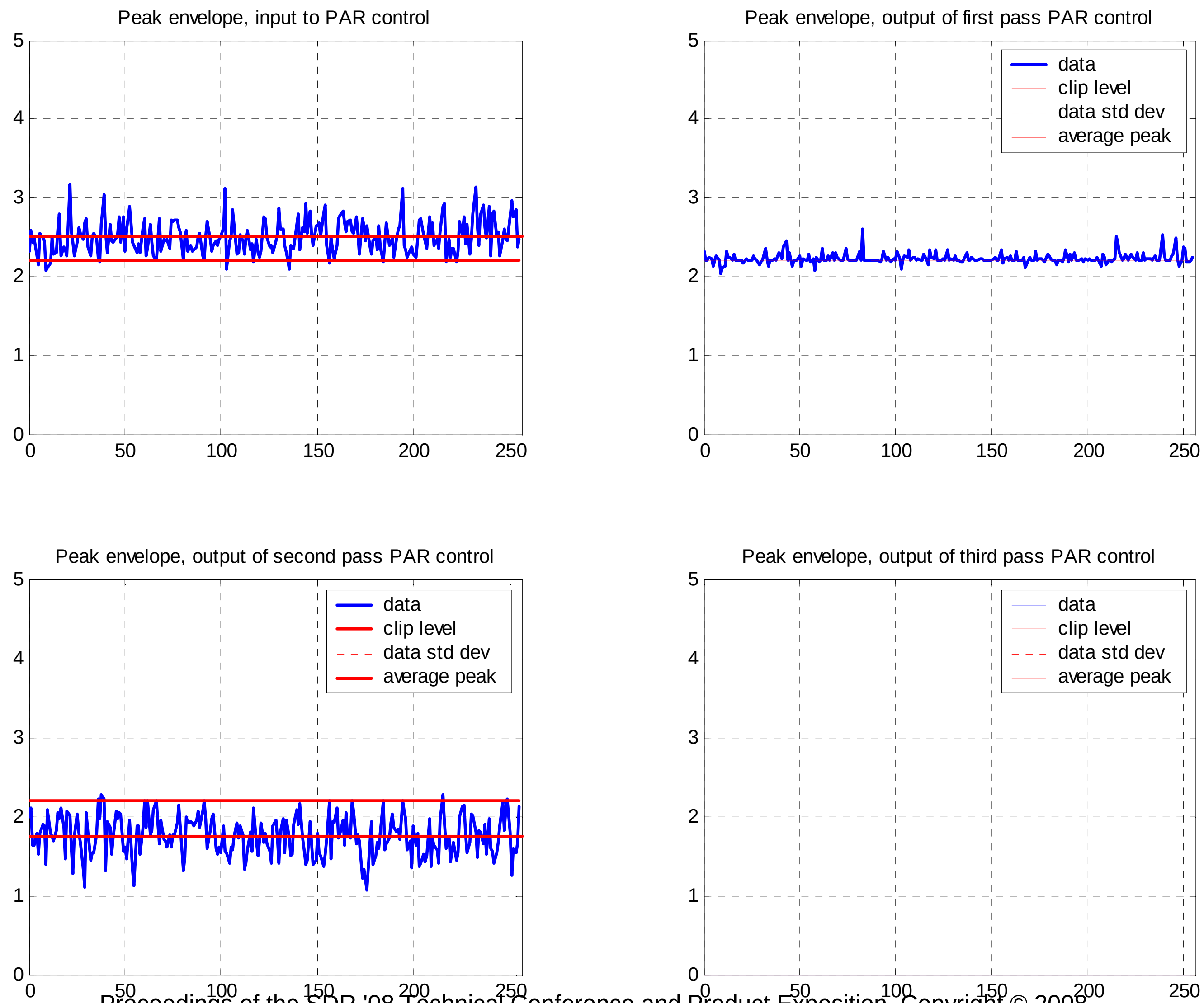
Statistics for Clip at 2.5 (8 dB)



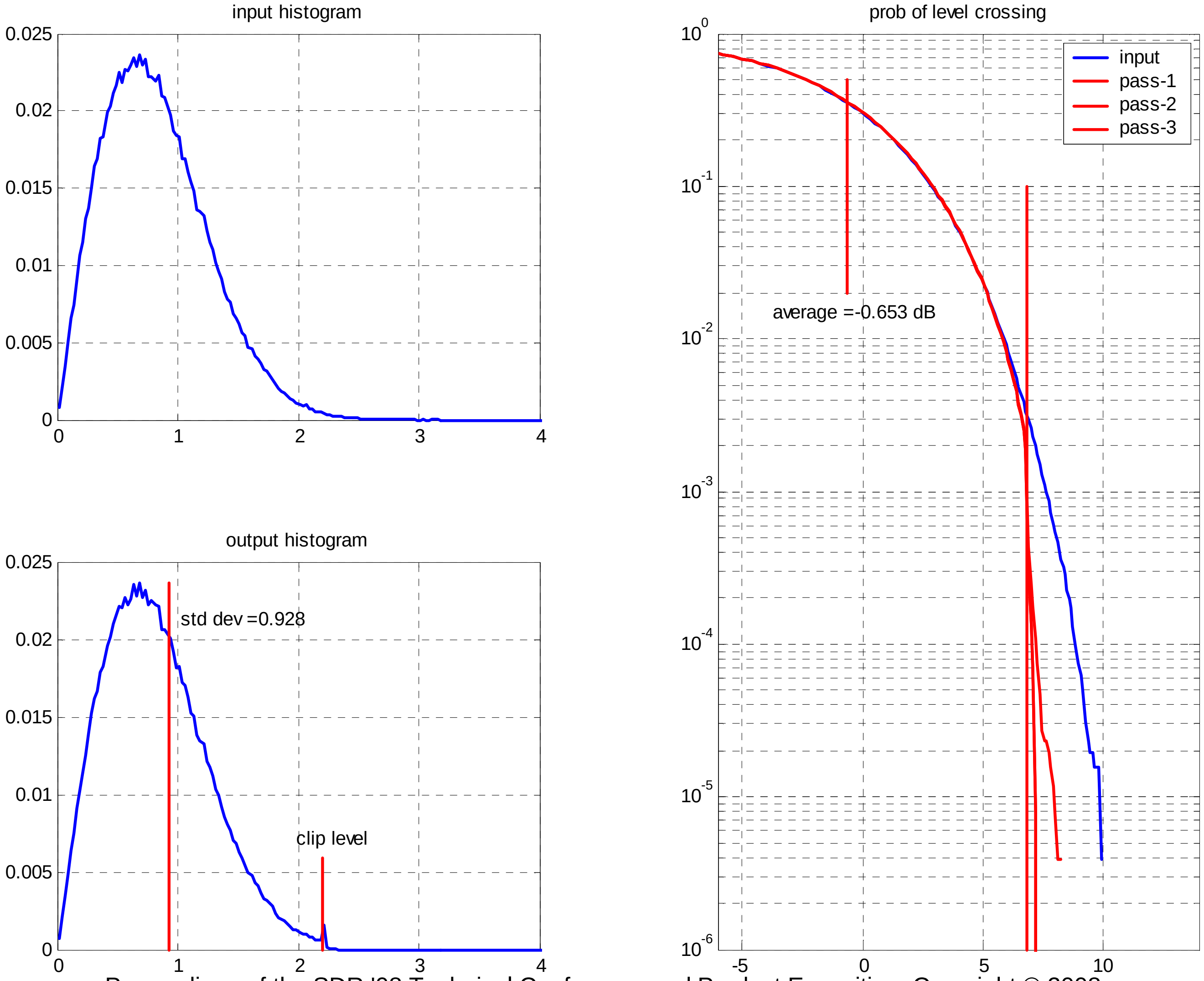




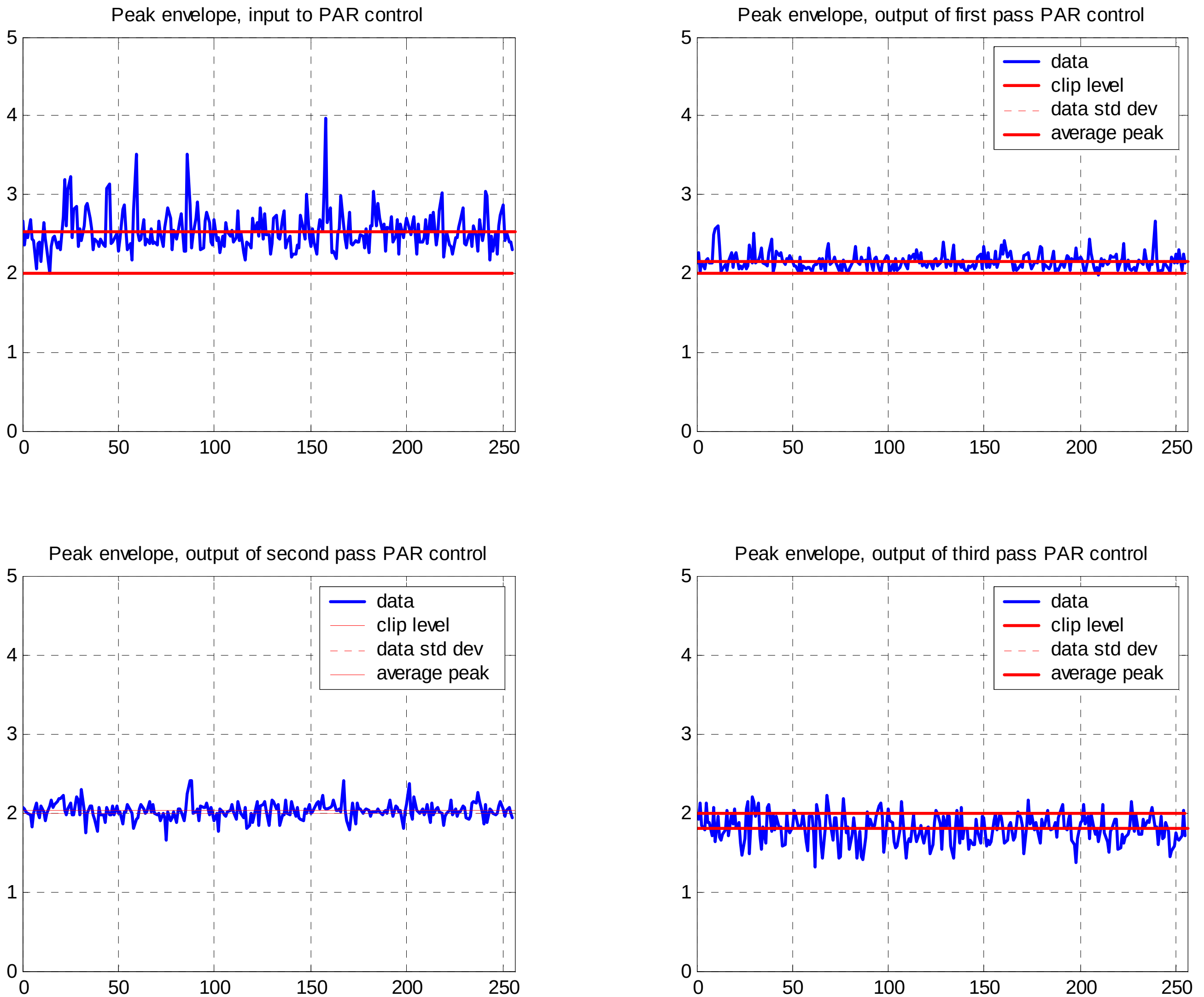
Reserve Bin Canceller Clipping at 2.2 σ (6.9 dB)



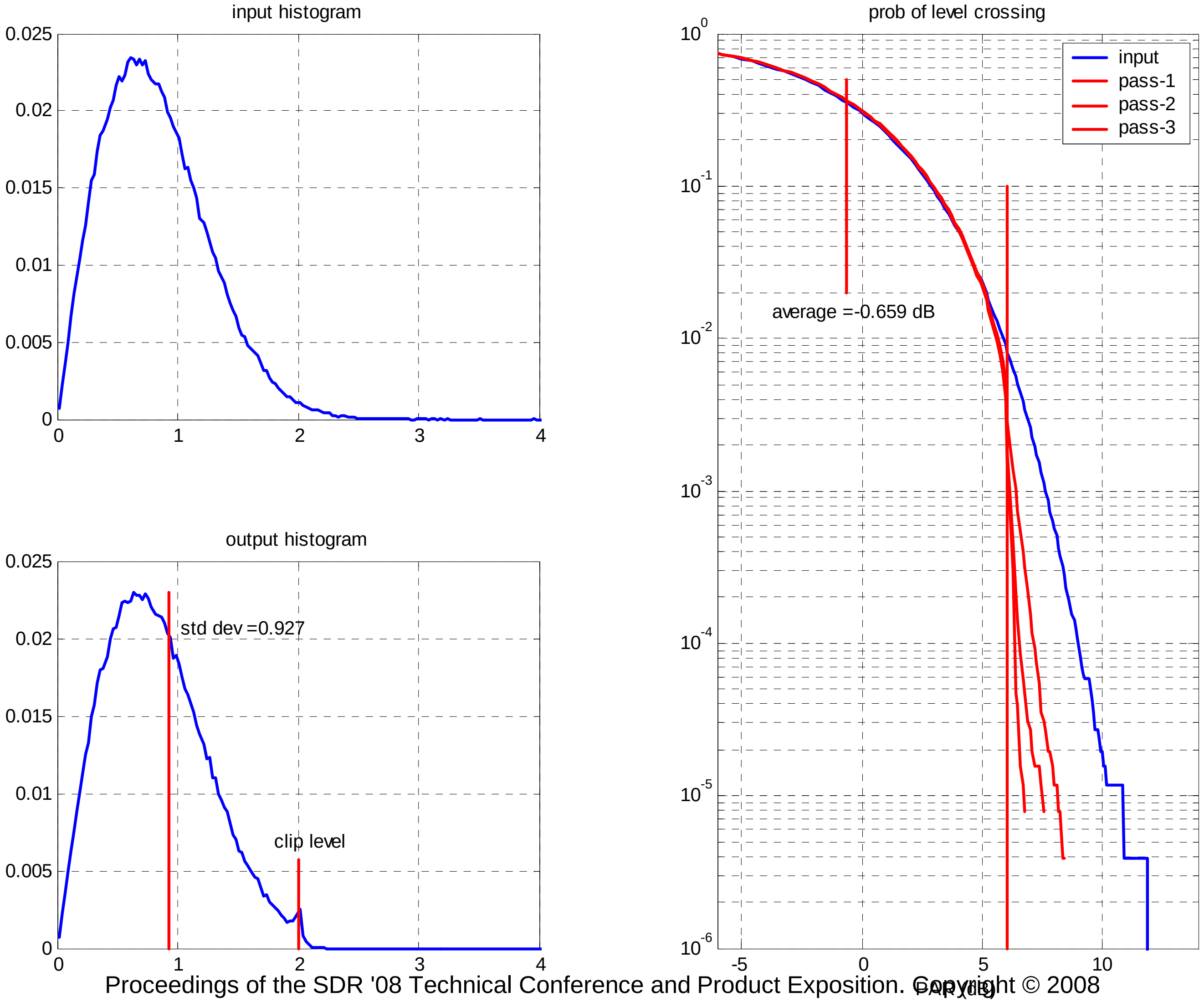
Statistics for Clip at 2.2 (6.9 dB)



Reserve Bin Canceller Clipping at 2.0 σ (6 dB)

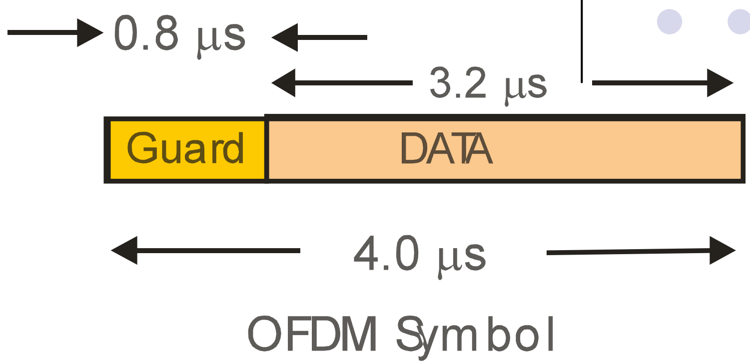


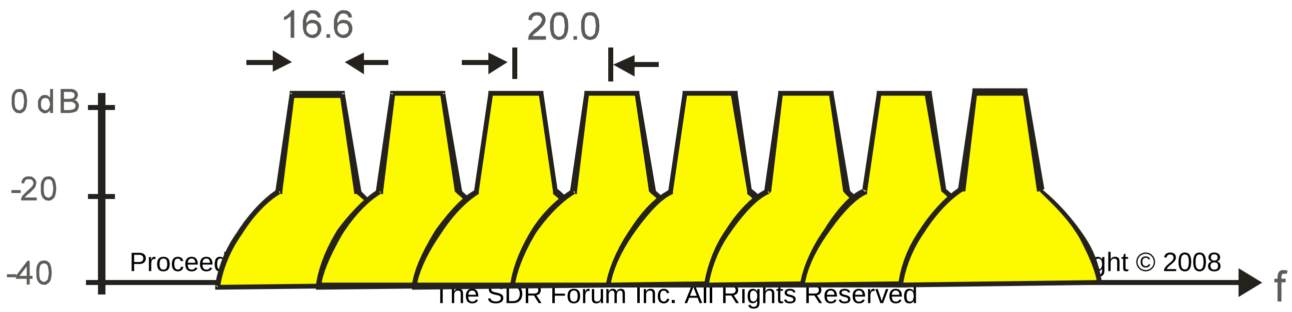
Statistics for Clip at 2.0 (6 dB)



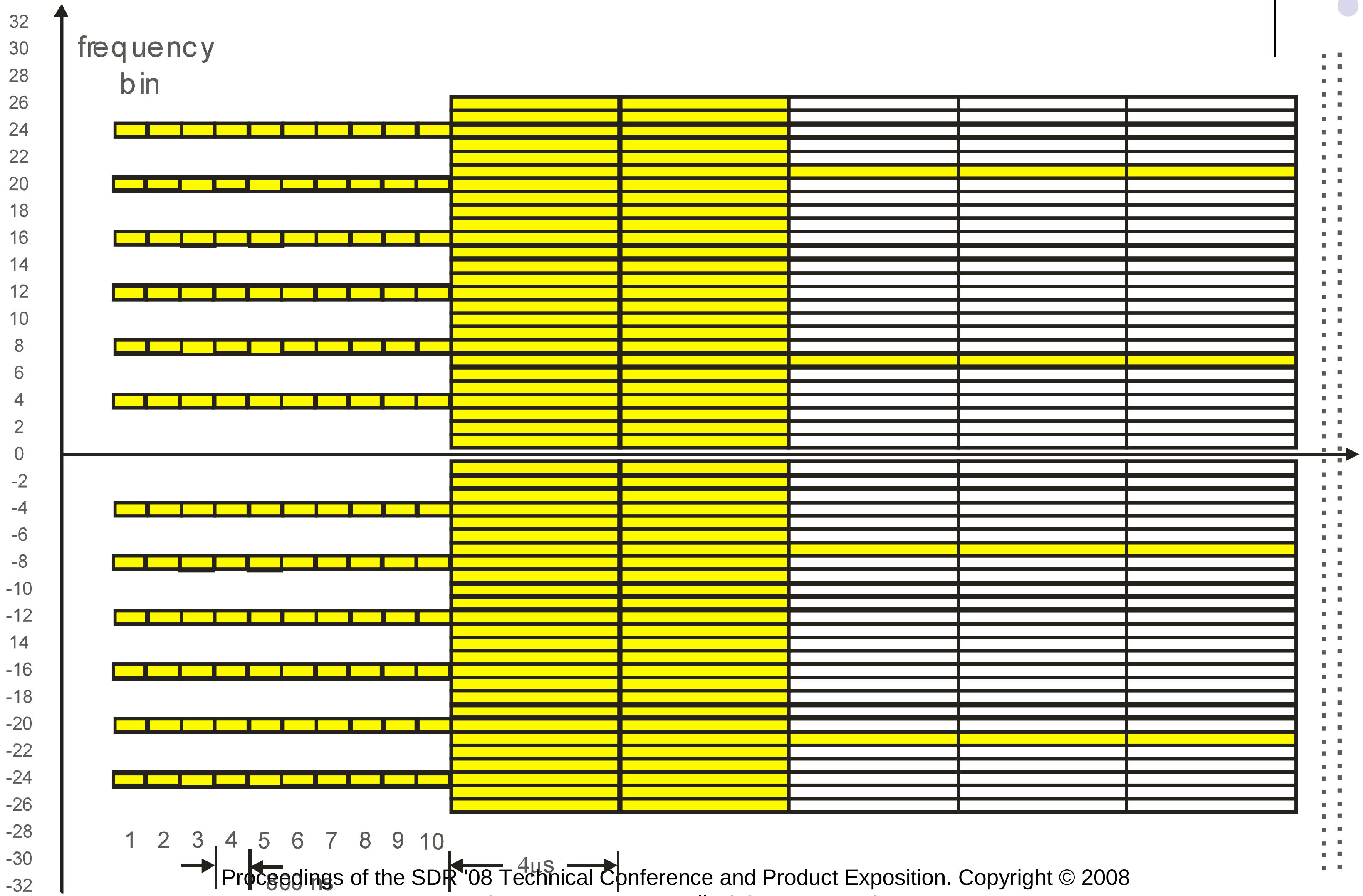
OFDM 802.11a

OFDM SYMBOL DURATION	4 μsec
Guard Interval	800 nsec
Orthogonal Tone Duration	3.2 μsec
Tone Center Spacing	312.5 kHz {1/3.2 μsec)
Number of Data Tones	48
Number of Pilot Tones	4
Total Number of Tones	52
Total Bandwidth	16.56 MHz {(52+1)*312.5 kHz)}
Modulation	BPSK, QPSK, 16-QAM, 64-QAM
Coding Rate	1/2, 2/3, 3/4
Coded Data Rates	6, 9, 12, 18, 24, 36, 48, 54 Mbps
Channel Spacing	20 MHz





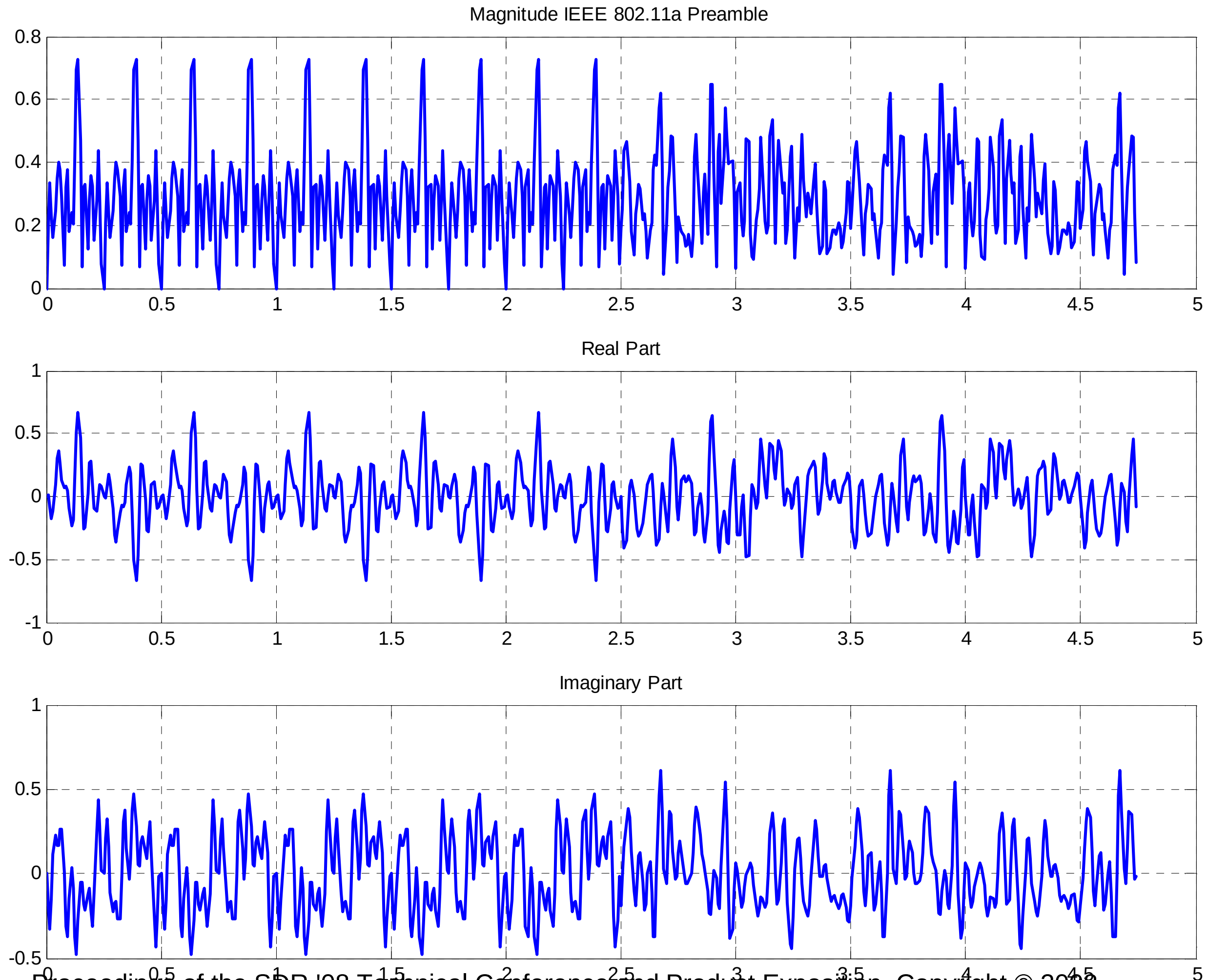
Time-Frequency Profile of 802.11a Tones
Pilot Tones Shown in Yellow



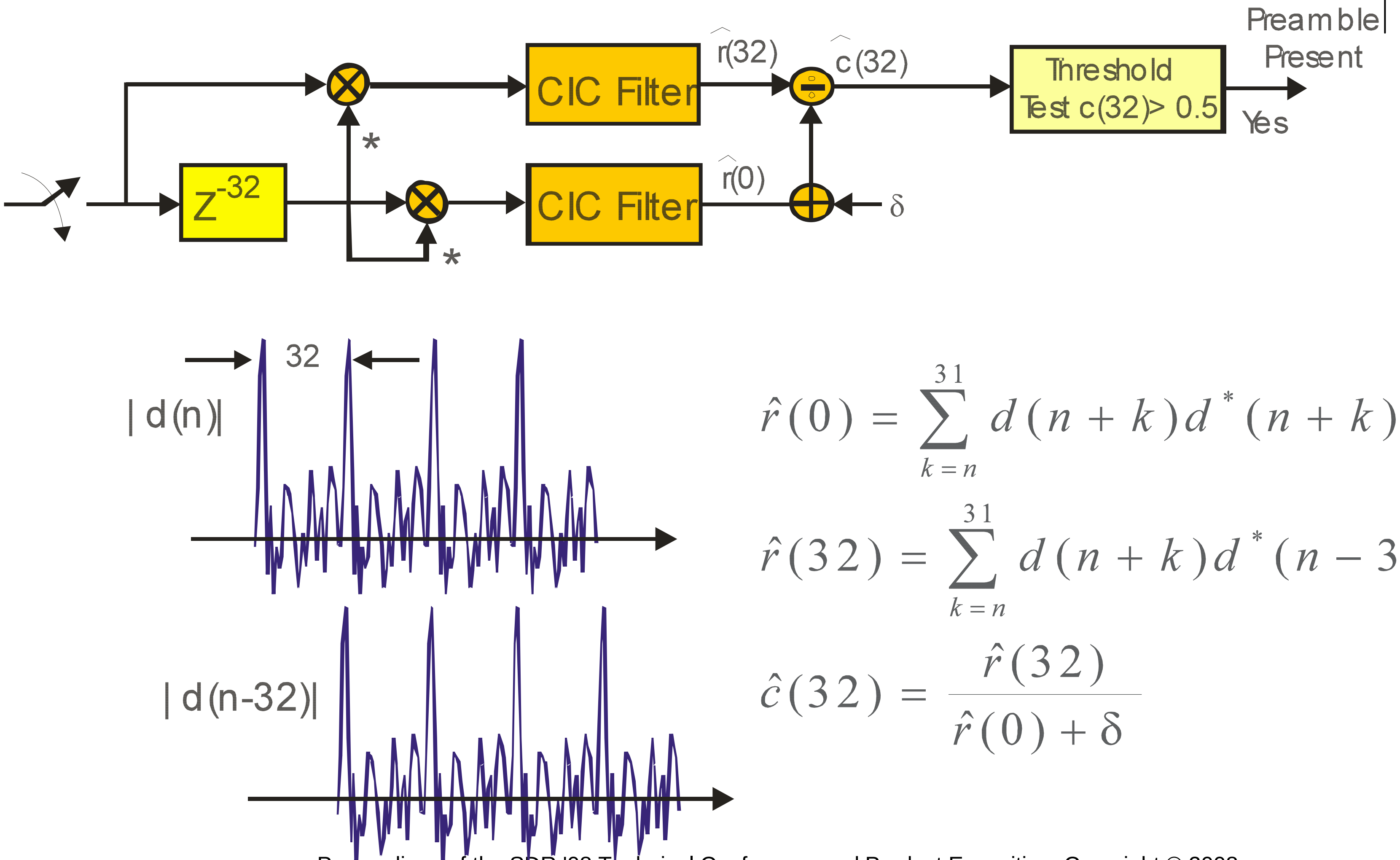
Preamble and Pilot Structure

- Short Symbols
  - Start of Frame Detection
  - Signal Strength Indication
  - Frequency Offset Resolution
- Long Symbols
  - Channel Estimate
  - Fine Time Resolution
- Distributed Pilots
  - Carrier Tracking
  - Sample Clock Tracking

Preamble Time Structure



Detecting Frame Start with Repeated Short Symbols

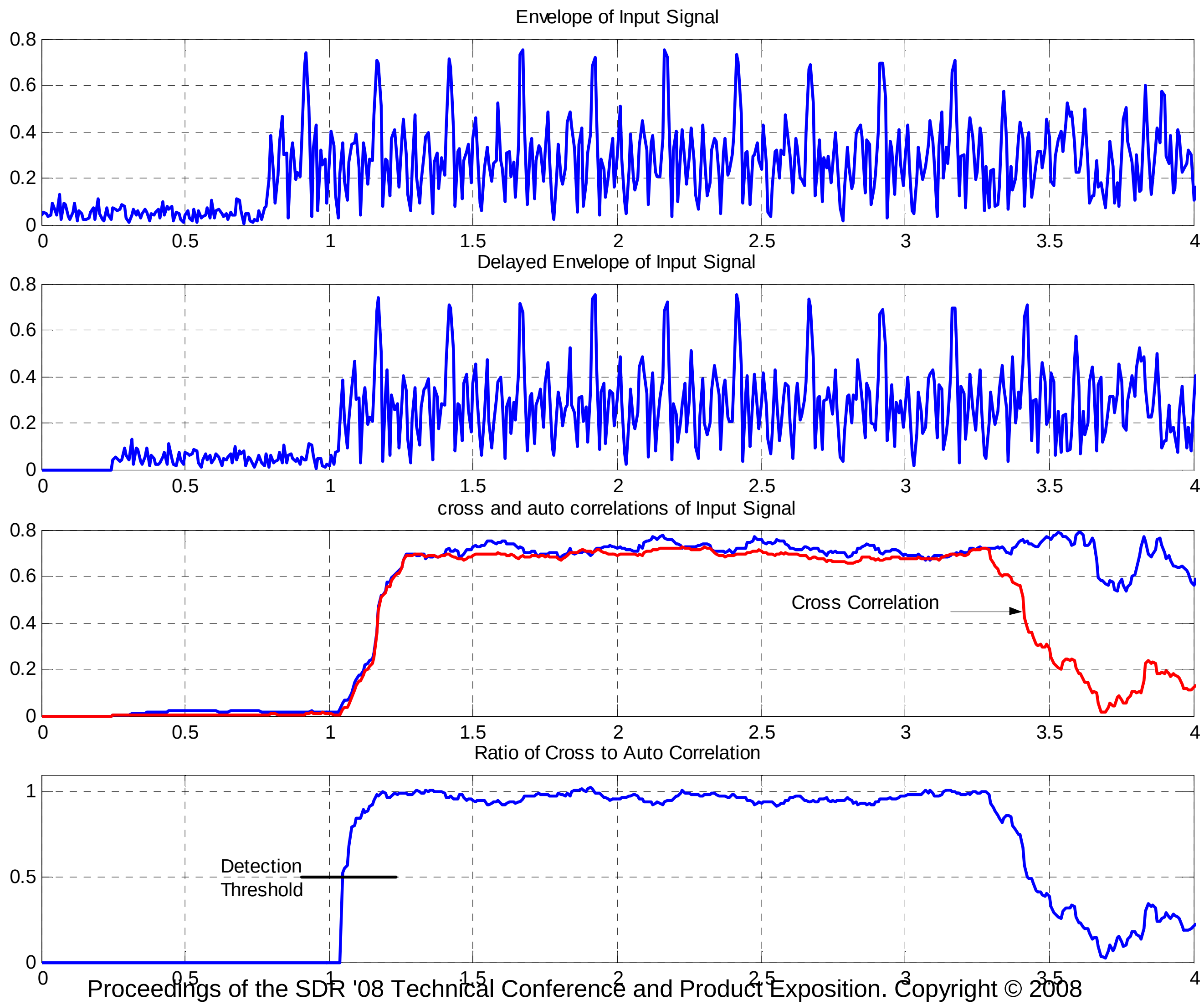


$$\hat{r}(0) = \sum_{k=n}^{31} d(n+k)d^*(n+k)$$

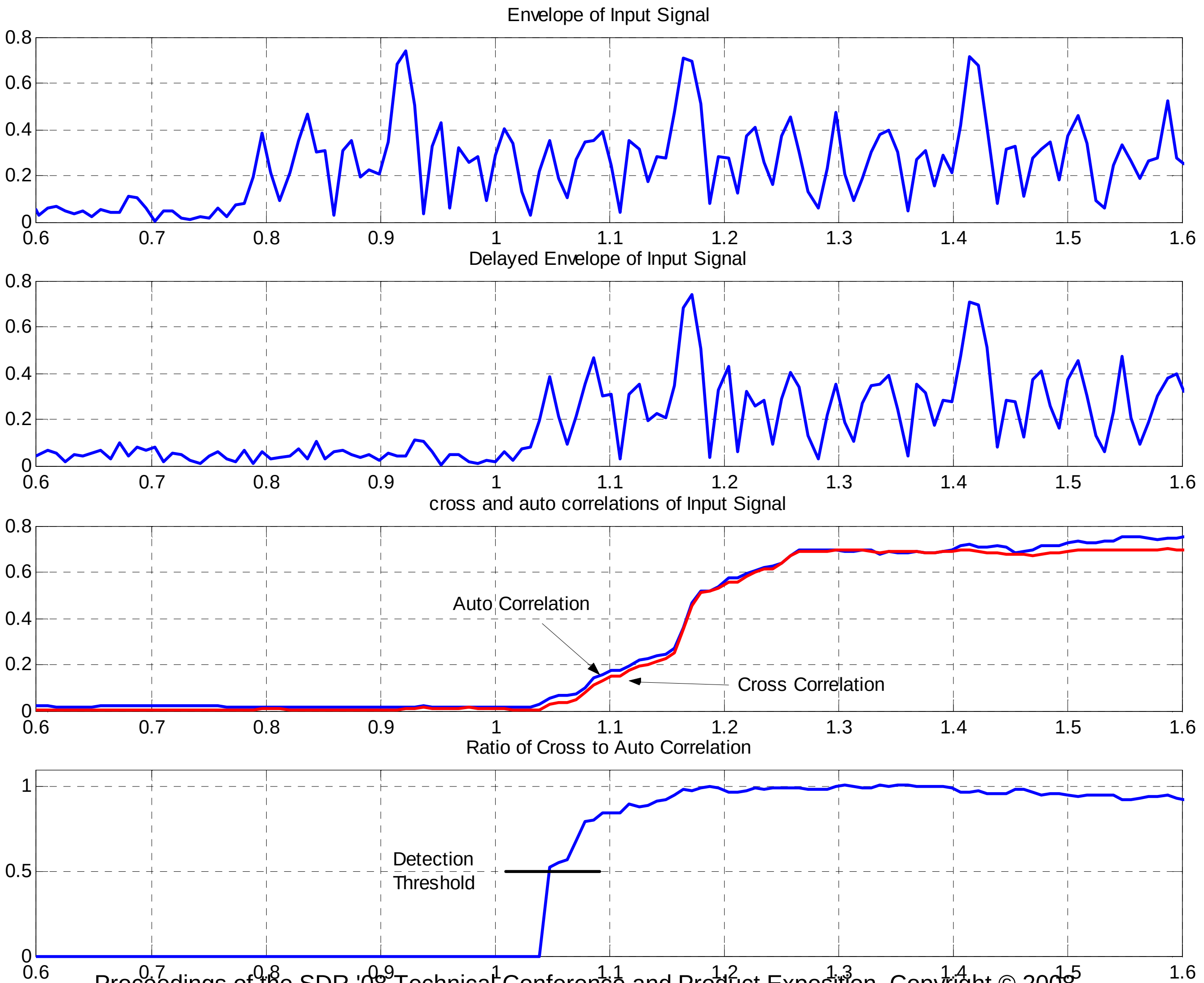
$$\hat{r}(32) = \sum_{k=n}^{31} d(n+k)d^*(n-32+k)$$

$$\hat{c}(32) = \frac{\hat{r}(32)}{\hat{r}(0)+\delta}$$

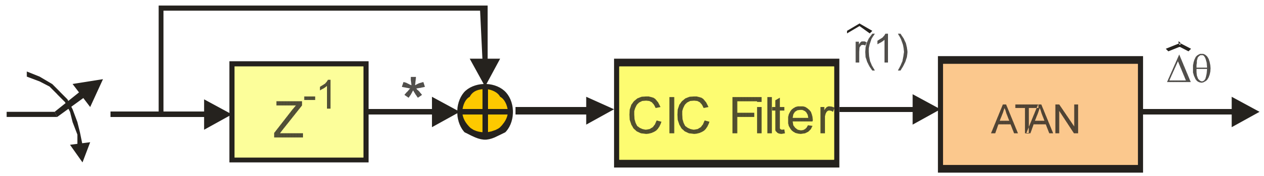
Signals in Preamble Detector



Detail of Signal in Preamble Detector



Maximum Likelihood Estimator for Frequency Offset



$$\hat{r}(1) = \sum_{k=n}^{31} d(n+k)\, d^{*}(n+k-1)$$

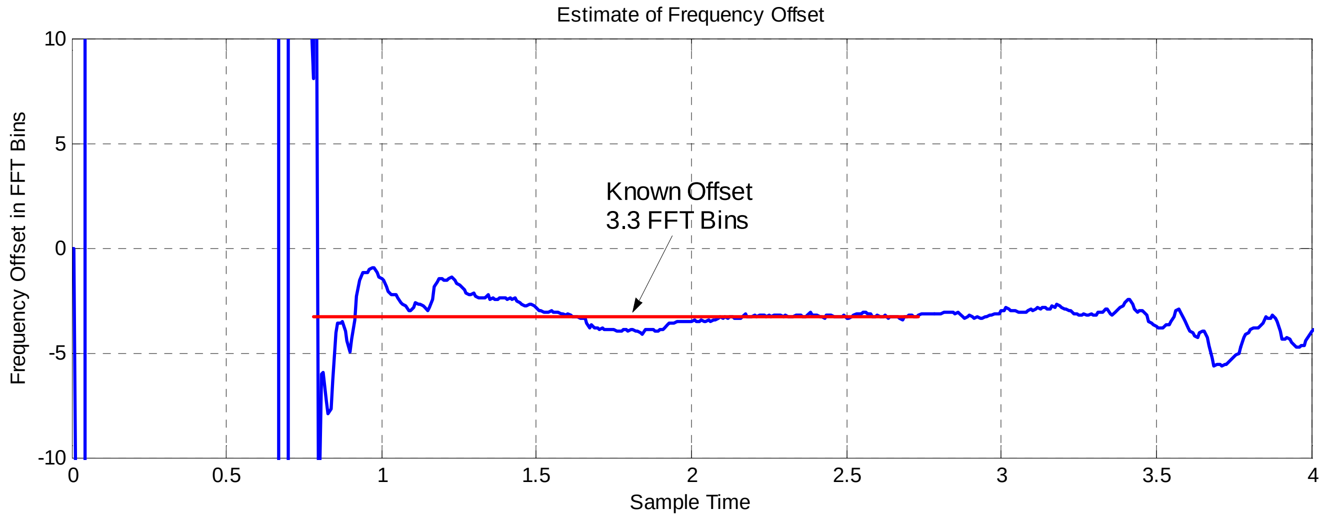
$$\hat{r}(1) = \sum_{k=n}^{31} a(n+k)\, e^{j\phi(n+k\}} e^{j\Delta\theta\cdot(n+k)} a(n+k-1)\, e^{-j\phi(n+k-1)} e^{-j\Delta\theta\cdot(n+k-1)}$$

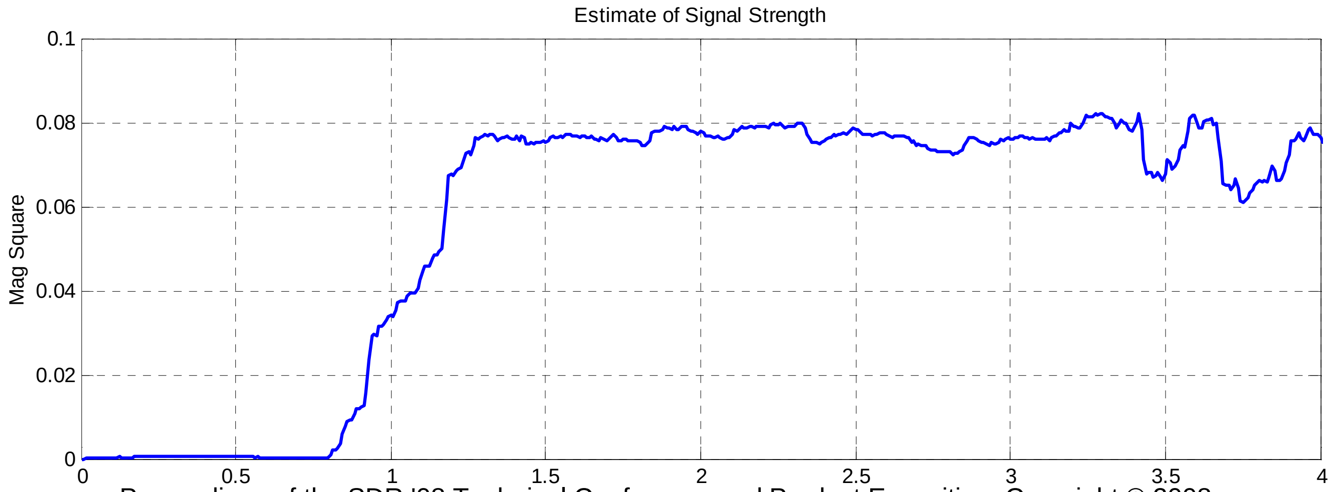
$$\hat{r}(1) = \sum_{k=n}^{31} a(n+k)\, a(n+k-1)\, e^{j[\phi(n+k\}-\phi(n+k-1)} e^{j\Delta\theta}$$

$$\hat{r}(1) = e^{j\Delta\theta} \sum_{k=n}^{31} a(n+k)\, a(n+k-1)\, e^{j[\phi(n+k\}-\phi(n+k-1)}$$

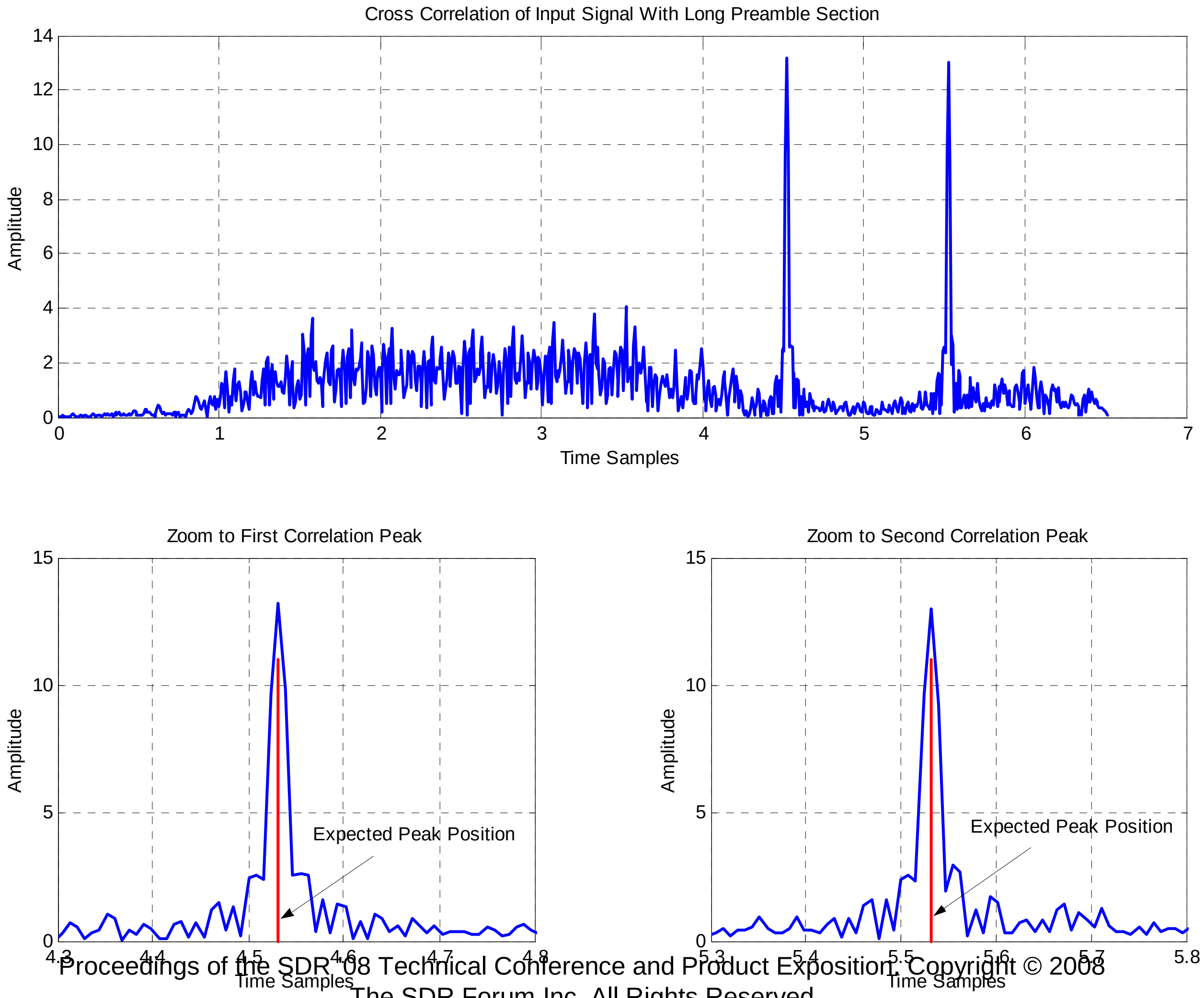
$$\hat{r}(1) = e^{j\Delta\theta}\, \hat{\rho}(1)$$

Frequency and Signal Strength Estimates

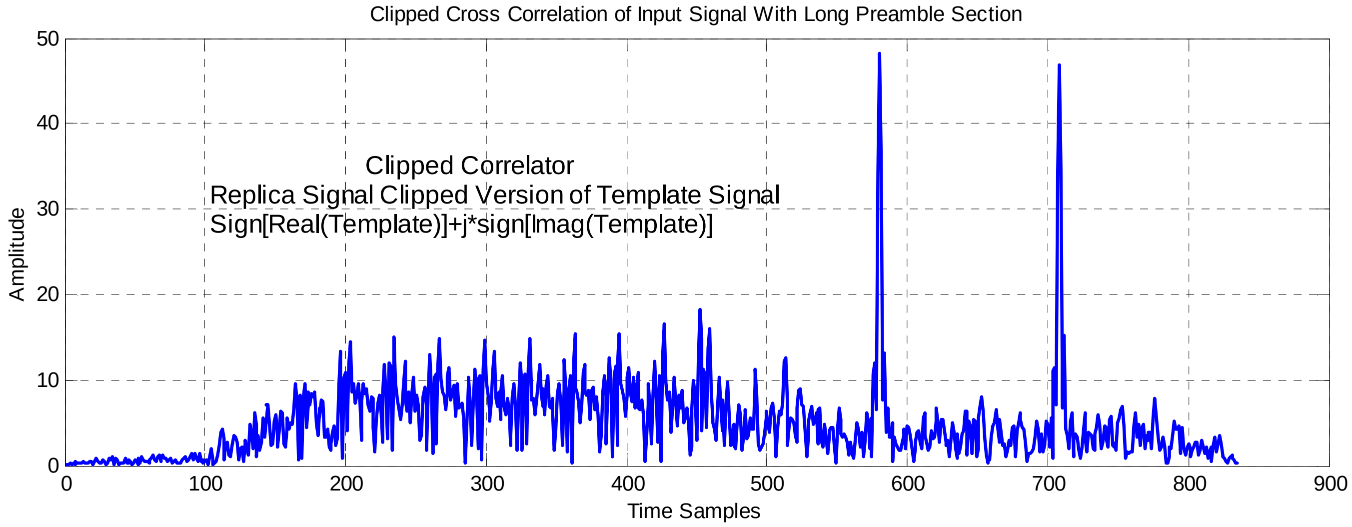


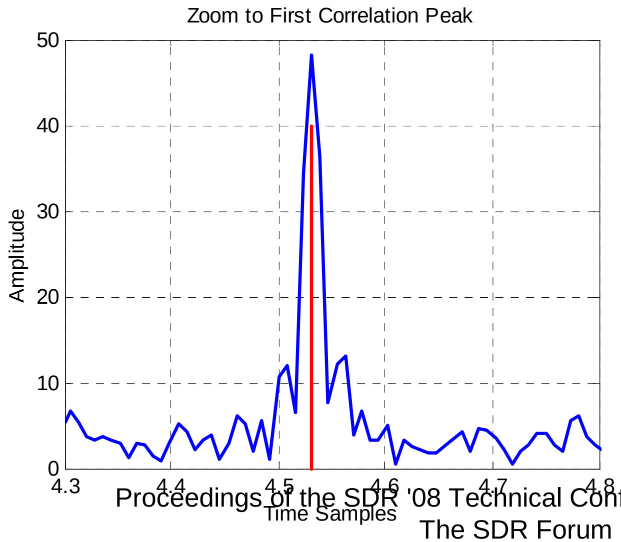


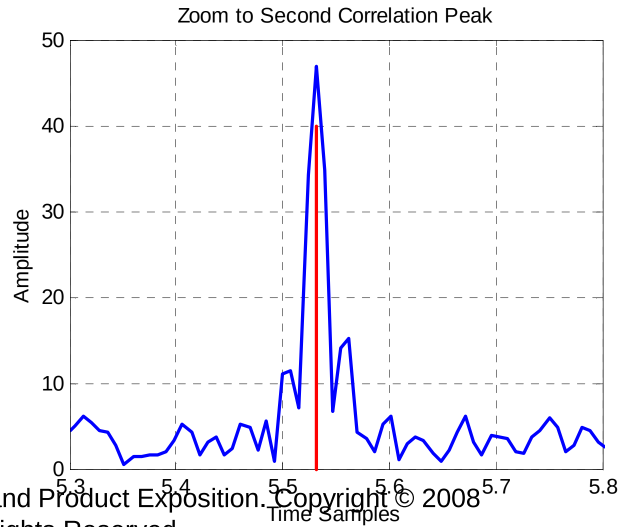
Cross Correlation of Long Preamble



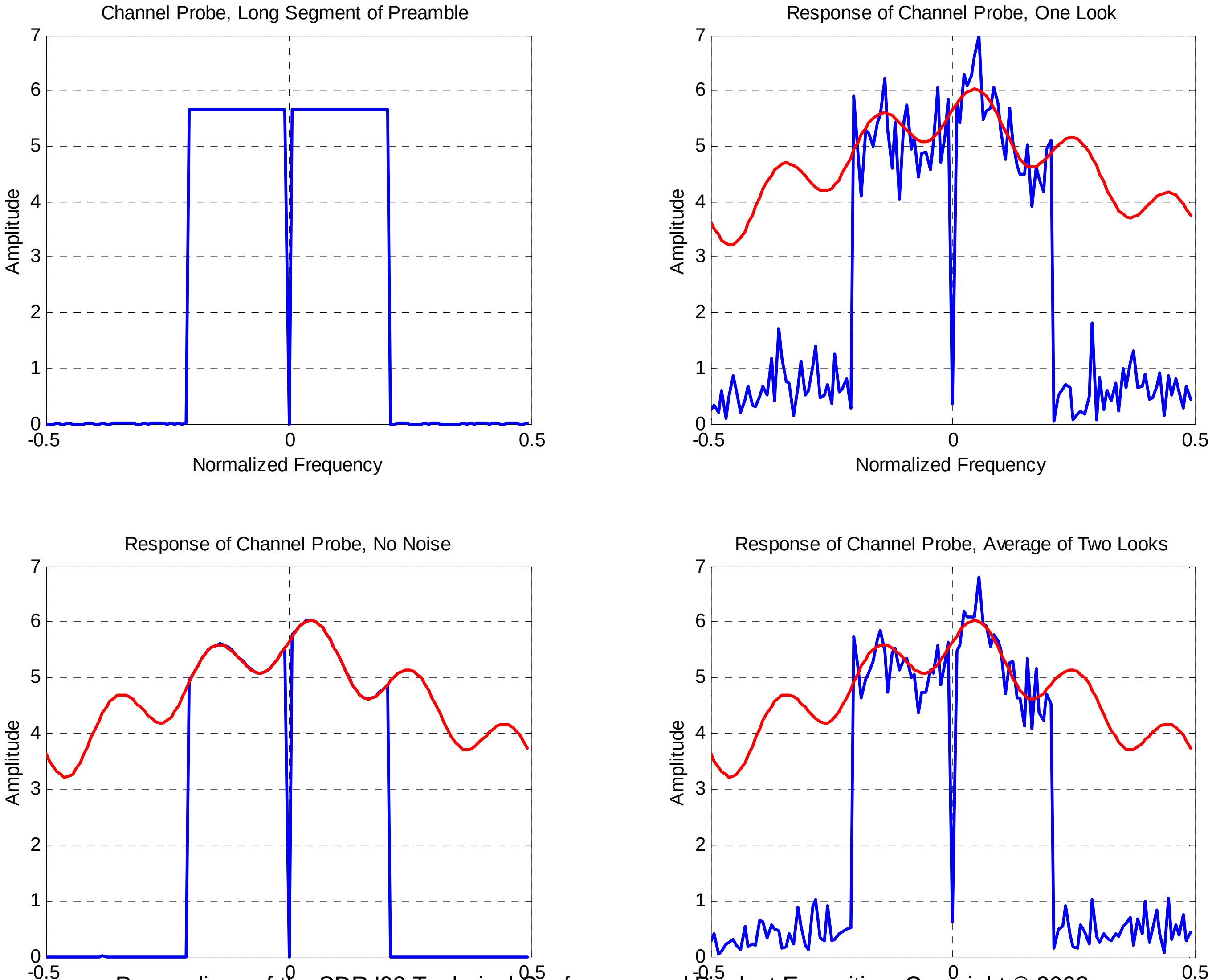
Clipped Cross Correlation of Long Preamble



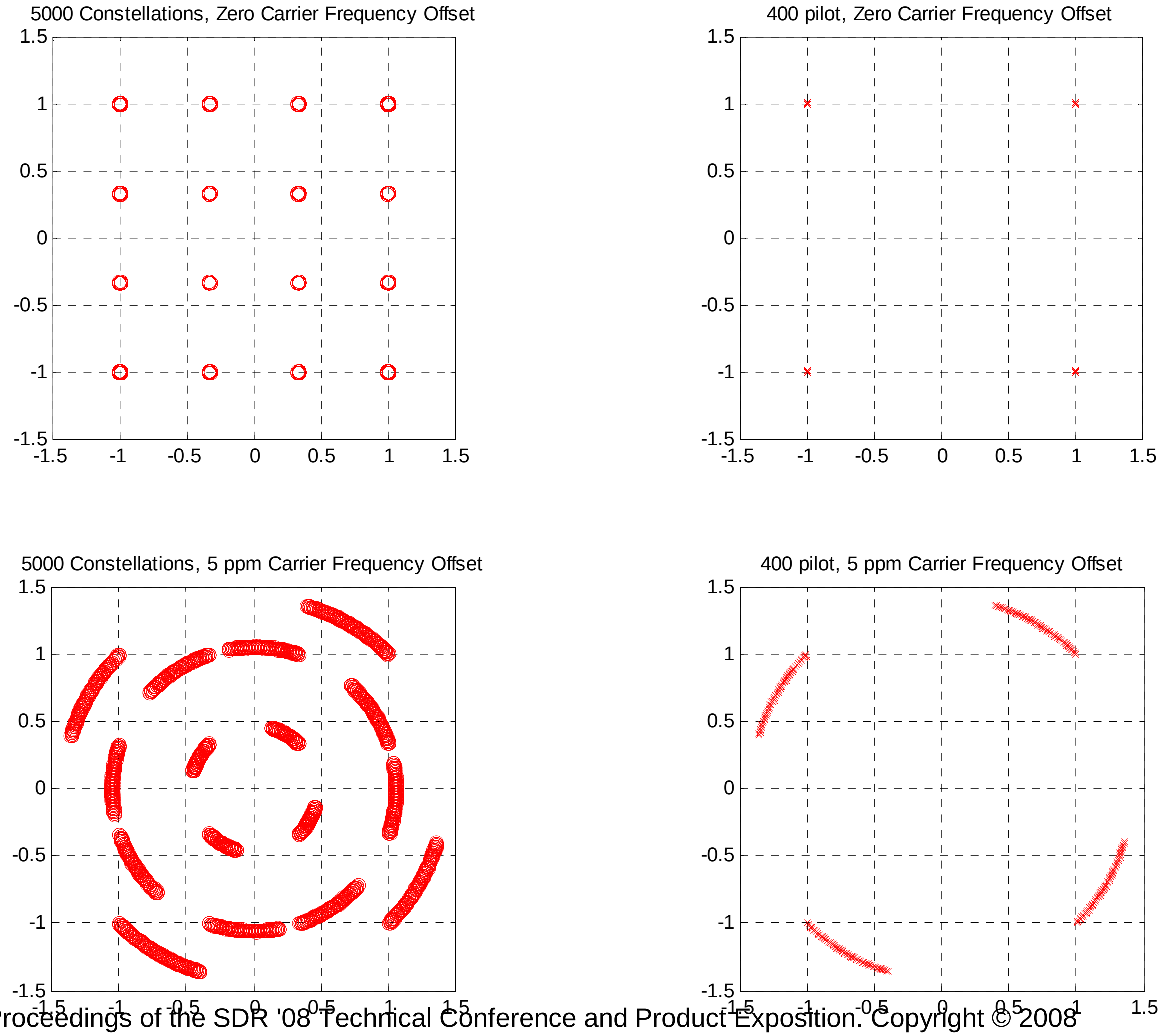




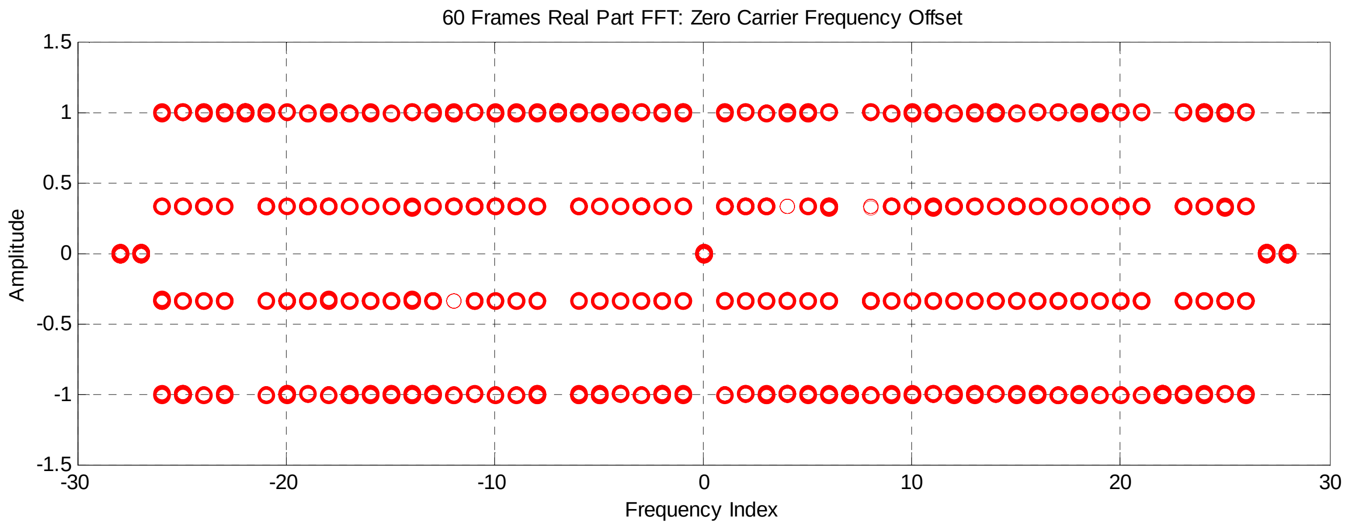
Channel Probe With Long Preamble

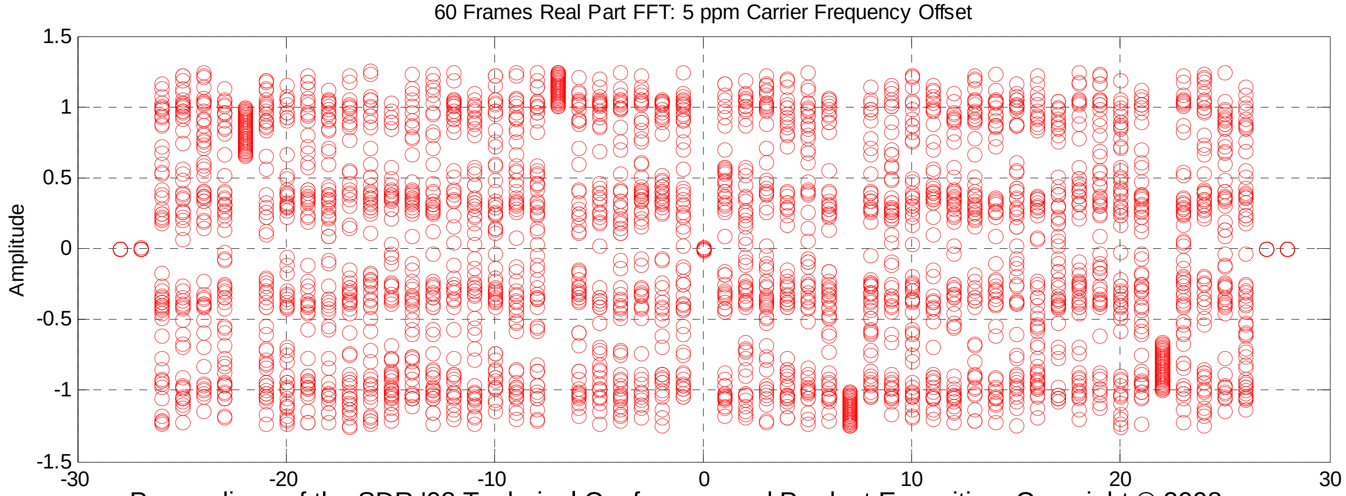


Constellation with Residual Carrier Offset

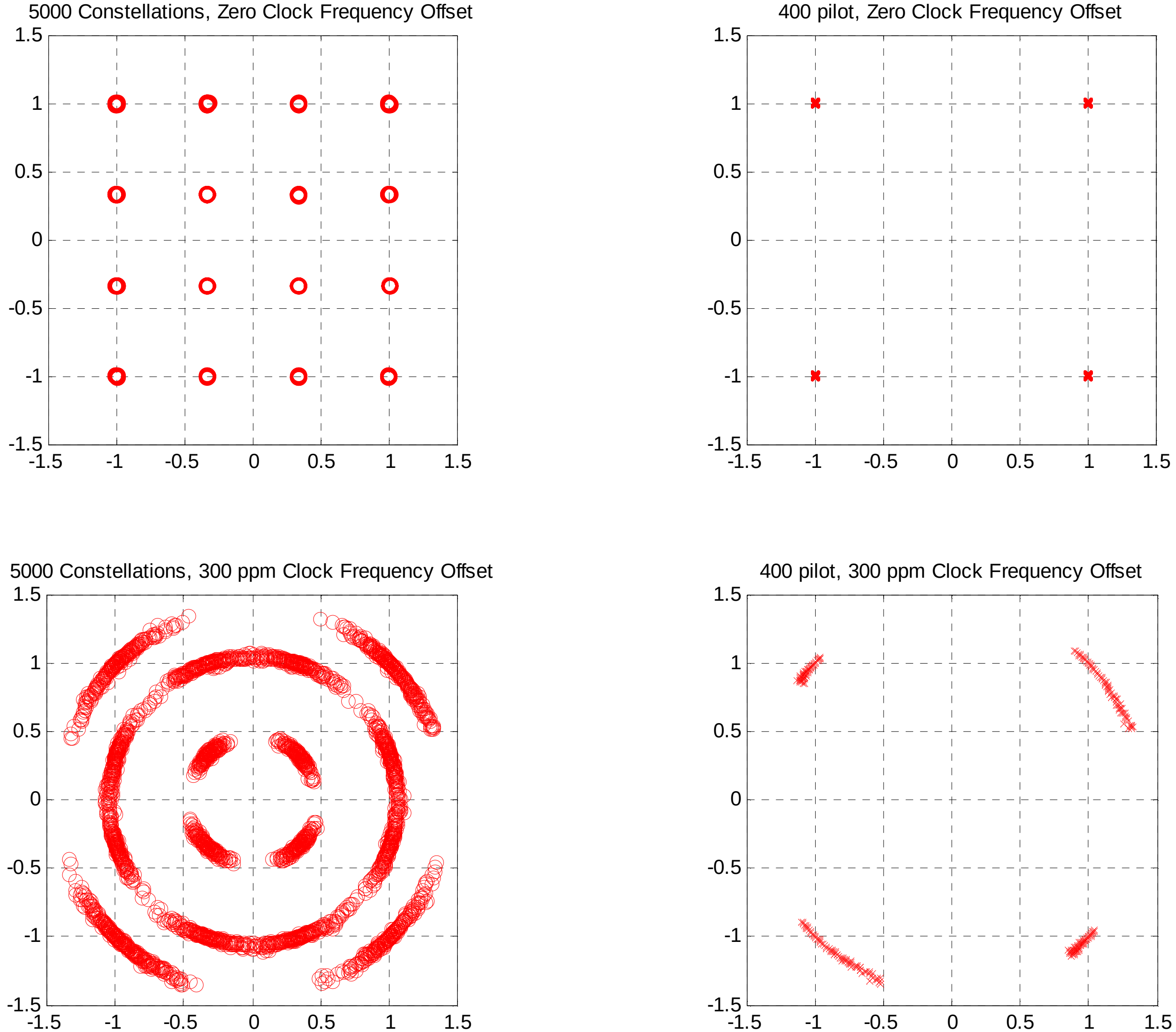


Frequency Domain Residual Carrier Offset

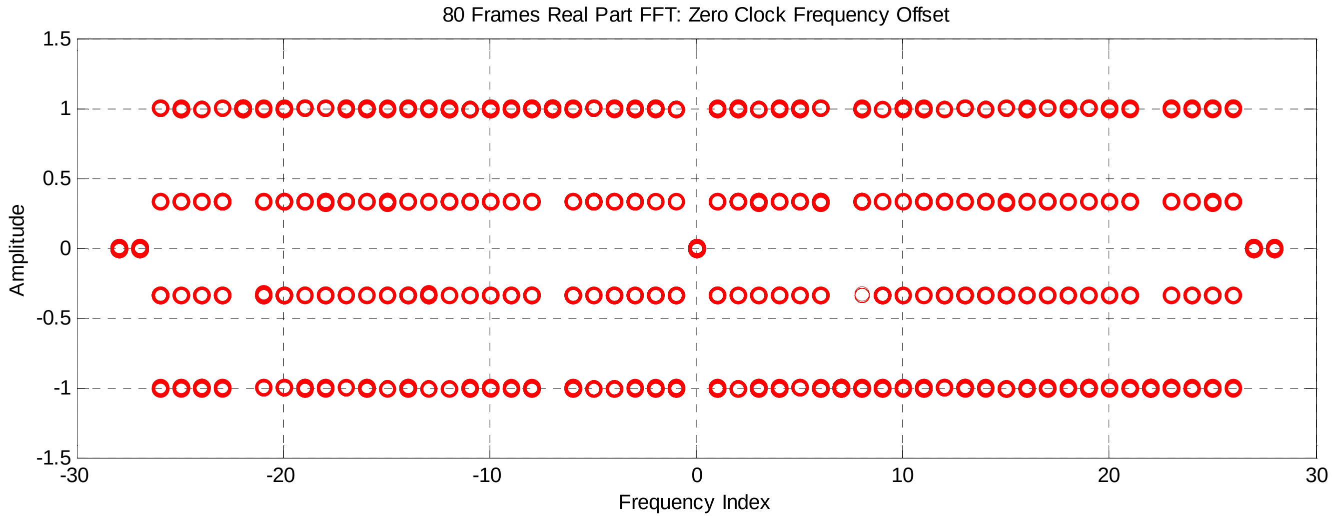


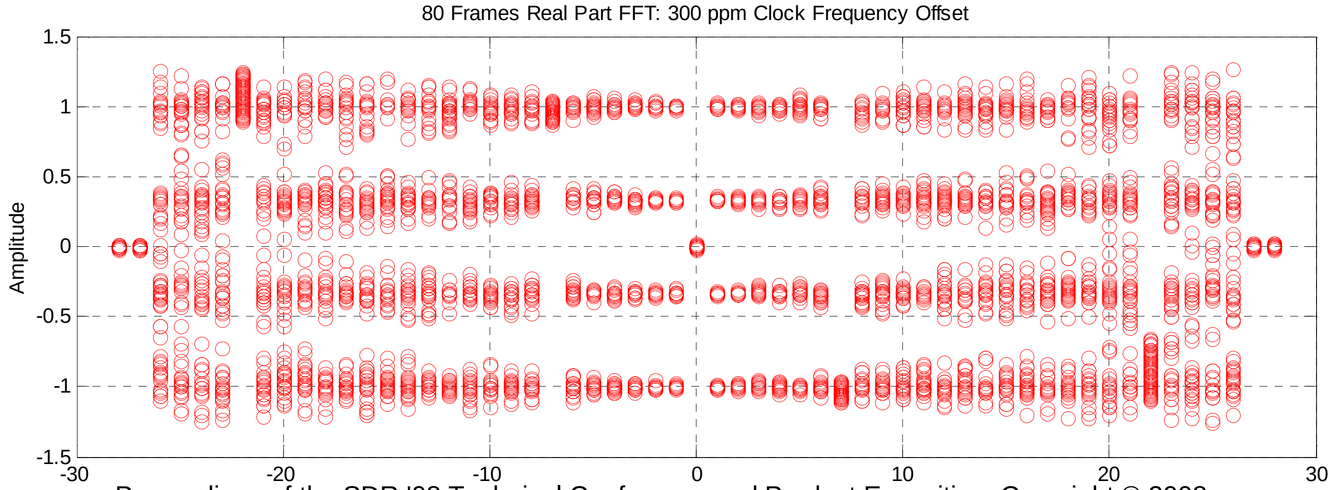


Constellations with Sample Clock Offset



Frequency Domain With Sample Clock Offset





Comparison of WLAN and WMAN Specifications
Wireless Local Area Network (WLAN),
Wireless Metropolitan Area Network (WMAN)

Standard		Frequency (GHz)	Max Data Rate (Mbps)	Transmission Method	Modulation Format
802.11 Wi-FI	802.11 a	5.15 - 825	54	OFDM	BPSK, QPSK 16-QAM, 64-QAM
	802.11 b	2.4 - 2.5	11	DSSS	CCK
	802.11 g	2.4 - 2.5	54	OFDM	BPSK, QPSK CCK
	802.11 n	2.4 - 2.5 5.15 - 8.825	248	OFDM	64-QAM
802.16 WiMAX	802.16 d	Licensed: 2.5,3.5 Unlicensed: 5,2, 5.8	70	OFDM	BPSK, QPSK 16-QAM, 64-QAM
	802.16 e	Various: 2.3, 2.5, 3.3, 3.5	70	SOFDMA	BPSK, QPSK 16-QAM, 64-QAM

Parameters of Wireless Local Area Network (WLAN) IEEE 802.11a

Parameters	Values
Channel Bandwidth	16.25 MHz
Sample Frequency	20 MHz
FFT Size (N_{FFT})	64
Number of Data Sub-Carriers	54
Number of Pilot Sub-Carriers	2
Number of Null Sub-Carriers	8
Sub-Carrier Spacing	312.5 KHz
IFFT Symbol Duration	3.2 μsec
Cyclic Prefix/Guard Time	0.8 μsec
OFDM Symbol Duration	4.0 μsec

Parameters of Fixed Wireless Local Area Network (WMAN) IEEE 802.16d

Parameters	Values
Channel Bandwidth	3.5 MHz
Sample Frequency	4.0 MHz
FFT Size (N_{FFT})	256
Number of Data Sub-Carriers	192
Number of Pilot Sub-Carriers	8
Number of Null Sub-Carriers	56
Sub-Carrier Spacing	15.625 KHz
IFFT Symbol Duration	64 μsec
Cyclic Prefix/Guard Time	8 μsec
OFDM Symbol Duration	72 μsec

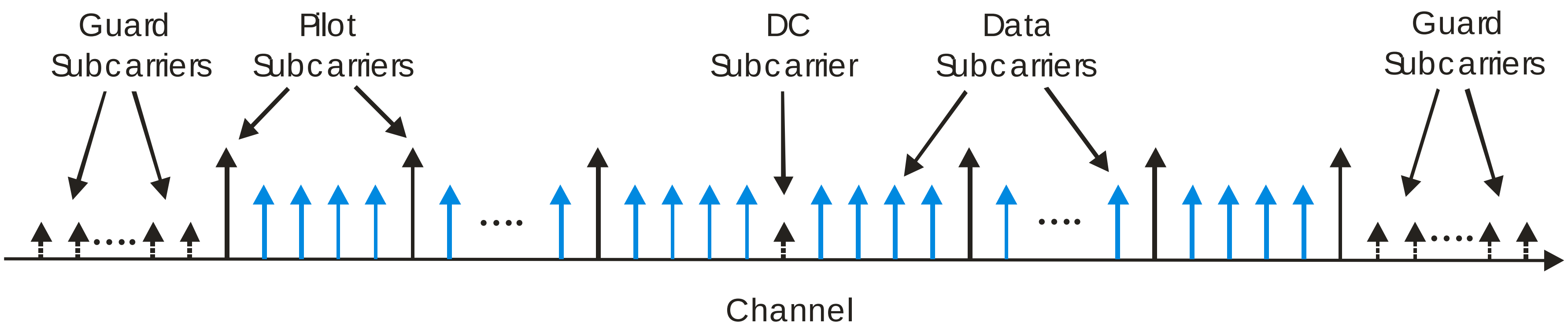
Parameters of Mobile Wireless Metropolitan Area Network (WMAN) IEEE 802.16e

Parameters	Values				
Channel Bandwidth (MHz)	1.25	2.50	5.00	10.0	20.0
Sample Frequency (MHz)	1.429	2.857	5.714	11.429	22.857
FFT Size (N_{FFT})	128	256	512	1024	2048
Number of Data Sub-Carriers	72	192	360	720	1440
Number of Pilot Sub-Carriers	12	8	60	120	240
Number of Null Sub-Carriers	44	56	92	184	368
Sub-Carrier Spacing	10.94 kHz				
IFFT Symbol Duration	91.41 μsec				
Cyclic Prefix/Guard Time	11.49 μsec				
OFDM Symbol Duration	102.9 μsec				

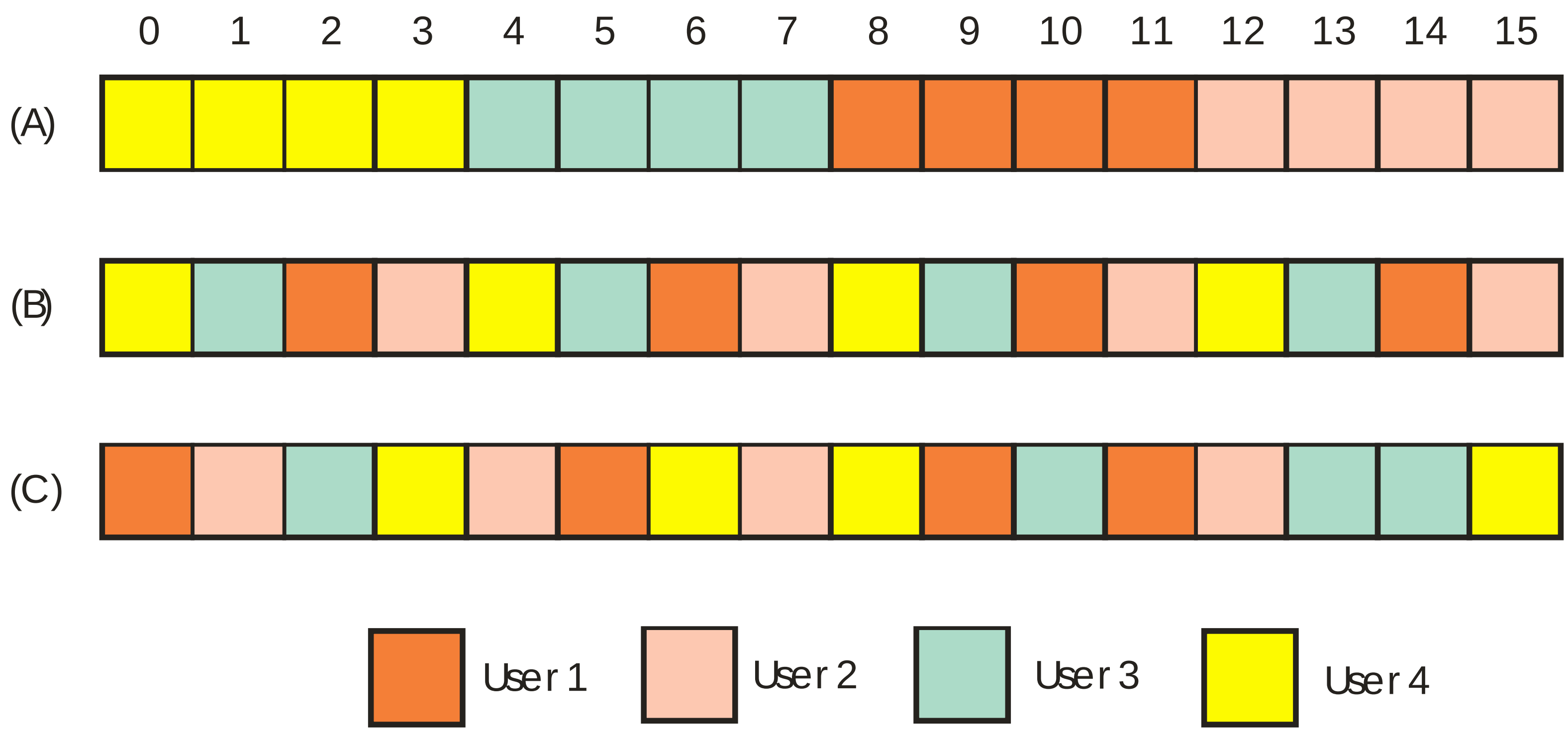
Parameters of Wideband Networking Waveform (WNW) JTRS Cluster 1

Parameters	Values			
Channel Bandwidth (MHz)	1.2	3.00	5.0	10.0
Signal Bandwidth (MHz)	0.908	2.236	3.721	7.432
Sample Frequency (MHz)	5.0	5.0	5.0	10.0
FFT Size (N_{FFT})	512	512	512	1024
Number of Data Sub-Carriers	92	228	380	760
Number of Reference Sub-Carriers	1	1	1	1
Number of Null Sub-Carriers	419	283	131	263
Sub-Carrier Spacing	9.7656 kHz			
IFFT Symbol Duration	102.4 μsec			
Cyclic Prefix/Guard Time	13.6 μsec			
OFDM Symbol Duration	116 μsec			

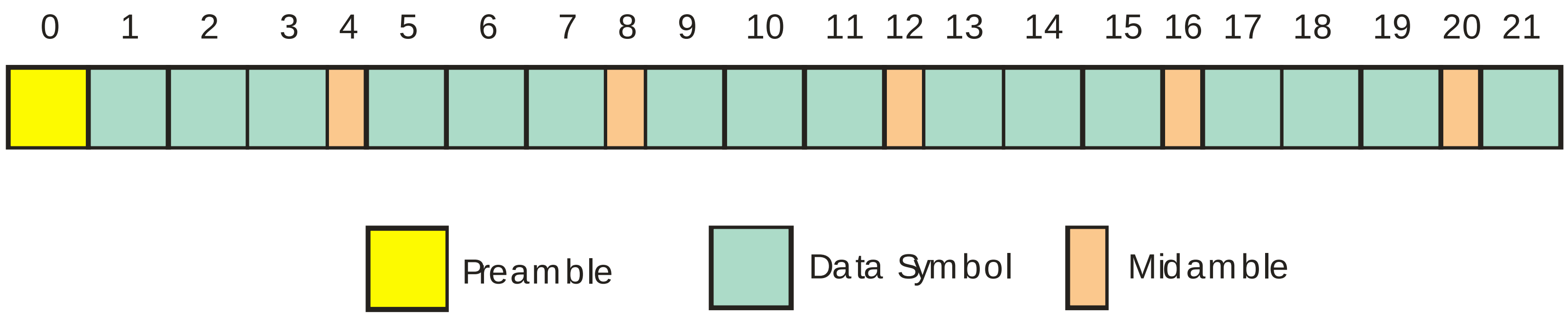
Sub-Carrier Assignment for 802.16: Data, Pilot, Guard, and DC Sub-carriers



Examples of Carrier Allocation Scheme CAS),
(A) Sub-band CAS,
(B) Interleaved CAS, and
(C) Generalized CAS.

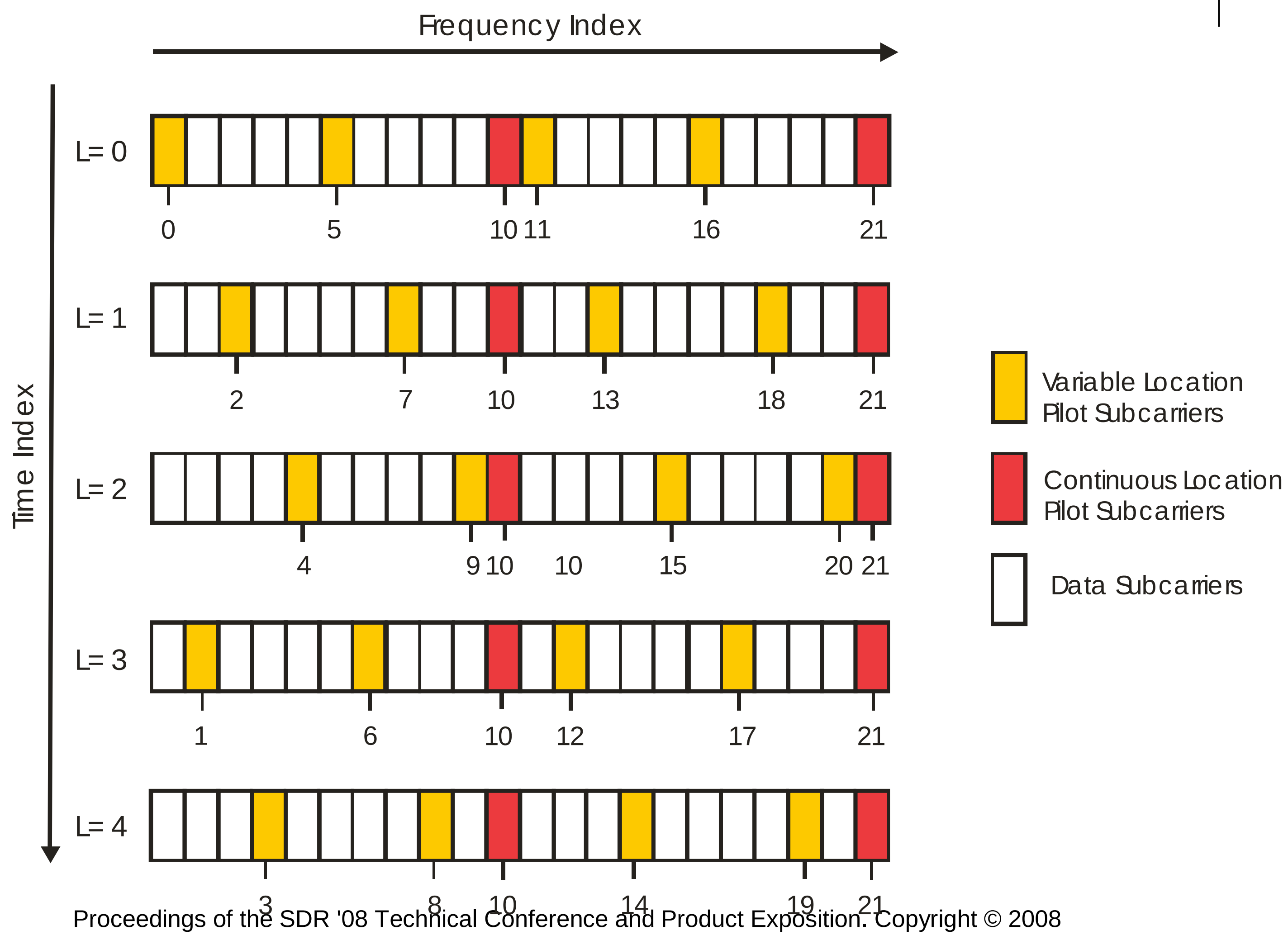


Frame Structure Example with Initial Pre-amble and Optional Mid-amble Inserted every Third OFDMA Symbol

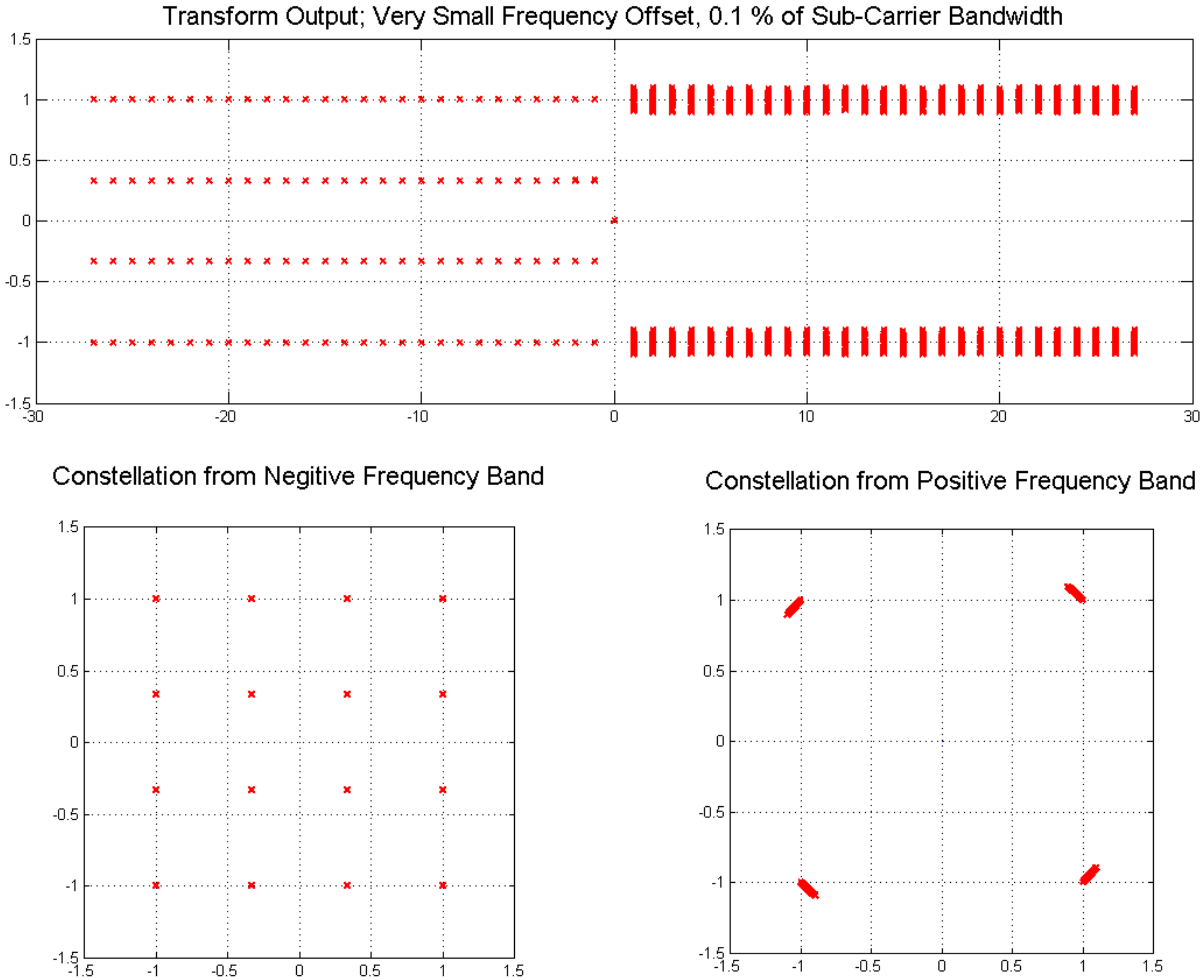


Mid-amble Options: 1. None, 2. L=8, 3. L=16, 4. L=32

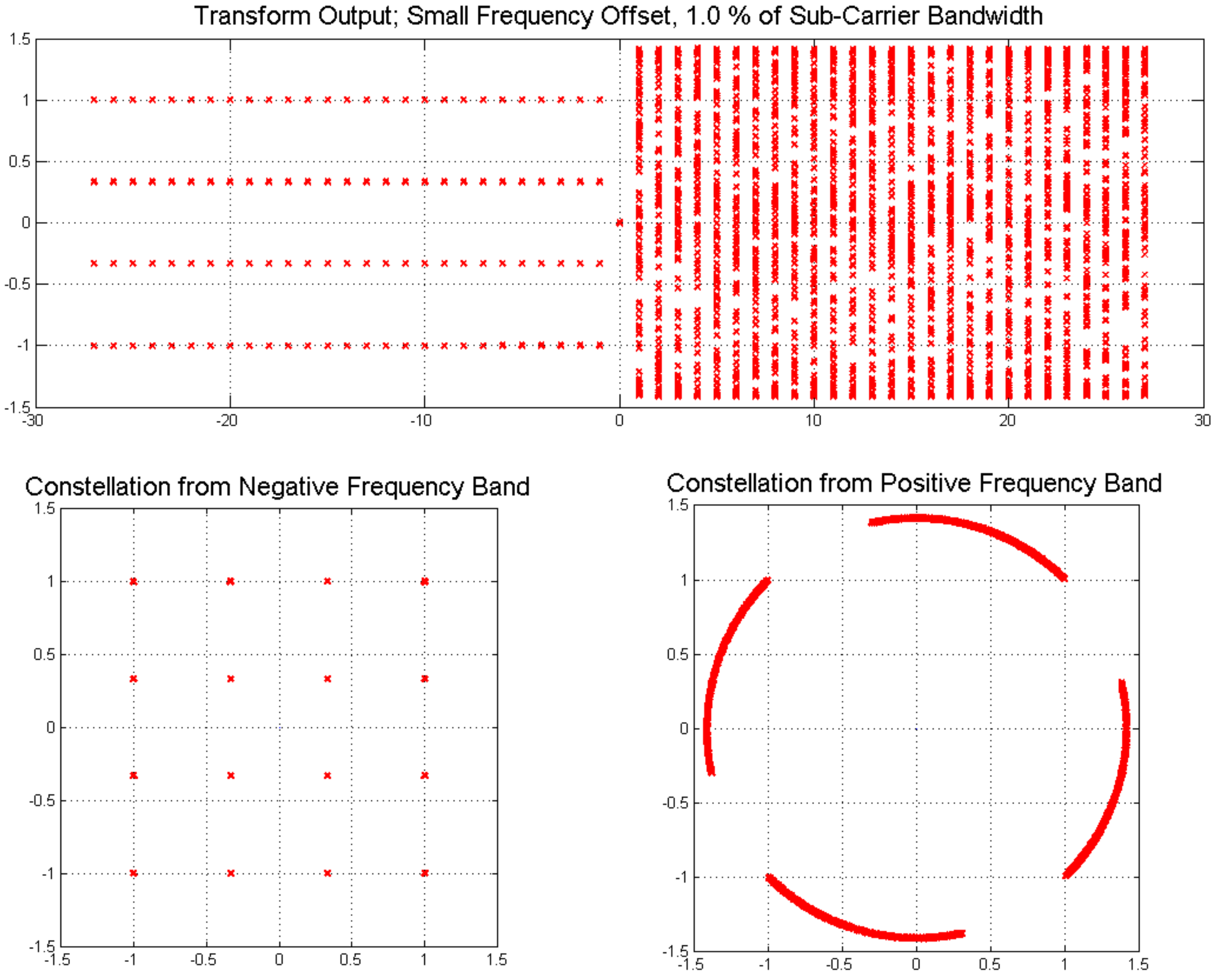
Sub-channel Occupancy:
Data, Fixed Pilots, Variable Pilots



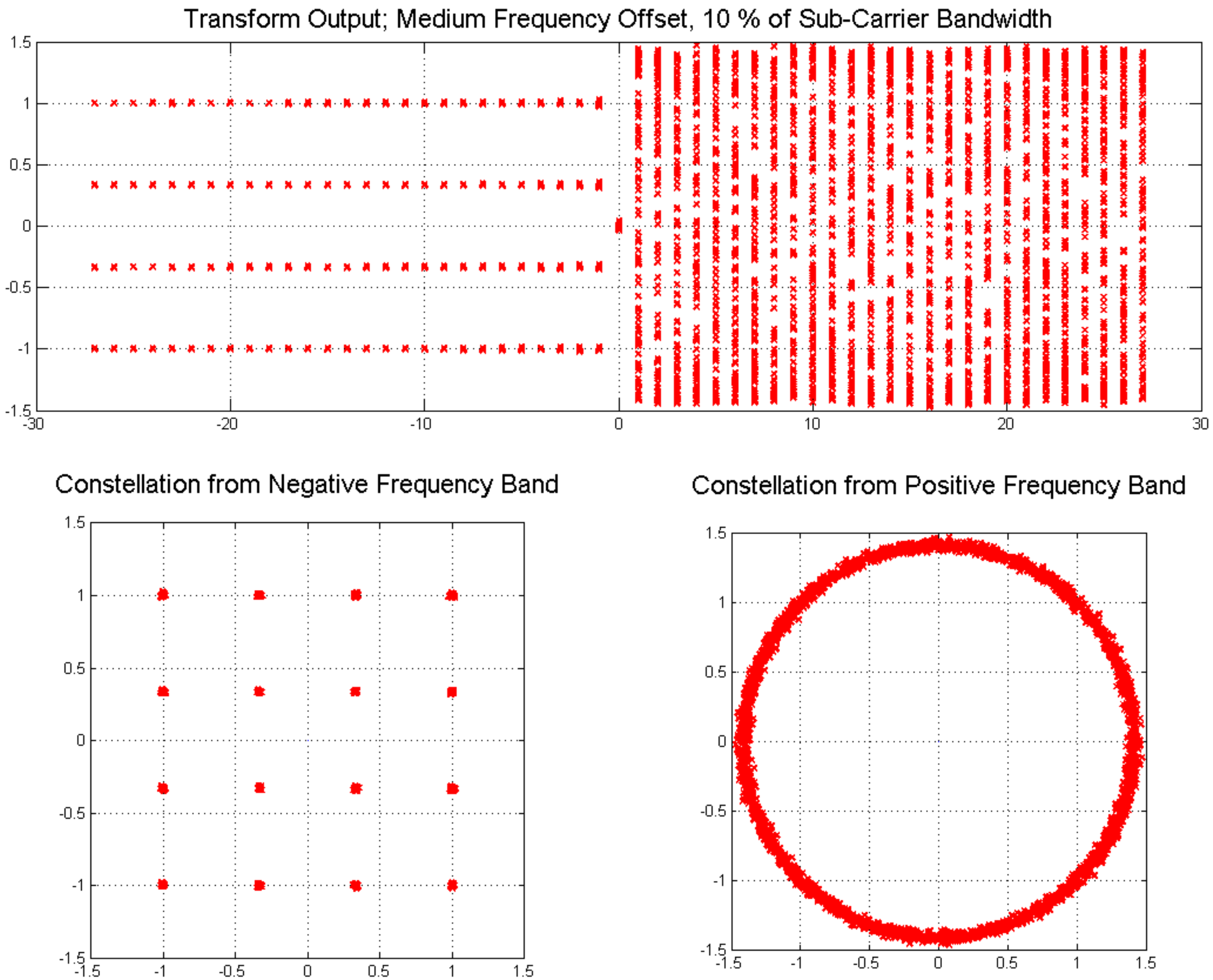
Spectral Terms and Constellations from Two-Band OFDMA Signal with 0.1% Frequency Offset Between two Bands



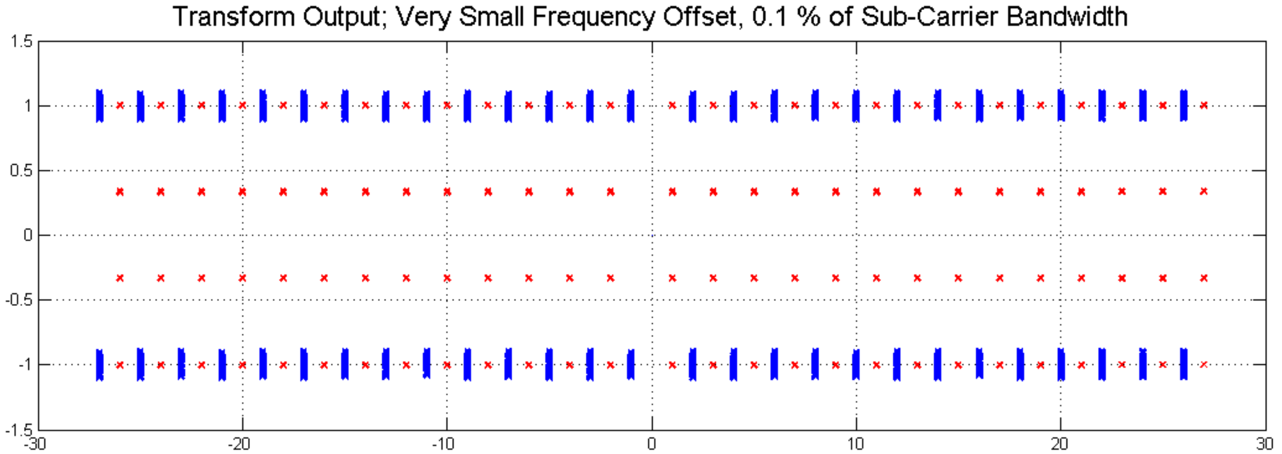
Spectral Terms and Constellations from Two-Band OFDMA Signal
with 1.0% Frequency Offset Between two Bands

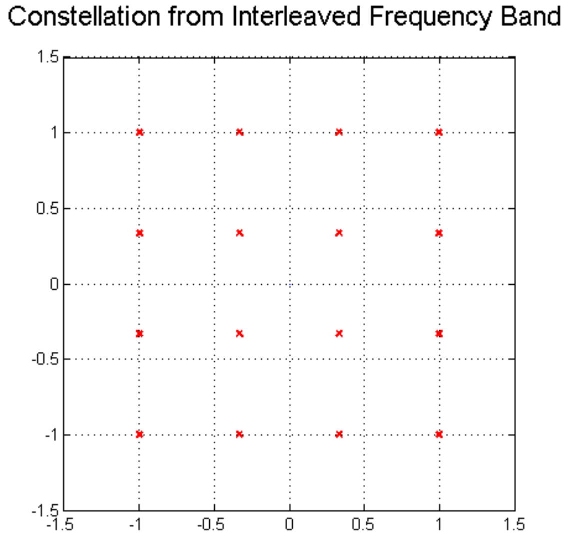


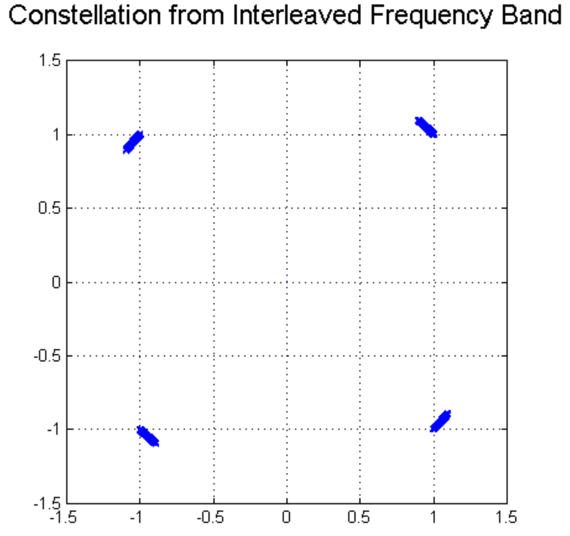
Spectral Terms and Constellations from Two-Band OFDMA Signal with 10.0% Frequency Offset Between two Bands



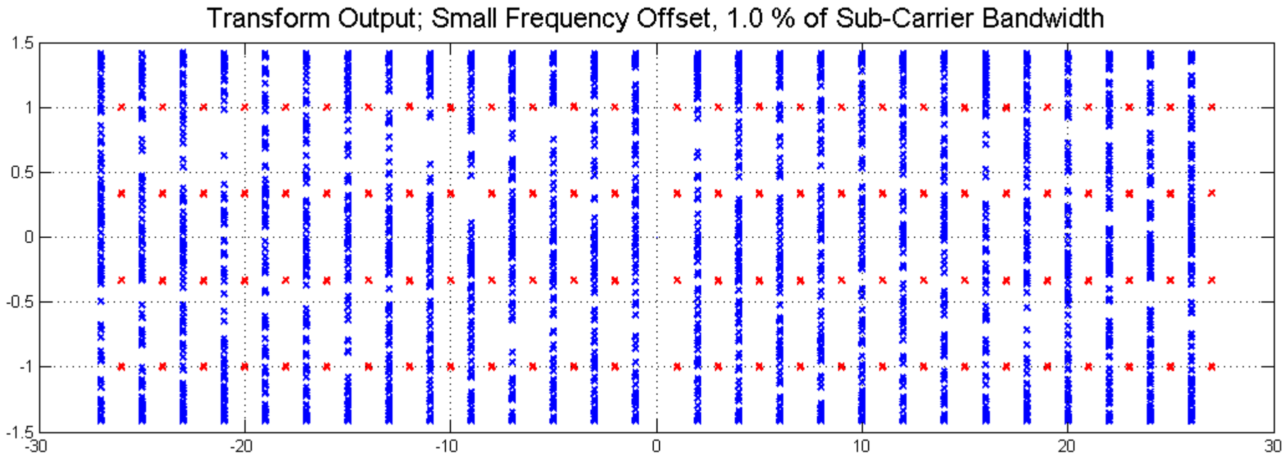
Spectral Terms and Constellations from Interleaved OFDMA Signal with 0.1% Frequency Offset Between two Bands

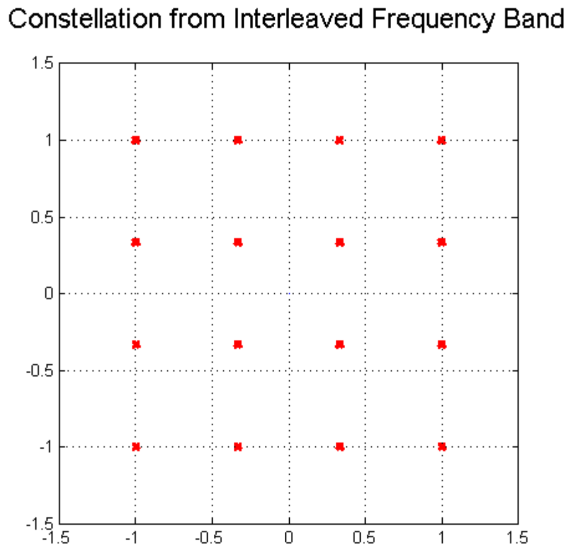


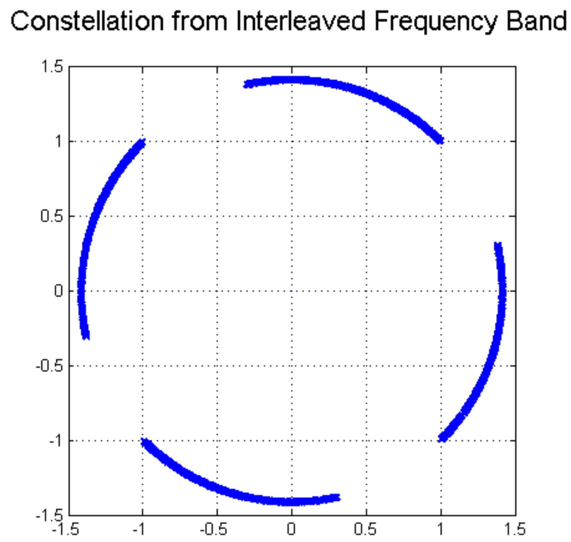




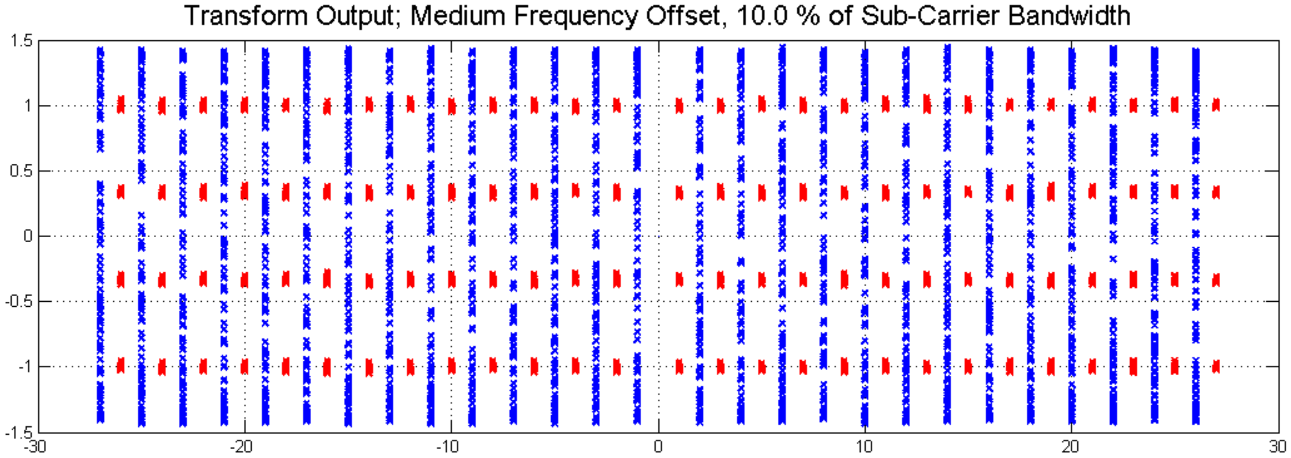
Spectral Terms and Constellations from Interleaved OFDMA Signal with 1.0% Frequency Offset Between two Bands

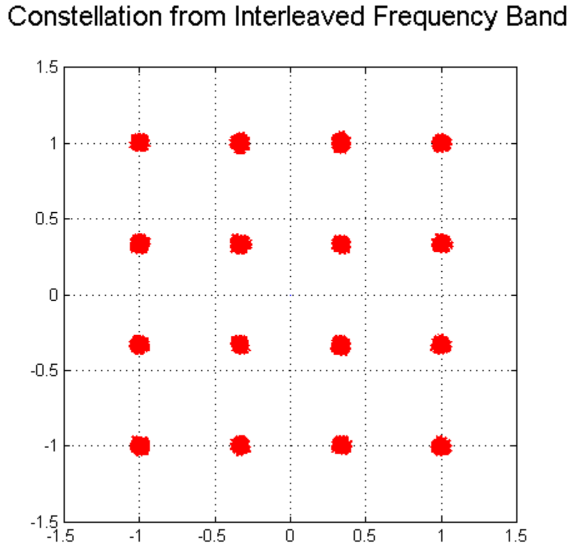


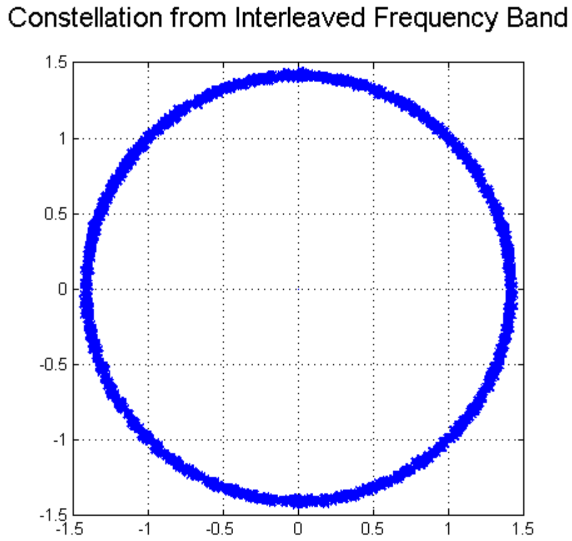




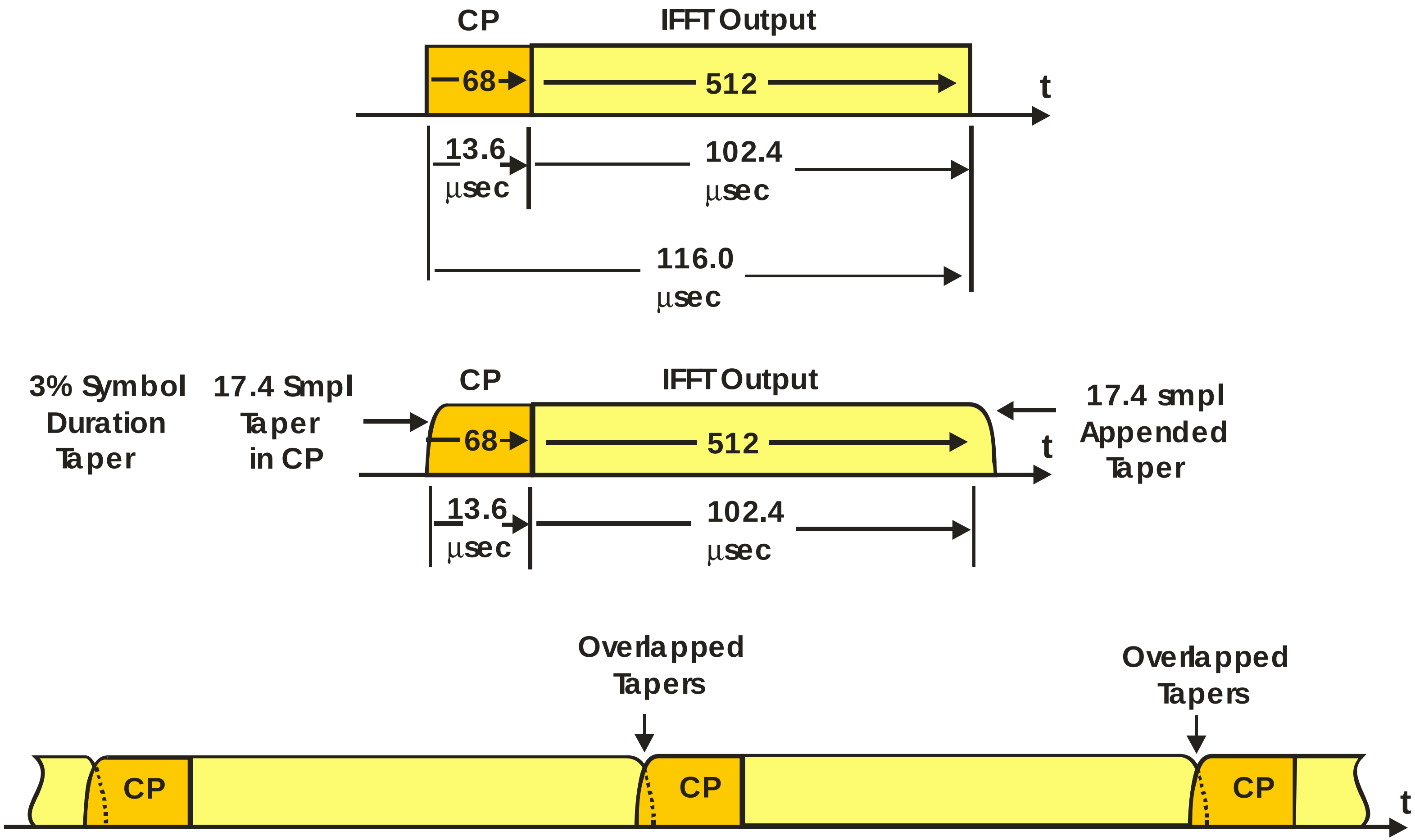
Spectral Terms and Constellations from Interleaved OFDMA Signal with 10.0% Frequency Offset Between two Bands



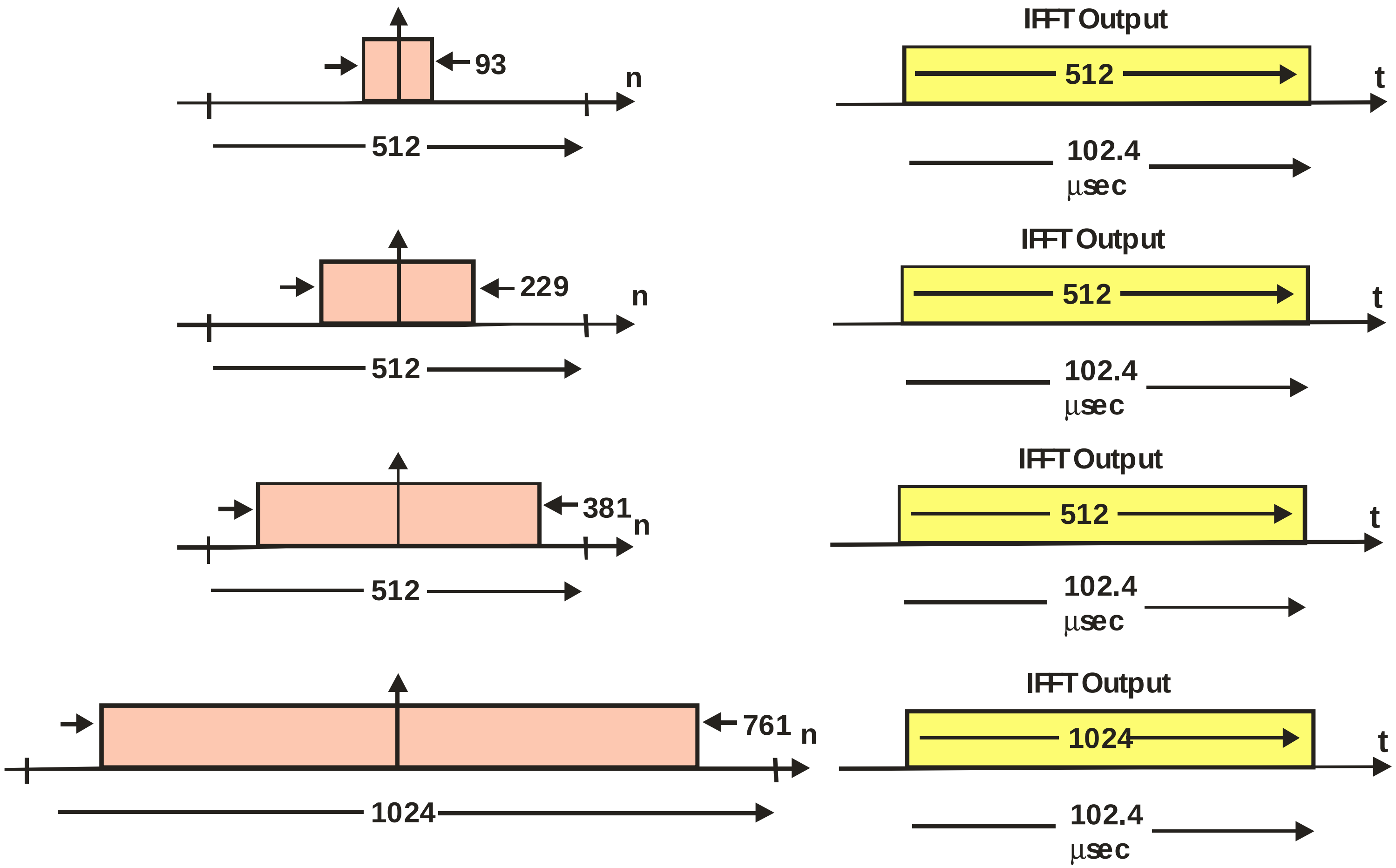




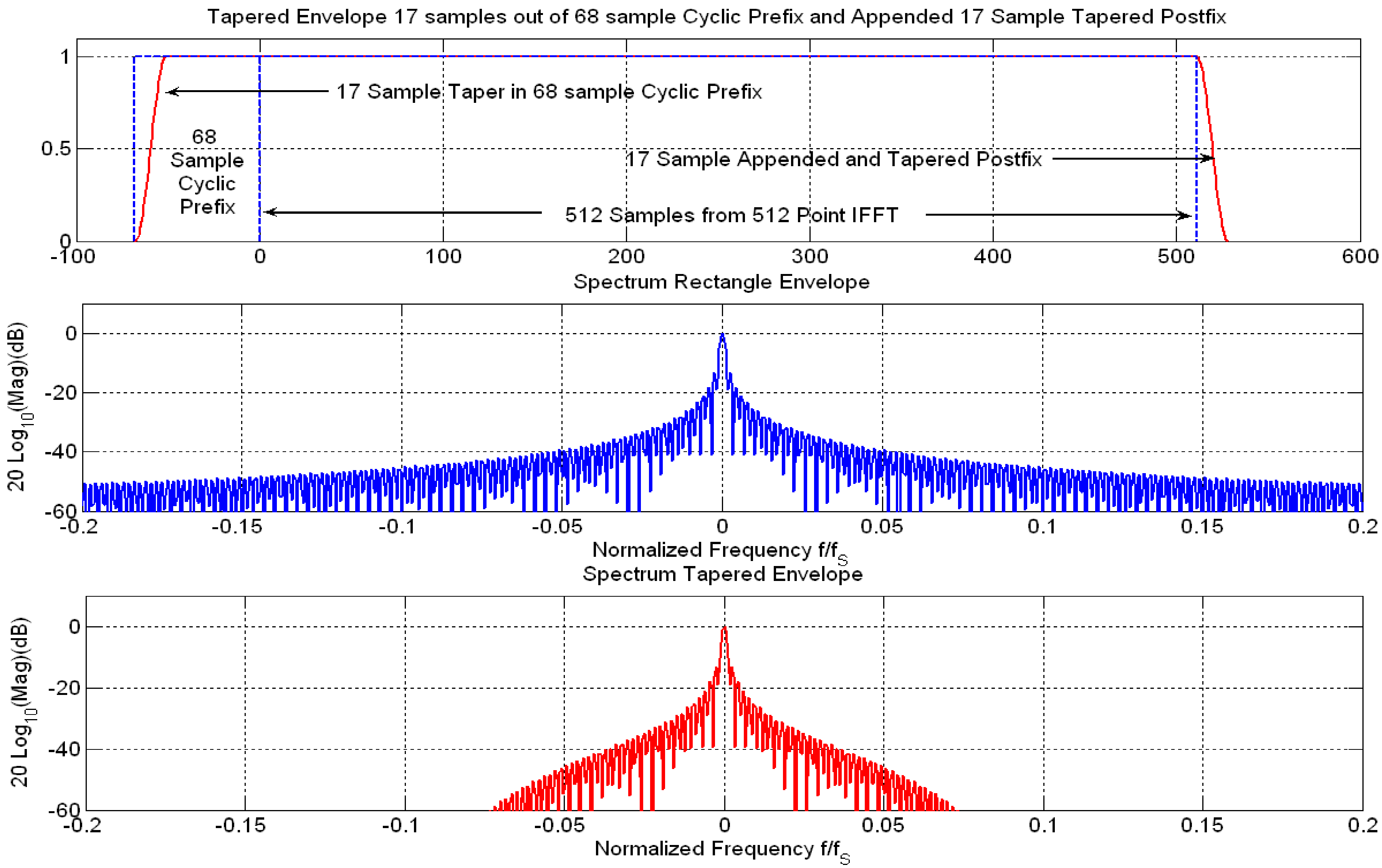
WNW OFDM Symbol;
Cyclic Prefix, Payload, and Tapers

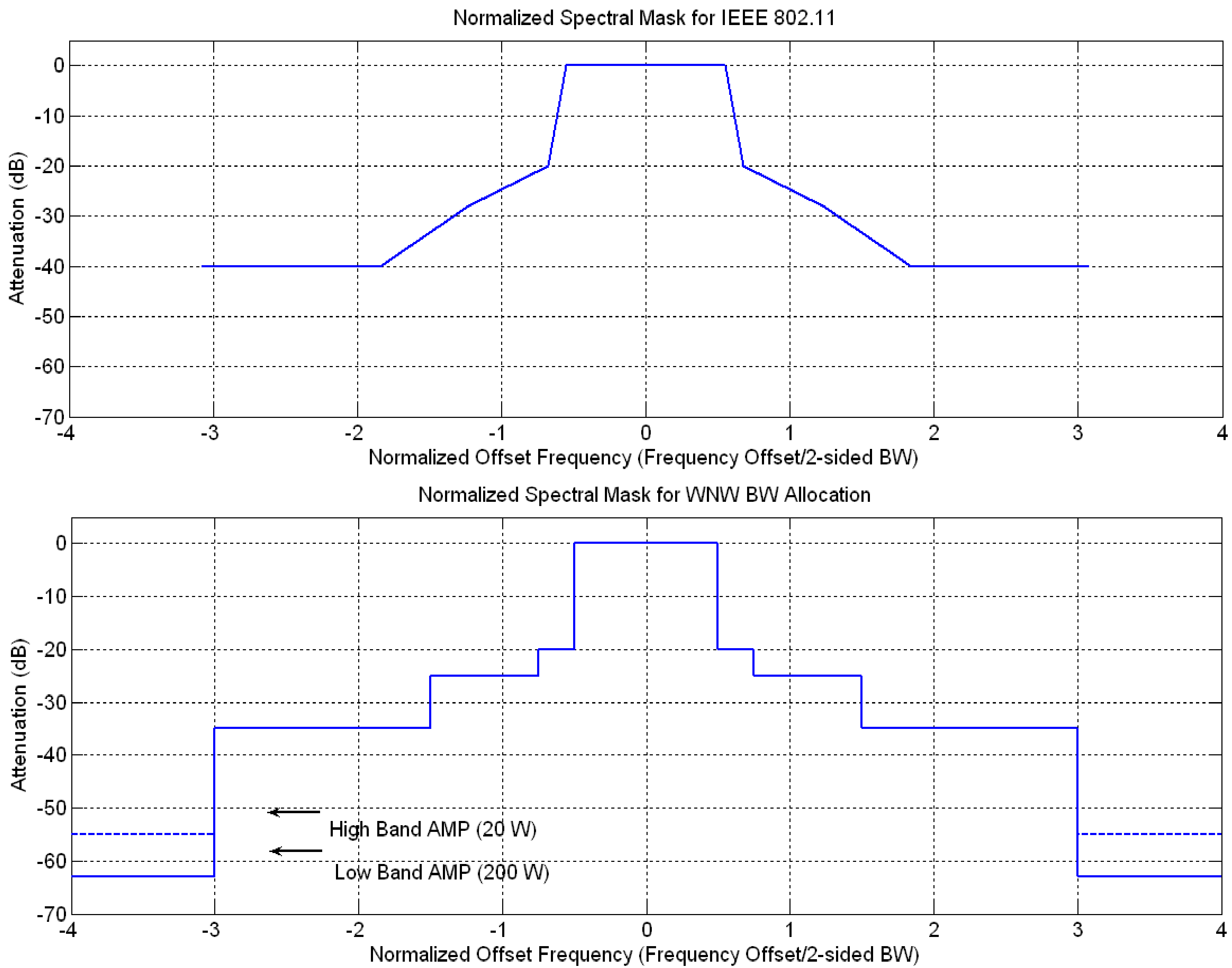


WNW OFDM Spectral Bin Width & IFFT Time Response and Duration

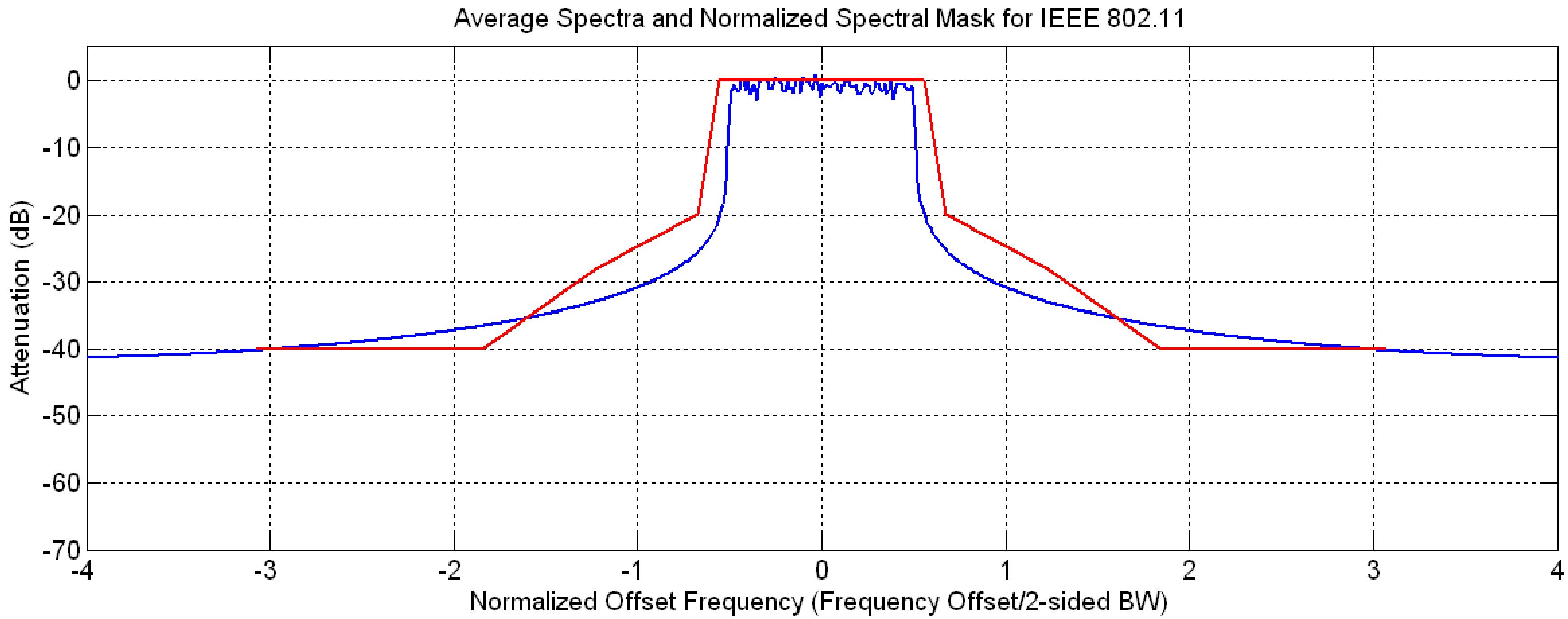


Tapered Envelope of WNW OFDM Symbol

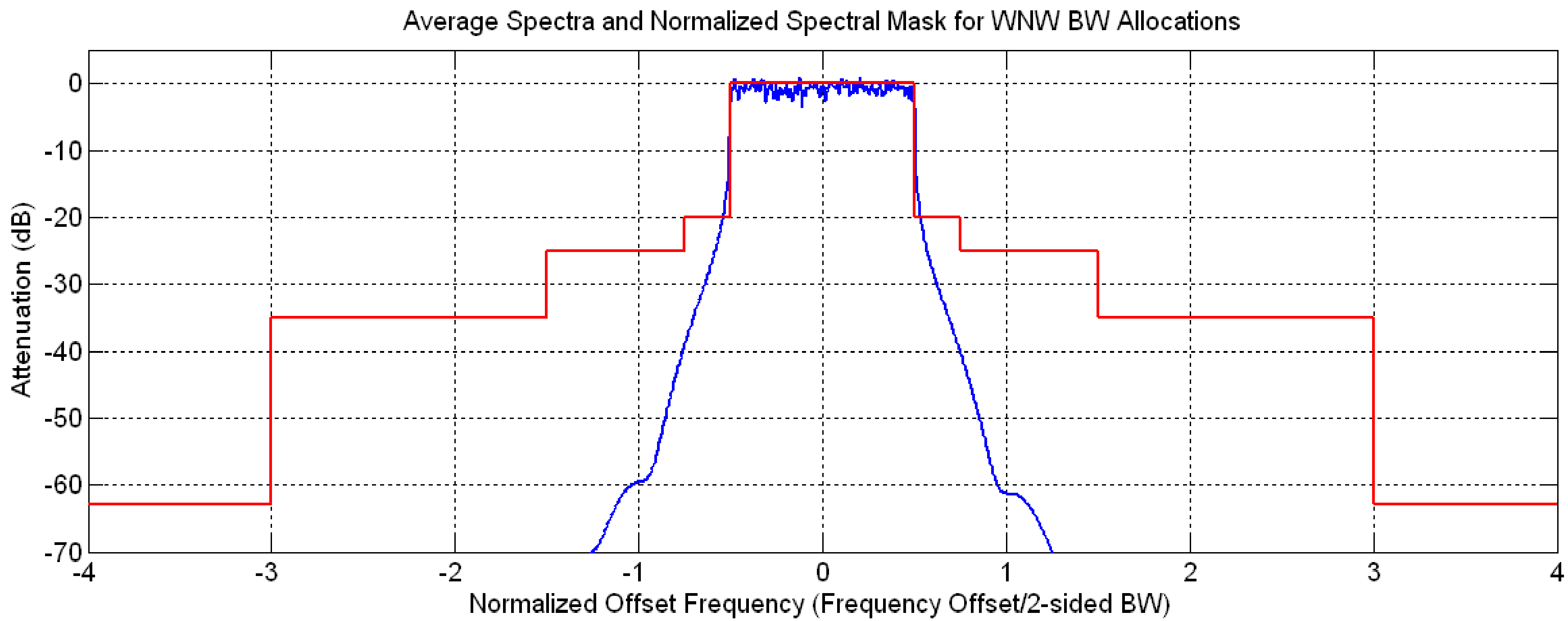




Normalized Spectral Mask for IEEE 802.11
Attenuation (dB)
Normalized Offset Frequency (Frequency Offset/2-sided BW)
Normalized Spectral Mask for WNW BW Allocation
Attenuation (dB)
High Band AMP (20 W)
Low Band AMP (200 W)
Normalized Offset Frequency (Frequency Offset/2-sided BW)

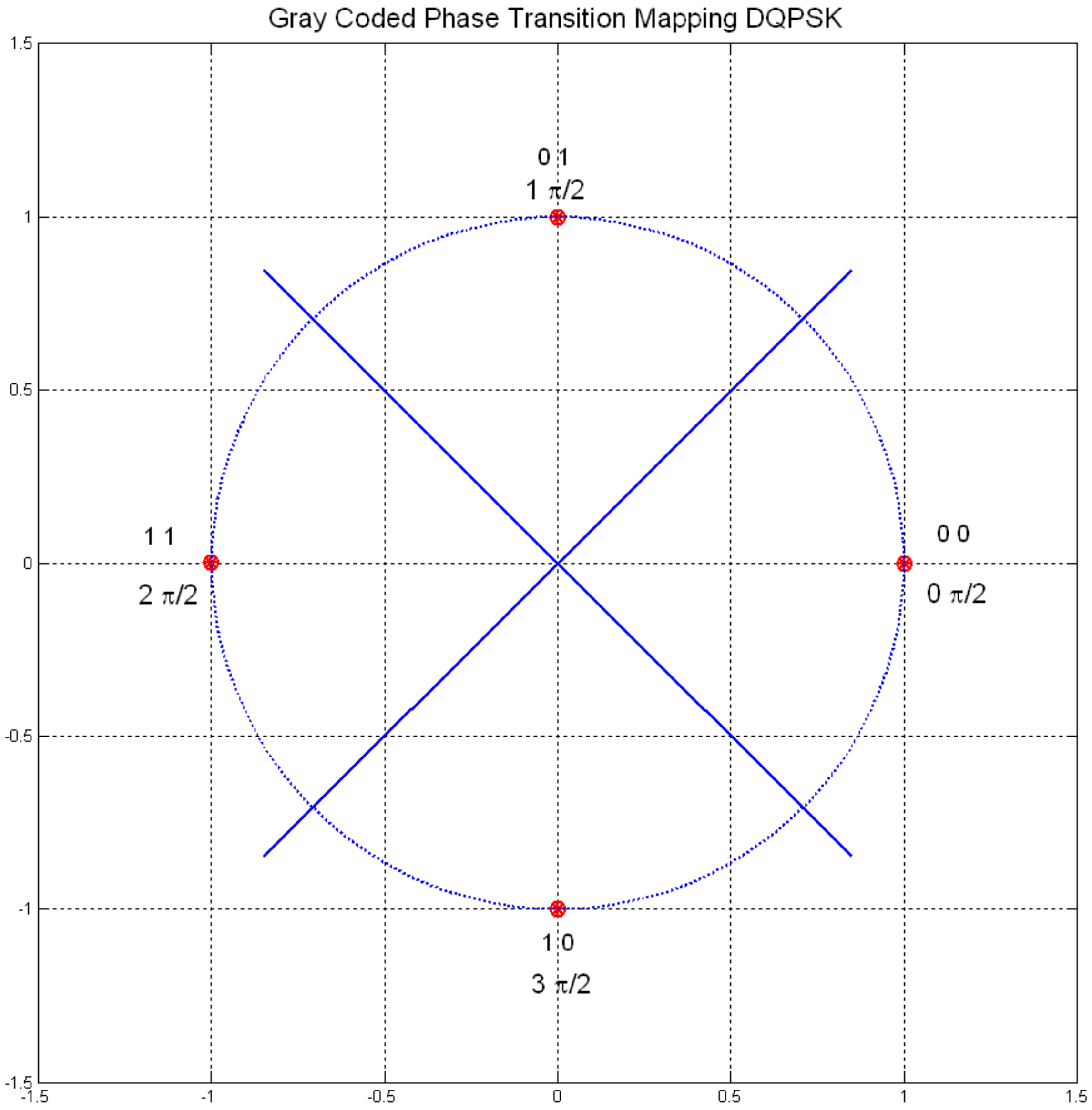


Average Spectra and Normalized Spectral Mask for IEEE 802.11
Attenuation (dB)
0
-10
-20
-30
-40
-50
-60
-70
-4
-3
-2
-1
0
1
2
3
4
Normalized Offset Frequency (Frequency Offset/2-sided BW)

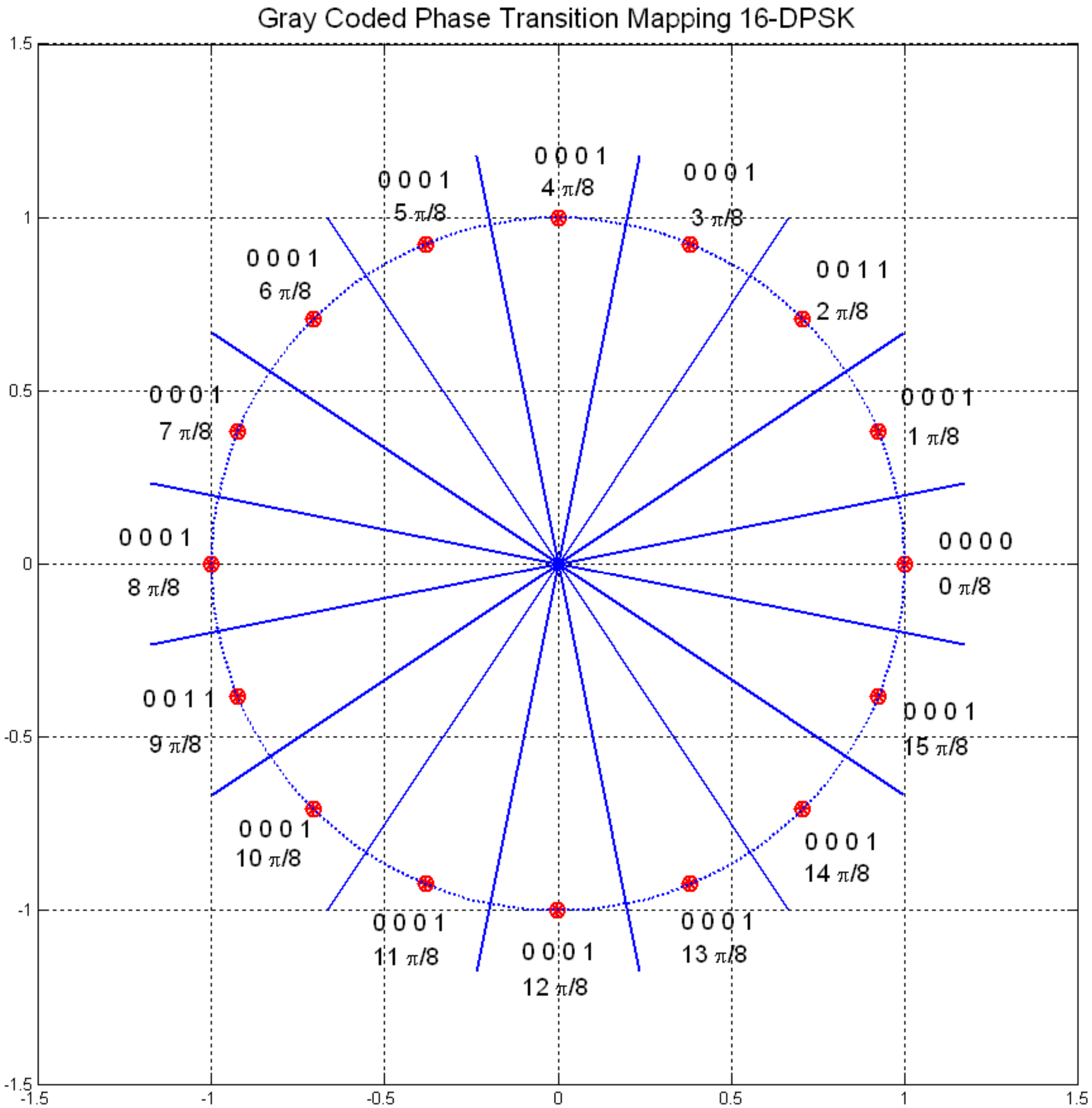


Average Spectra and Normalized Spectral Mask for WNW BW Allocations
Attenuation (dB)
0
-10
-20
-30
-40
-50
-60
-70
-4
-3
-2
-1
0
1
2
3
4
Normalized Offset Frequency (Frequency Offset/2-sided BW)

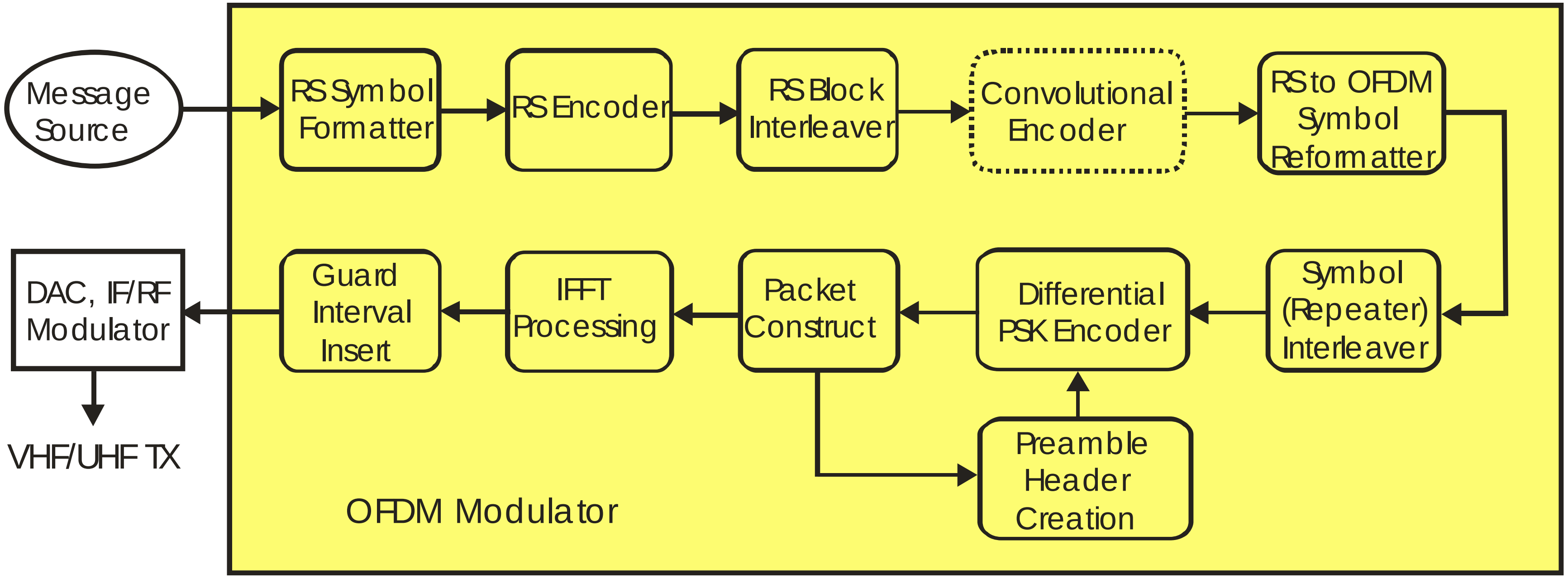
Phase Transition Mapping DQPSK



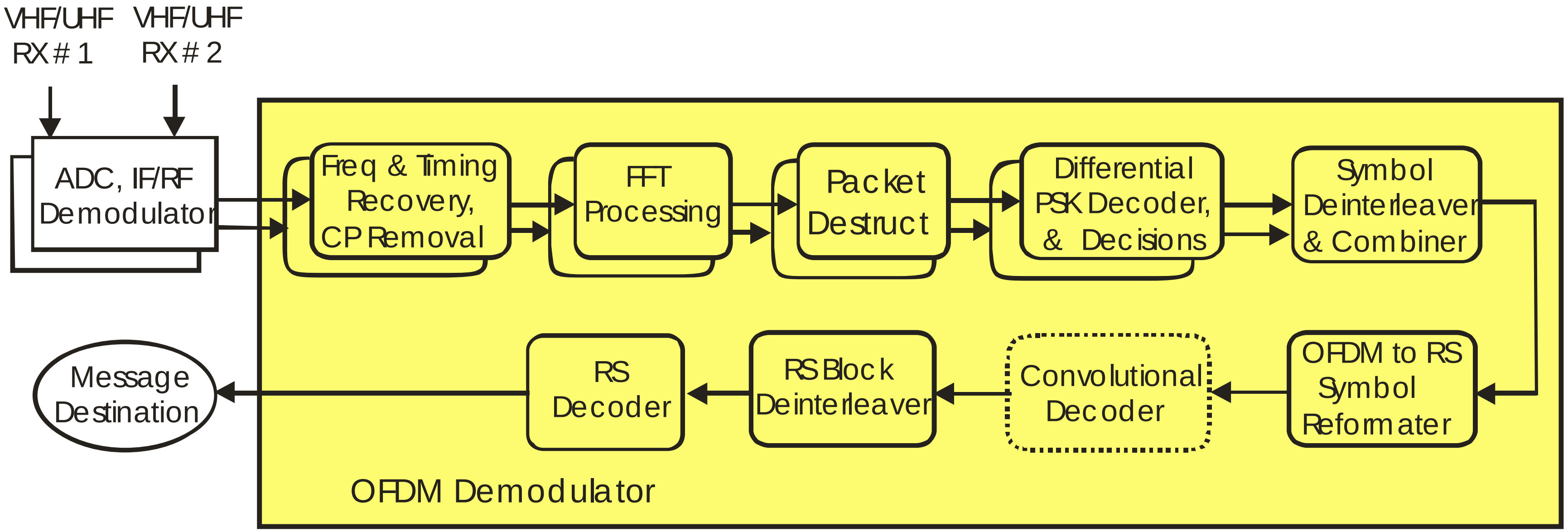
Phase Transition Mapping 16-DQPSK



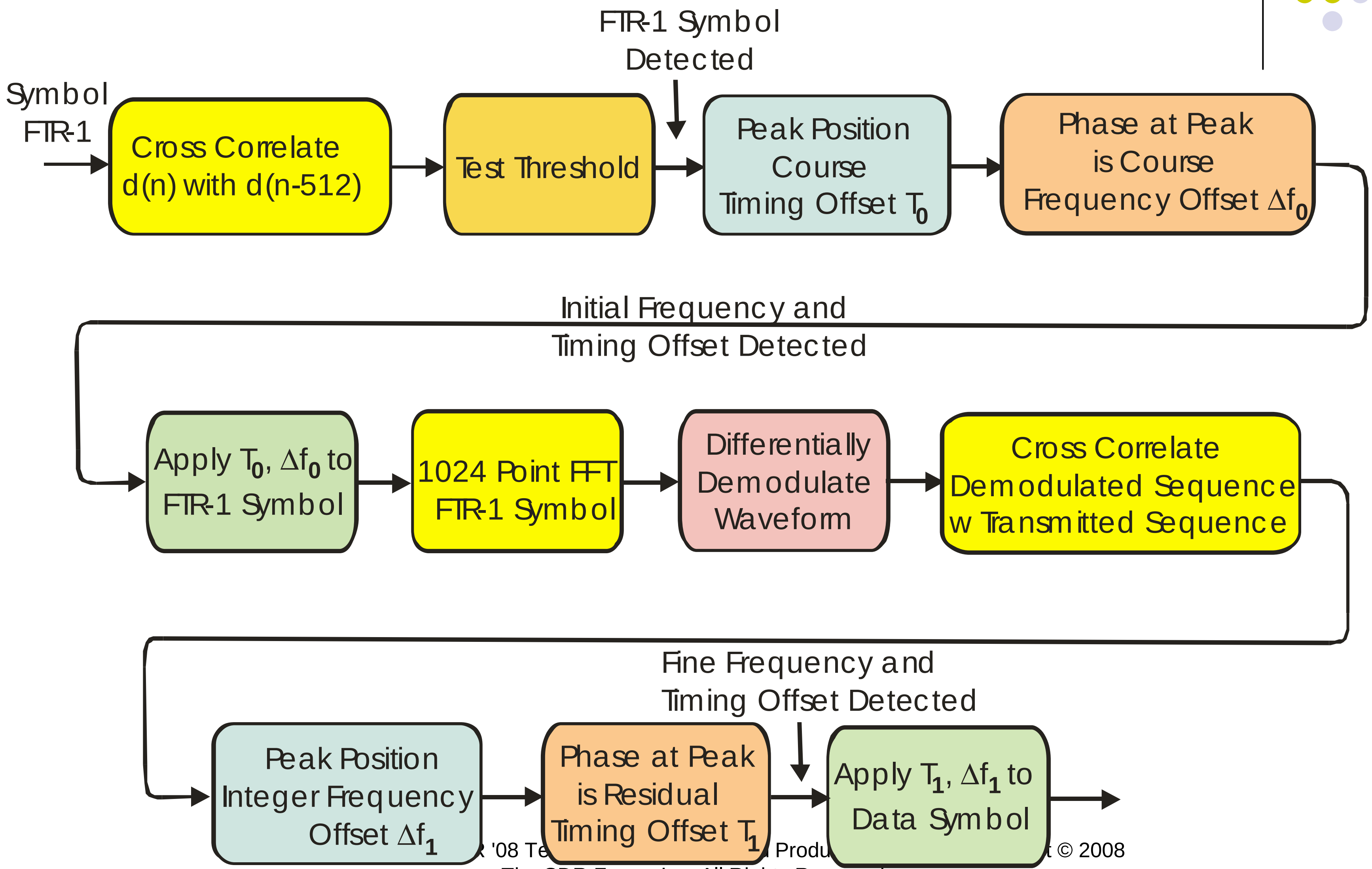
OFDM Modulator



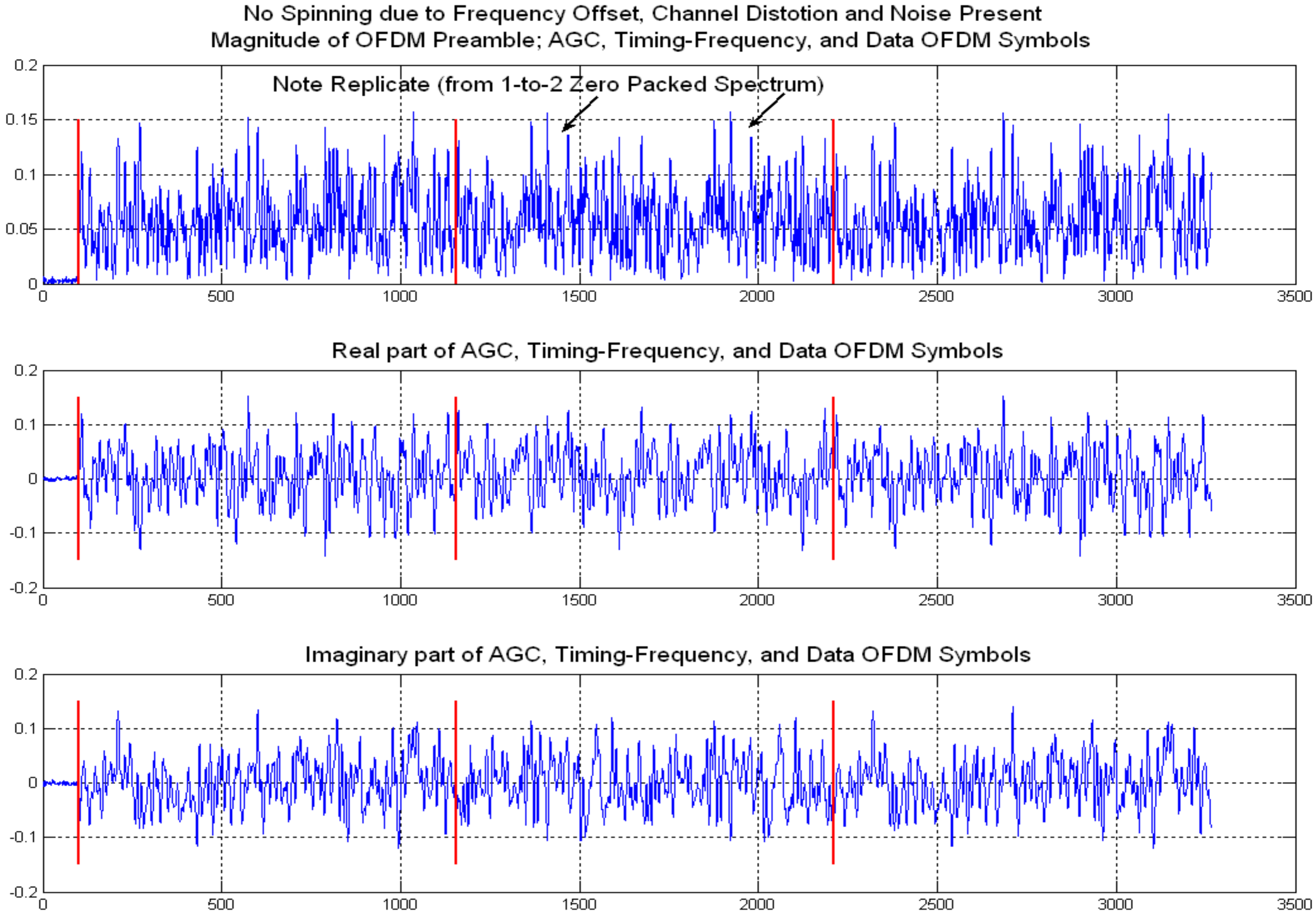
OFDM Demodulator



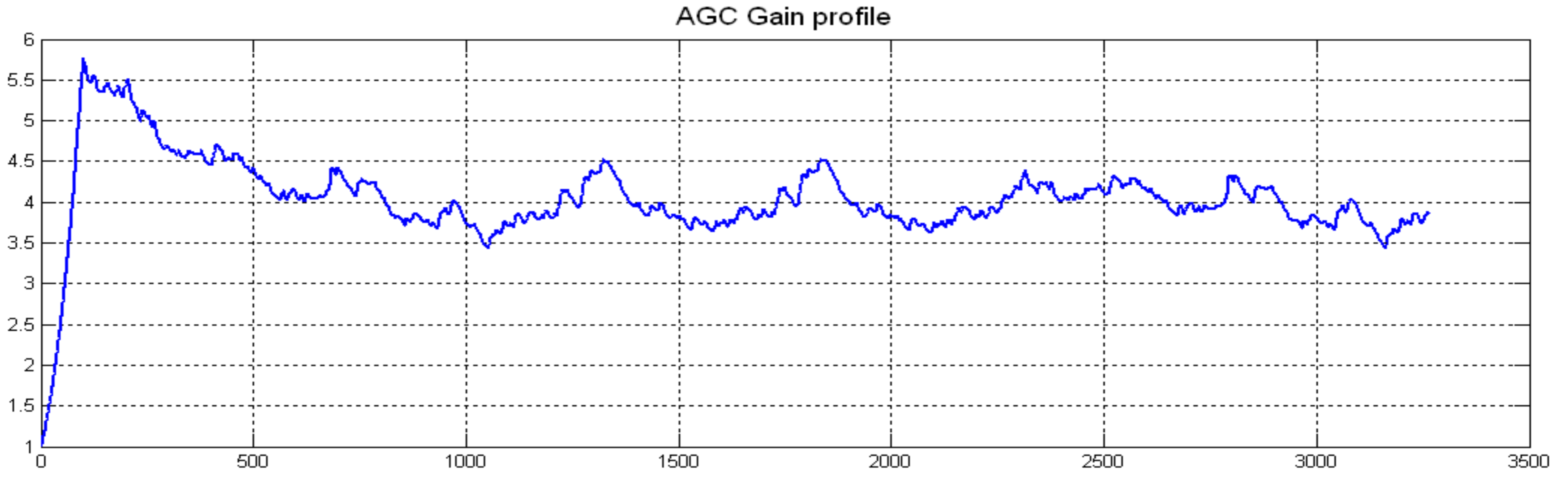
Processing Flow for Timing Frequency Recovery (FTR) Symbol

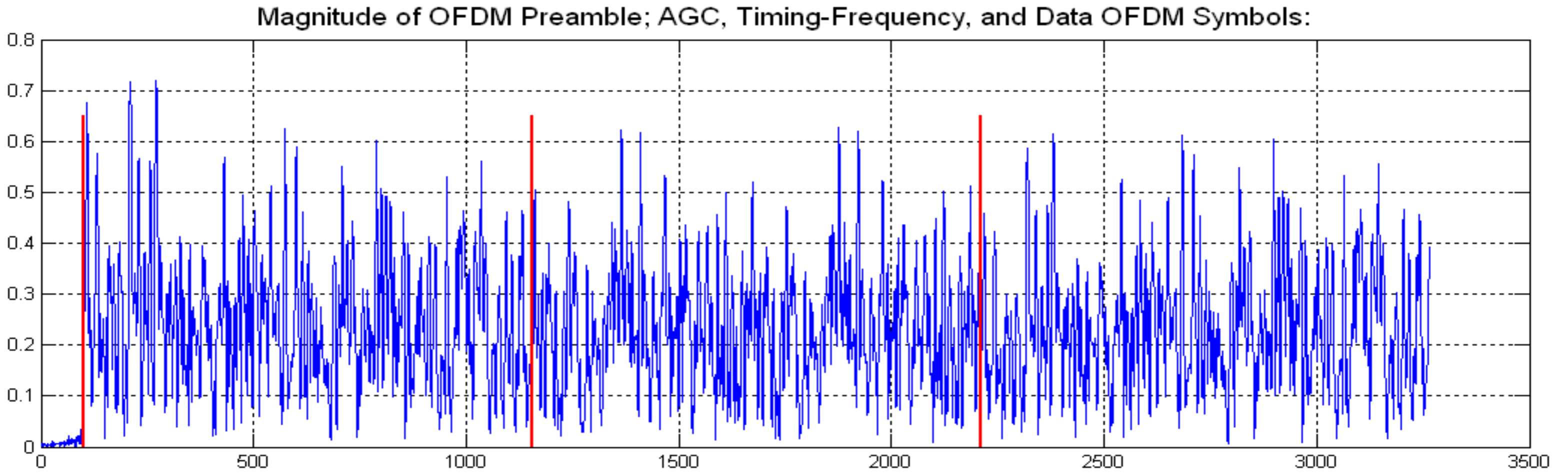


AGC & Timing-Frequency Symbols

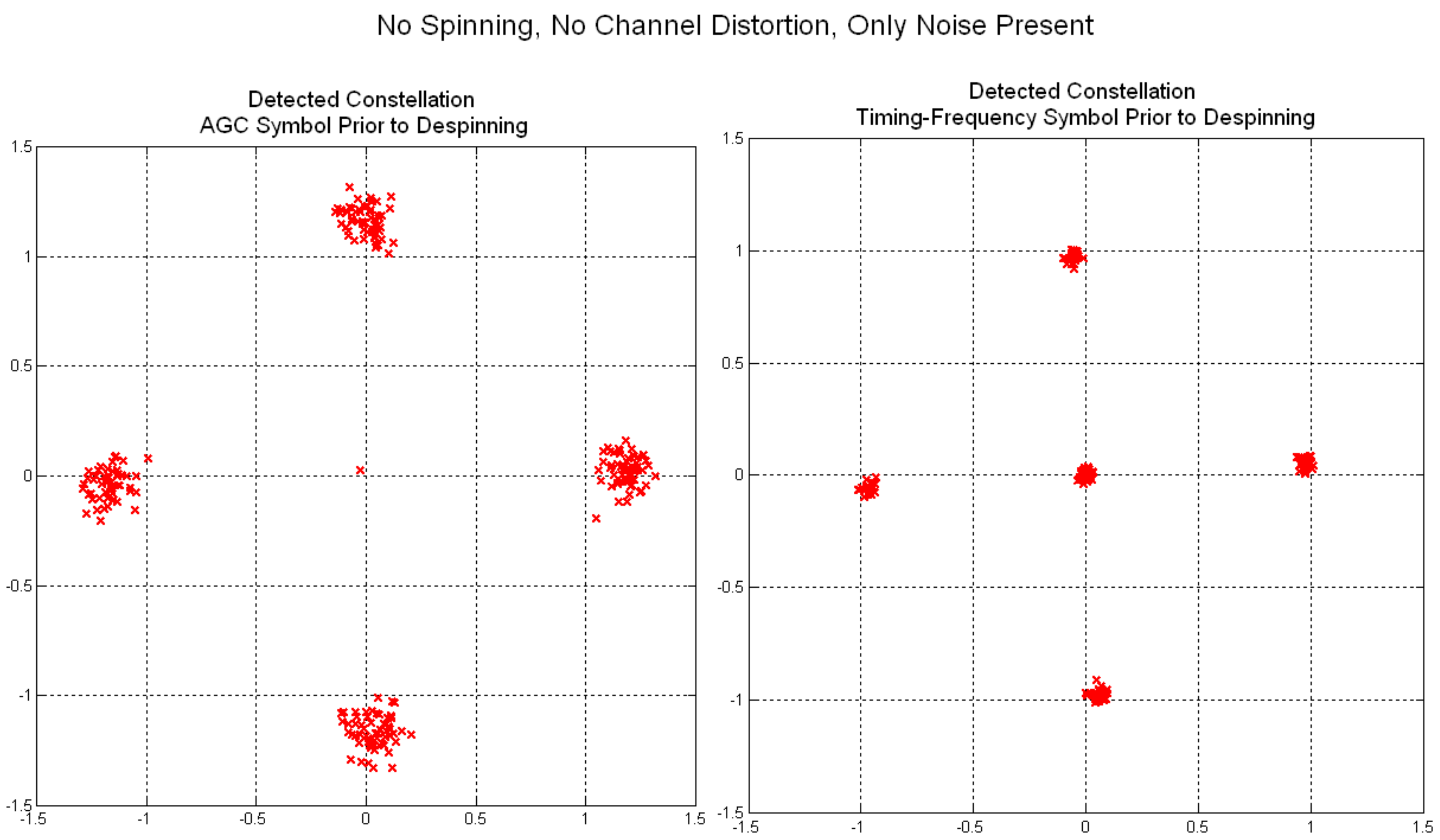


AGC Gain Profile & AGC'd Preamble

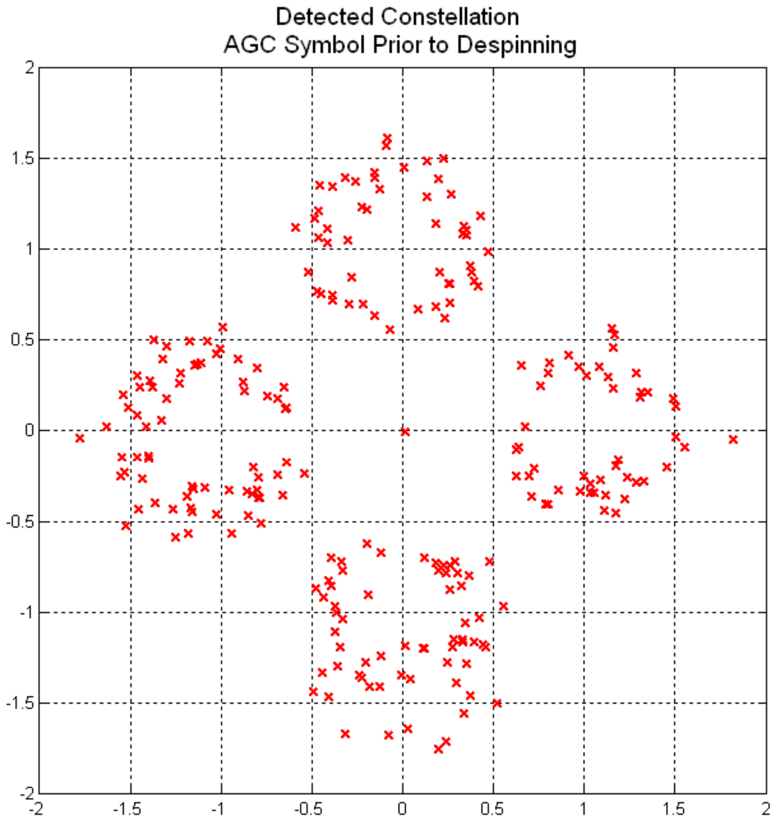


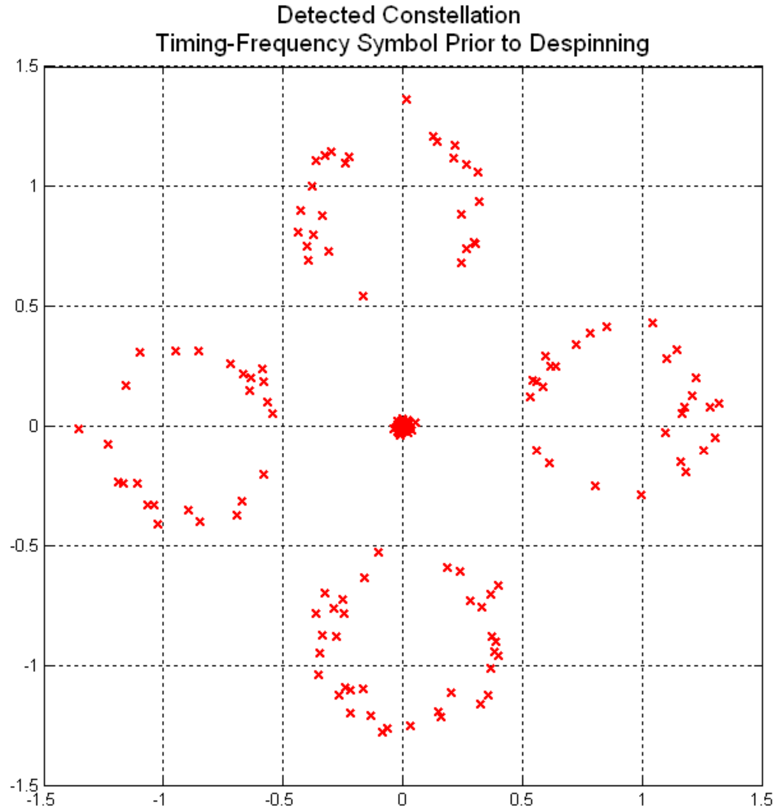


Constellations:
No Channel Distortion

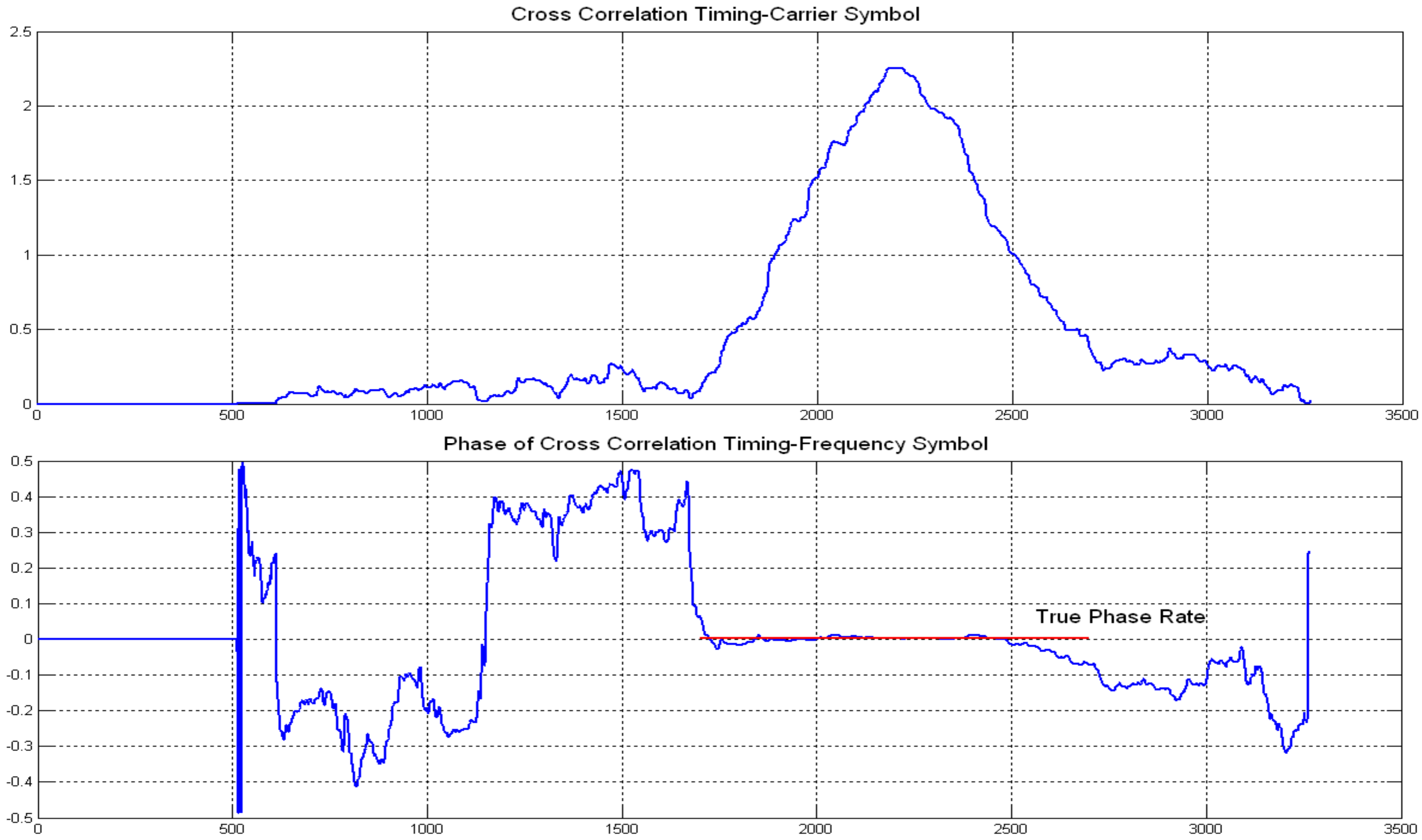


Constellations: Channel Distortion Effect

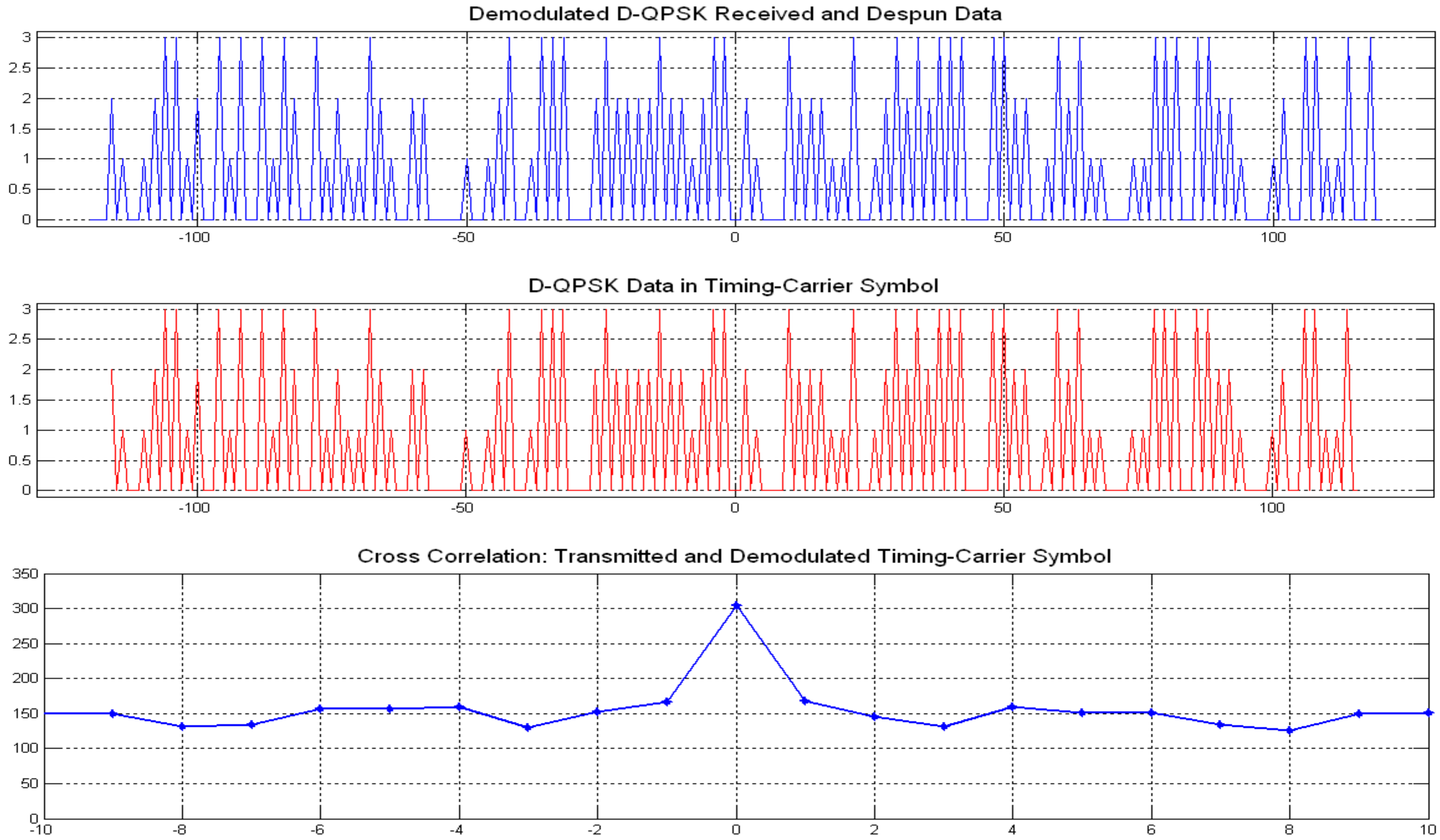




Cross Correlation Amplitude and Phase Profiles

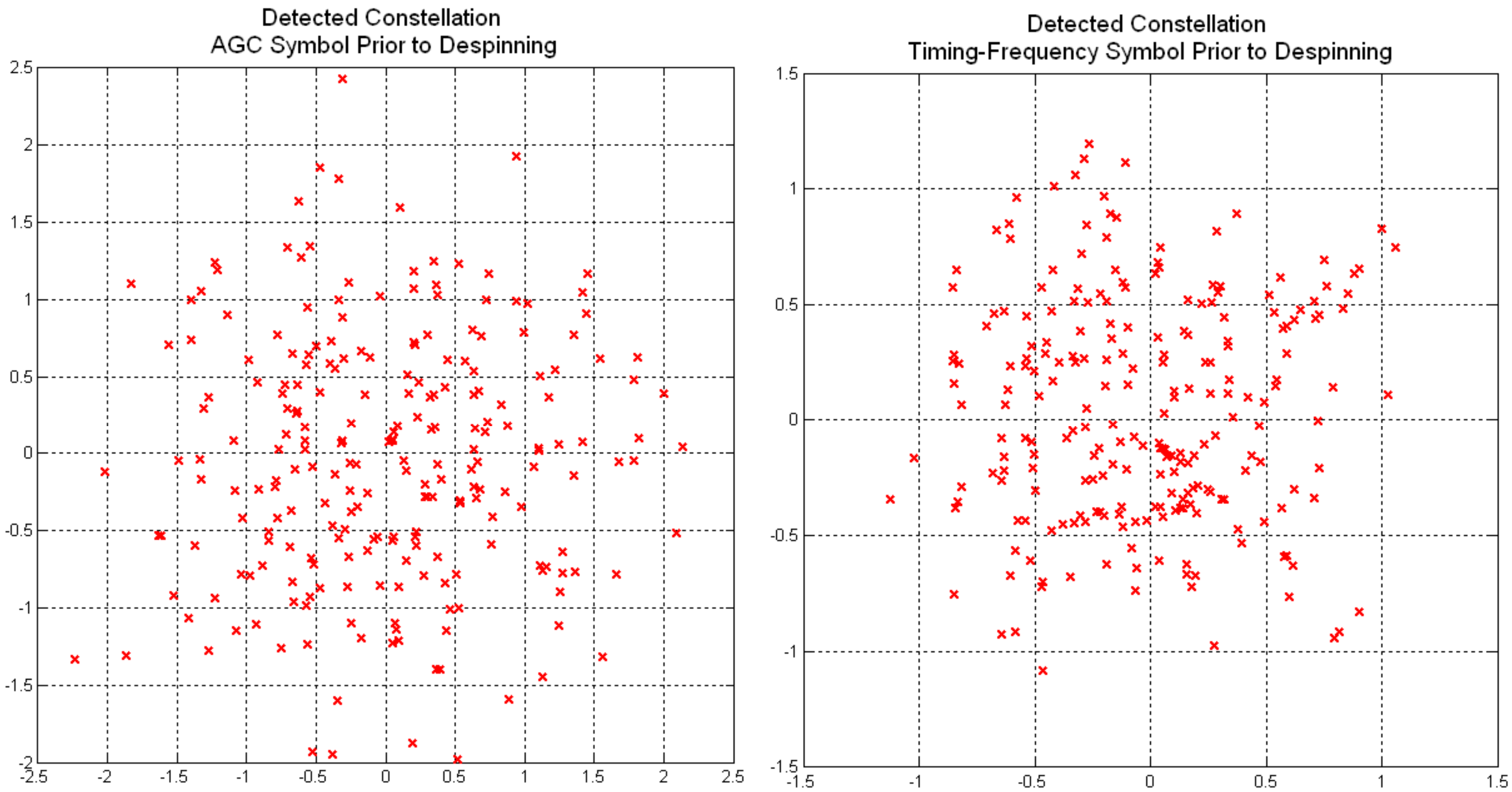


Received and Transmitted Data in Time-Frequency Symbol and Cross Correlation of Two Data Sets

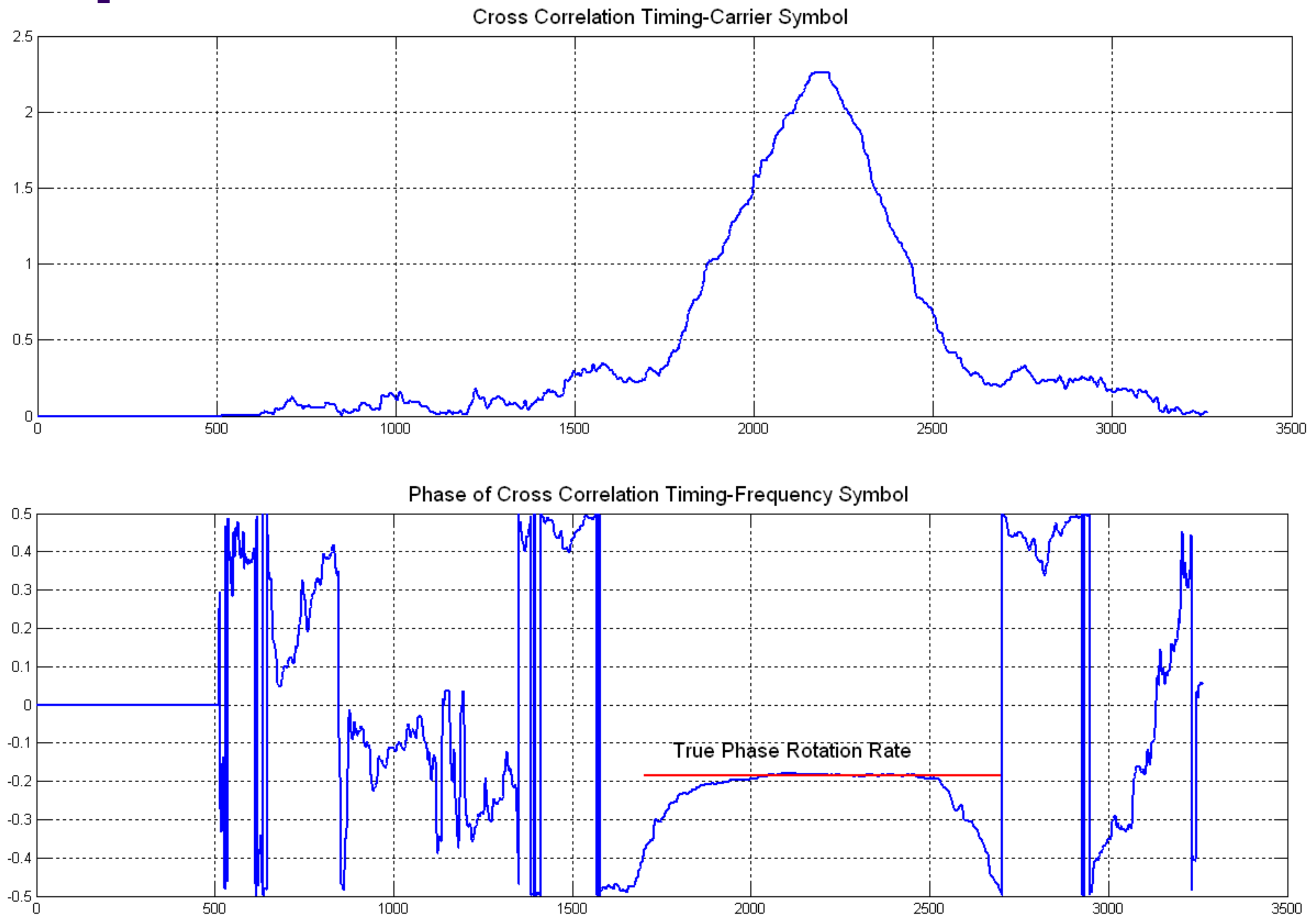


Constellations: Spinning and Channel Distortion Effect

Data Spinning, Channel Distortion, and Noise Prior to Despinning



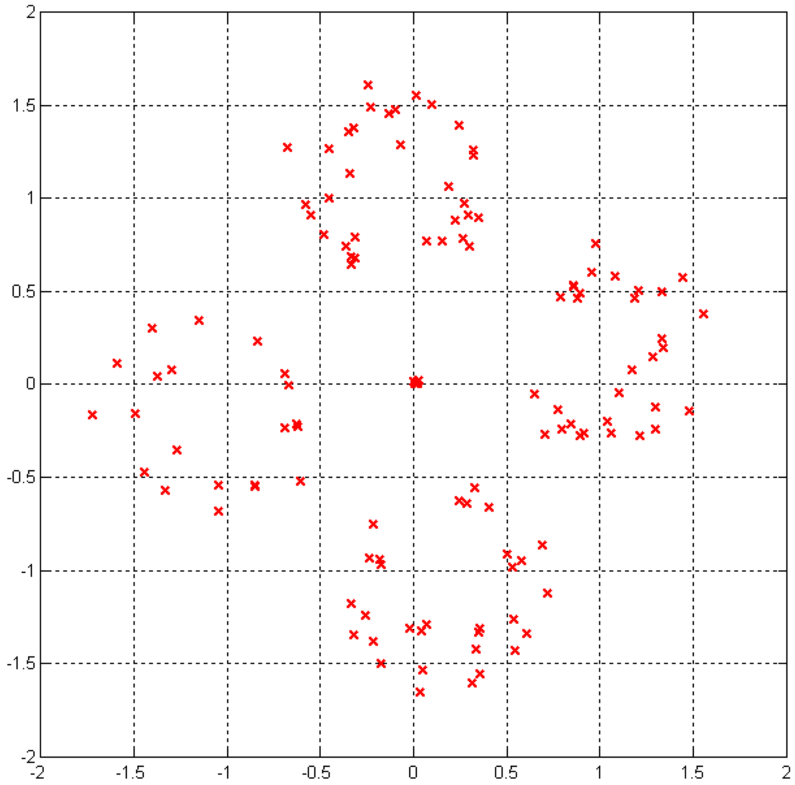
Cross Correlation Amplitude and Phase Profiles



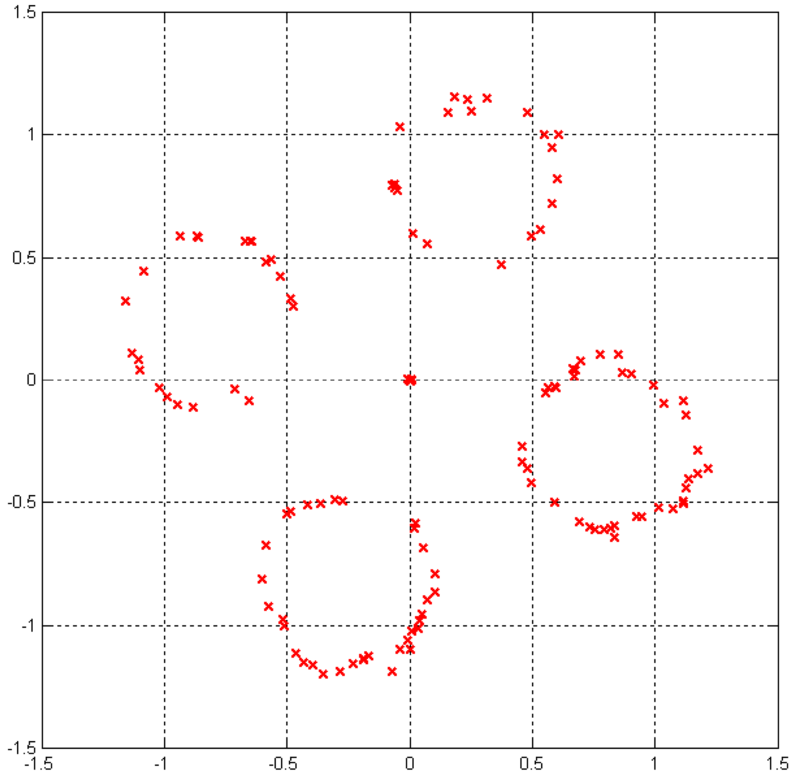
Constellations: After De Spinning, Channel Distortion Effect

Channel Distortion and Noise, After Despinning Operation

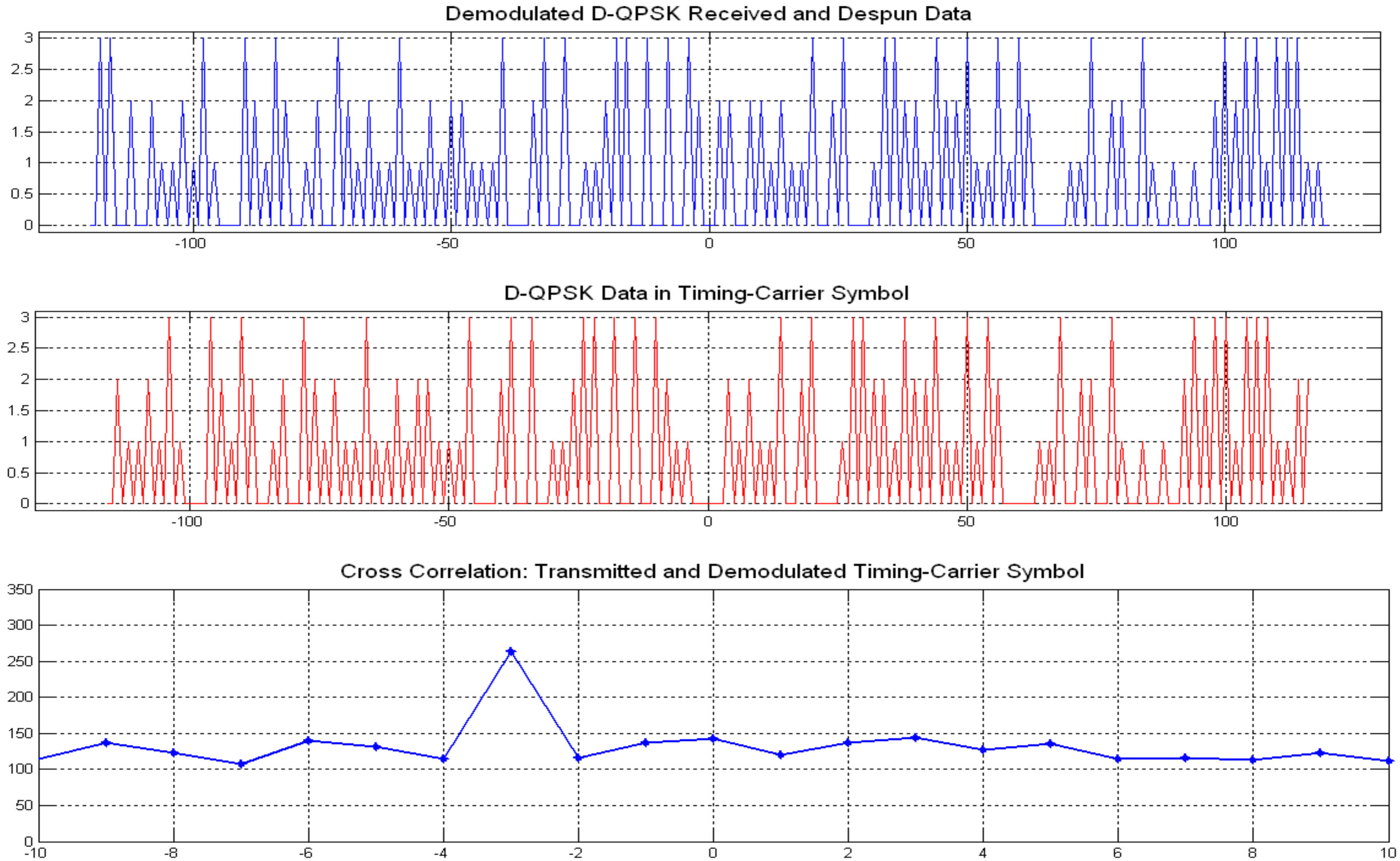
Detected Constellation AGC Symbol After Despinning



Detected Constellation Timing-Frequency Symbol After Despinning



Received and Transmitted Data in Time-Frequency Symbol and Cross Correlation of Two Data Sets



Important Variants of OFDM

OFDM with Amplitude and Phase Overlays

OQAM OFDM

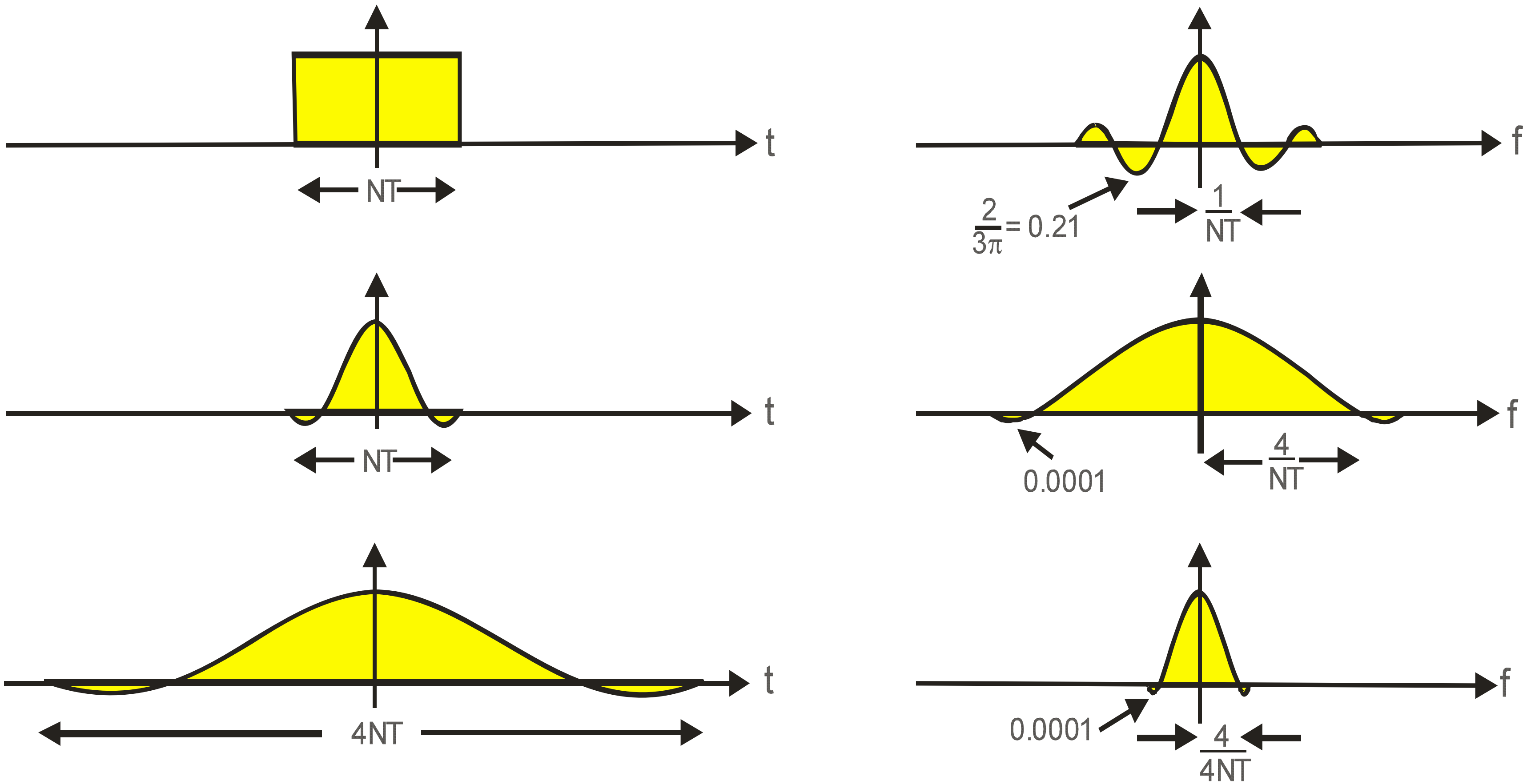
Offset Quadrature

Amplitude Modulation

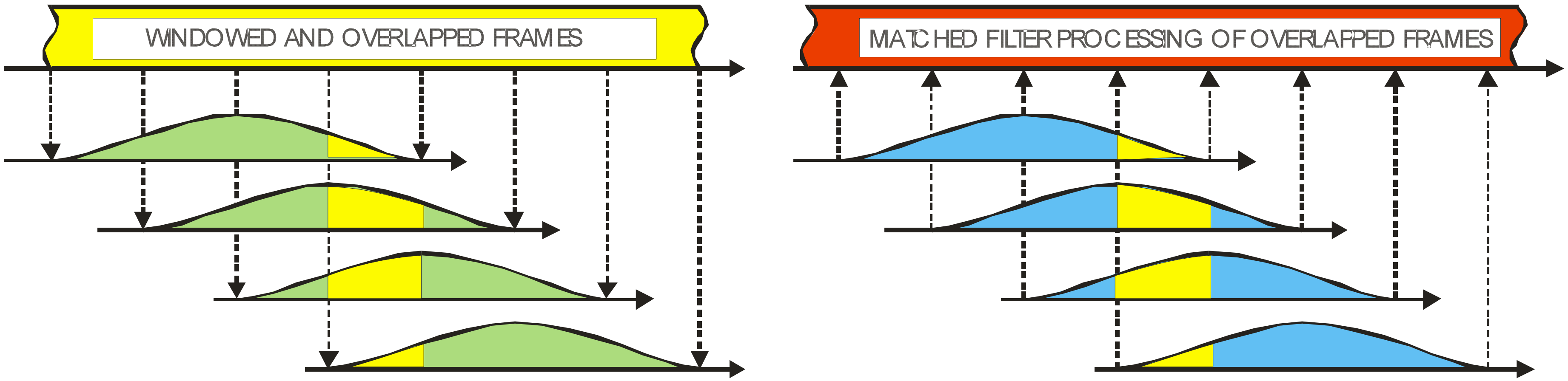
Complementary Code Keying

CC-OFDM

Shape to Control Spectral Side Lobes



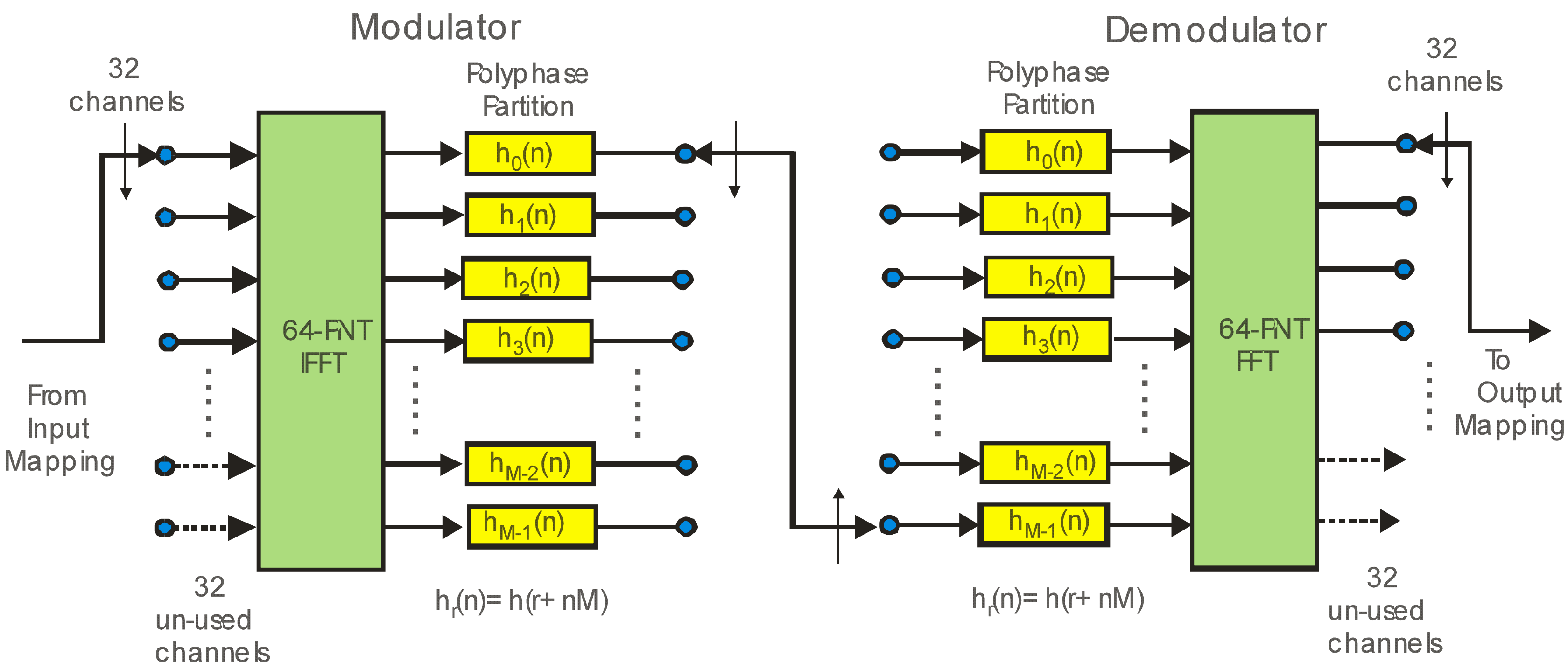
Overlapped OFDM Frames



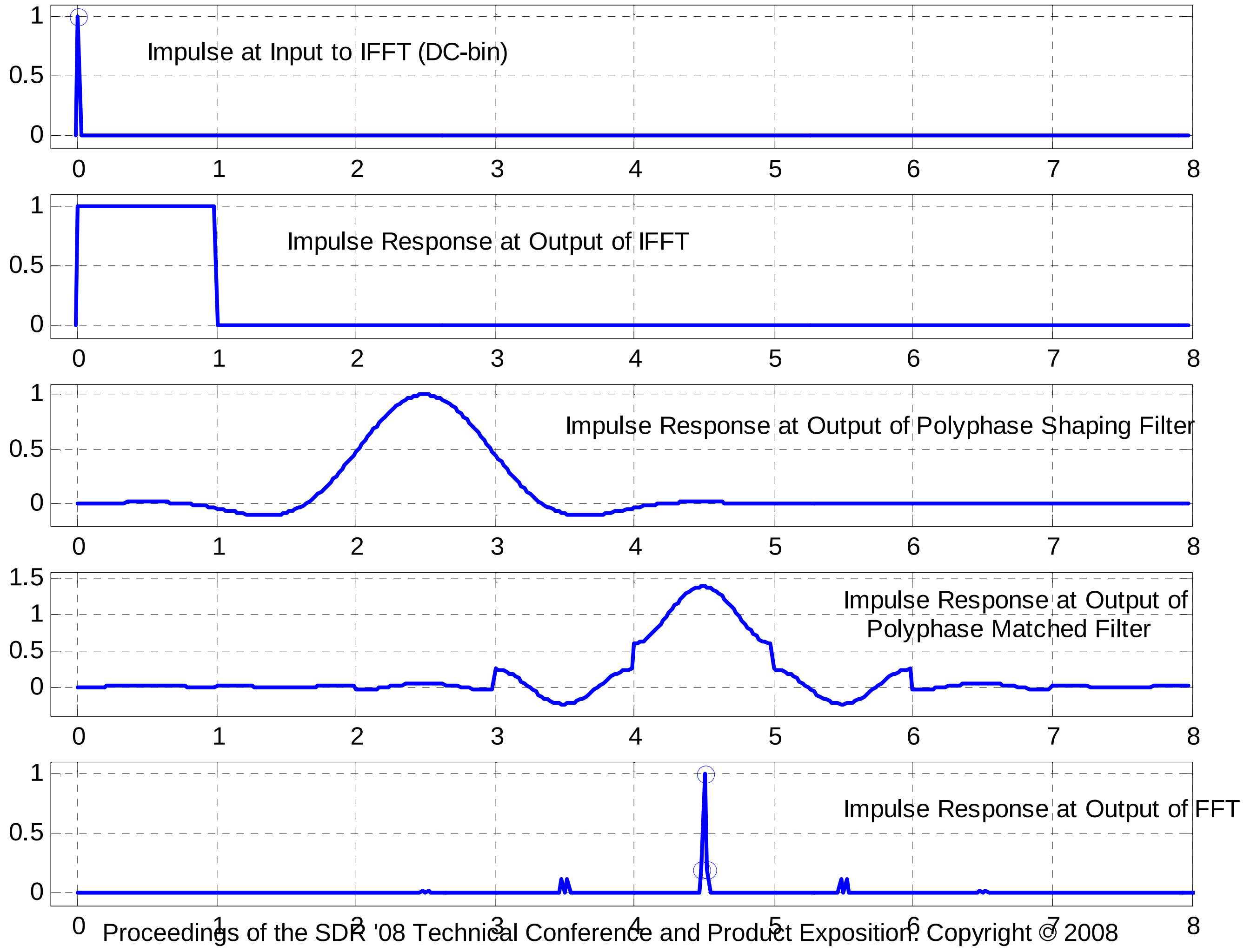
Overlapped Frame Time Intervals
at Modulator

Overlapped Frame Time Intervals
at Demodulator

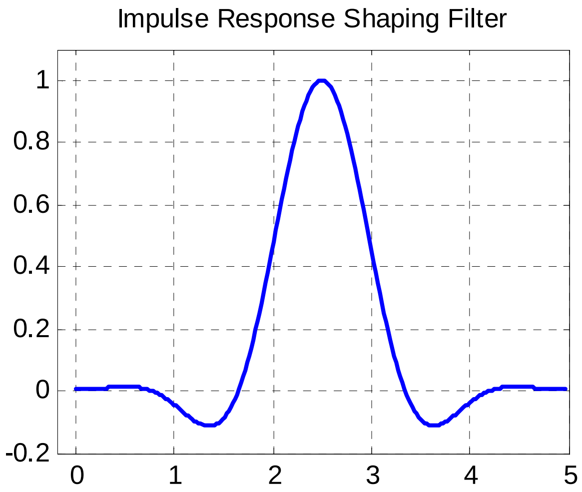
Polyphase Filter For Shaped OFDM Shaping and Matched Filter

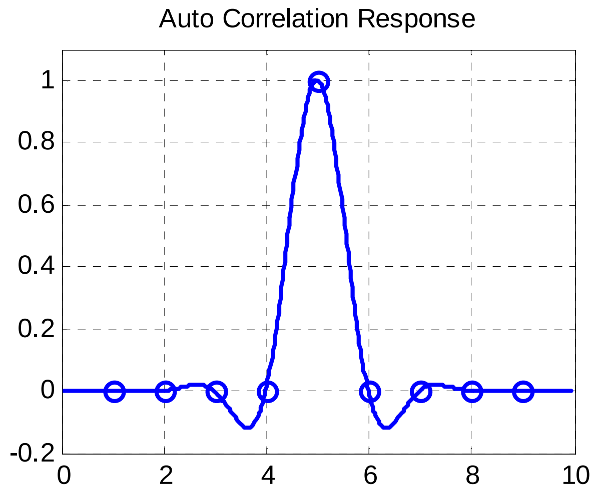


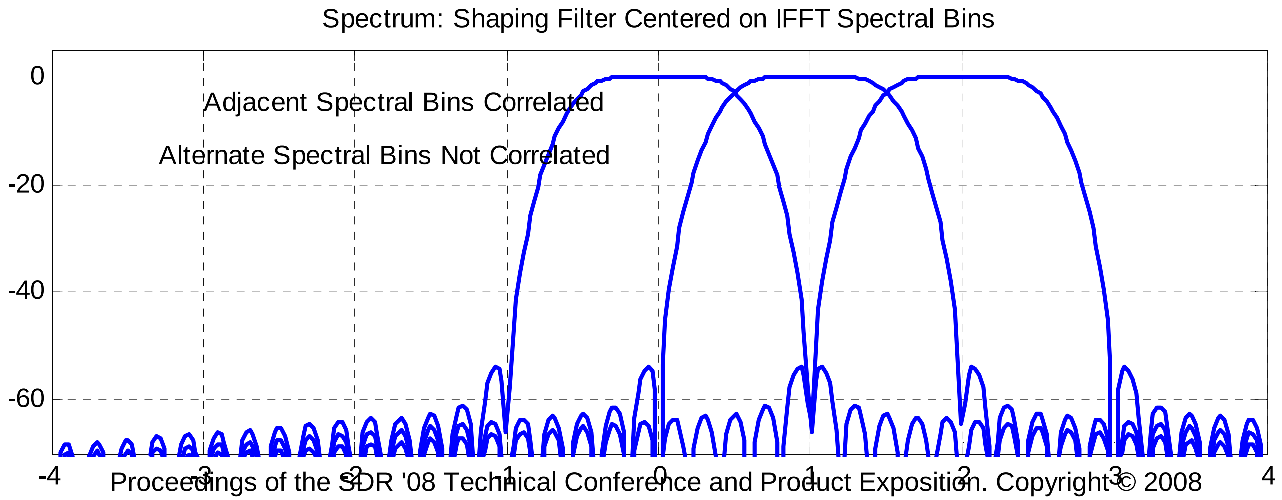
Impulse Response of Shaped OFDM Modulator and Demodulator



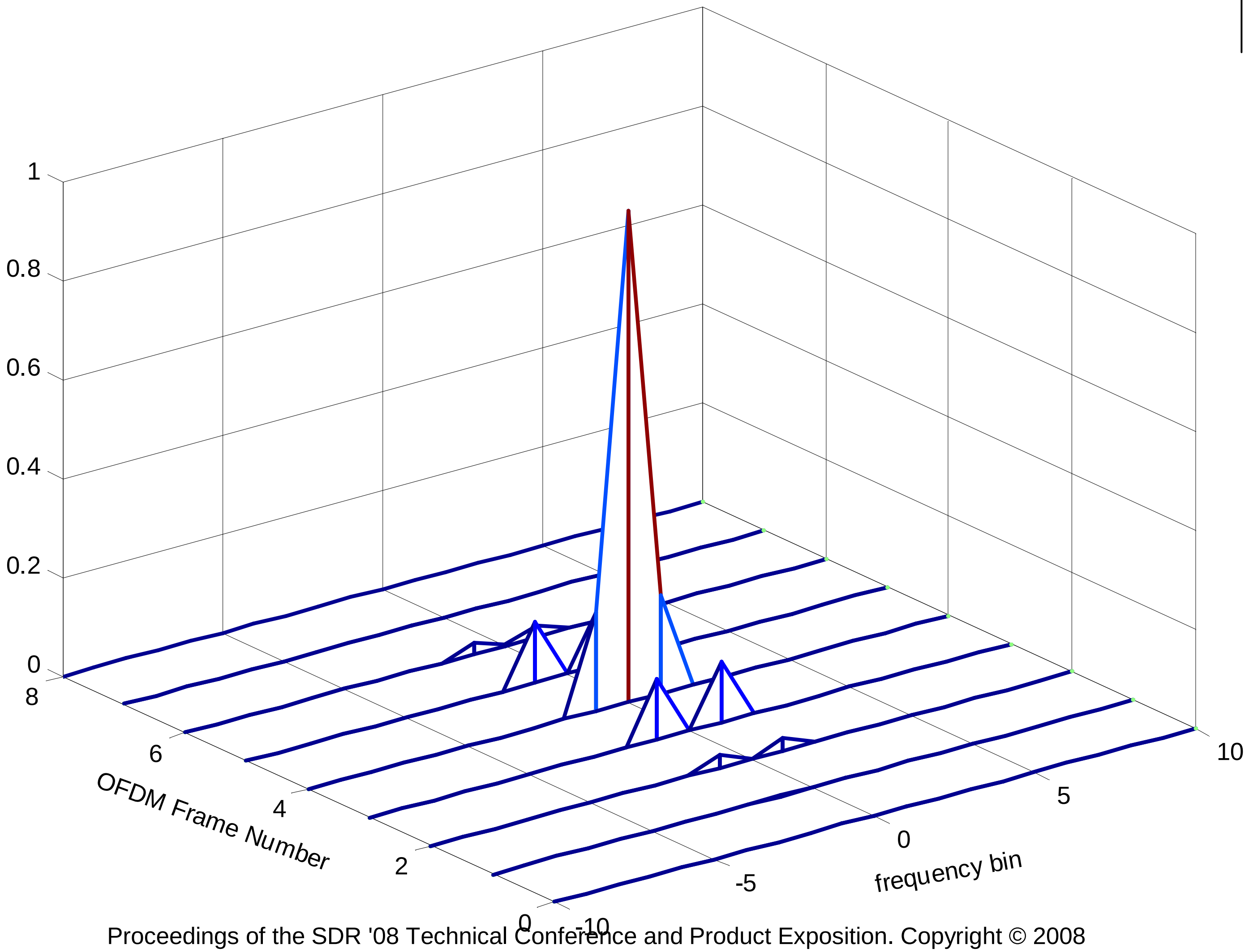
Orthogonal: Adjacent Time Slots Non Adjacent Frequency Bins



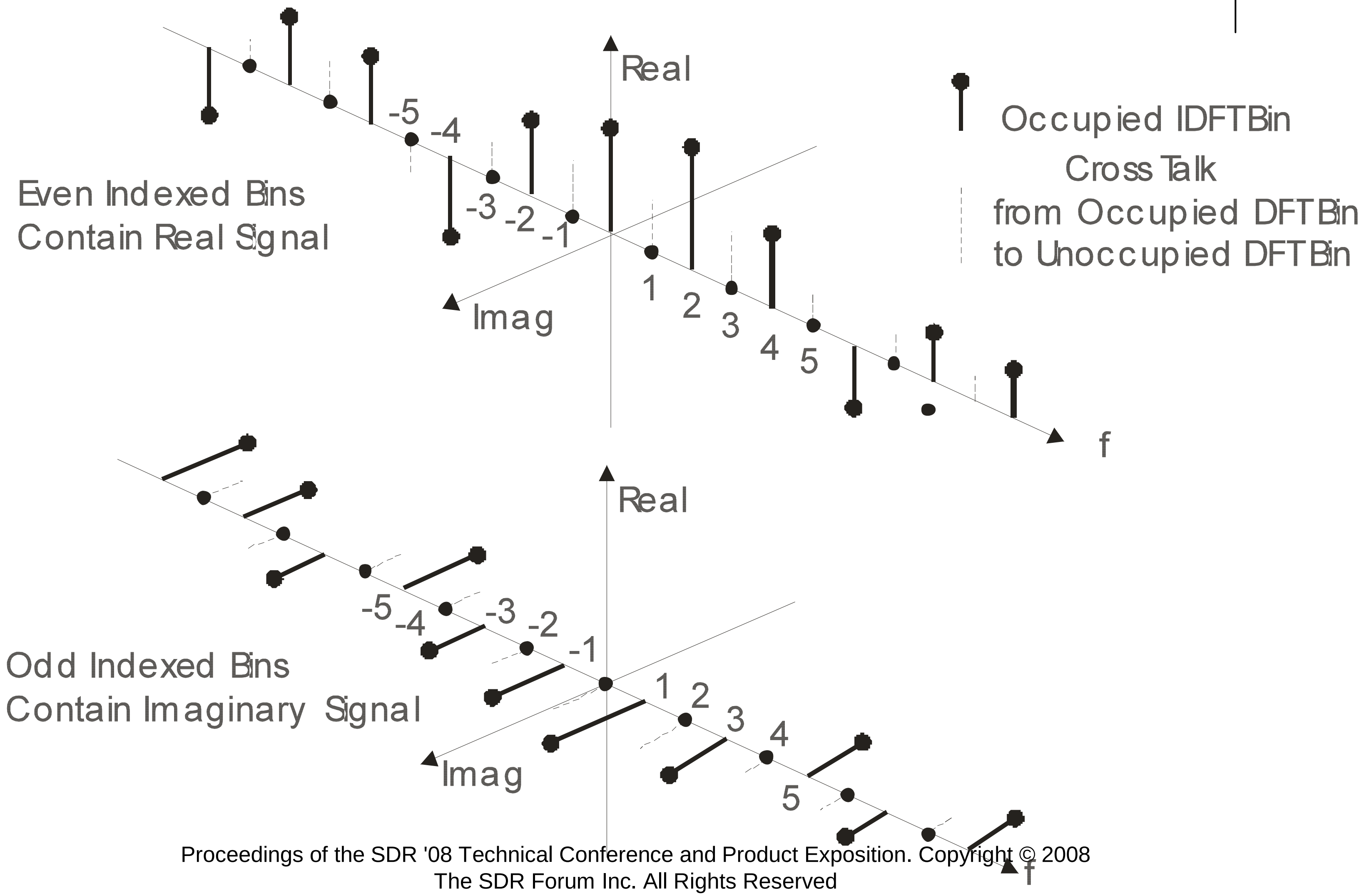




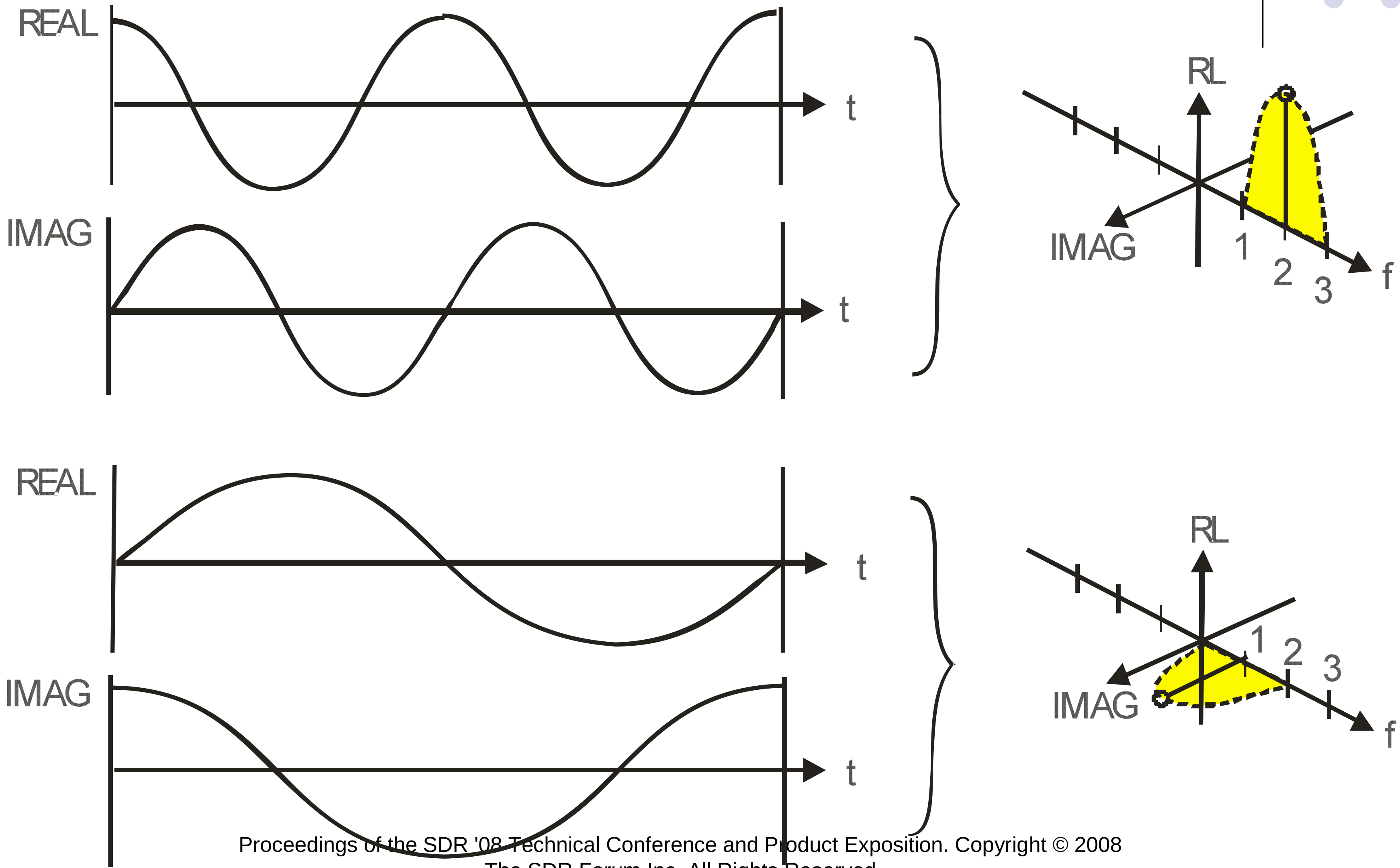
Impulse Response Time-Frequency Profile



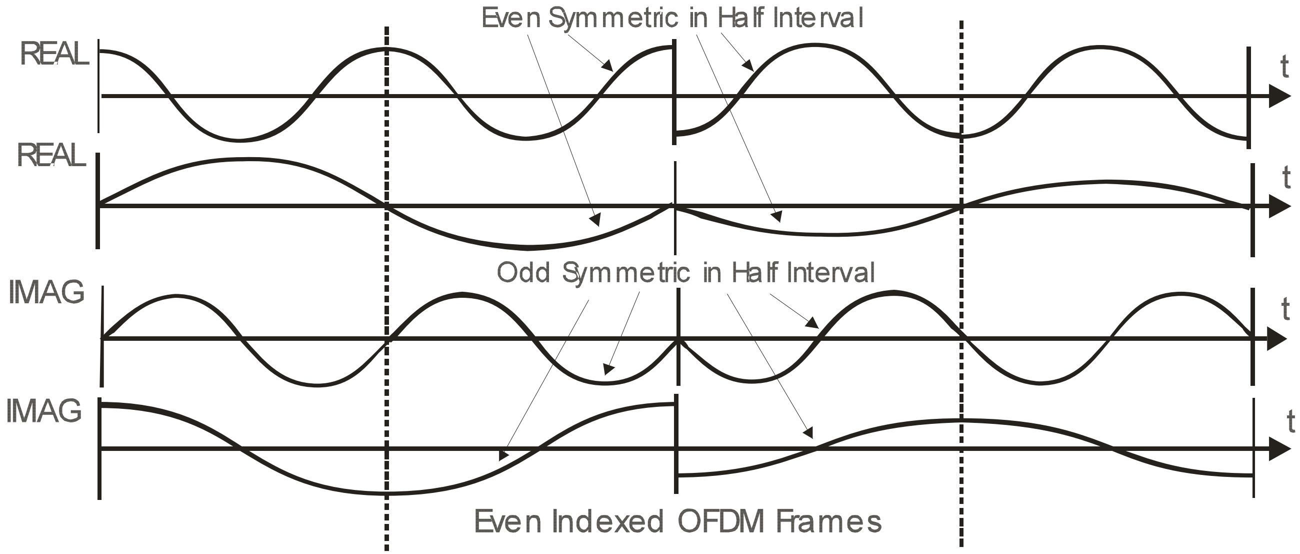
Orthogonality Between Real and Imaginary Part of Shaped OFDM Frequency Bins

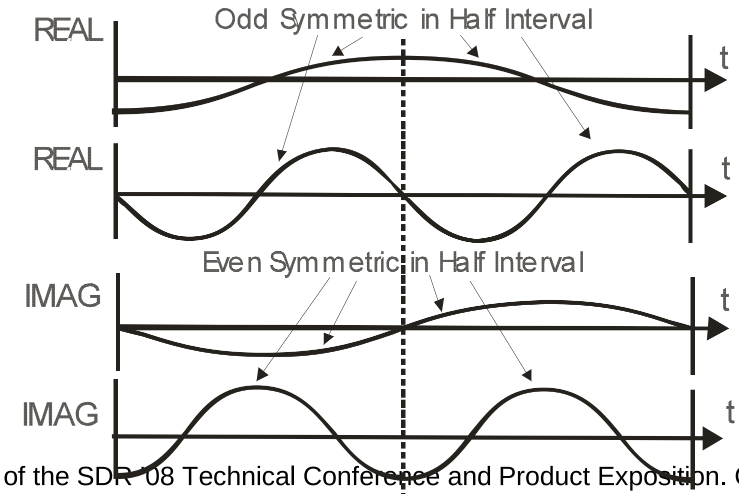


Even and Odd Symmetric Wave Shapes from Adjacent Bins are Orthogonal in Shaped OFDM



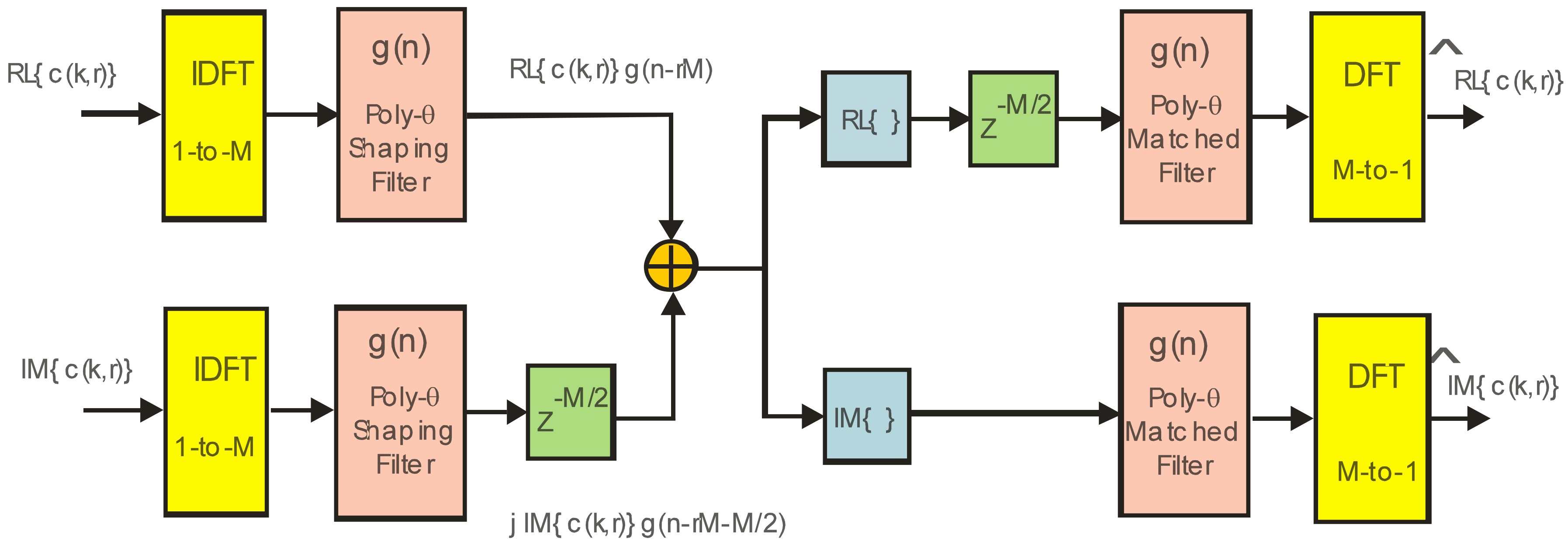
Symmetry Considerations in Real and Imaginary Components of Offset Shaped OFDM Frames



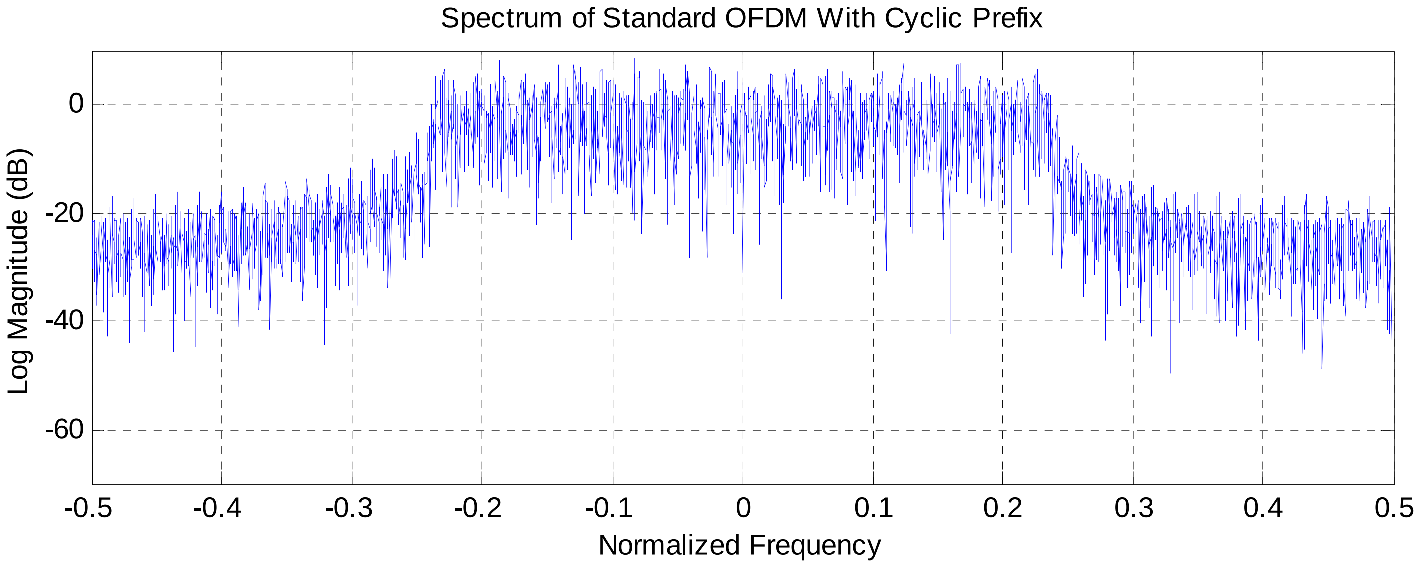


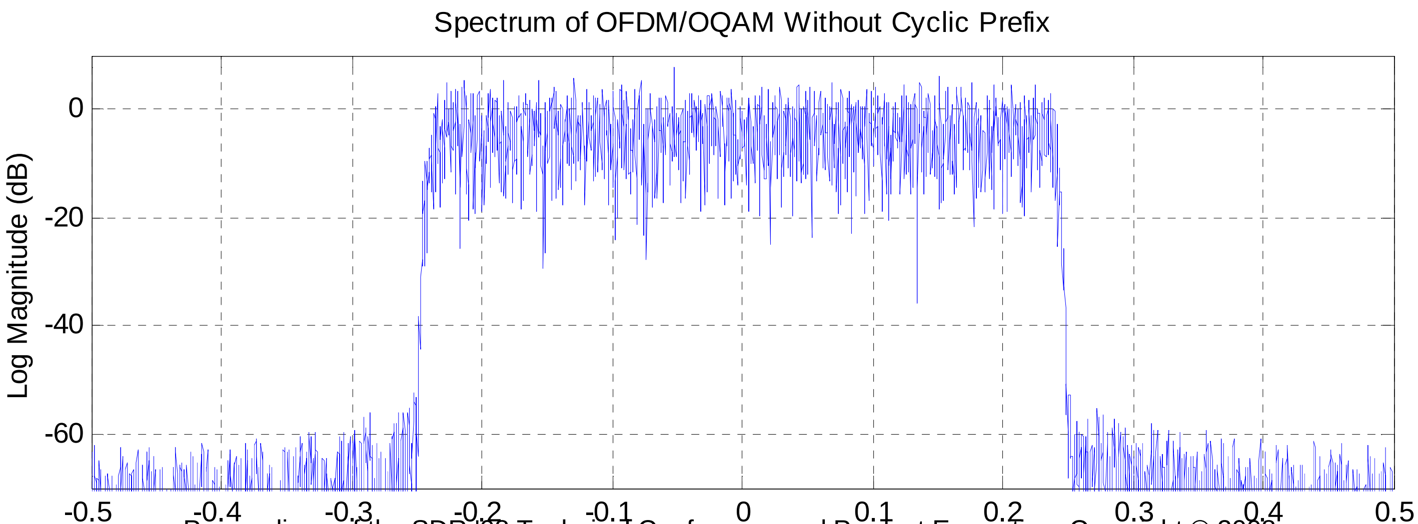
Odd Indexed Offset OFDM Frame

Offset OFDM

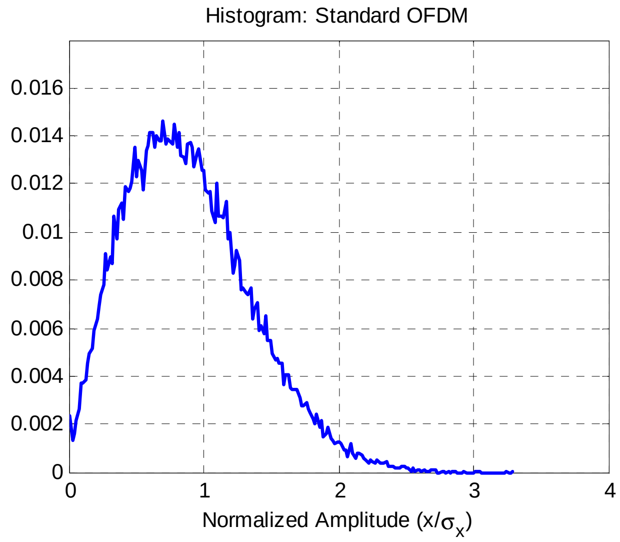

RL{ c(k,r)}
IDFT
1-to-M
g(n)
Poly-θ
Shaping
Filter
RL{ c(k,r)} g(n-rM)
IM{ c(k,r)}
IDFT
1-to-M
g(n)
Poly-θ
Shaping
Filter
Z -M/2
j IM{ c(k,r)} g(n-rM-M/2)
RL{ }
Z -M/2
g(n)
Poly-θ
Matched
Filter
DFT
M-to-1
RL{ c(k,r)}
IM{ }
g(n)
Poly-θ
Matched
Filter
DFT
M-to-1
IM{ c(k,r)}

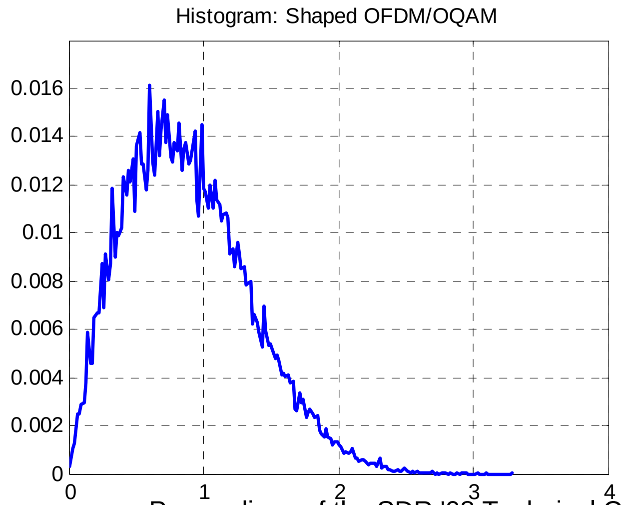
Compare Spectra

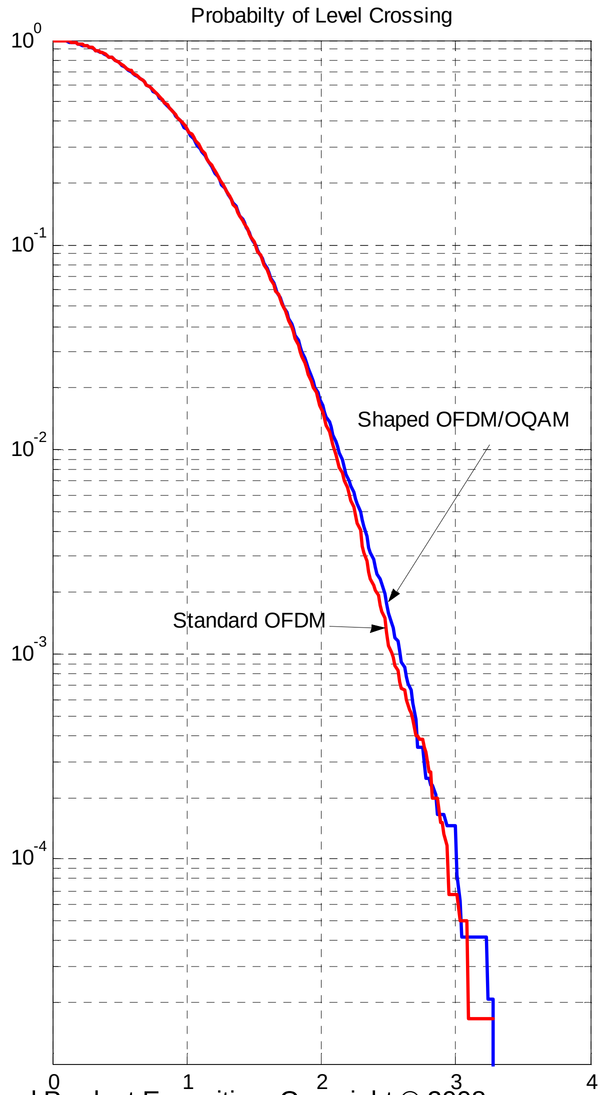




OFDM and Shaped OFDM PAR







Complementary Codes

From Initial Condition

A_0 and B_0

Iterate

$$A_{n+1} = [A_n \; B_n]$$

$$B_{n+1} = [A_n \; \overline{B}_n]$$

n	0	1	2	3	4
A_n	[1],	[1 1],	[1 1 1 -1],	[1 1 1 -1 1 1 -1 1],	[1 1 1 -1 1 1 -1 1 1 1 1 -1 -1 -1 1 -1]
B_n	[1],	[1 -1],	[1 1 -1 1],	[1 1 1 -1 -1 -1 1 -1],	[1 1 1 -1 1 1 -1 1 -1 -1 -1 1 1 1 -1 1]

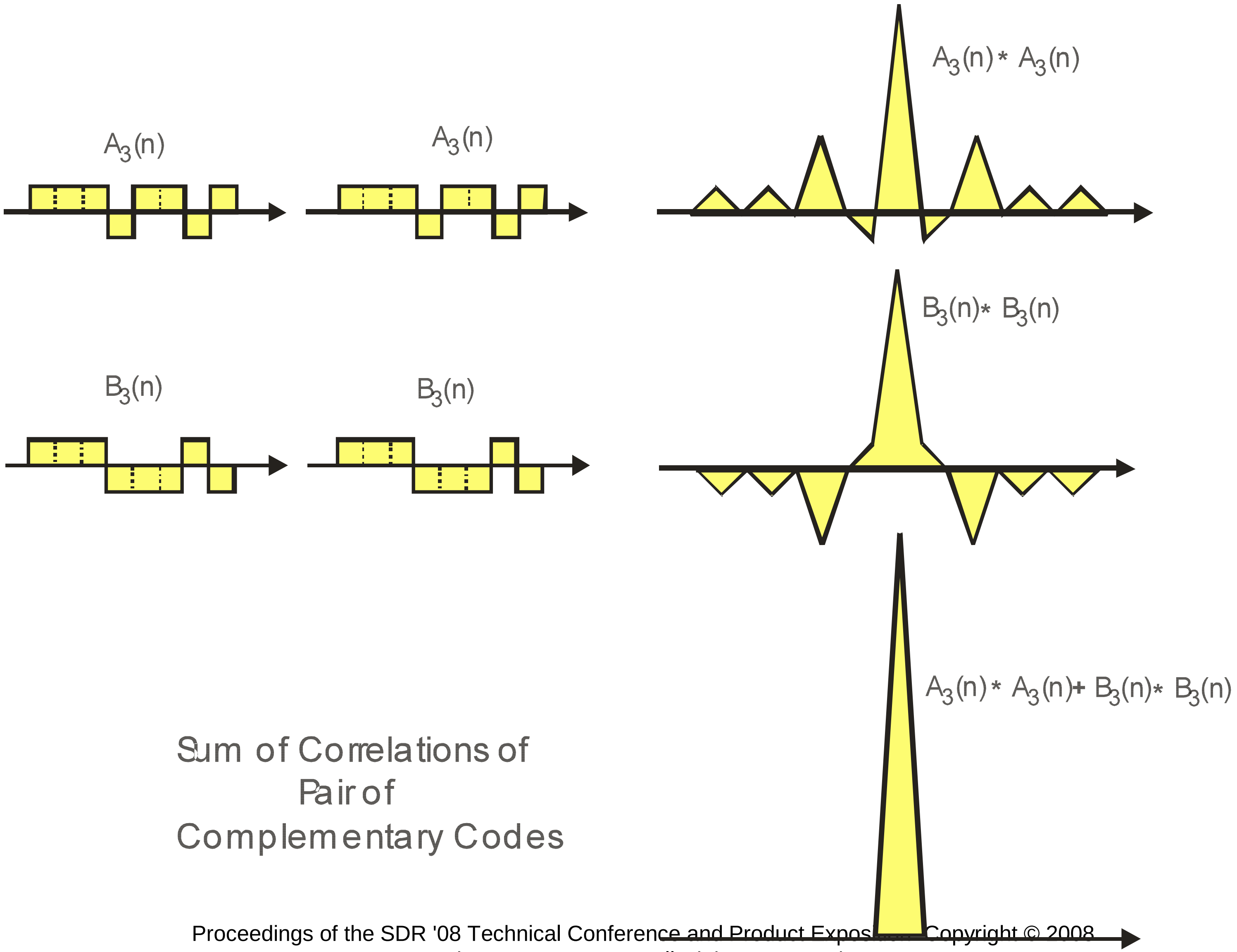
$$A_3 * A_3 = [\,1 \;\; 0 \;\; 1 \;\; 0 \;\; 3 \;\; 0 \; -1 \;\; 8 \; -1 \;\; 0 \;\; 3 \;\; 0 \;\; 1 \;\; 0 \;\; 1\,]$$

$$B_3 * B_3 = [-1 \;\; 0 \; -1 \;\; 0 \; -3 \;\; 0 \;\; 1 \;\; 8 \;\; 1 \;\; 0 \; -3 \;\; 0 \; -1 \;\; 0 \; -1]$$

$$A_3 * A_3 + B_3 * B_3 = [\,0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 16 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0\,]$$

$$A_N * A_N + B_N * B_N = 2N\, d(n)$$

Canceling Correlation Side Lobes



Inserting CC in OFDM

$$A_N(n) * A_N(n) + A_N(n) * A_N(n) = 2N\ \delta(n)$$

$$\left|A_N(\omega)\right|^2 + \left|B_N(\omega)\right|^2 = 2N \text{ (A Constant Power Level)}$$

Since Sample Values $A_N(n)$ are equal to 1

Average Power in $\left|A_N(\omega)\right|^2$ = N

Thus Peak to Average Power Ratio $\leq \frac{2N}{N} = 2$

Now Reverse Domains

Use Complementary Code Sequence

as amplitude of Carriers in Frequency Domain

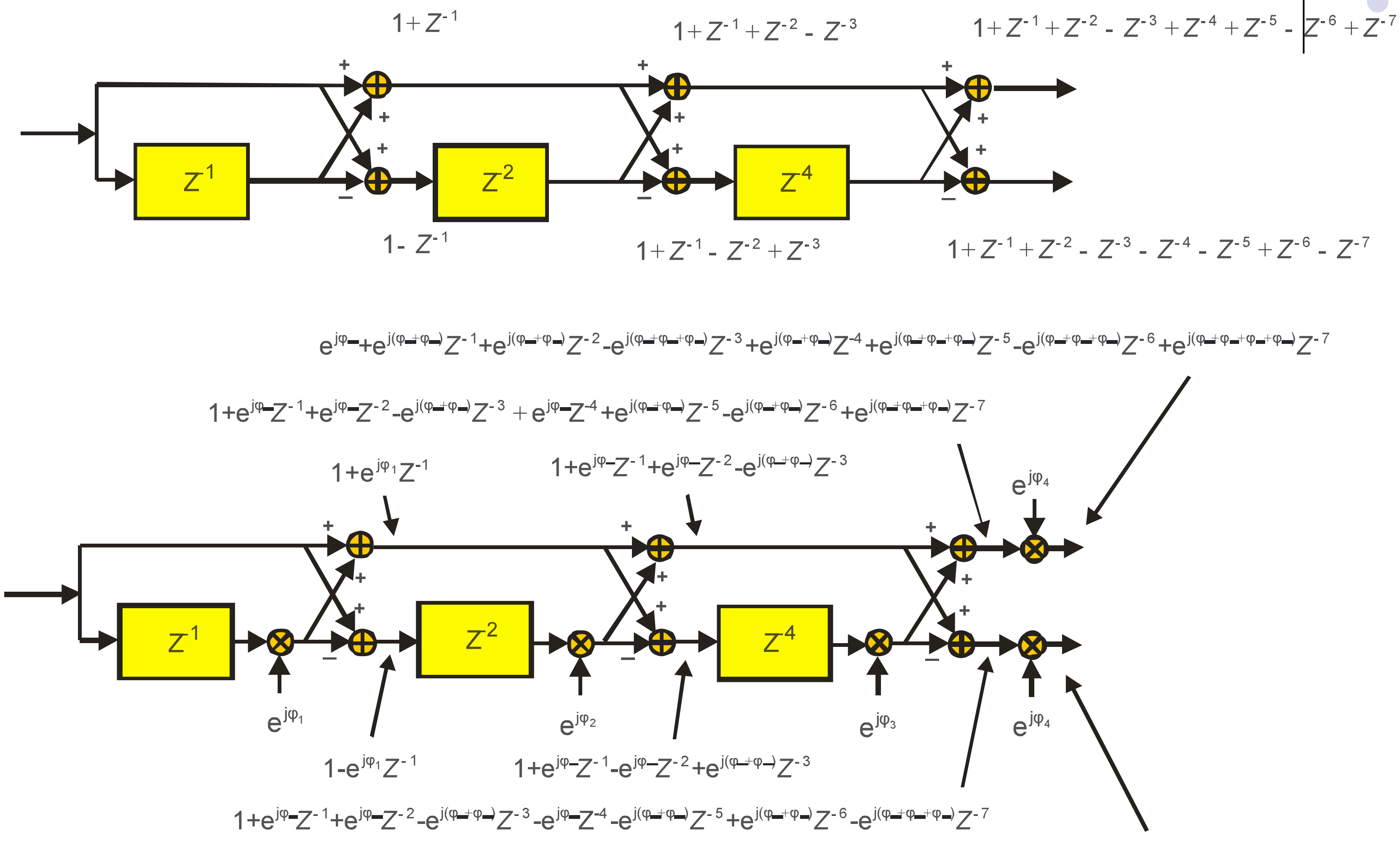
Then time series has

Peak Squared Magnitude = 2N

Average Magnitude = N

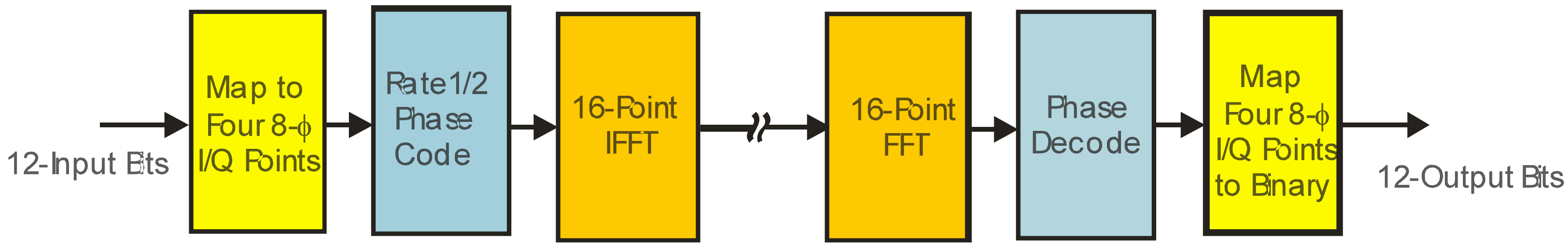
for Peak to Average Power Ratio = 2

CC and Digital Filters

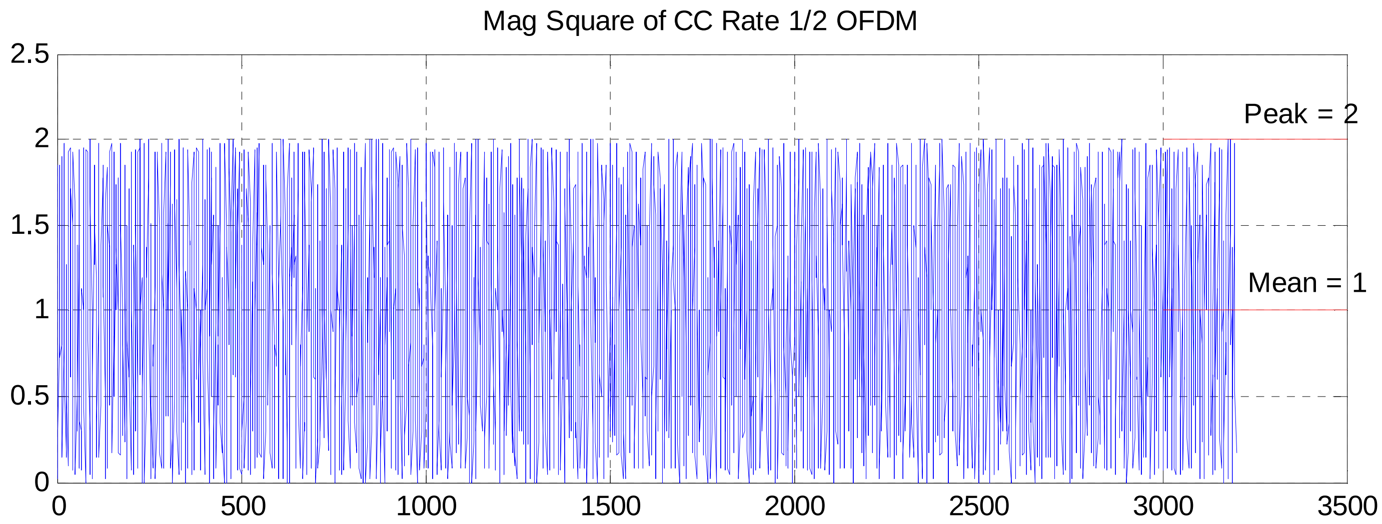


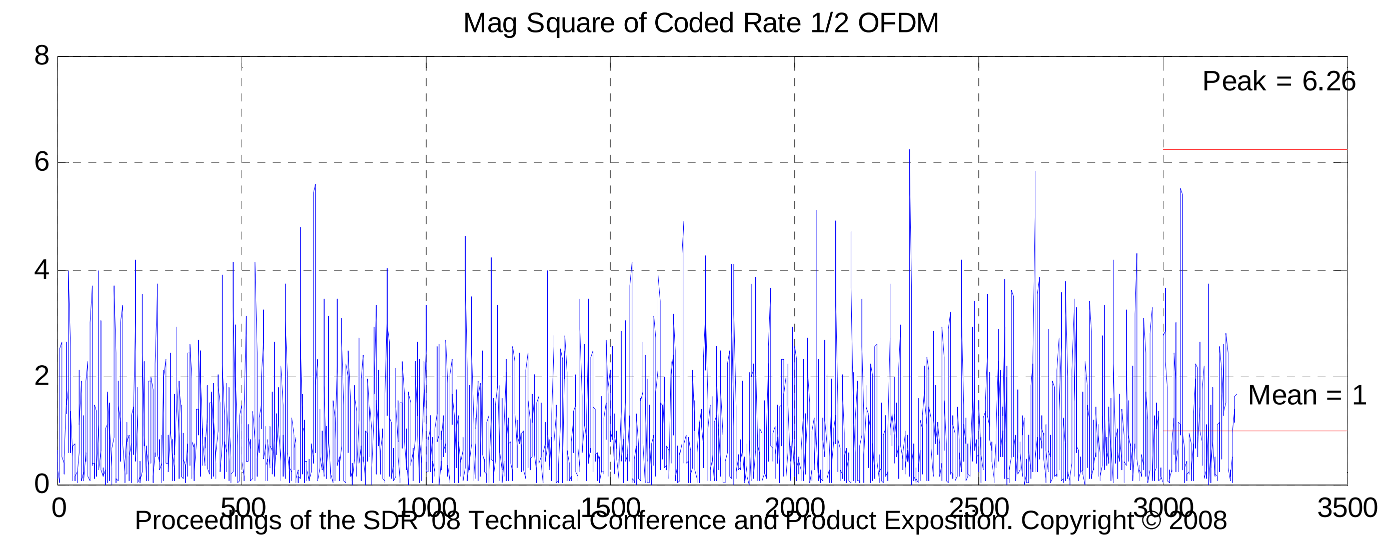
Equivalent Phase Coding

$$\begin{bmatrix} \theta_1 \\ \theta_2 \\ \theta_3 \\ \theta_4 \\ \theta_5 \\ \theta_6 \\ \theta_7 \\ \theta_8 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 & 0 \\ 1 & 1 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 & 0 \\ 1 & 0 & 1 & 1 & 0 \\ 0 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 0 \end{bmatrix} \begin{bmatrix} \varphi_1 \\ \varphi_2 \\ \varphi_3 \\ \varphi_4 \\ \pi \end{bmatrix}$$

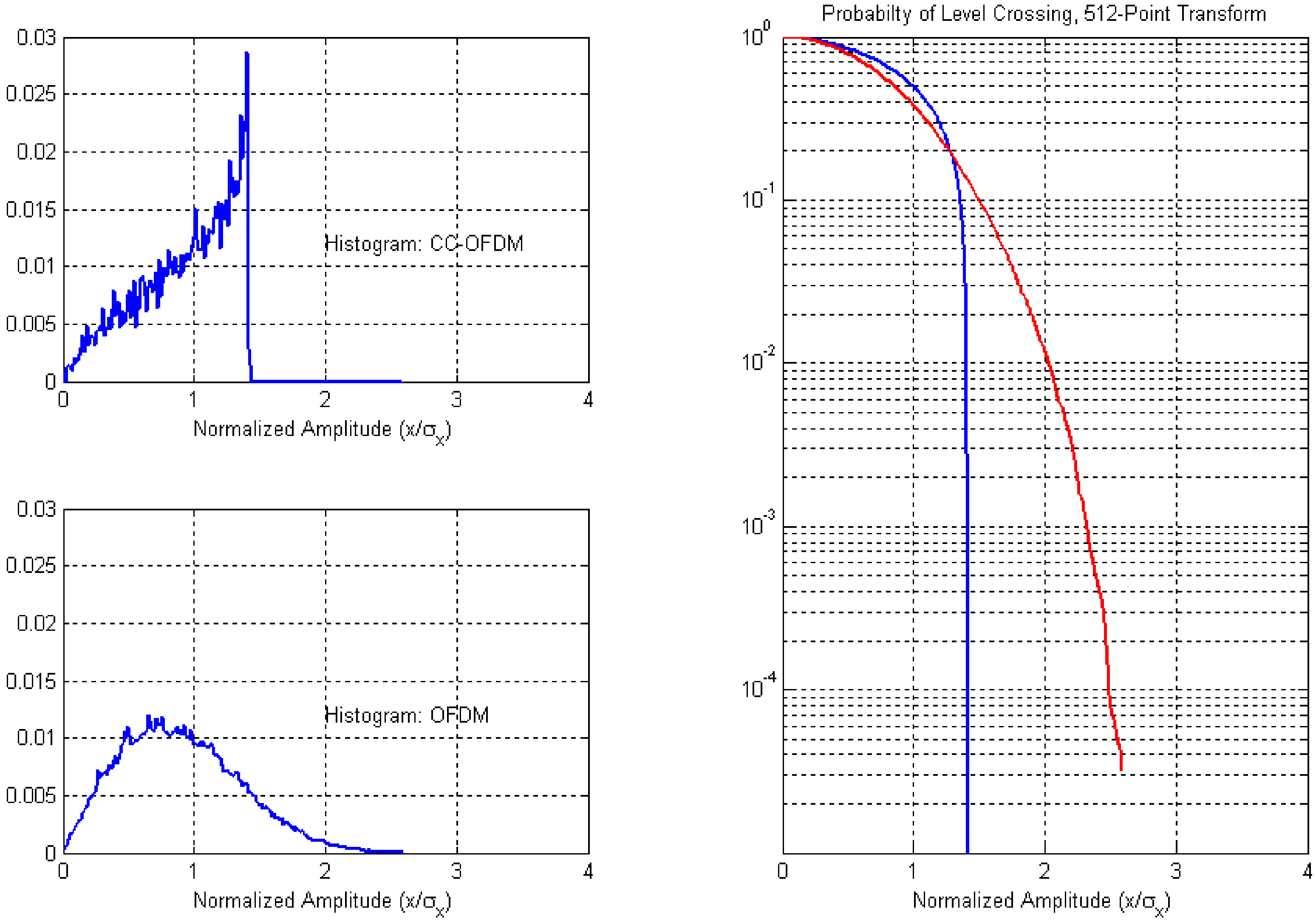


PAR in CCK OFDM and Standard OFDM

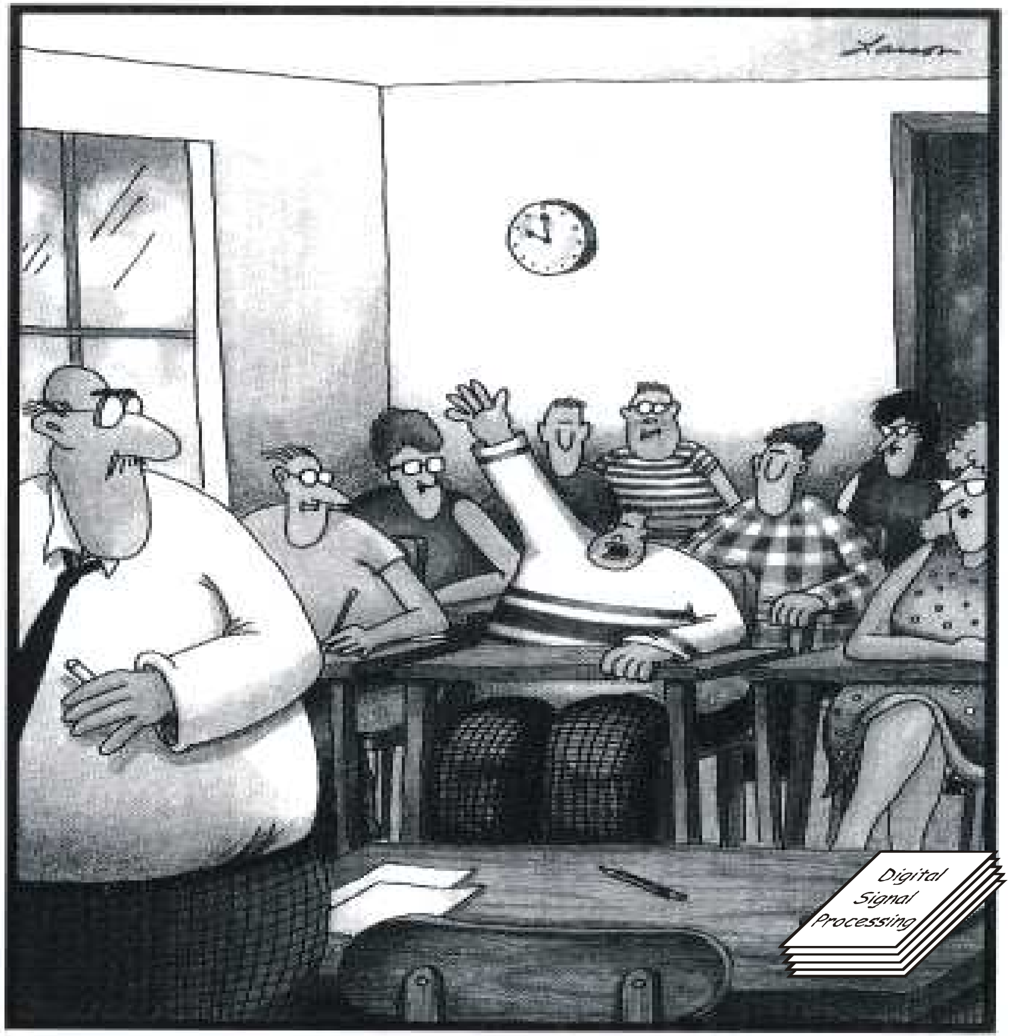




OFDM and CC-OFDM PAR



That's all Folks



Professor harris, may I be excused?
My brain is full.


Dilbert, is it true that DSP makes the world go around but multirate signal processing supplies the music for the ride?

SIN X

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Textbooks and References

- “Wireless OFDM Systems: How to Make Them Work”
  Marc Engels, Editor
- “OFDM Wireless LANs: A Theoretical and Practical Guide”
  Juha Heiskala and John Terry
- “OFDM for Wireless Multimedia Communications”
  Richard Van Nee and Ramjee Prasad
- “Single and Multi-Carrier Quadrature Amplitude Modulation”
  Lajos Hanzo, William Webb, and Thomas Keller
- “ADSL, VDSL, and Multicarrier Modulation”
  John Bingham
- “Implementing ADSL”
  David Ginsburg
- “DSL Advances
  Massimo Sorbara, John Cioffi, and Peter Silverman