Implementation of OFDM

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ECE 641 Project

INTRODUCTION

- OFDM is a frequency division multiplexing with many closely spaced subcarrier signals.
- Each subcarriers are orthogonal to each other.
- Orthogonality is obtained by the help of FFT module.
- Due to orthogonality cross-talk is reduced.
- No complex equalizers needed because OFDM may be viewed as using many slowly modulated narrowband signals rather than one rapidly modulated wideband signal

Discrete Fourier Transform

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DFT $$X(k) = \sum_{n=0}^{N-1} x(n) W_N^{kn} \qquad k = 0,1,2....N-1$$

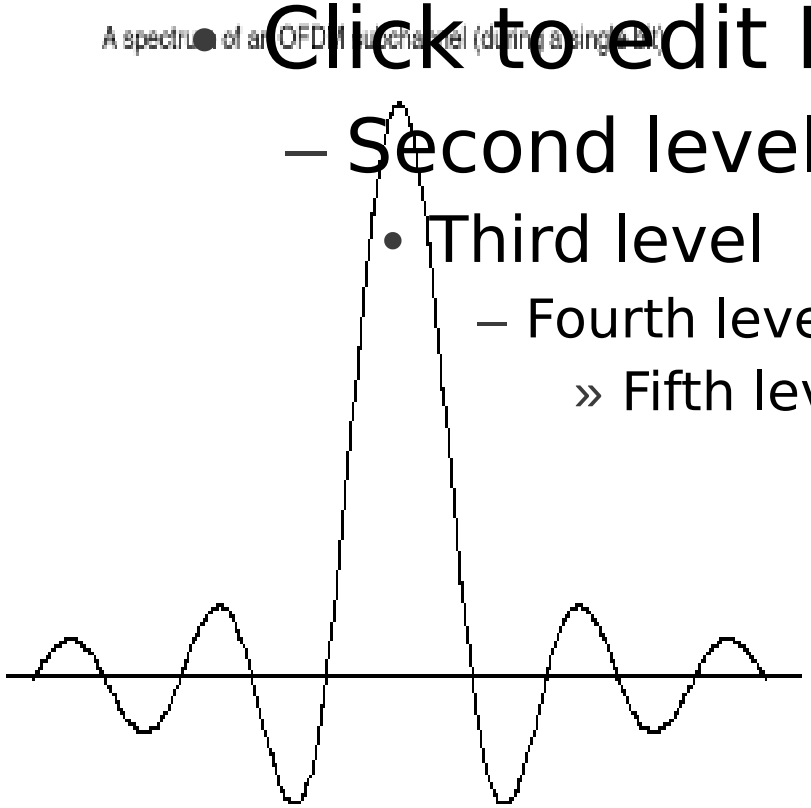
where $$W_N = e^{-j2\pi/N}$$

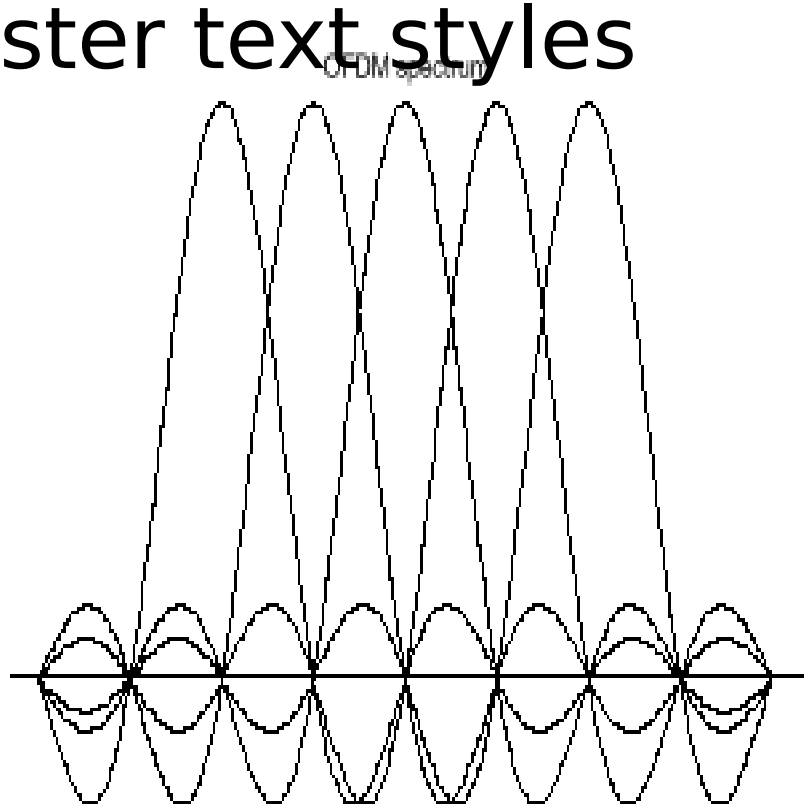
W_N is called as Phase factor or Twiddle factor

IDFT $$x(n) = \frac{1}{N} \sum_{k=0}^{N-1} X(k) W^{-kn} \quad n = 0,1,2....N-1$$

Spectrum

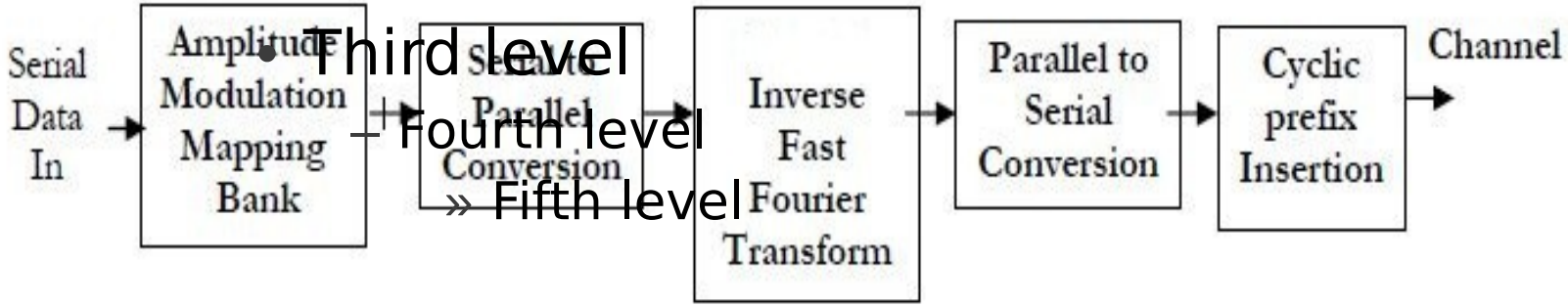
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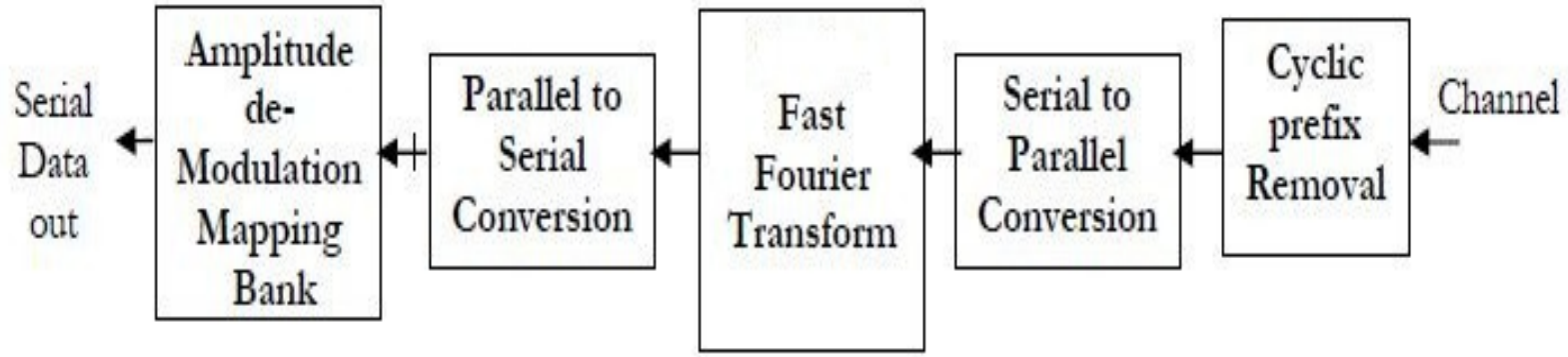




OFDM Transmitter & Receiver

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Why FFT

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To compute one DFT point

N complex multiplications are required

N-1 complex additions are required

To compute N DFT points (k = 0,1, …,N-1)

N^2 complex multiplications (N x N)

N^2-N complex additions. ((N-1) x N)

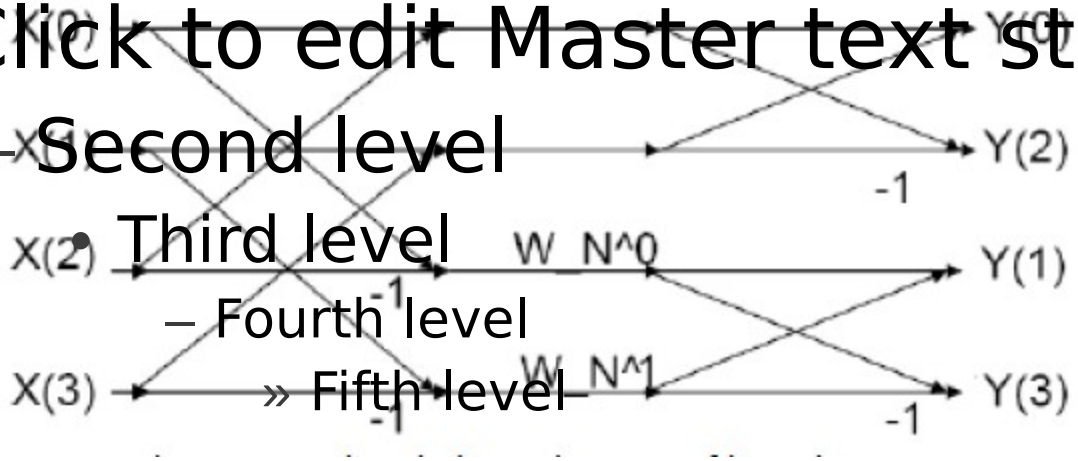
FFT Algorithm

$$Y(k)=\sum_{n=0}^{N-1}x(n)W_N^{kn};\quad k=0,1,\ldots,N-1;\quad W=e^{j\frac{2\pi}{N}};\quad N=even$$

$$Y(k)=\sum_{n=0}^{N/2-1}x(n)W_N^{kn}+W_N^{kN/2}\sum_{n=0}^{N/2-1}x(n+N/2)W_N^{kn}$$

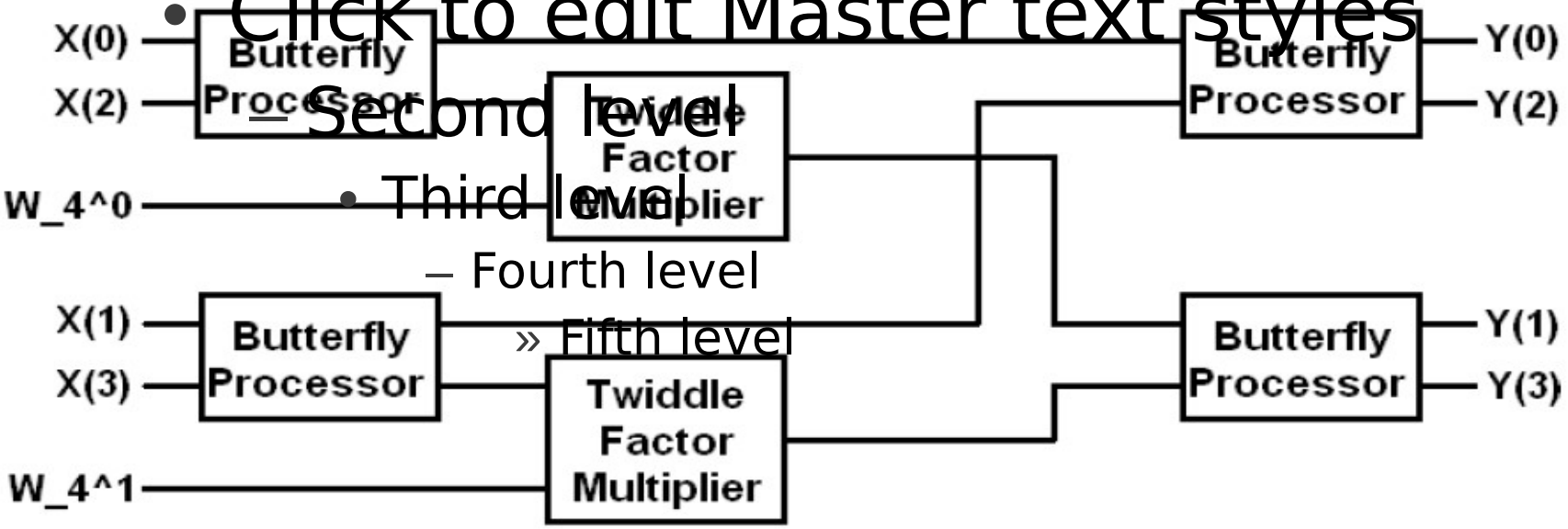
$$=\sum_{n=0}^{N/2-1}[x(n)+(-1)^k x(n+N/2)]W_N^{kn};\quad k=0,1,\ldots,N-1$$

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FFT Algorithm

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Complex Multiplications are : $\frac{N}{2}\log_2 N$

Complex Additions are : $N\log_2 N$

Functional simulation of IFFT module

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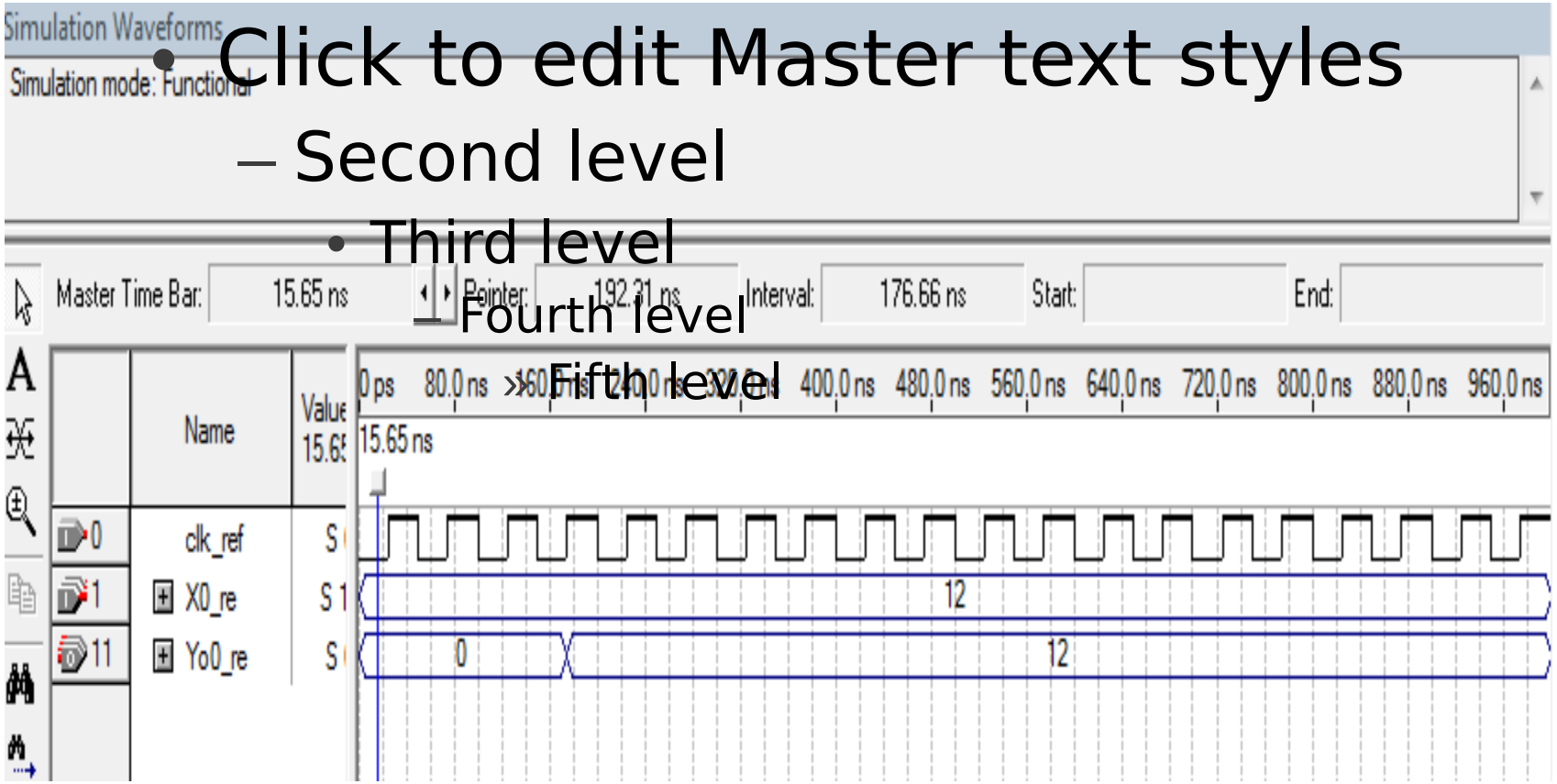
Functional simulation of FFT module

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Functional Simulation

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Simulation Report

- Total logical Elements: 440
- Fmax=22.07 MHz
- Total thermal power dissipation=195.94mW
- Worst case tco=12.801ns

Pin Planner

Named:

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	Node Name	Direction	Location	I/O Bank	VREF Group	I/O Standard	Reserved
1	clk_ref	Input	PIN_AD19	7	B7_N3	3.3-V LVTTL (default)	
2	X0_re[8]	Input	PIN_AD24	6	B6_N3	3.3-V LVTTL (default)	
3	X0_re[7]	Input	PIN_AD25	6	B6_N3	3.3-V LVTTL (default)	
4	X0_re[6]	Input	PIN_AC23	6	B6_N3	3.3-V LVTTL (default)	
5	X0_re[5]	Input	PIN_AC24	6	B6_N3	3.3-V LVTTL (default)	
6	X0_re[4]	Input	PIN_AC26	6	B6_N3	3.3-V LVTTL (default)	
7	X0_re[3]	Input	PIN_AC25	6	B6_N2	3.3-V LVTTL (default)	
8	X0_re[2]	Input	PIN_AB25	6	B6_N2	3.3-V LVTTL (default)	
9	X0_re[1]	Input	PIN_AB26	6	B6_N2	3.3-V LVTTL (default)	
10	X0_re[0]	Input	PIN_AA23	6	B6_N2	3.3-V LVTTL (default)	
11	Yo0_re[12]	Output	PIN_AC12	8	B8_N2	3.3-V LVTTL (default)	
12	Yo0_re[11]	Output	PIN_AB13	8	B8_N0	3.3-V LVTTL (default)	
13	Yo0_re[10]	Output	PIN_AC13	8	B8_N1	3.3-V LVTTL (default)	
14	Yo0_re[9]	Output	PIN_AD14	8	B8_N0	3.3-V LVTTL (default)	
15	Yo0_re[8]	Output	PIN_AH3	8	B8_N3	3.3-V LVTTL (default)	
16	Yo0_re[7]	Output	PIN_AJ2	8	B8_N3	3.3-V LVTTL (default)	
17	Yo0_re[6]	Output	PIN_AJ3	8	B8_N3	3.3-V LVTTL (default)	
18	Yo0_re[5]	Output	PIN_AH4	8	B8_N3	3.3-V LVTTL (default)	
19	Yo0_re[4]	Output	PIN_AK3	8	B8_N3	3.3-V LVTTL (default)	
20	Yo0_re[3]	Output	PIN_AJ4	8	B8_N3	3.3-V LVTTL (default)	
21	Yo0_re[2]	Output	PIN_AJ5	8	B8_N3	3.3-V LVTTL (default)	
22	Yo0_re[1]	Output	PIN_AK5	8	B8_N3	3.3-V LVTTL (default)	
23	Yo0_re[0]	Output	PIN_AJ6	8	B8_N2	3.3-V LVTTL (default)	
24	<<new node>>						

Interesting Observation

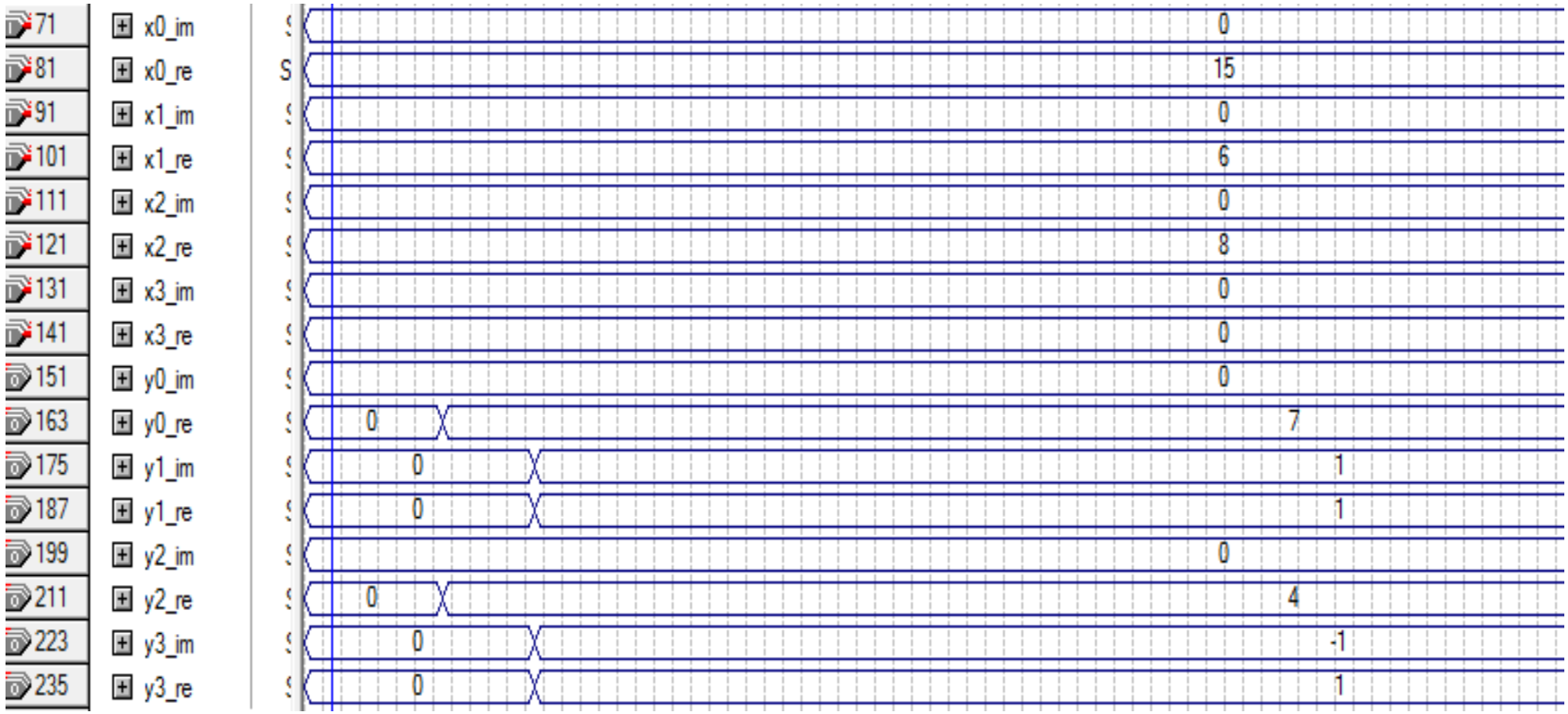
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Command Window
New to MATLAB? Watch this Video, see Demos, or read Getting Started.

>> x=[15,6,8,0];
>> y=ifft(x)

y =

   7.2500          1.7500 - 1.5000i   4.2500          1.7500 - 1.5000i
```



DEMO