

Ongoing MIMO Wireless Testbed Development in Shandong University

Presenter: Dr. Jian Sun

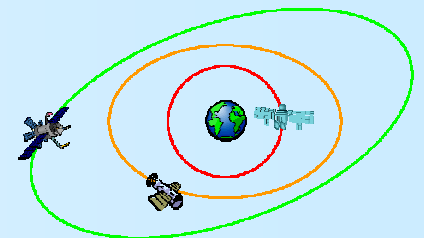
Tel: 13685416980

URL: <http://202.194.20.8>

Wireless Mobile Communication and Transmission (WMCT) Lab.
Shandong University



Shandong University



Outline

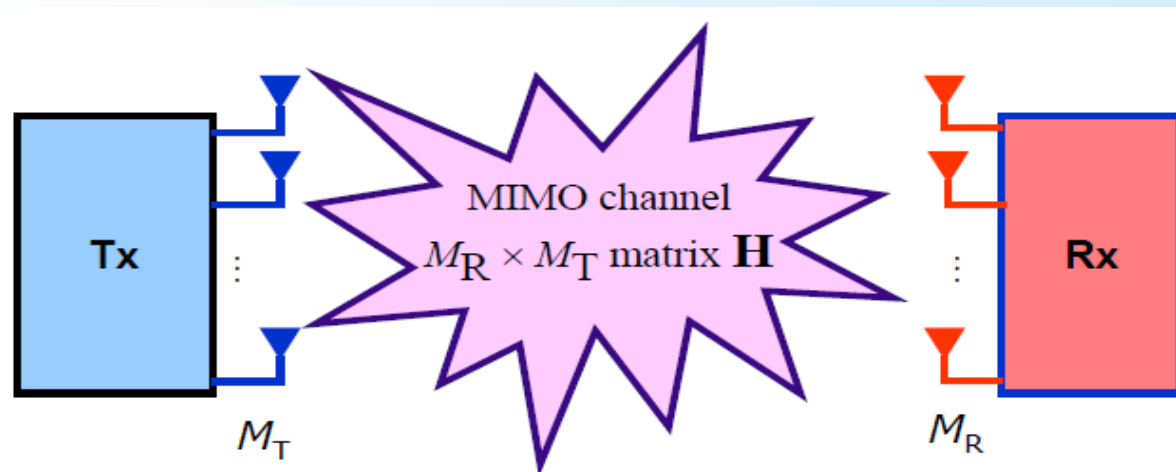
- **Introduction and Motivation**
- Non-real Time MIMO Testbed
- Non-real Time MIMO Testbed
- Future work



Introduction and Motivation(1)

- **MIMO-Multiple Input Multiple Output:**

- Exploits the spatial dimension of mobile propagation channels.
- Main benefits: spatial multiplexing gain and spatial diversity gain
- Widely used in wireless communication standards: 3GPP LTE, Wi-Fi (802.11n), WiMAX(802.16d), mobile WiMAX(802.16e), etc.



Introduction and Motivation(2)

- Verification Algorithm of MIMO Techniques
 - Computer Simulation
 - Easy, low cost
 - Simulated channel model, (3GPP SCM(E), WINNER II, TGn), maybe not coincide with the true environment
 - MIMO Testbed
 - Complex, higher cost
 - True physical channel



Introduction and Motivation(3)

- MIMO Testbed
 - Non-real-time testbed
 - non-real-time (offline) signal processing by PC software
 - Univ. of Vienna (ICS based, 2005) ,University of Texas(Hydra,2005)
 - Real-time testbed
 - Real time signal processing by DSP & FPGA
 - ETH Zurich(2004-),NTT DoCoMo(2004-), Siemens AG 和 Heinrich Hertz(2004-),), University of South Australia(2006), Univ. of Rice(WARP,2006), Univ. of Duisburg(Sundance,2008)
 - SEU: Beyond 3G system (Gao Xiqi,2006), Gbps Wireless Communication Testbed (Wang Xiangyang, 2008)



Progress on MIMO Testbed Development in SDU

Non-real Time System

	2006.3	2006.10	2007.6	
System Scheme	Equipment Purchase	System Completeness	Continuous Research(802.11n,etc)	

Real Time System

	2006.9	2008.1	2009.5	2009.10	2009.12	
System Scheme	Equipment Purchase	SISO Video Transmission	OFDM System	2x2 MIMO-OFDM System	...	

Only one channel DAC supported by current hardware, so still stay at SysGen simulation stage



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Photographs of non-real time system

Transmitter System



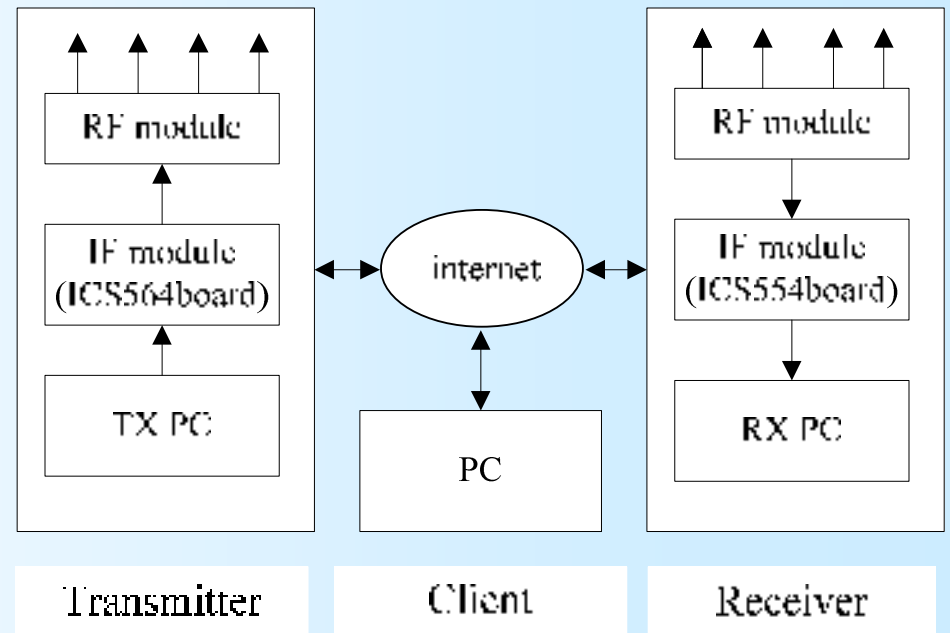
Receiver System



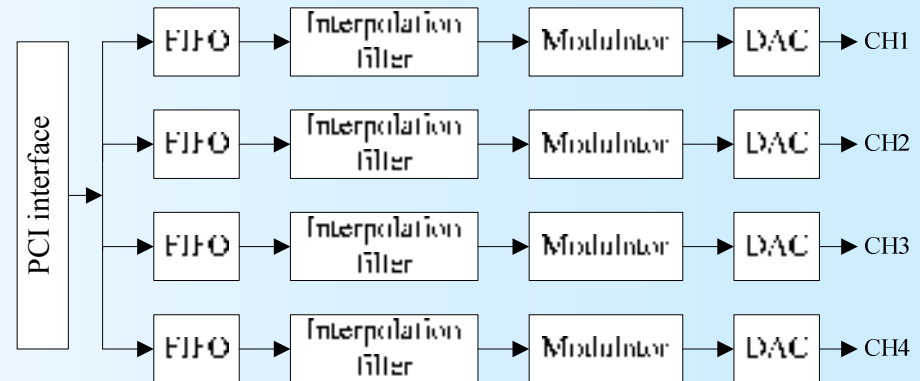
Non-real Time MIMO Testbed

- General Description

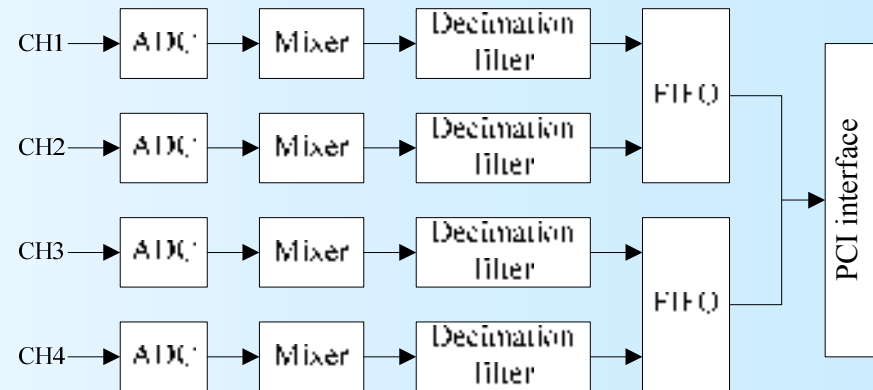
- Linear Antennas Array
- Transmitter/ Receiver RF converter
- Transmitter PC/Receiver PC: DUC /DAC, ADC/DDC
- Client PC: Baseband Signal Processing (data generation and recovery)



Intermediate Frequency (IF) Processing



- **ICS 564 baseband-IF conversion**



- **ICS 554 IF-baseband conversion**

Radio Frequency / IF converter

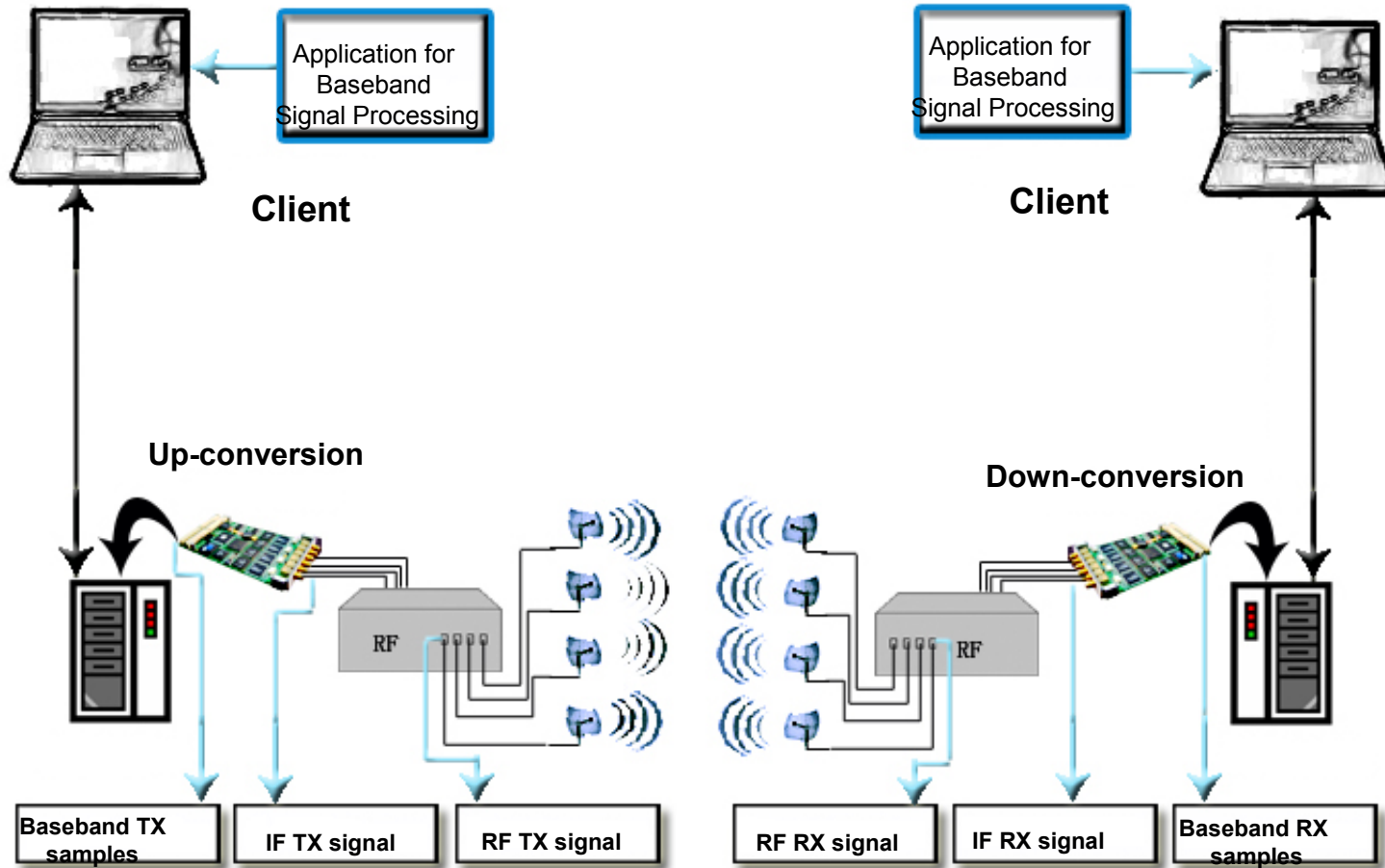
● Parameters

- RF frequency : 2453MHz
- Intermediate Frequency: 70MHz
- Number of Channel: 4
- BW: $\leq 20\text{MHz}$ (for RF), 10MHz (for BB)
- Frequency stability of LO: $\Delta f/f \leq \pm 2\text{ppm}$
- Phase Noise of LO: $\Phi < -85\text{dBc}@10\text{KHz}$
- Output IM3: -35dBc
- Power per Antenna: 20dBm
- Isolation between channels: 40dB
- Noise Figure: $<4.5\text{dB}$
- Receiving Level: $-80\text{dBm} \sim -30\text{ dBm}$

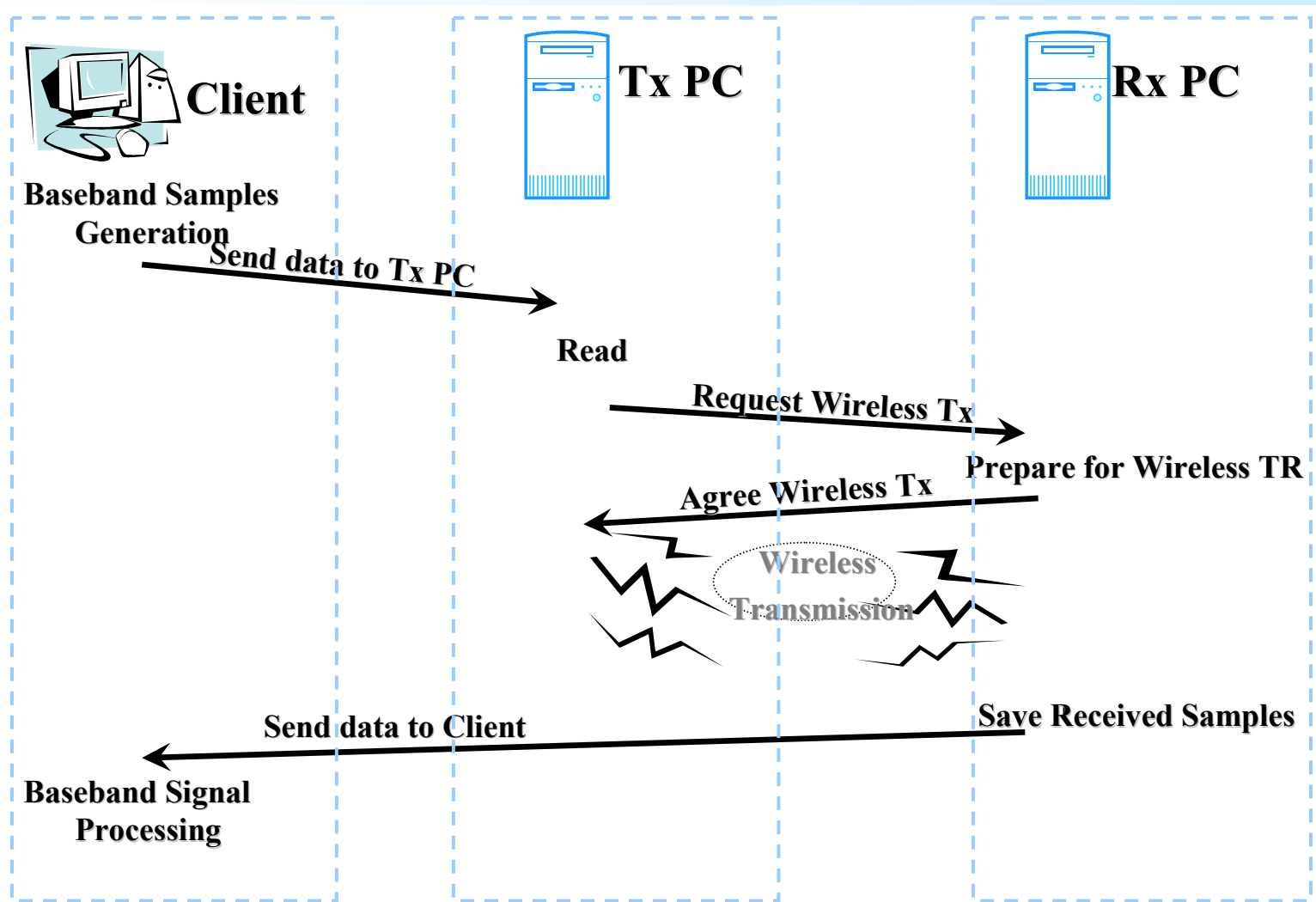
- Antenna Gain: 6dBi omni-directional
- Space between antennas: Adjustable



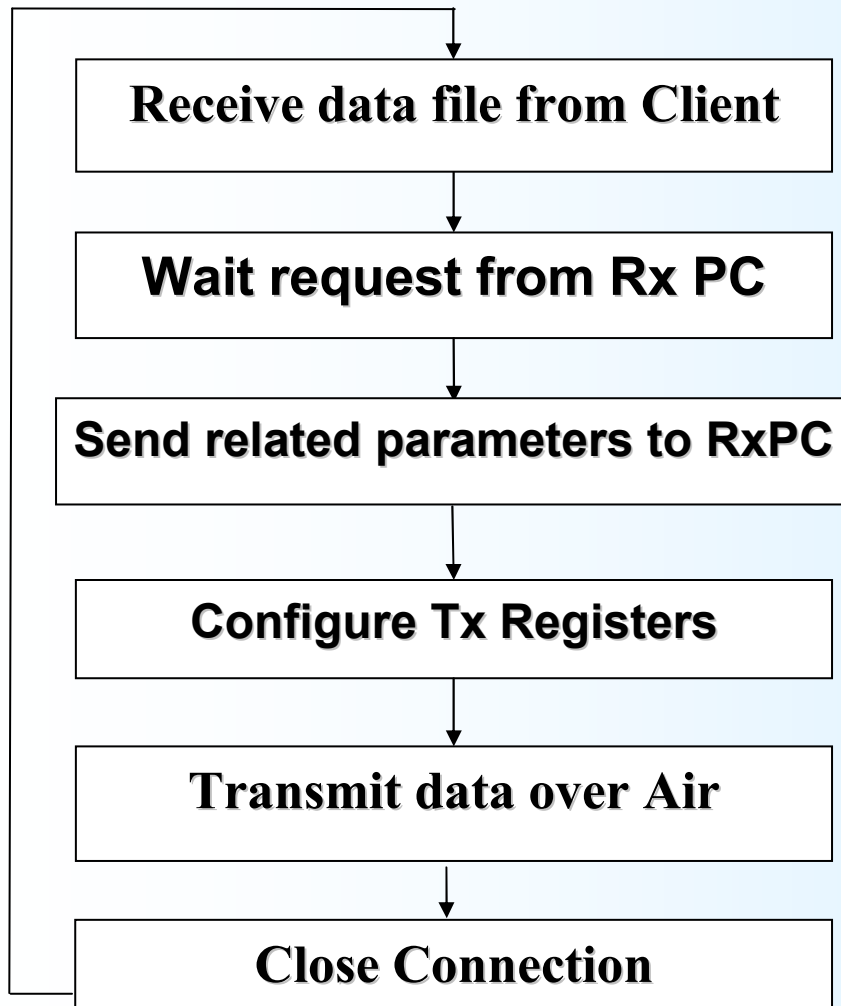
System Architecture



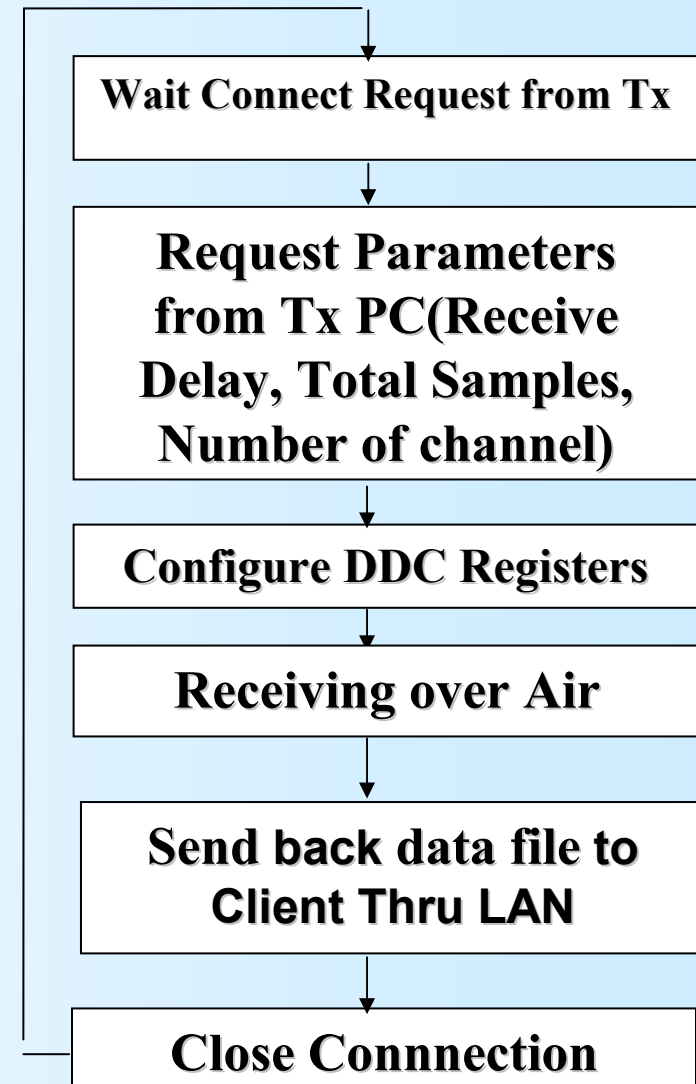
Data Transfer Flow



Program Flow @Tx PC



Program Flow @Rx PC



Software Programming @ Client

Programmer: C/Matlab

```
>> edit test.m
>> edit frame_detection

Editor - D:\Testbed\NonRealTime\802.11nPHY\test.m
File Edit Text Go Cell Tools Debug Desktop Window Help
Stack: Base
This file uses Cell Mode. For information, see the rapid code iteration video, the publishing video, or help.

167
168 - R1=real(txData(:,1))'; I1=imag(txData(:,1))';
169 - R2=real(txData(:,2))'; I2=imag(txData(:,2))';
170 - R3=real(txData(:,3))'; I3=imag(txData(:,3))';
171 - R4=real(txData(:,4))'; I4=imag(txData(:,4))';
172
173 - DataLength=length(I1);
174 - save('test.mat','DataLength','I1','I2','I3','I4','R1','R2','R3','R4');
175 - %% Call dynamic link library
176 - filename='ClientDll.dll';
177 - filehead='ClientDll.h';
178 - loadlibrary(filename, filehead);
179 - calllib('ClientDll','process','test.mat');
180 - unloadlibrary ClientDll;
181
182 - %% Use received mat file
183 - load 'dataFrom554.mat'
184
185 - recvdData(:,1)=complex(double(ChaOneReal'), double(ChaOneImag'));
186 - recvdData(:,2)=complex(double(ChaTwoReal'), double(ChaTwoImag'));
```

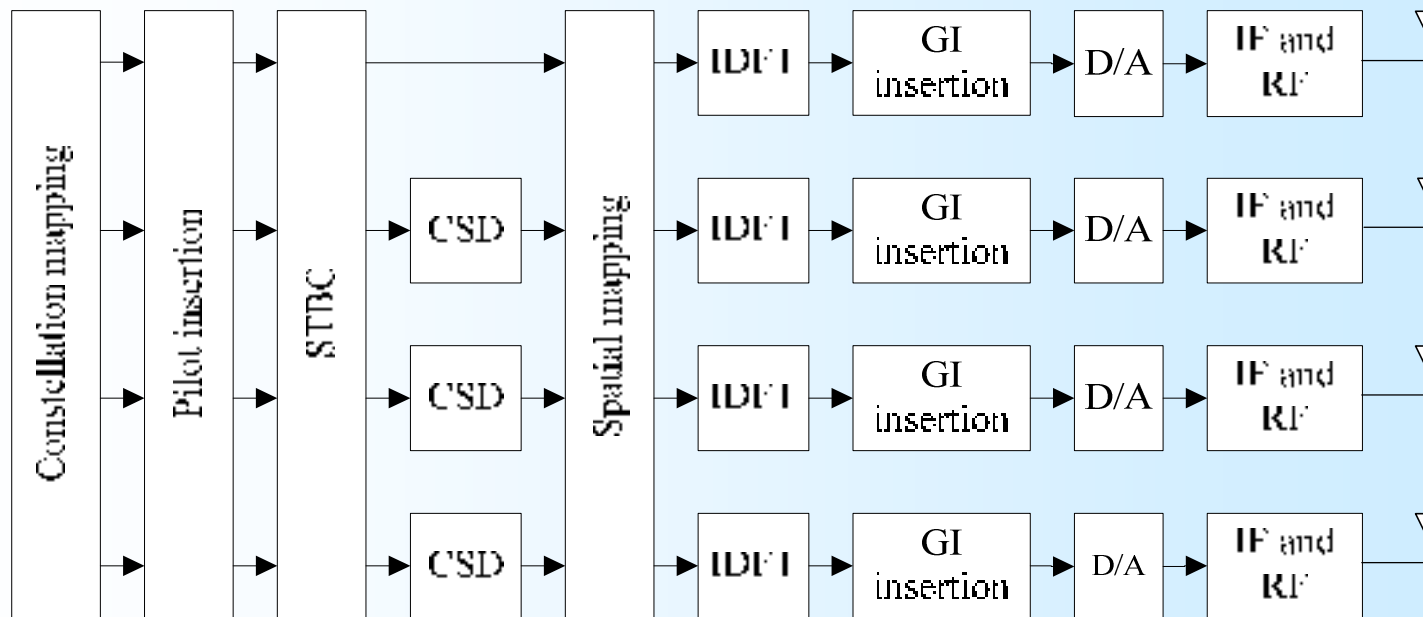
Command History

```
---clc
---edit test.m
---edit frame_detection
---edit stbc_decoder.m
```



Research on Non-real Time Platform

- link-level Test, simplex transmission
- 802.11n System



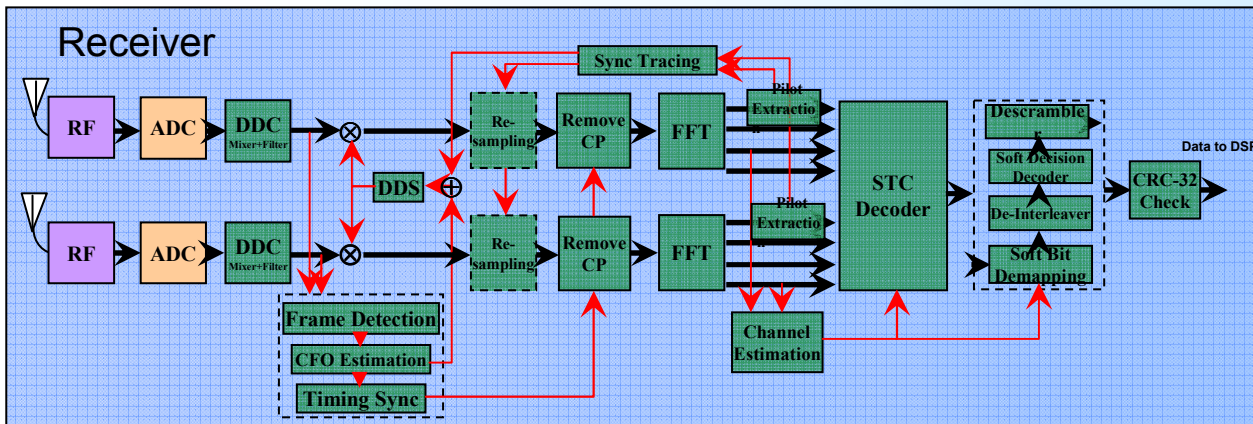
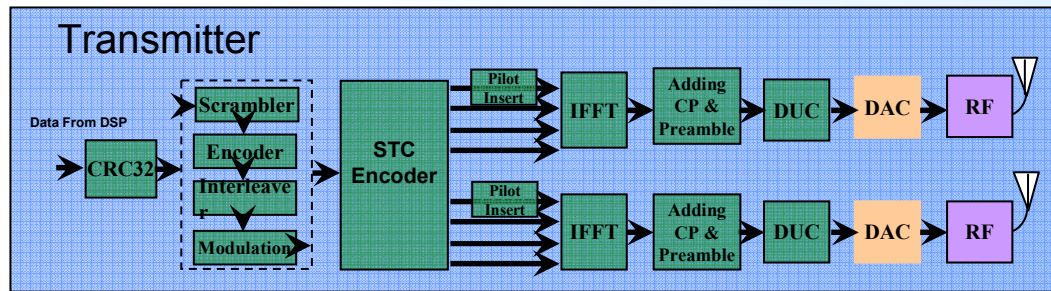
- WiMAX, etc

Outline

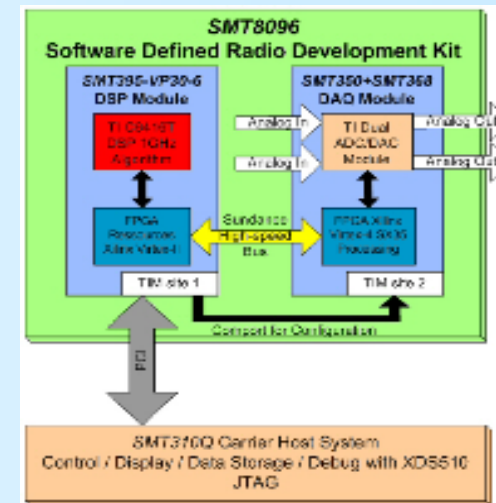
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- **Real Time MIMO Testbed**
- Future work



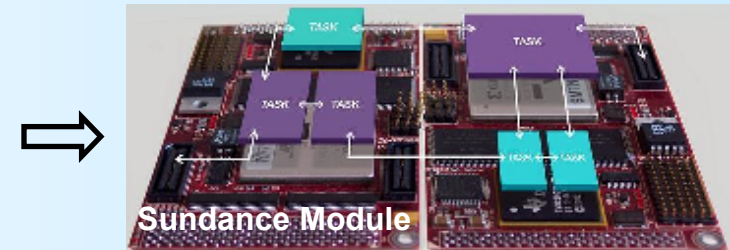
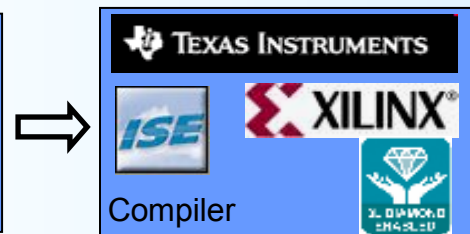
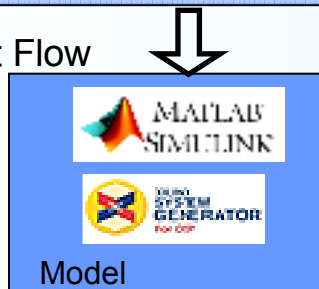
Implementation of MIMO-OFDM System



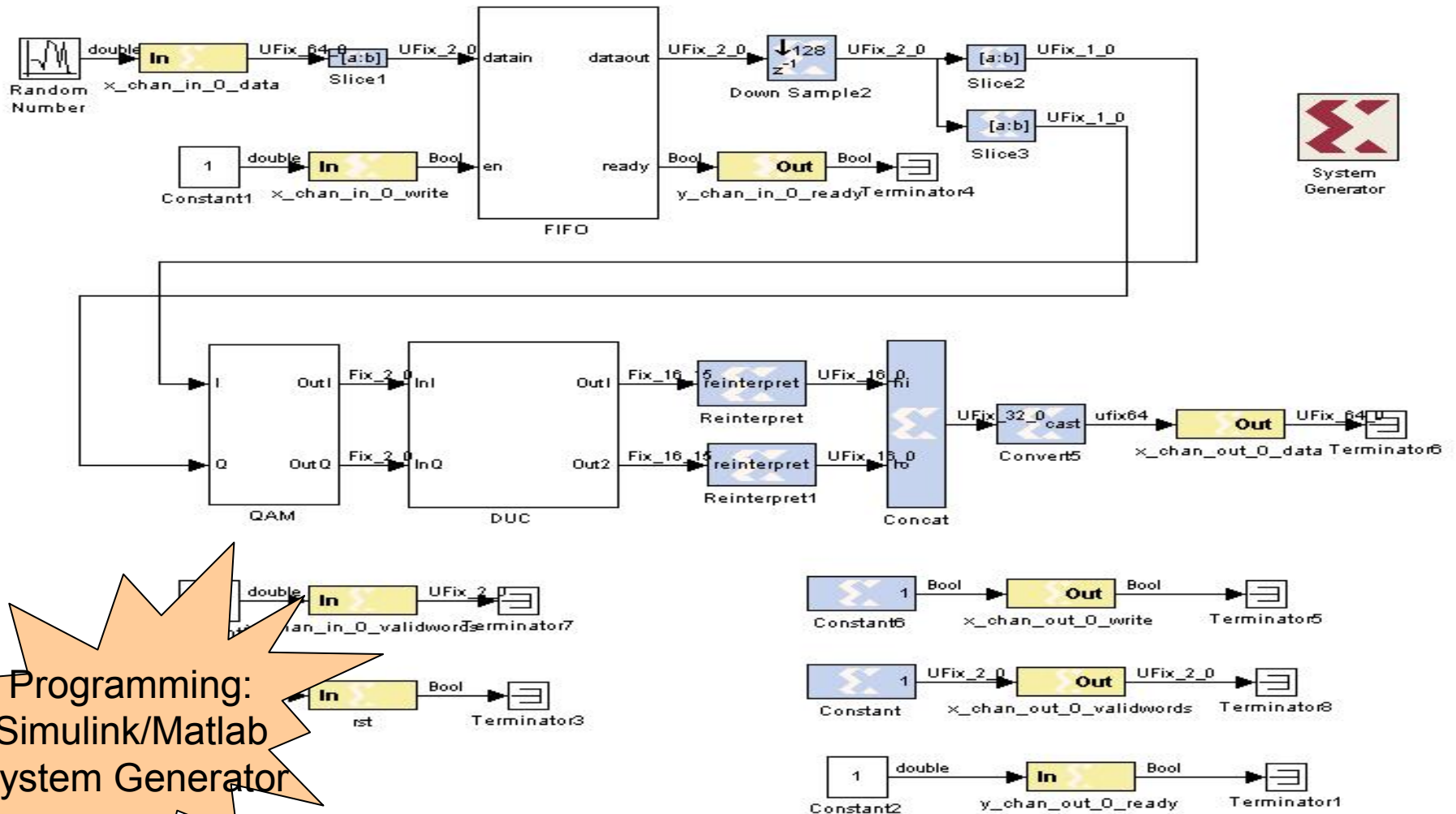
- Implemented in FPGA
- Sundance SMT 350
- RF Module (max 4 ch)



Development Flow



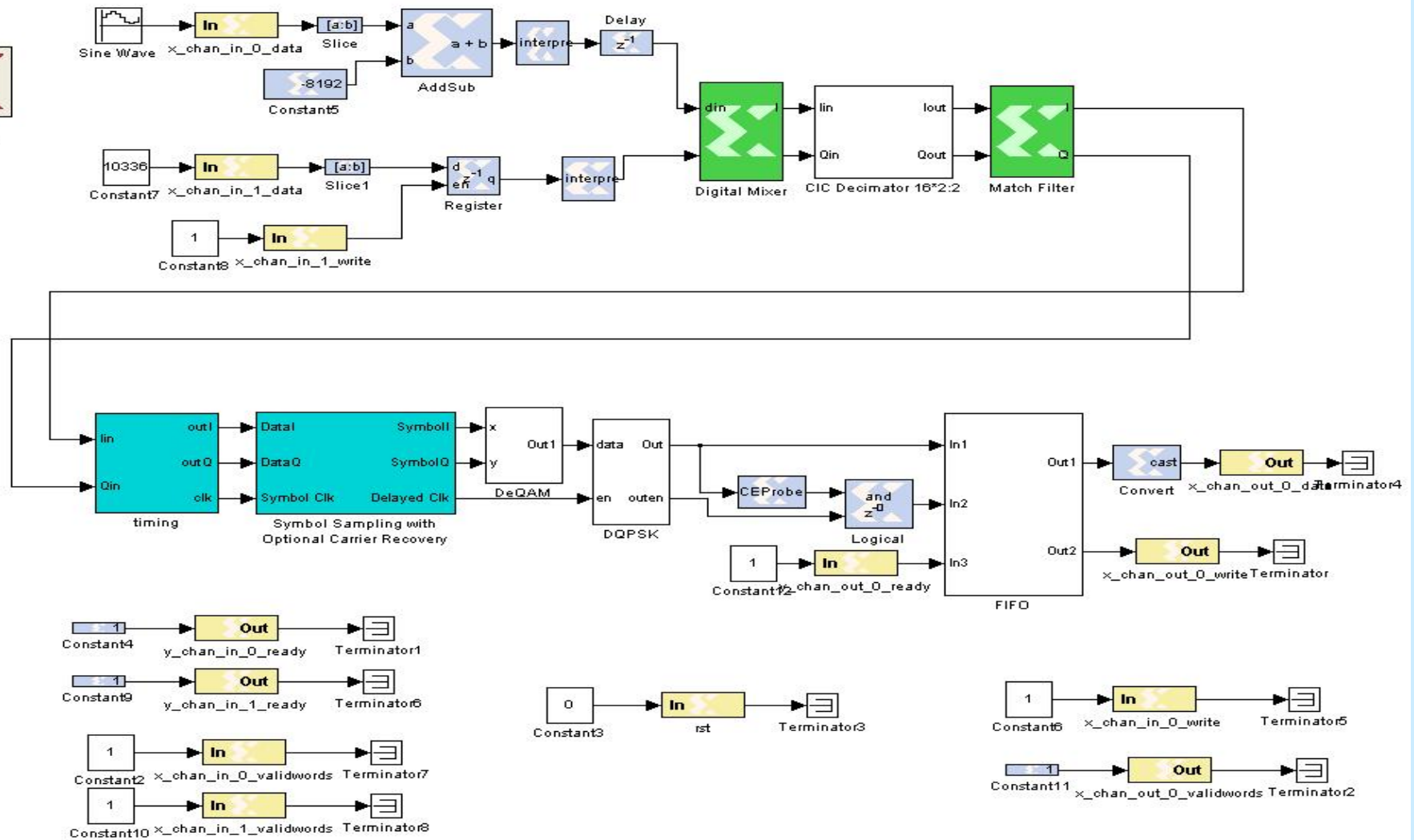
SISO Transmitter



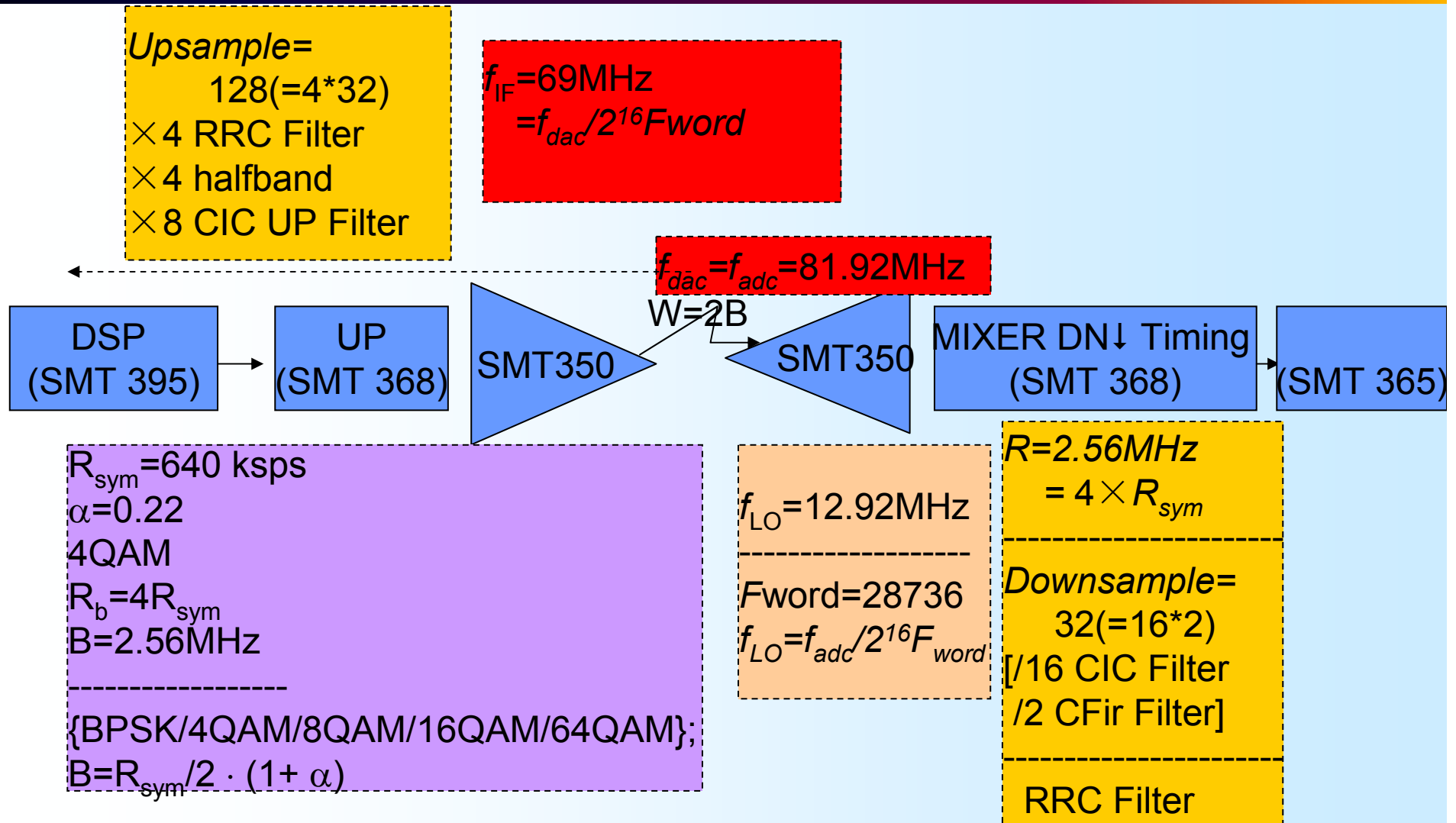
Programming:
Simulink/Matlab
System Generator



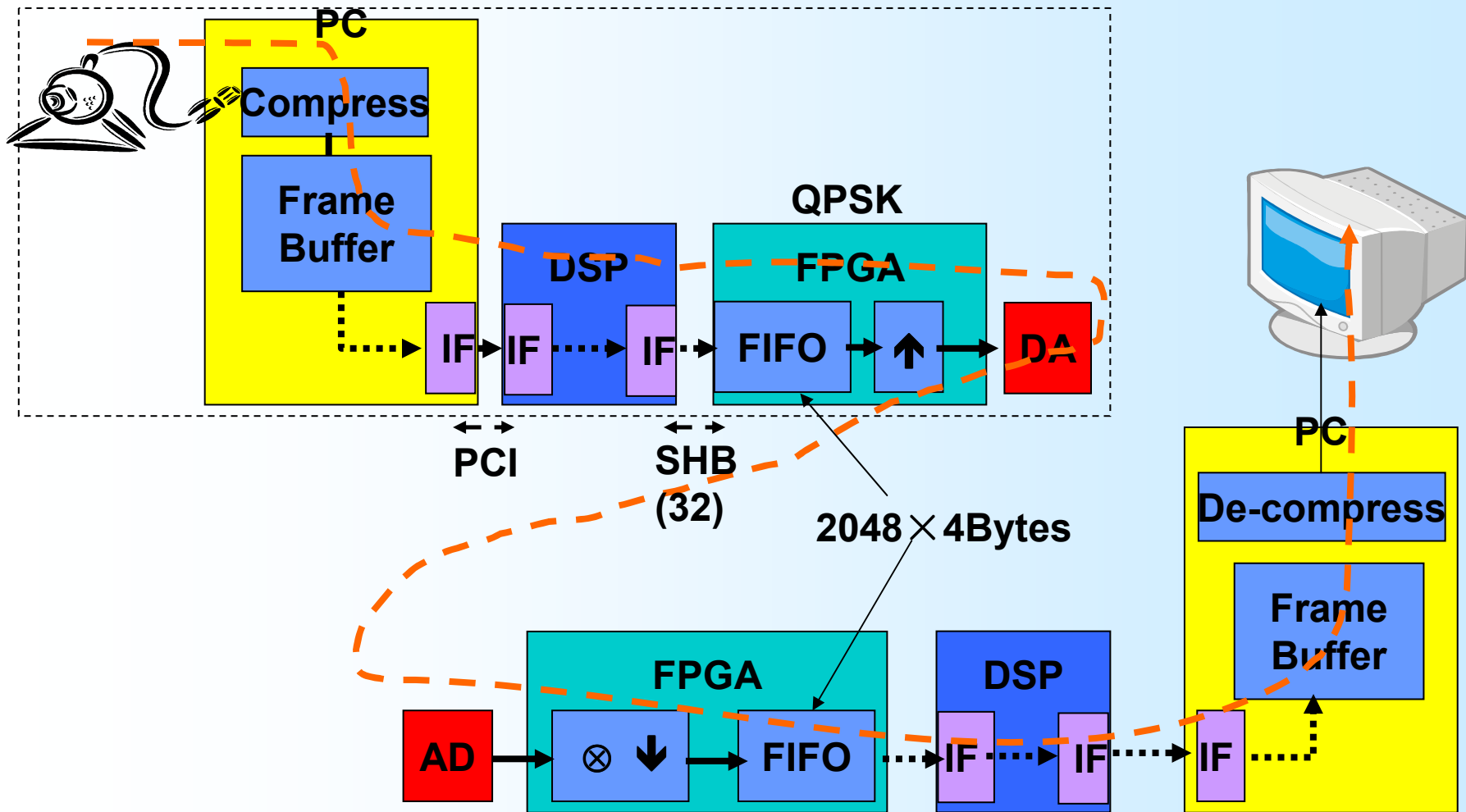
SISO Receiver



SISO--parameters




Video Transmission --Data Flow



Video transmission

USBVIDEO

File Capture Options Help



```
lock ok  
bKeyFrame 0  
  
write data to FIFO  
write FIFO
```

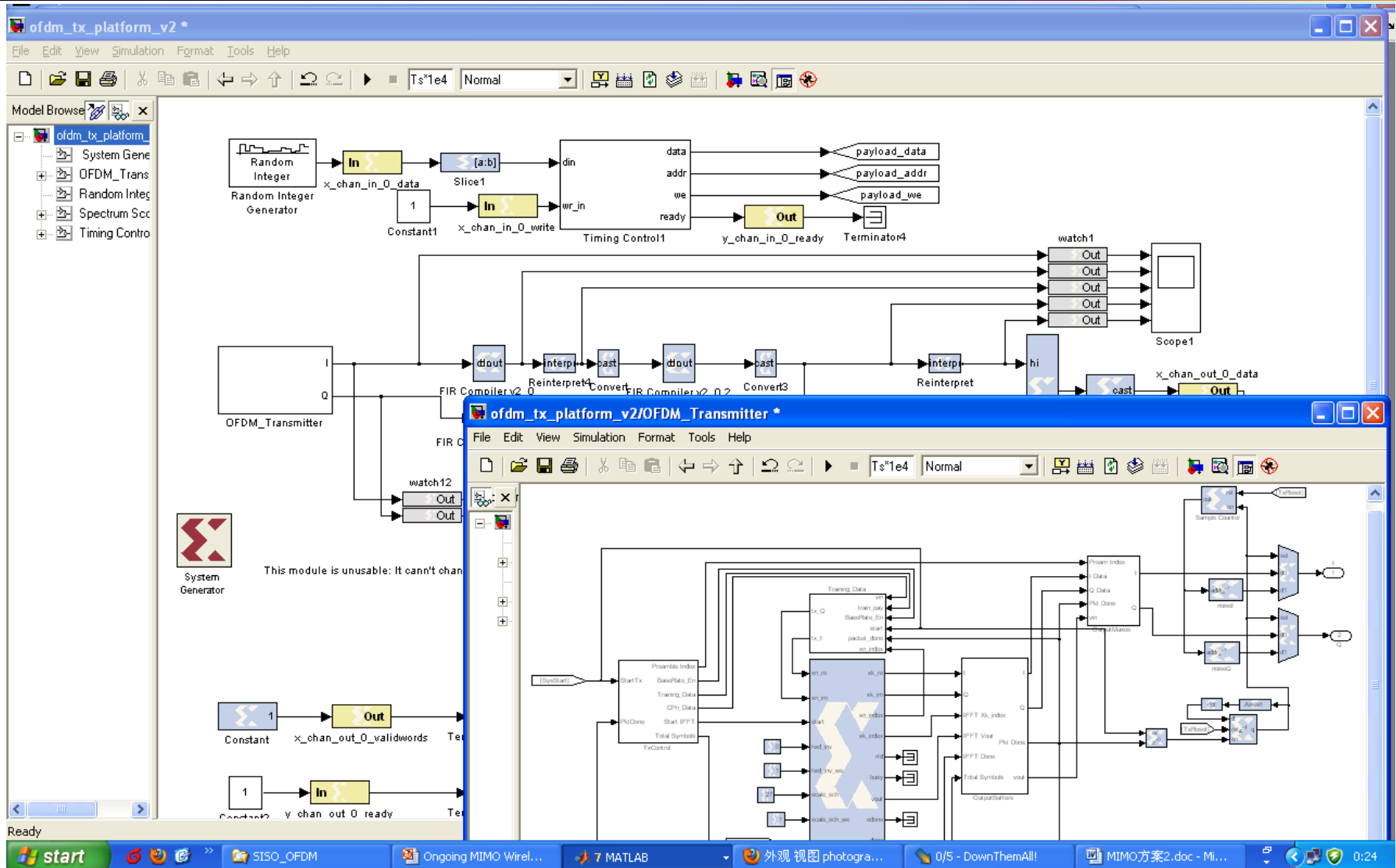
Transmitter

Receiver

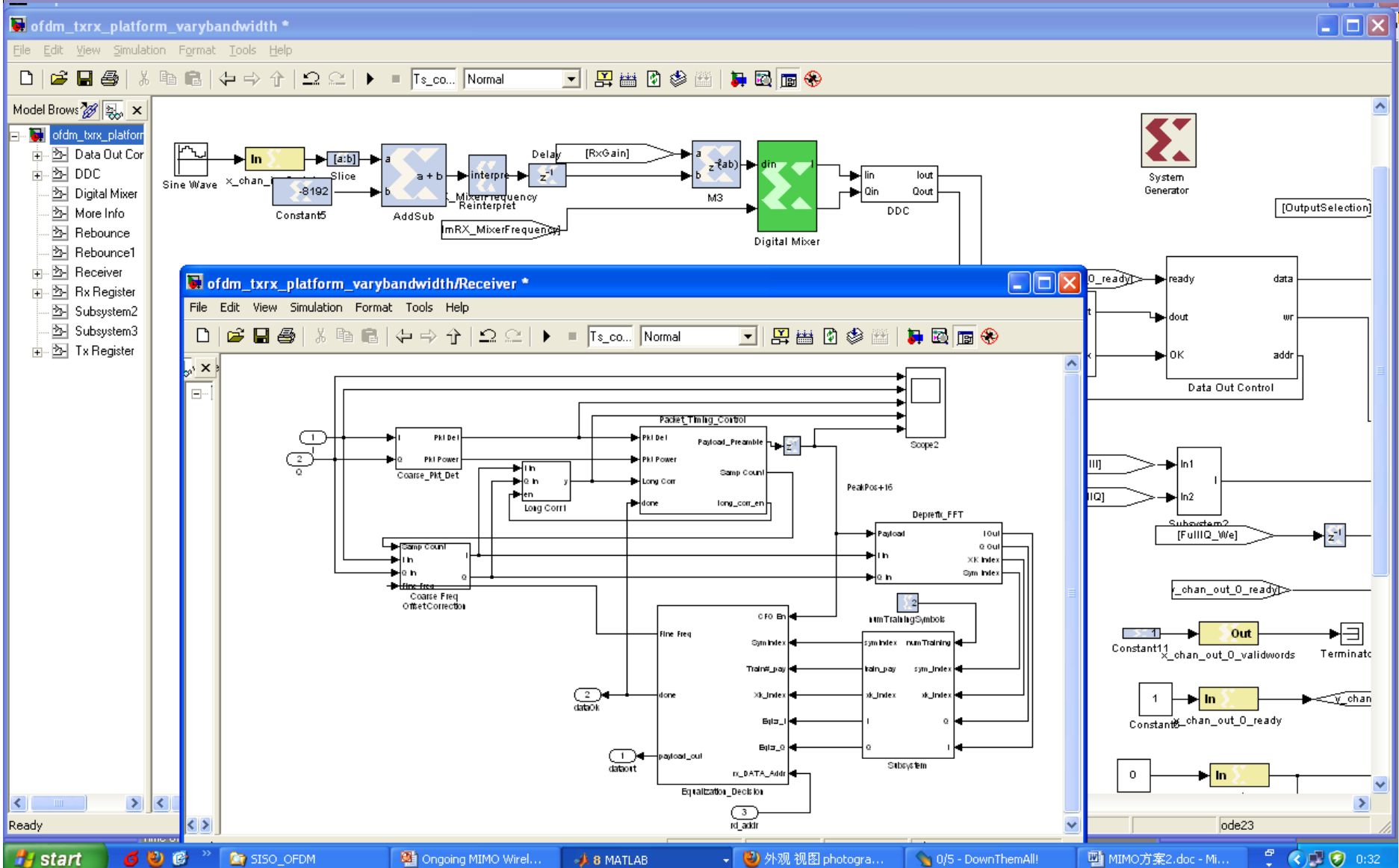
```
framesize=4020  
  
bKeyFrame 0  
framenum 153  
  
read from dsp  
read data from FIFO
```



OFDM Transmitter (refer to WARP)

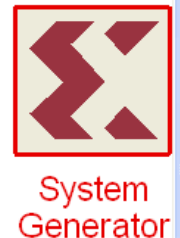


OFDM Receiver (refer to WARP)



Processing Simulink/System Generator

The screenshot displays the MATLAB System Generator environment. The main workspace shows a Simulink model titled "OFDM Tx MIMO" with various blocks such as "Training_Data", "IFFT", and "OutputBuffers". A "System Generator: ofdm_txrx_mimo" dialog box is open, showing configuration options for compilation and clocking. The dialog includes fields for "Compilation" (HDL Netlist), "Part" (Virtex2P xc2vp70-6ff1517), "Target directory" (./TxRx_netlist), "Synthesis tool" (XST), and "Hardware description language" (VHDL). It also has sections for "Clocking Options" (FPGA clock period, DCM input clock period) and "Block icon display". The bottom of the screen shows the Windows taskbar with several open applications including MATLAB and Microsoft Word.



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Future Work

- Non-real Time System
 - Faster and easier development of new system.
 - Non-real Time Signal Processing
 - ICS554+ICS564 Cost about 200,000RMB (~28,600\$)
 - Cheaper Solution: USRP (Universal Software Radio Peripheral) , 2 USRP1s and 2 USRP2s for Cognitive Radio testing are ordering from Ettus.



Future Work

- Real Time System
 - Real Time signal Processing
 - Complexity: more complex than C/Matlab, simpler than VHDL/Verilog
 - Cost of Sundance SMT8036/SMT8096 cost also about 200,000 RMB
 - Cheaper Solution: System Design by reference to WARP Project.
 - Higher deployment complexity of new algorithm
 - Expected solution??? :MPP-DSP (proposal of National S&T Major Project in 2011)



Thank You & Welcome to visit Shandong University

