

# UWB System simulator

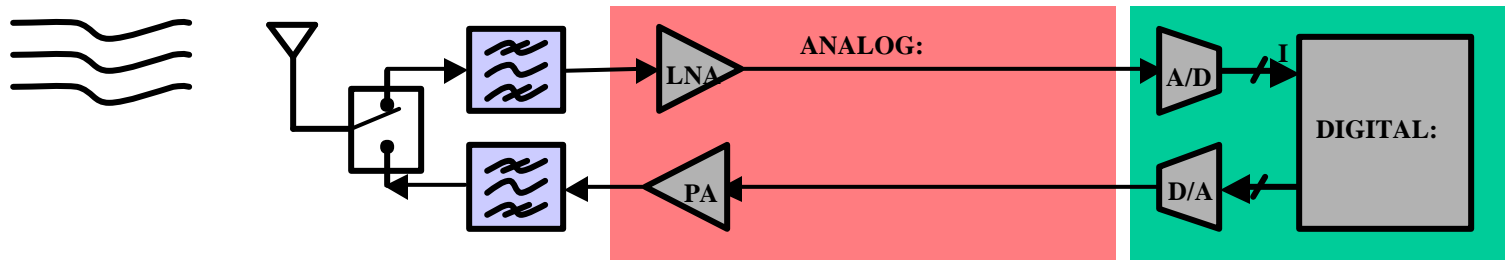
## **Why Simulator?**

- Verify the functionality of RF front end.
- Get the sense of how the hardware parameters affect the whole system performance.

## **Why Simulink?**

- Friendly graphic interface.
- Hierarchy based structure is easier to be modified as the research phase proceeds.
- Unified simulation environment, both in RF simulator and digital backend.
- The relations between BER could be achieved by running one sample through the channel model, and then feed into the rest of the receiver to save simulation time.

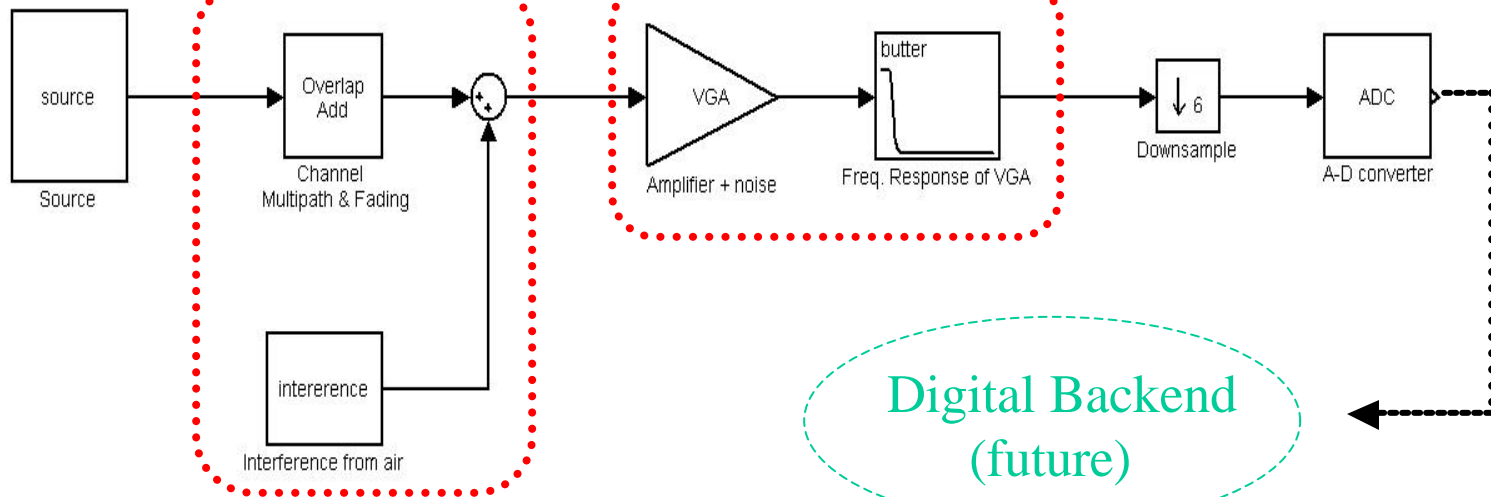
# System Overview



Short impulse

Channel Model

Front end Amplifier Model

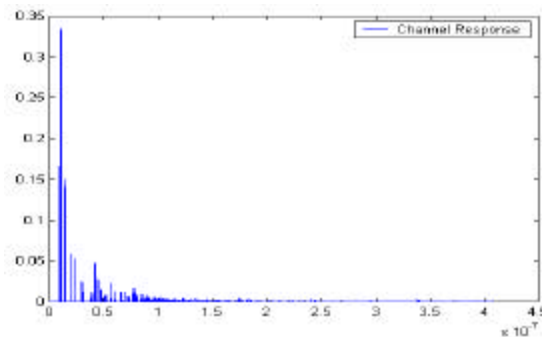


# Channel Model

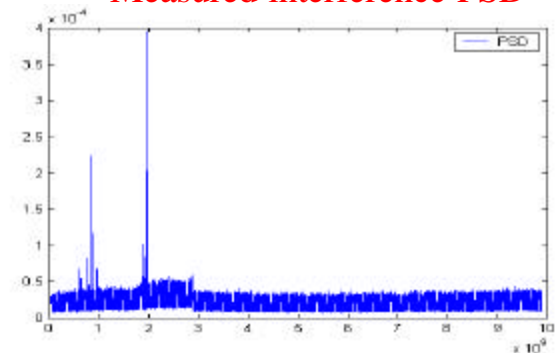
## Considerations:

- Multipath fading & free space loss:
  - Using Tang's Birst model (Berkeley Indoor Radio Simulation Toolsuite)
- Interference from air:
  - Extract from measured data, and pick out the 5 biggest interference as the noise inputs
- Example: A distance of 3 meters at Cory 2<sup>nd</sup> floor

Impulse response



Measured interference PSD



# Model RF Front End (1)

## **Antenna:**

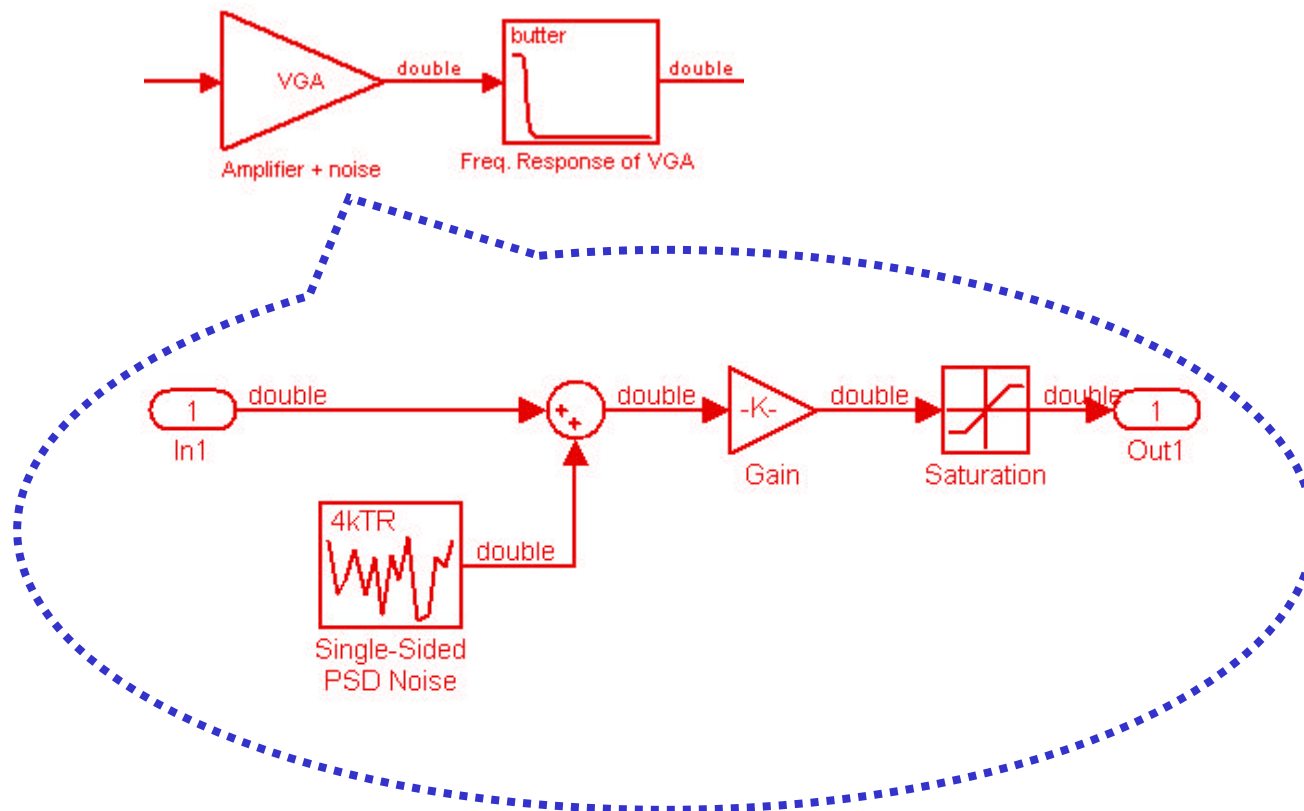
- According to Friis transmission equation, the antenna gain  $G_T$  and  $G_R$  are not constants, because UWB is over a wide frequency band.
- We haven't included the antenna frequency response, and still look for the suitable antenna design for UWB.
- For noise contributed by antenna, we currently assume it's a 50 ohm white noise.

## **LNA & VGA:**

- So far, we just include the gain and noise of these two stages, excluding the nonlinearities.
- Frequency response is modeled by a low pass filter, whose rolling-off frequency is 1 GHz.

## Model RF Front End (2)

-VGA is now given a constant gain to amplify the incoming signal to full scale without a feedback loop.



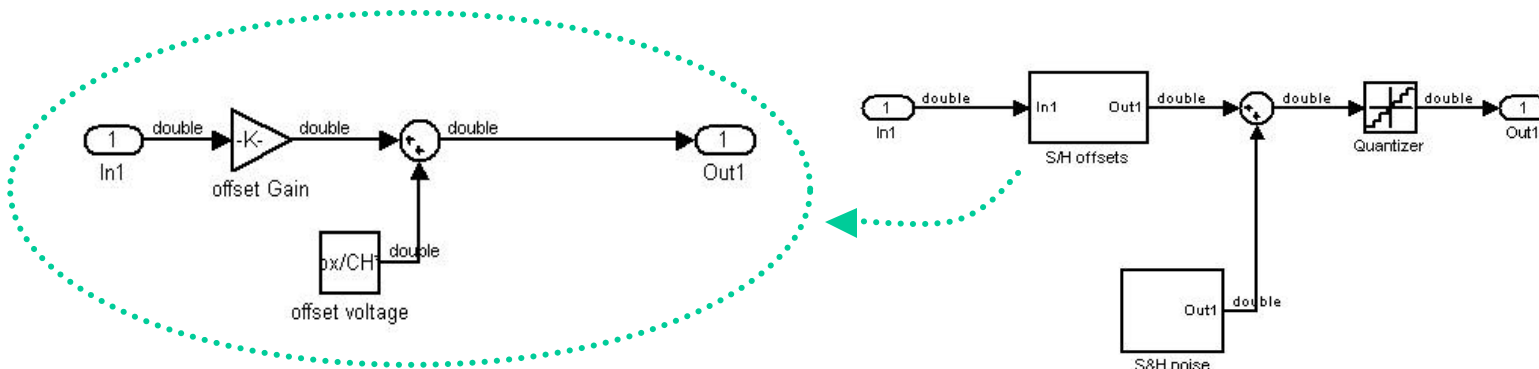
# ADC

## Sample and Hold:

Use 1-pole approximation to model the noise induced by the switched-capacitor circuit, i.e.  $KT/Cs$ . There is also offset voltage and gain caused by clock feedthrough and charge injection.

## Quantization:

The quantization interval is determined by the Full scale divided by the number of bits.



# Simulation Results

Example: Input a doublet-like triangle impulse with peak voltage 1V

-Input doublet



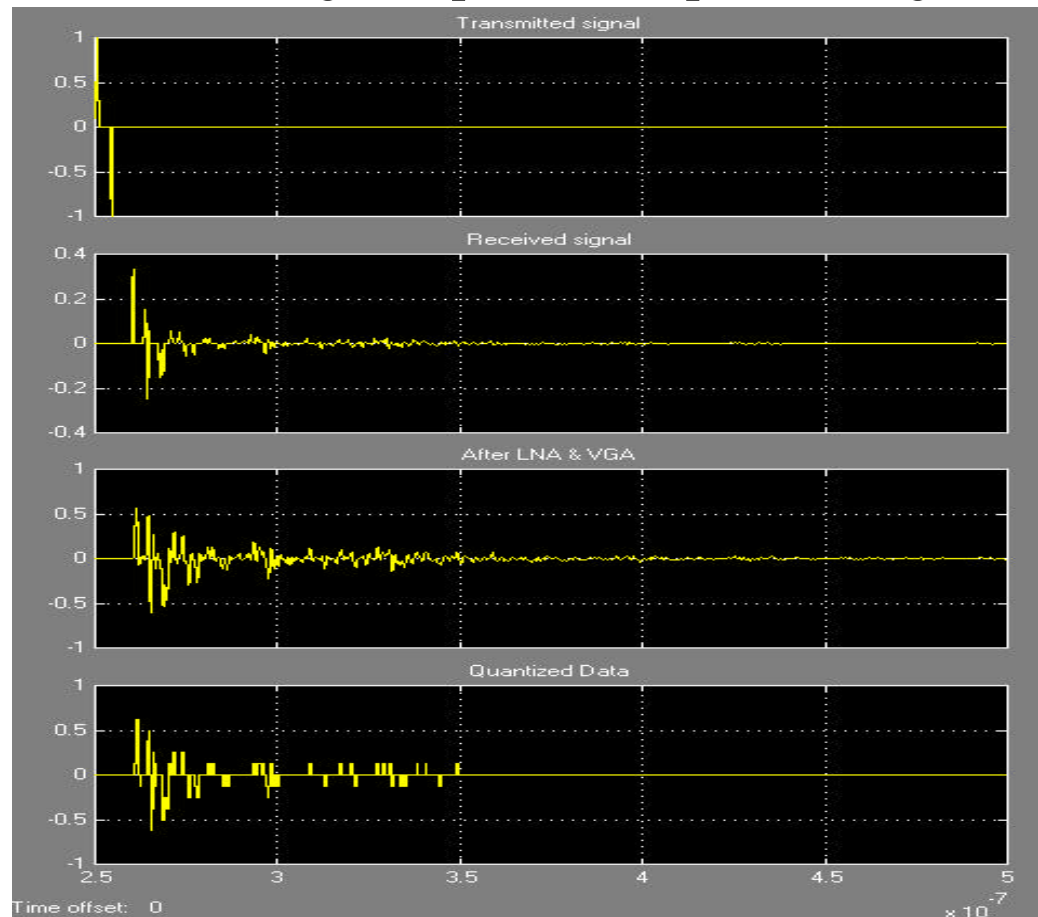
-Through air



-Through RF ckt



-Quantized data



# Digital Backend

## **Functionality:**

### **-Data recovery**

Using spreading codes, we need to correlate the quantized data with the expected sequence to recover the original bit.

### **-Synchronization**

## **Components in Digital Backend:**

### **-Matched filter:**

In order to get rid of the noise effect, we have to correlate with the expected received impulse shape. Plus the uncertainty of the phase shift of the received spreading code, we need a large array of correlators.

### **-Max value detector:**

A maximum value detector is required to find out the position of impulse being captured in the sampling window.

# Future work

## **-Updating the RF simulator**

As the progress moves on, we will keep on modifying the parameters and even structures in the simulator without too much labors.

## **-Move to digital backend**

Use simulink to build the digital backend, and applies the model to SSHAFT design flow or FPGA test bed.

## **-Find the optimum UWB design via simulator**

Once the complete simulation environment being set up, we could try to optimize the whole system designs more easily, such as the trade-offs between power and speed issues.

## **-Build the link model for the UWB front end**

Build up the noise model through the receiver so that we could find out the optimum specs for ADC and gain amplifier.