Lab 4: Wideband system

NTU communication laboratory
Spring, 17
2017.05.03

Outline

- ■OFDM系統架構
  - ◆基本原理與實驗目的
- ■相關module的I/O
  - ◆核心元件簡介
  - ◆FFT/IFFT
- ■實驗內容
  - ◆LabVIEW模擬程式
  - ◆USRP實驗系統
  - ◆實驗問題說明
- ■注意事項

實驗目的

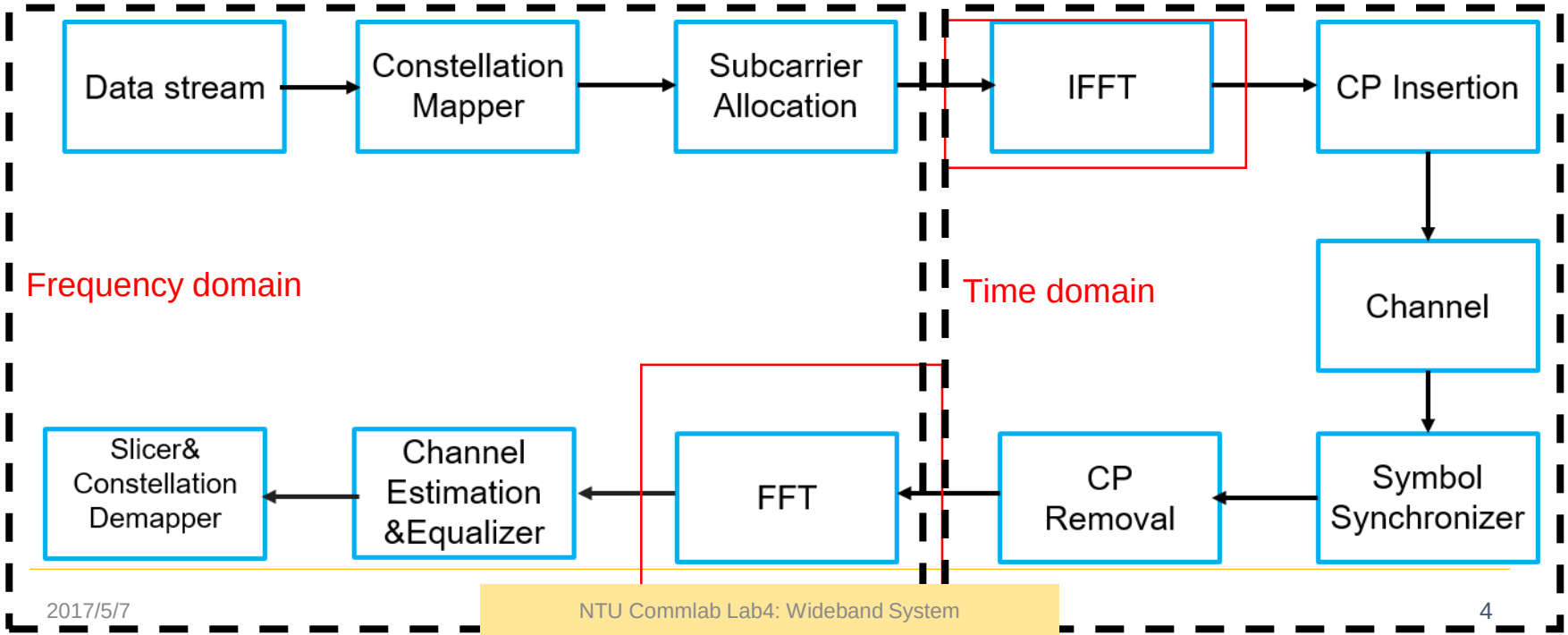
■熟悉並實作OFDM系統
- ◆TX傳輸端 及 RX接收端如何設計?
- ◆OFDM系統如何運作?

■比較OFDM與傳統調變的差異

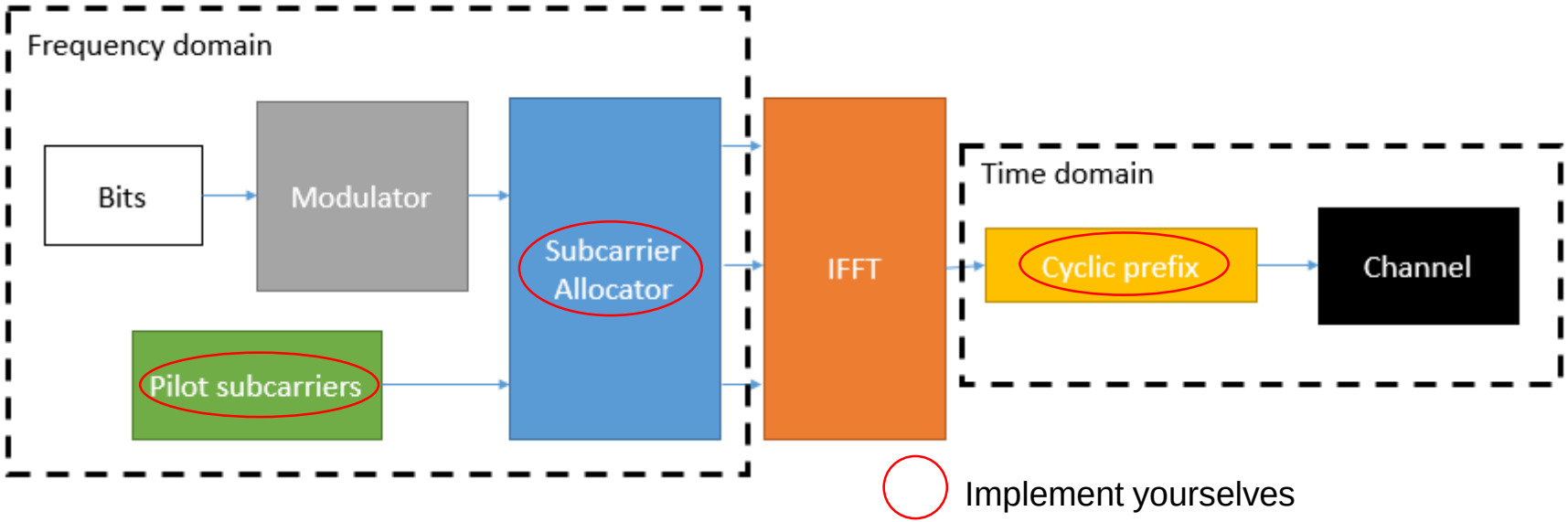
■透過實際傳輸觀察OFDM的效能

基本原理與系統架構

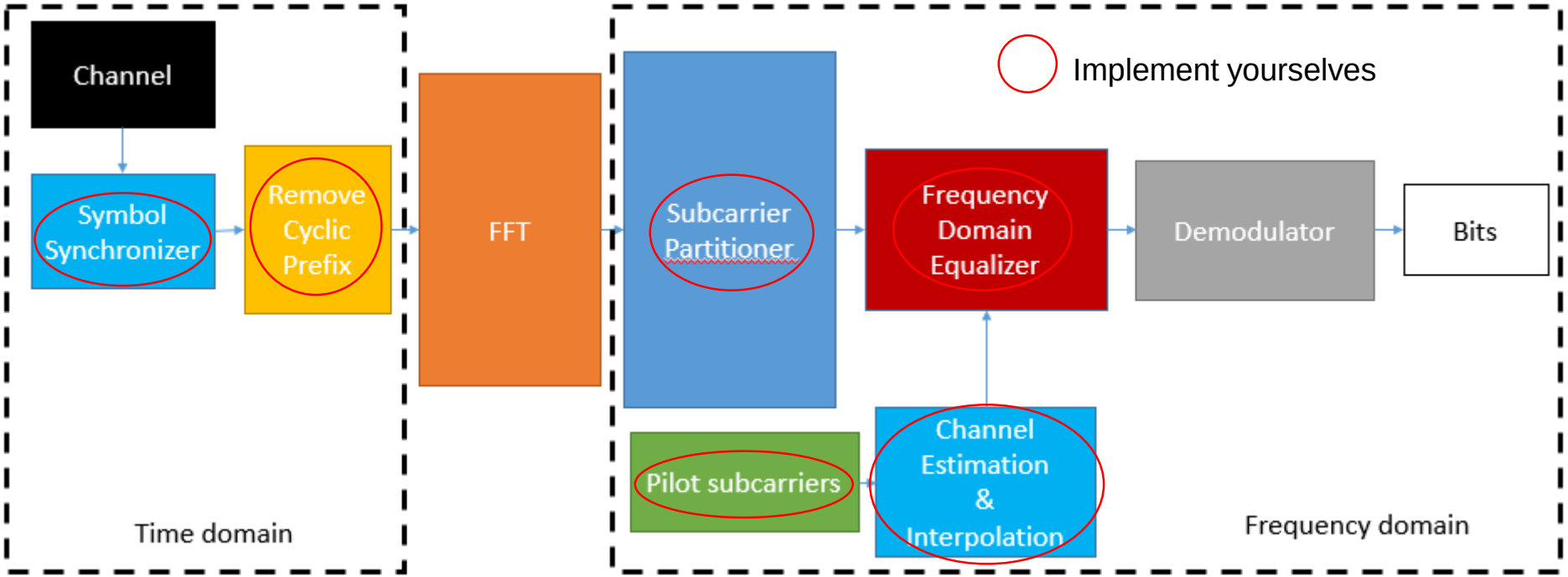
■整體系統架構



OFDM 傳輸端 架構圖


Frequency domain
Bits
Modulator
Subcarrier Allocator
Pilot subcarriers
IFFT
Time domain
Cyclic prefix
Channel
Implement yourselves

OFDM 接收端 架構圖


Channel
Symbol Synchronizer
Remove Cyclic Prefix
FFT
Subcarrier Partitioner
Frequency Domain Equalizer
Demodulator
Bits
Implement yourselves
Pilot subcarriers
Channel Estimation & Interpolation
Time domain
Frequency domain

基本原理與系統架構

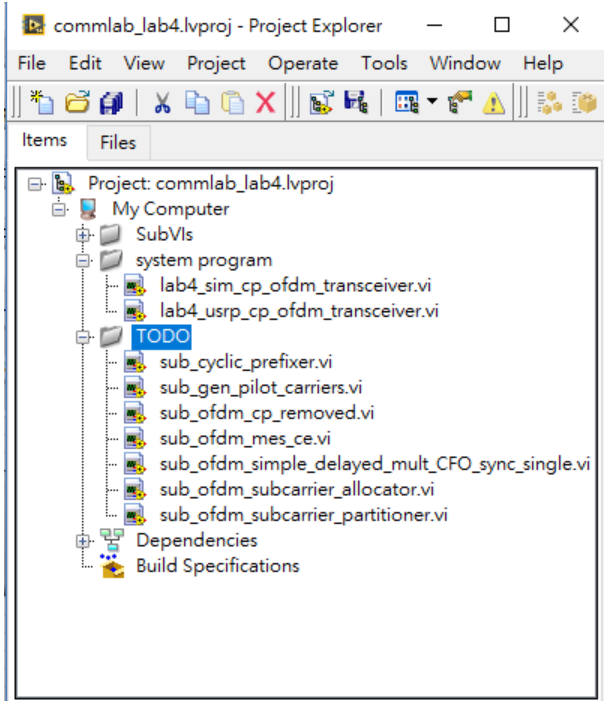
■實作項目:

◆TX:

1. Cyclic prefixer
2. Pilot carrier generator
3. Subcarrier allocator

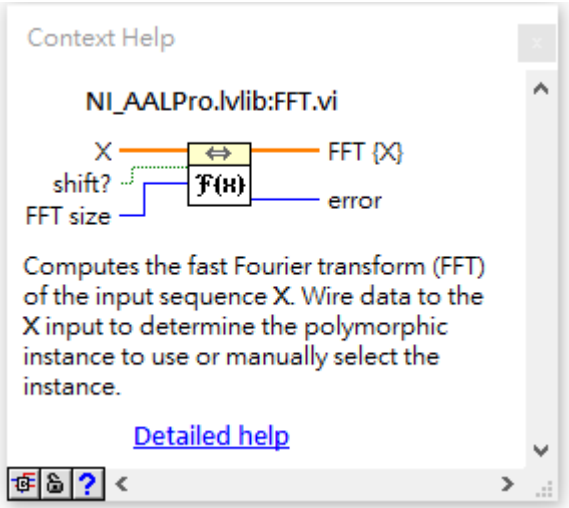
◆RX:

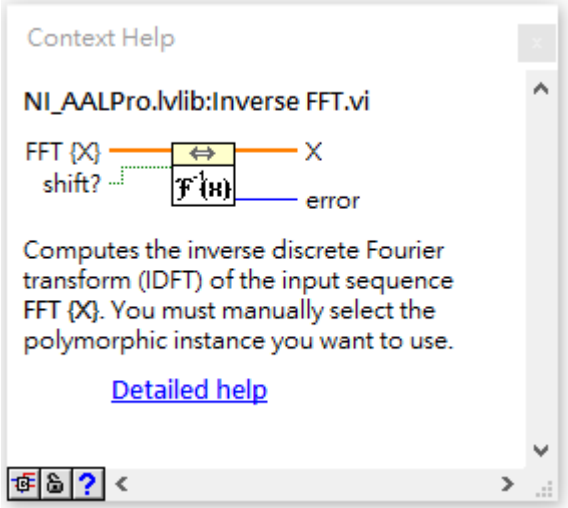
1. Cyclic prefix remove
2. Channel estimator
3. OFDM synchronizer
4. Subcarrier partitioner



FFT/IFFT in LabVIEW

■Location: Signal processing->Transforms





LabVIEW 模擬

- ■模擬內容:
  - ◆OFDM系統實作
    - ◘subcarrier allocation
    - ◘OFDM synchronization
    - ◘利用pilot subcarrier做 channel estimation並補償 (Zero-forcing FEQ)
- ■效能觀測:
  - ◆與傳統調變之BER比較
  - ◆調整 cyclic prefix的長度觀察錯誤率之變化
  - ◆Peak-to-Average Power Ratio (PAPR)

USRP實作

■實驗內容:

◆延伸LabVIEW 模擬, 以USRP傳收封包

■觀測重點:

◆傳送與接收後之FFT spectrum差異

◆實際傳收OFDM訊號，觀察與模擬結果之差異

◆量測PAPR

實驗問題

■LabVIEW simulation:

1. 調整CP的長度 {16,32,64,128} 量測BER (到10^{-4}即可) 並作圖 (FFT=256)
2. 計算Peak-to-Average Power Ratio(PAPR)

   ◘PAPR definition:

$$PAPR = \frac{Subcarrier\ of\ maximum\ power}{Average\ power\ of\ all\ subcarriers}$$

3. 擷取任一次OFDM symbol估計出data subcarrier之channel gain

   ◘請作兩張圖

   a. Magnitude versus indices
   b. Phase versus indices

實驗問題

■USRP experiment

1. 調整CP的長度 {32,64,128} 量測BER (到10^{-3}即可) 並作圖 (FFT=256)
2. 紀錄任一次接收之OFDM symbol於time domain的Quadrature phase signal.
   - ◘兩張圖: 1. CP=32, 2. CP=64 (FFT=256)
   - ◘可以將zero subcarrier 之power 作多次平均作為noise power
   - ◘也可以將TX button關閉並記錄接收端之avg. power 作為noise power
3. 擷取任一次OFDM symbol估計出data subcarrier之channel gain
   - ◘請作兩張圖
     a. Magnitude versus indices
     b. Phase versus indices
     c. 與simulation作比較 (建議使用天線延長線)

注意事項

■DUE: 21:00, 5/26 (Fri.)
- ◆請盡早開始進行

■ BER of OFDM
- ◆Some power are distributed to pilot subcarriers
- ◆Some power are distributed to cyclic prefix
- ◆You should think of how to represent $\frac{E_b}{N_0}$ from symbol energy correctly!

■OFDM之效能好壞，依賴subcarrier間的orthogonality
- ◆偶發性的error屬正常現象
- ◆請善用模擬來驗證各元件之實作成果