Practice #3 – October 01, 2020

Ultra Wide Band Radio Fubndamentals

Introduction to UWB

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Outline

- UWB vs non-UWB: review
- Generate waveforms, BW Computations
- Define: UWB vs non-UWB signals
- Proposed exercises

Definition of UWB signal

A base-band (radio-frequency) signal x (t) is UWB iff:

$$\rho_{FB} \geq \rho_{FBth} = 0.2 \qquad \text{if } f_c \leq f_{th} = 2.5\,[\text{GHz}]$$
$$B \geq B_{th} = 0.5\,[\text{GHz}] \qquad \text{if } f_c > f_{th} = 2.5\,[\text{GHz}]$$

where: $\rho_{FB} = B/f_c$ is the fractional bandwidth;

B is the bandwidth;

f_c is the center (carrier) frequency.

Historically there have been several definitions with different parameter settings.

According to (DARPA, 1990):

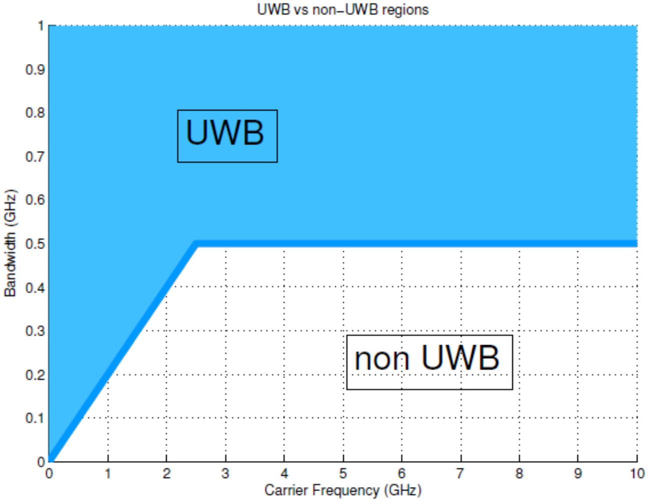
- the bandwidth is taken @ -20 dB,
- $\rho_{FBth} = 0.25$,
- $f_{th} = 6$ GHz (that leads to 1.5 GHz of bandwidth limit).

According to (FCC, 2002):

- the bandwidth is taken @ -10 dB,
- $\rho_{FBth} = 0.2$,
- $f_{th} = 2.5$ GHz (that leads to 0.5 GHz of bandwidth limit).

In the following, we will use the FCC definition.

(FCC, 2002) definition



Outline

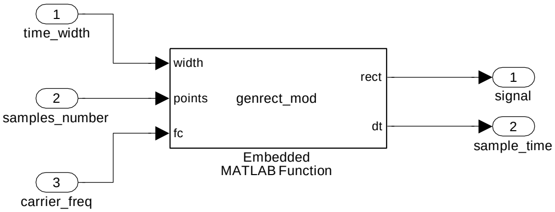
BW Computations

CHECKPOINT 1–1

Generate **two** waveforms, both rect:

1. in BB @ f_c = 0 Hz,
2. in RF @ f_c = 1 KHz.

```
[signal, sample_time] =
    genrect_mod(time_width,samples_number,carrier_freq)
```



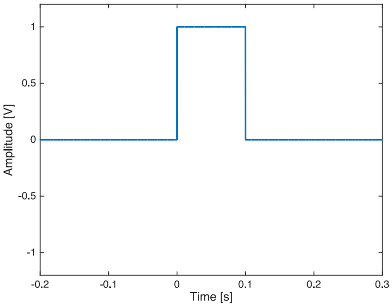
BW Computations

CHECKPOINT 1–1

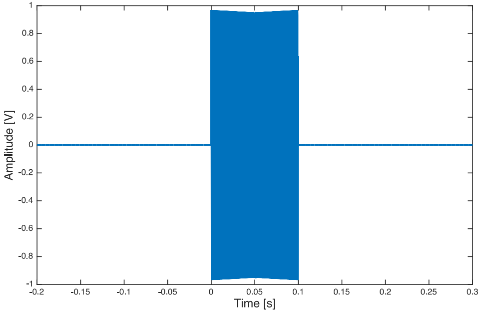
Input given:

1. width t = 100 ms,
2. points = 1000.

1. BB:rect_A



2. RF:rect_B

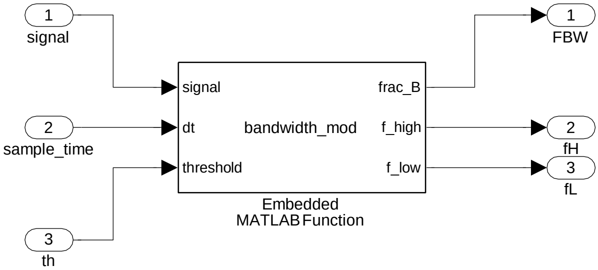


BW Computations

CHECKPOINT 1–1

Compute the bandwidths of the previous signals.

```
[frac_B, fH, fL] = bandwidth_mod(signal, sample_time, th)
```

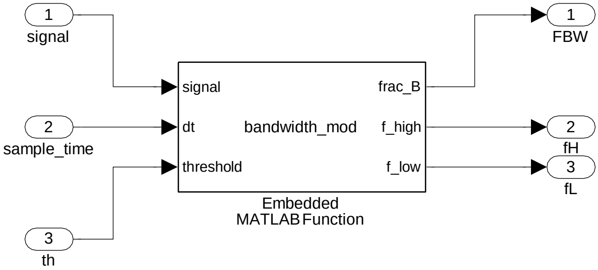


BW Computations

CHECKPOINT 1–1

Compute the bandwidths of the previous signals, given:

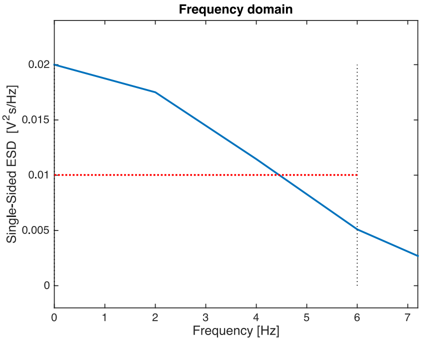
1. signal = rect_A or rect_B
2. dt = dt_A or dt_B (dt = width/points)
3. threshold = - 3 (dB)

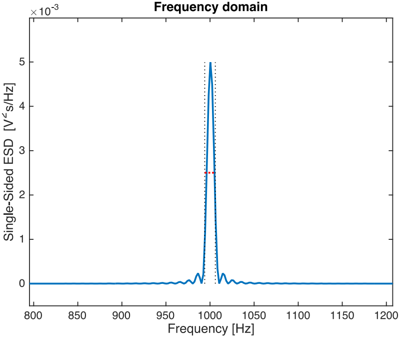


BW Computations

CHECKPOINT 1–1

Single-sided ESD of rect_A and rect_B





Outline

UWB vs non-UWB

CHECKPOINT 1–2

Generate **two sinusoidal modulated** signals with **rect** envelope, *fixing* the number of cycles N_c and:

A. The *time duration* T_p of the rect.

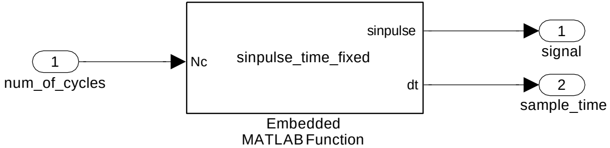
B. The *frequency* F_p of the sinusoid.

The BW can be computed with the coarse $2/T_p$ rule-of-thumb.

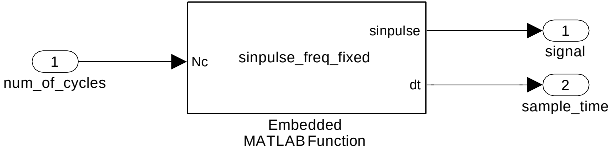
UWB vs non-UWB

CHECKPOINT 1–2

```
[sinpulse, dt] = sinpulse_time_fixed(Nc)
```




```
[sinpulse, dt] = sinpulse_freq_fixed(Nc)
```



UWB vs non-UWB

CHECKPOINT 1–2

- CASE A: **time-fixed** *(Nc defines the frequency of the sinusoid):*
  1. $T_p = 10$ [ns], $N_c = 8$,
  2. $T_p = 10$ [ns], $N_c = 16$.
- CASE B: **freq-fixed** *(Nc defines the time duration of the sinusoid) :*
  1. $F_p = 0.8$ [GHz], $N_c = 8$,
  2. $F_p = 0.8$ [GHz], $N_c = 16$.

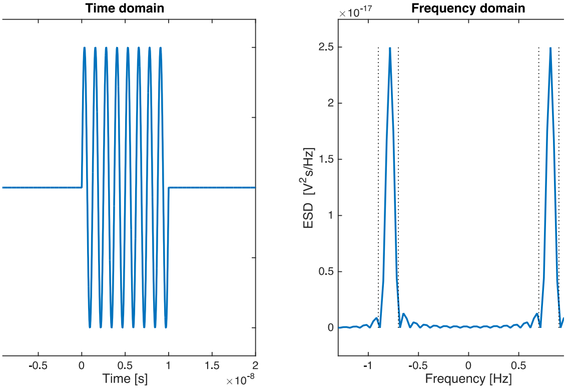
Additional input parameters:

- smp = 1000 (number of samples for each sinusoid cycle)
- A = 1 pulse amplitude [V]

UWB vs non-UWB

CHECKPOINT 1–2

› CASE A: **time-fixed** $(N_c = 8)$



UWB vs non-UWB

CHECKPOINT 1–2

Is it UWB?

Answers.

- CASE A: **time-fixed**:
  1. Y/N?
  2. Y/N?

- CASE B: **freq-fixed**:
  1. Y/N?
  2. Y/N?

Outline

Proposed exercises

Exercise (UWB vs non-UWB)

Find the maximum number of cycles N_c allowed to produce a UWB signal with $F_p = 3.1$ [GHz].

Hints:

1. $1 \leq N_C \leq 16$, BW_th = 500 MHz
2. improve the module, name it as `sinpulse_freq_fixed_impr`.