University
of Pardubice
Faculty
of Electrical Engineering
and Informatics

DVB-T Signal Analysis on Passive Coherent Location system in Single Frequency Network

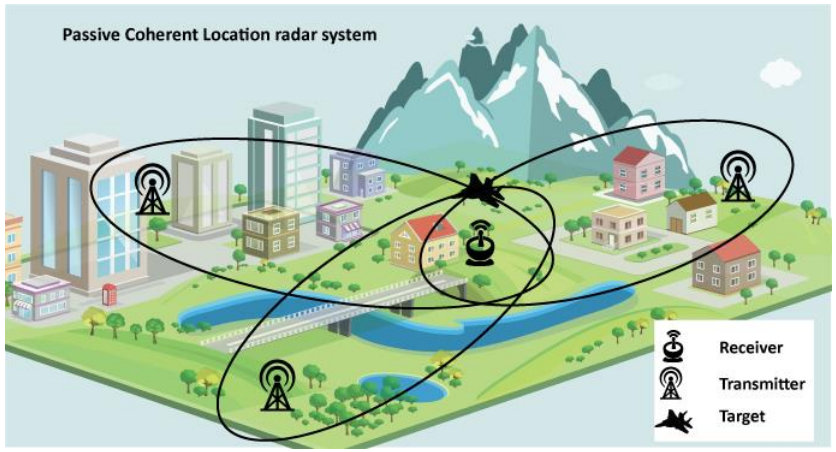
Karel Juryca

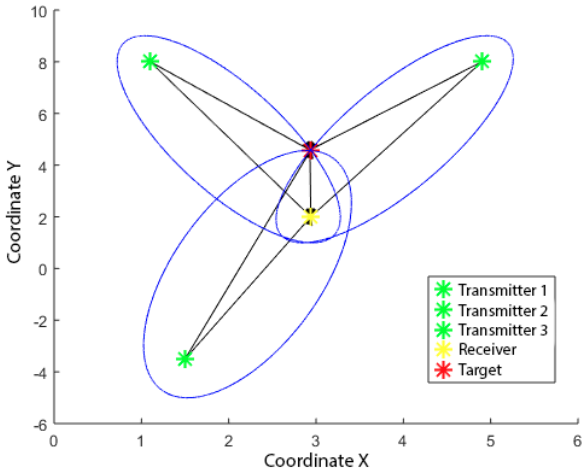
INTRODUCTION

- The development of passive radar systems has long history in Czech Republic
- The DVB-T analysis in terms of guard interval, symbols quantity, scattered pilot carries

Passive Coherent Location

- The PCL system is based on the **bistatic radars**
- Type of the bistatic radars
  - Bistatic radars I. - consist of **own** transmitter and receiver
  - Bistatic radars II. - consist of receiver and transmitters in environment

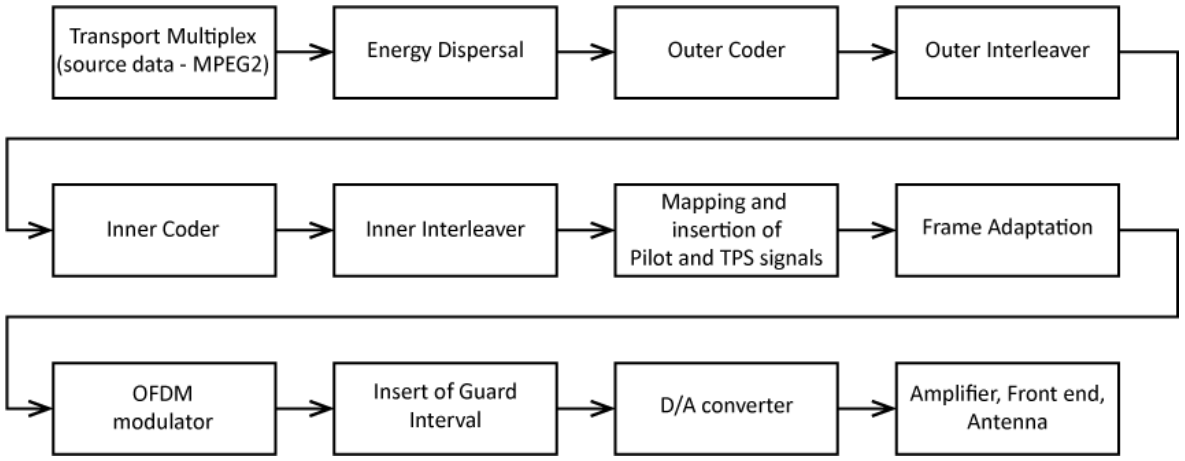




The DVB-T Signal Analysis

- The digitization of the terrestrial broadcasting services (radio, television broadcasting) brings new possibilities for the PCL systems
- The DVB-T, DVB-T2, and DAB standards will require new signal processing techniques, algorithms, etc. for future PCL systems
- The analysis of DVB-T signal based on CA function is required for new generation of PCL systems
- The analysis focuses on parameter description from the point of view the CA function
- The description of DVB-T standard is in norm ETSI EN 300 744

The block scheme of the DVB-T generator



OFDM frame structure

- Transmission mode
  - 2K, 4K, 8K
- Frame include 68 symbols

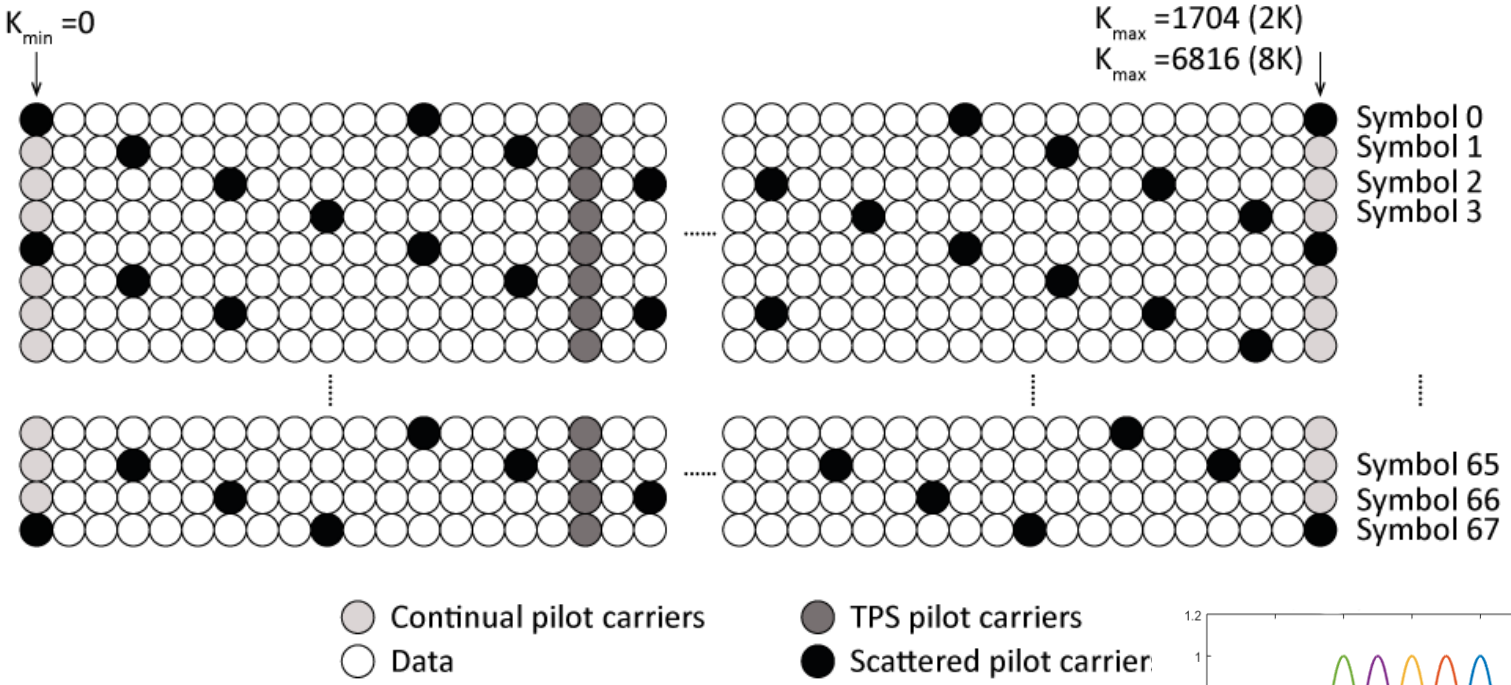
Parameters	Transmission modes	
	2K	8K
The number of data carrier frequencies	1705	6817
Useful time interval (without guard interval)	224 μs	896 μs
Distance between neighboring carrier frequencies	4464 *Hz*	1116 *Hz*
Distance between first and last carrier frequency	7,61 M*Hz*	7,61 M*Hz*

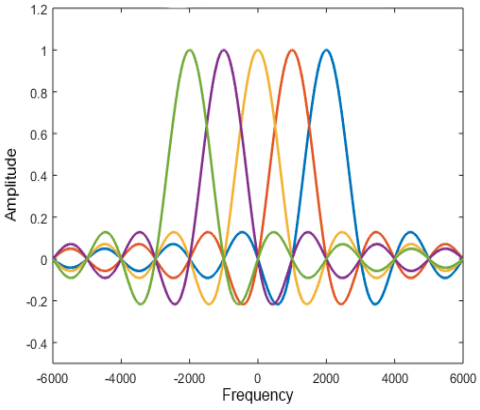
$$k' = k - \left(K_{\min} + K_{\max}\right)/2$$

$$s(t) = \mathrm{Re}\left\{ e^{j2\pi f_c t} \sum_{m=0}^{\infty} \sum_{l=0}^{67} \sum_{k=K_{\min}}^{K_{\max}} c_{m,l,k} \times \psi_{m,l,k}(t) \right\}$$

$$\psi_{m,l,k}(t) = \begin{cases} e^{j2\pi \frac{k'}{T_U}(t-\Delta-lT_s-68mT_s)} & (l+68m)T_s \le t \le (l+68m+1)T_s \\ 0 & other \end{cases},$$

OFDM carrier frequencies in DVB-T system



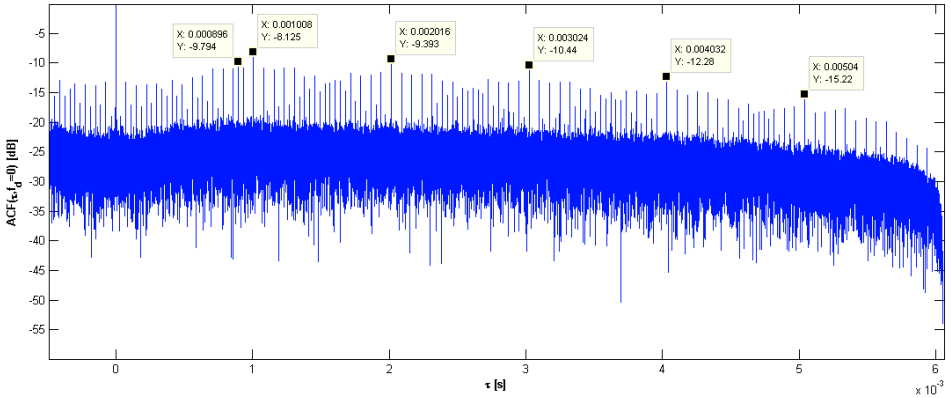


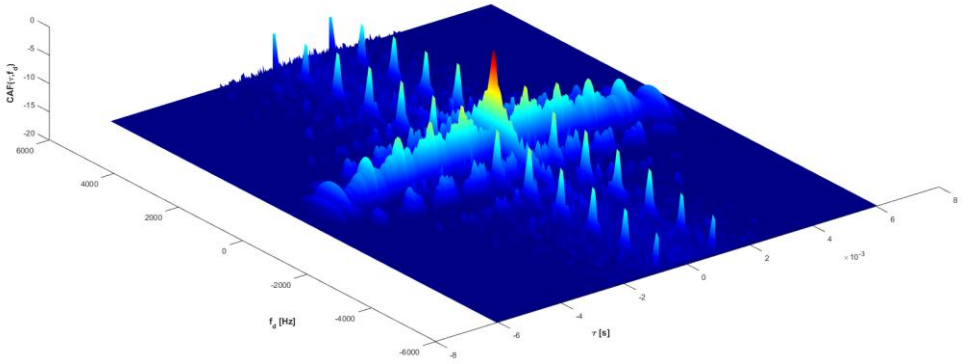
- Pilot carriers → protection of a transmitted signal
- Main function → synchronization and equalization
- Scattered & Continual Pilot carriers

$$k = K_{\min} + 3 * \mathrm{mod}(l, 4) + 12 * p$$

Analysis of the symbols quantity

- The analysis of the CA function for higher quantity of received symbols





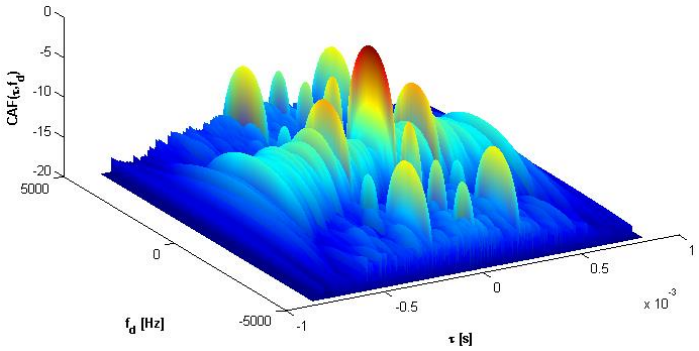
The cursor	Time delay	Description
1	896	The time duration of one symbol without GI
2	1008	The time duration of one symbol with GI
3	2016	The copy of the symbol with GI (2x1008)
4	3024	The copy of symbol with GI (3x1008)
5	4032	The copy of the symbol with GI (4x1008)
6	5040	The copy of symbol with GI (5x1008)

- Every peaks that presents a replica of time length of one symbol, with GI, have several local maxima around this copy
- This periodicity occurs during receiving of more symbols in the CA function

Parameters 8K mode: GI 1/8, No of symbols: 6, 16QAM, CR 5/6

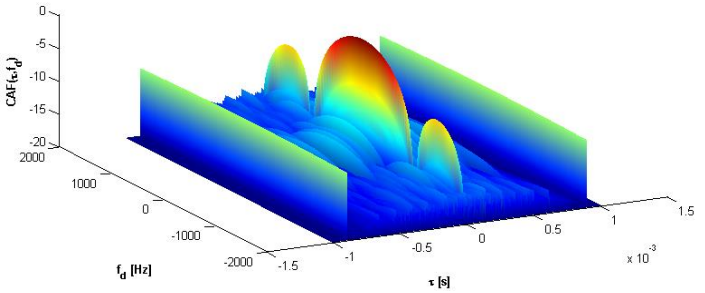
Analysis of the guard interval

- Shape of CA function → $\mathrm{sinc}(x)$
- Significant minima in both modes
- The length of guard interval influence length of symbol → influence of minima position

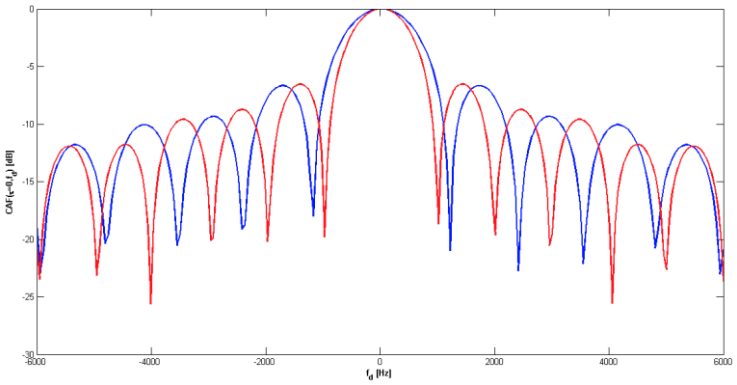


Parameters 2K mode: GI 1/4, No of symbols: 3, 16QAM, CR 1/2 (red)

$$f_t = \frac{1}{\frac{N_s}{N_t}(T_U + \Delta)}$$



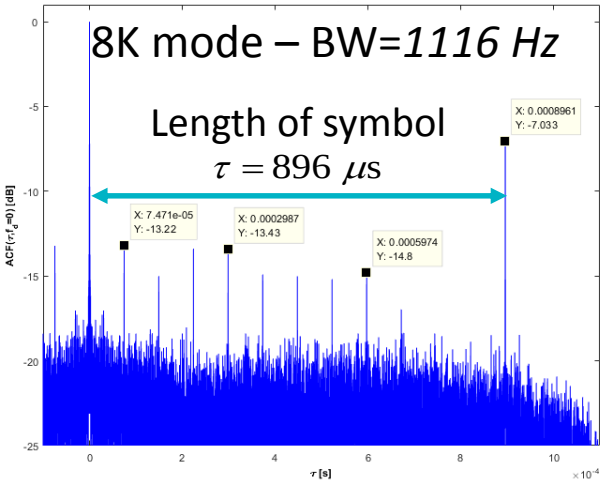
Parameters 8K mode: GI 1/8, No of symbols: 1, 64QAM, CR 7/8 (blue)

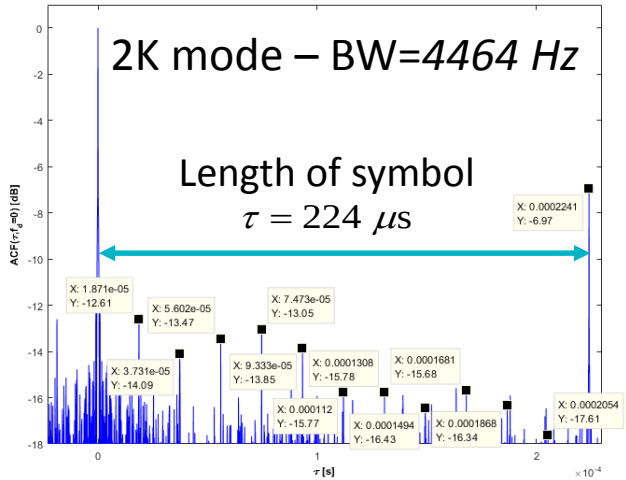


Cut in $\tau = 0$

Analysis of the scattered pilot carriers

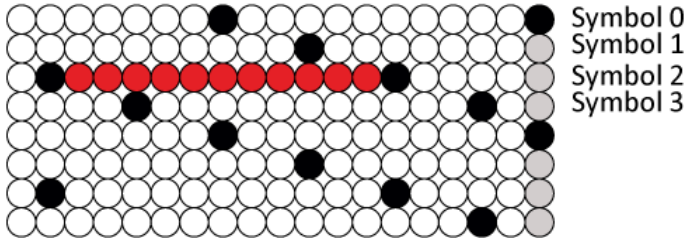
- The output from the CA function in $f_d = 0$ (equal to autocorrelation function)





- Between the „length of symbol“ is eleven peaks placed with constant distance
- Distance is equal for any values of guard interval, code rate or type of modulation
- Influence of scattered pilot carriers
- The derived general formula for computation of maxima of the scattered pilot carriers

$$\tau_n = \frac{1}{(13-n)BW}\ [s]$$



Parameters 2K/8K mode: GI 1/4, No of symbols: 1, 16QAM, CR 1/2

Conclusion I.

- Analysis of the DVB-T signal from the point of view of detection possibilities of the PCL system that exploit DVB-T emitters in a Single Frequency Network

- The detailed description of DVB-T signal is presented and DVB-T generator developed (ETSI EN 300 744 v1.6.1)
- The individual parameters of the DVB-T signal are shown in the behavior of the CA function

Influence parameters of DVB-T signal	Not-influence parameters of DVB-T signal
quantity of the symbols	code rate
length of the guard interval	type of modulation
position of the scattered carriers	TPS and continual pilot carriers

- Elimination of the mentioned influence parameters will be the next step in future research

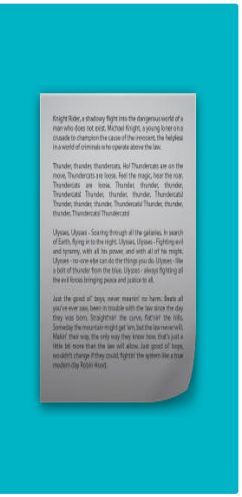
Conclusion II.

- The principle of SFN was described from the point of view of principle target detection of the PCL radar in SFN
- Preliminary analysis of the target detection in the SFN network
- The simulated situation is presented for one/multiple target with a multipath effect
- The multipath effect clearly and significantly influences the determination of the precise accuracy of the maximum of the CA function

Future work

- Upgrading DVB-T generator for DVB-T2 standard
- The analysis of the DVB-T 2 signal from the point of view of the CA function
- The elimination of the DVB-T/DVB-T2 signal parameters that negatively influence the behavior of the CA function
- The detection of the multiple targets in the PCL system exploiting DVB-T/DVB-T2 emitters on the SFN
- The elimination of the multipath effect and influence of the SFN for the PCL system for real data
- The detection of the multiple targets in the PCL system exploiting DVB-T/DVB-T2 emitters on the SFN

ACKNOWLEDGEMENT & CONTACT



Karel Juryca
Karel.juryca@student.upce.cz
Department of Electrical Engineering

Faculty of Electrical Engineering and Informatics
University of Pardubice
Czech Republic

http://www.upce.cz/en/fei/ke.html

The described research was supported by the Internal Grant Agency of University of Pardubice, the project No. SGS_2016_022