Research and education in the Laboratory for Computer-aided design in communications in Technical University-Sofia

Galia Marinova,

associate professor, Ph.D.

Technical University – Sofia,

***Kick-off Meeting for* CEEPUS Network: CIII-BG-1103-01-1617**

05-09 October 2016, Technical University-Sofia, Bulgaria

TECHNICAL UNIVERSITY-SOFIA
70 years old, 14 faculties

Faculty of Automatics
Faculty of Electrical Engineering
Faculty of Power Engineering and Power Machines
Faculty of Industrial Technology
Faculty of Mechanical Engineering
Faculty of Electronic Engineering and Technologies
Faculty of Telecommunications – B, M, Ph.d., 200 B.
Faculty of Computer Systems and Control
Faculty of Transport
Faculty of Management
Faculty of Applied Mathematics and Informatics
German Engineering Education and Industrial Management
French Faculty of Electrical Engineering
Faculty of English Language Faculty of Engineering

COURSES

- Computer-aided design – Bachelor in Telecommunications, compulsory
- Computer-aided design of digital communication circuits with VHDL, Bachelor in Telecommunications, optional
- Nanocommunication devices and networks
  Master "Microtechnologies and nanoengineering", compulsory
- Internet based Computer-aided design, Master in Telecommunications, optional

Outline

Recent research projects:

- Research on pseudo random bit sequences for compressive sensing applications – with University of Sannio, Benevento, Italy

- Online assisted platform and Cloud technologies for Computer-aided design of communication circuits and systems

- USRP-based SDR for cognitive radio: Platform for cooperative spectrum sensing and primary user localization – with CENTRALE-SUPELEC, Rennes, France, www.phcrila15.free.bg

- Optimization in smart microgrid scheduling

Erasmus+

CEEPUS

The quality of random signals determines the signal quality reconstruction in compressive sensing.

M-sequences, Kasami, Golden pseudorandom bit sequences and random generator circuits are studied through NIST test suite in order to estimate their abilities to be used for Analog–to-information converters and sub-Nyquist communication receivers based on compressive sensing.

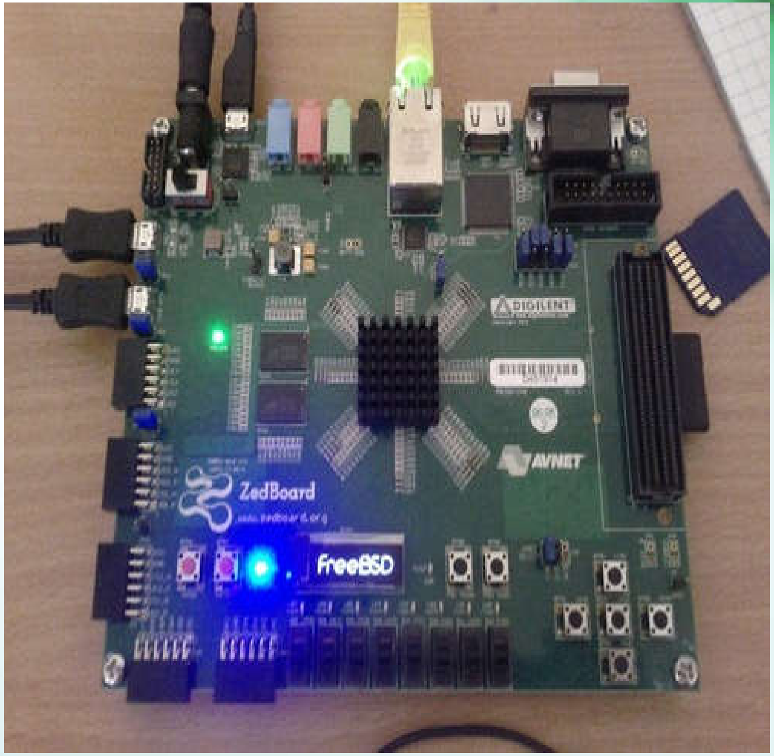
Golden sequence has proven to pass all NIST tests and to improve with 3 to 5 dB the SNR of AIC, compared to MATLAB PRSG.

NIST test suit 15 tests for randomness

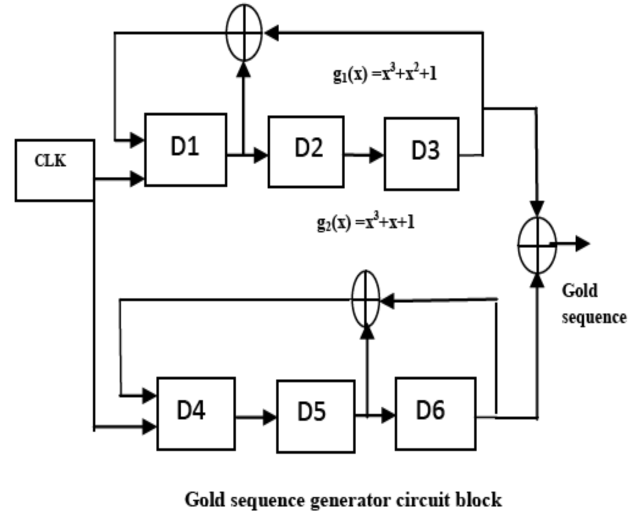
http://csrc.nist.gov/groups/ST/toolkit/rng/documents/SP800-22rev1a.pdf

1. The Frequency (Monobit) Test,
2. Frequency Test within a Block,
3. The Runs Test,
4. Tests for the Longest-Run-of-Ones in a Block,
5. The Binary Matrix Rank Test,
6. The Discrete Fourier Transform (Spectral) Test,
7. The Non-overlapping Template Matching Test,
8. The Overlapping Template Matching Test,
9. Maurer's "Universal Statistical" Test,
10. The Linear Complexity Test,
11. The Serial Test,
12. The Approximate Entropy Test,
13. The Cumulative Sums (Cusums) Test,
14. The Random Excursions Test, and
15. The Random Excursions Variant Test.

Tests on Zedboard,
VIVADO (XILINX)



Circuits for Gold sequence and Marsenne Twister (MATLAB)

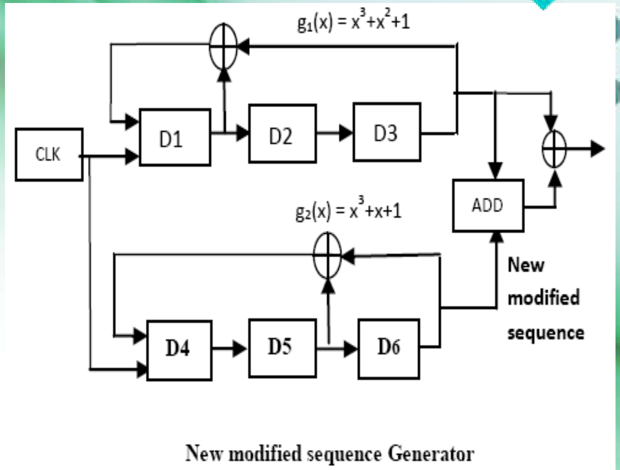


Gold sequence generator circuit block

Gold sequence generator for the preferred pair

$g_1(x)=x^3+x+1$

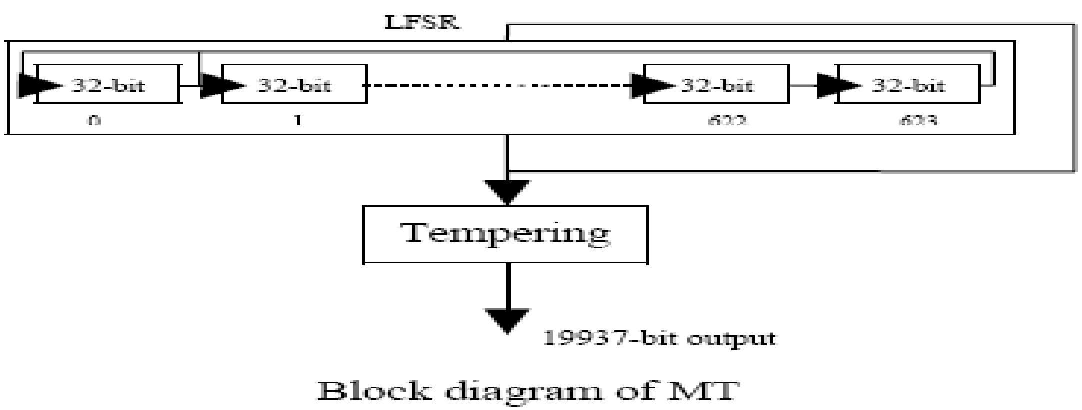
$g_2(x)=x^3+x^2+1$



New modified sequence Generator

S.Kalita, P.Salun, A New Modified Sequence Generator for Direct Sequence Spread Spectrum (DSSS), NCECS, September, 2011

High Level Block diagram of Marsenne Twister



Block diagram of MT

MT works in 2 steps: recurring (form of LFSR) and tempering (multiplying by a Tempering matrix T for a better equidistribution).

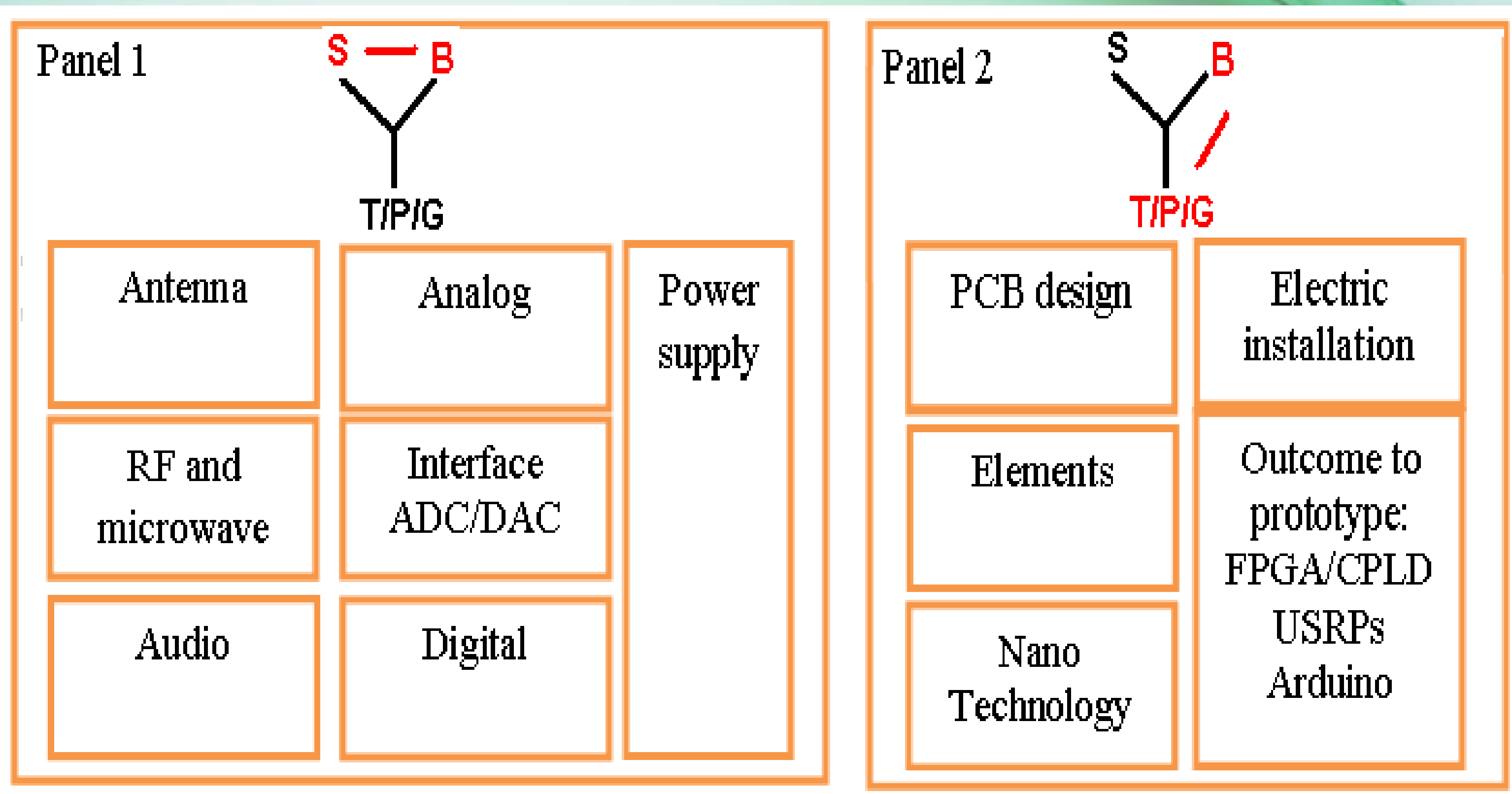
A. Jagannatam, Marsenne Twister – a pseudo random number generator and its variants, *cryptography.gmu.edu/~jkaps/download.php*

2. Online assisted platform and Cloud technologies for Computer-aided design of communication circuits and systems

This platform is developed to integrate **more than 250 online tools**, which are first studied, tested, selected and provided with **unified passports** in order to be used for solving design tasks in communications.

Cloud technologies are used **to share** designs and documents connected to the use of the tools integrated in the platform.

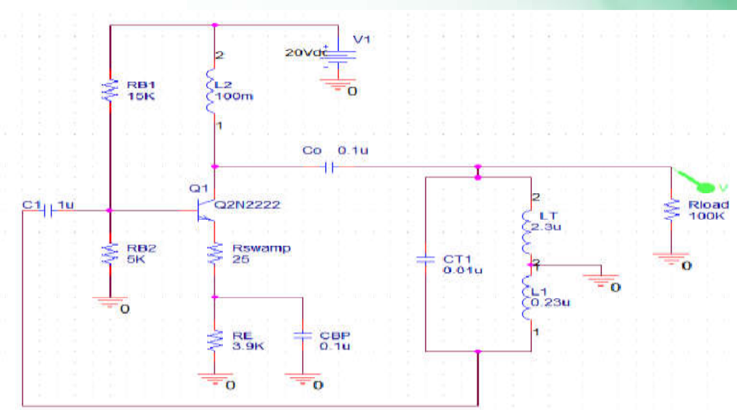
Structure of ONLINE-CADCOM
Panels on the home page

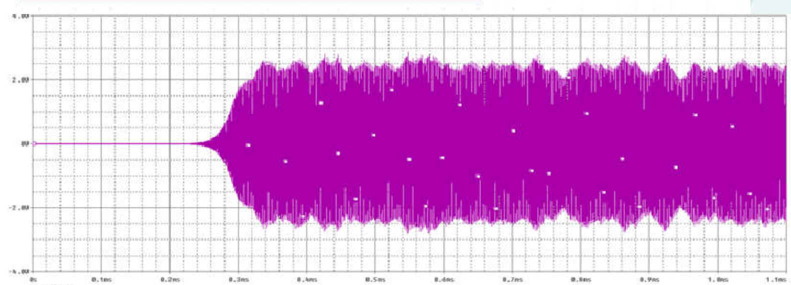


SmartCircuitCalc – Online circuit calculator

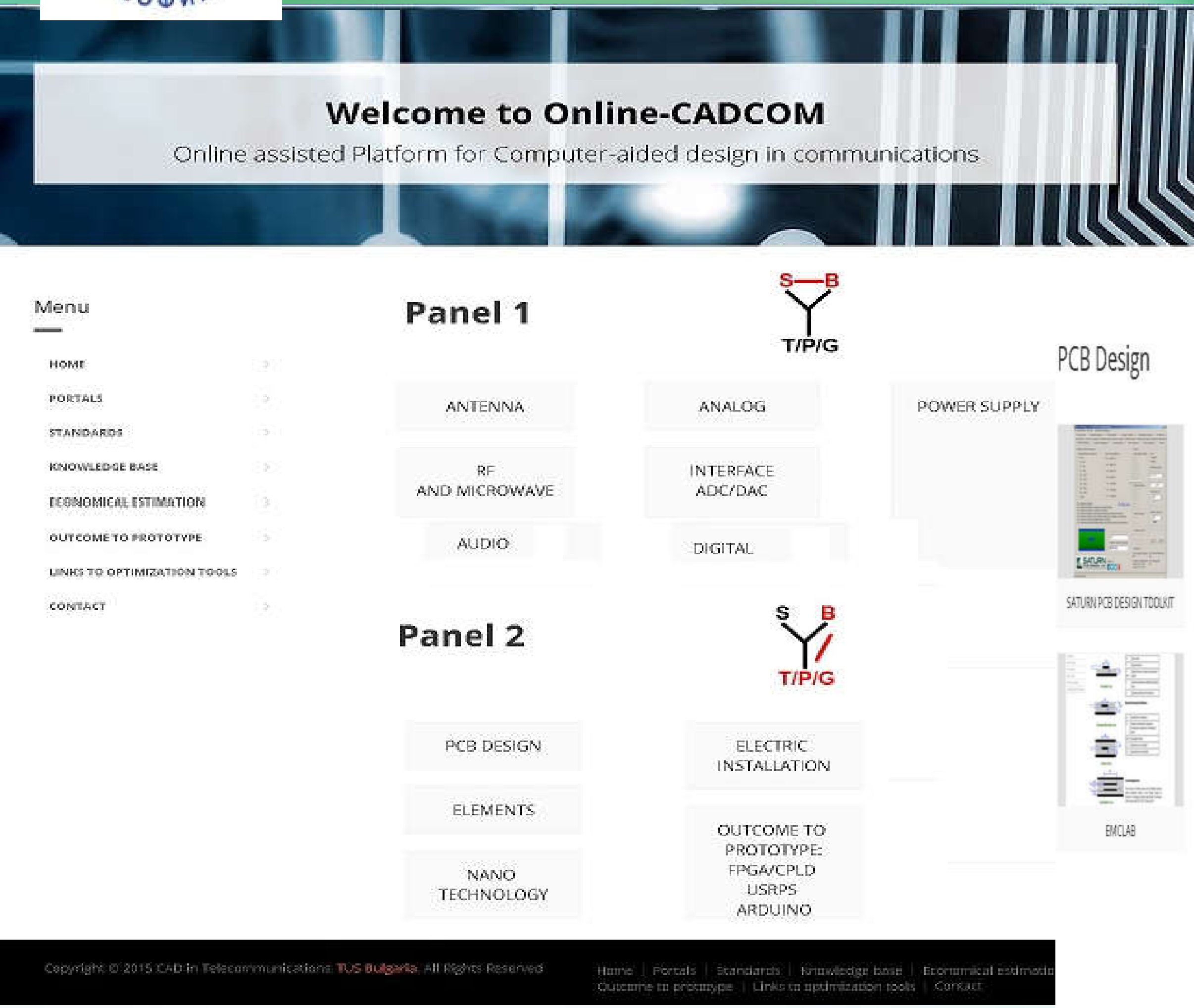
G. Marinova, V. Guliashki, O. Chikov, “Concept of Online Assisted Platform for Technologies and Management in Communications – OPTIMEK”, International Conference in Computer Science, Information System and Telecommunication, ICCSIST 2014, 7-9 November 2014, Durres, Albania, 2014, pp.55-62, ISBN 978-9951-437-31-8

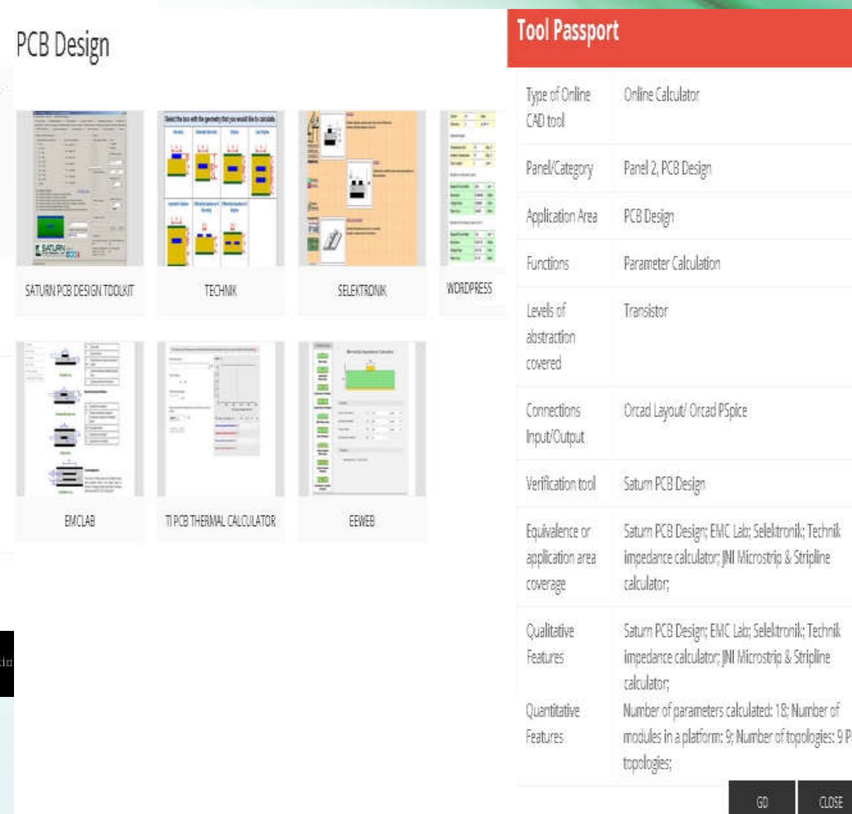
Hartley oscillator circuit designed in SmartCircuitCalc and then simulated in ORCAD/Capture and ORCAD/PSpice environment





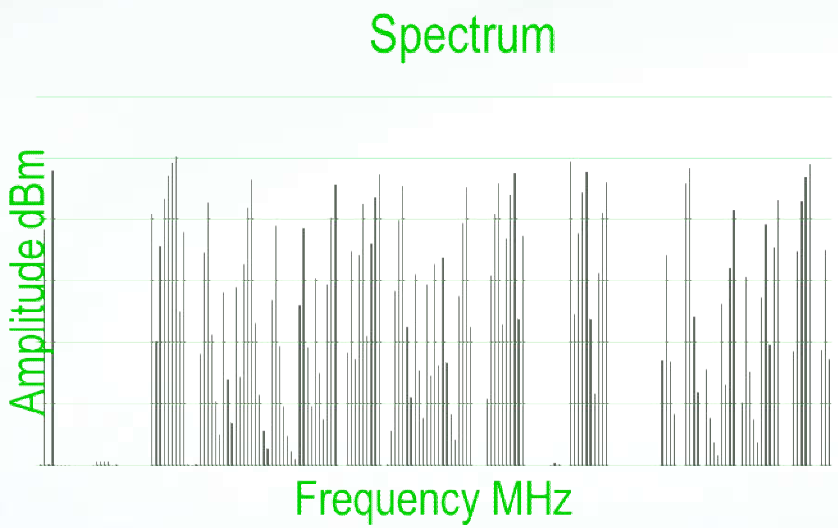
Home page of the Platform Online CADCOM (developed on a virtual server)





3. USRP-based SDR for cognitive radio

The spectrum sensing aims to find spectrum holes and to decide whether this part of spectrum is available or not at a particular instant of time.



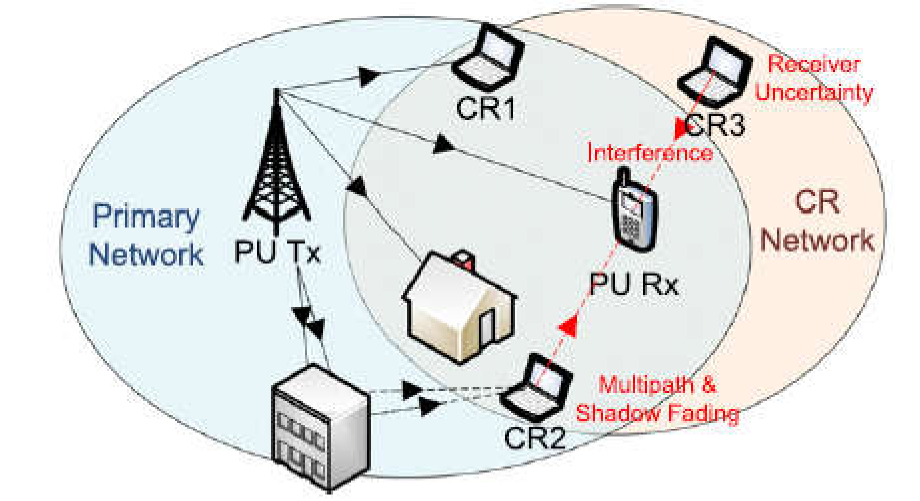
Hardware implementation for CSS with more than 3 SUs with different performance, treating outlying signals, testing different scenarios in the FC, tending to estimate and overcome uncertainty.

The CSS implementation is centralized with hard decision algorithm in the FC.

Cooperative Spectrum Sensing

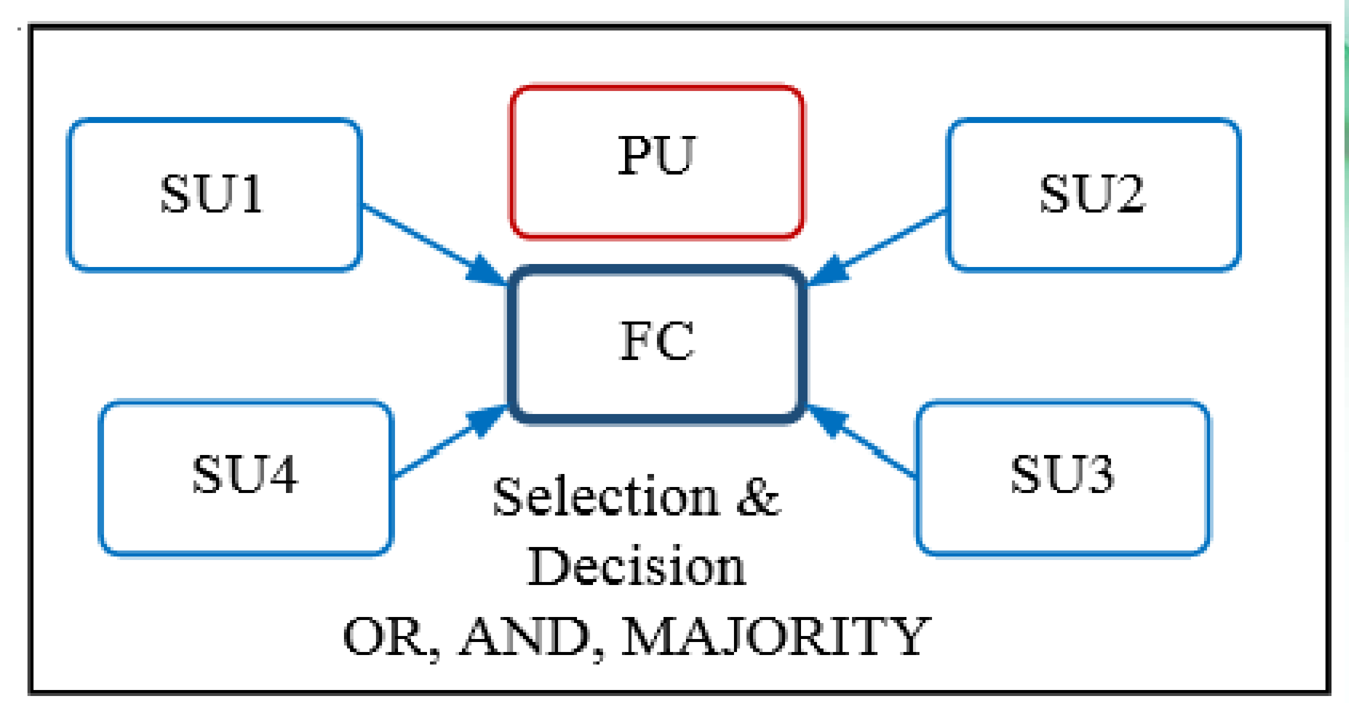
Reliable spectrum sensing is not always guaranteed due various factors, such as:

- Multipath fading
- Shadowing
- Receiver uncertainty
- Interference



Reference: Cooperative spectrum sensing in cognitive radio networks: A survey Ian F. Akyildiz, Brandon F. Lo, Ravikumar Balakrishnan

Centralized model of cooperative sensing system



The FC combines sensing results and makes the global decision by “**AND**”, “**OR**” and “**MAJORITY**” rule.

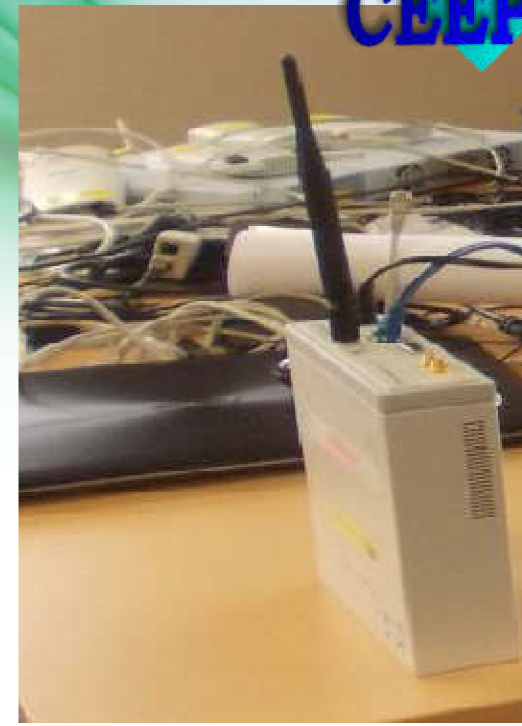
Test Bed – transmitter - PU

A signal generator SMY01 9 kHz – 1.040 GHz Rohde & Schwarz is used as a transmitter – PU.

The generator is set to a carrier frequency of 433MHz, with FM modulation with a deviation 200 kHz.

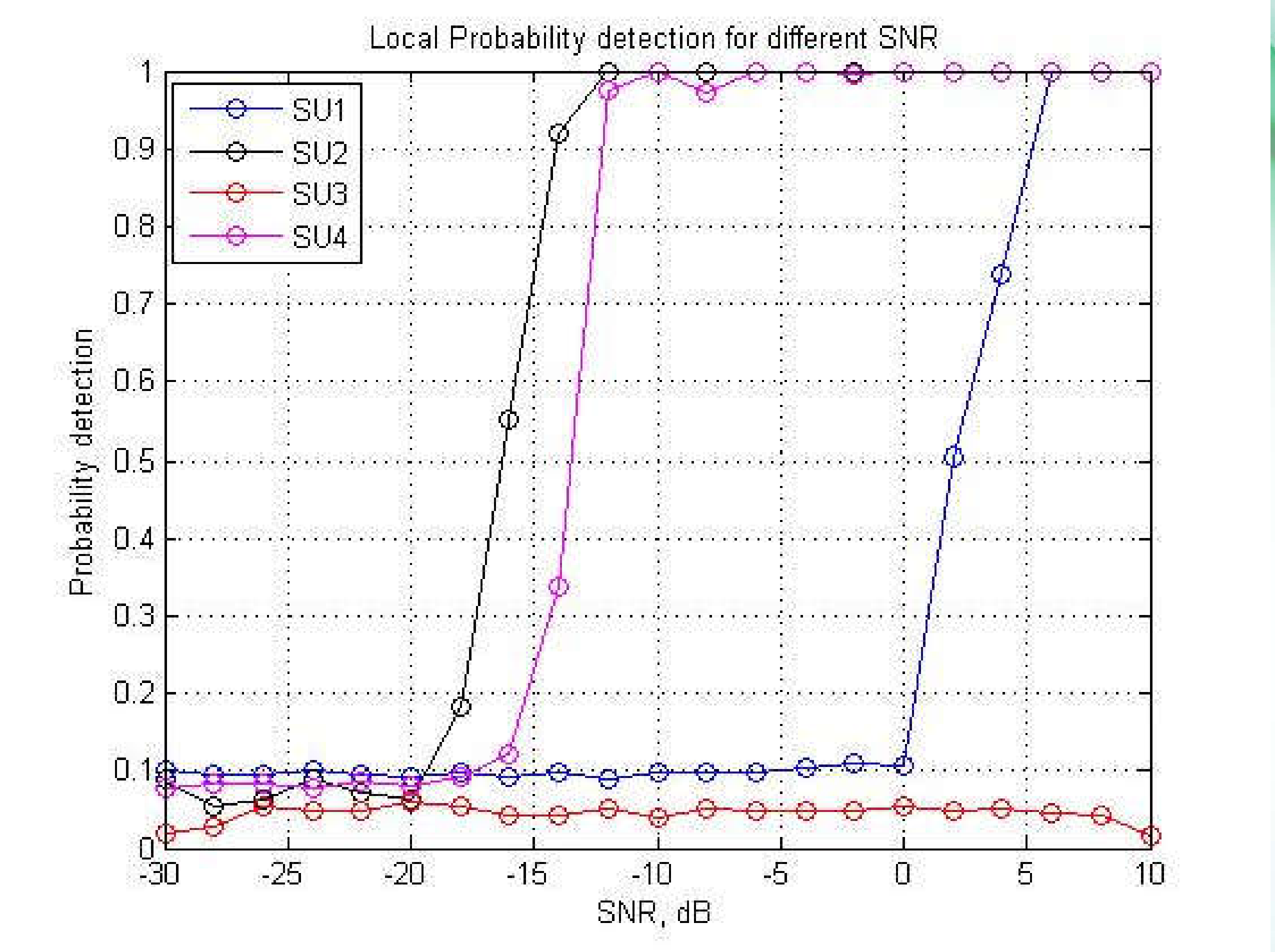
The generator provides values with different power of the transmitted signal in the range – **30 dBm to 10 dBm with a step of 2 dBm/5 dBm**.

Test Bed – receivers – 4SUs



The receivers are implemented with 4 USRP N210 of Ettus Research (NI), connected to a host PC via Gigabit Ethernet, with GNU Radio and ED block installed. 1 SU is behind a screen.

Pd(SNR) curves for all 4 SUs



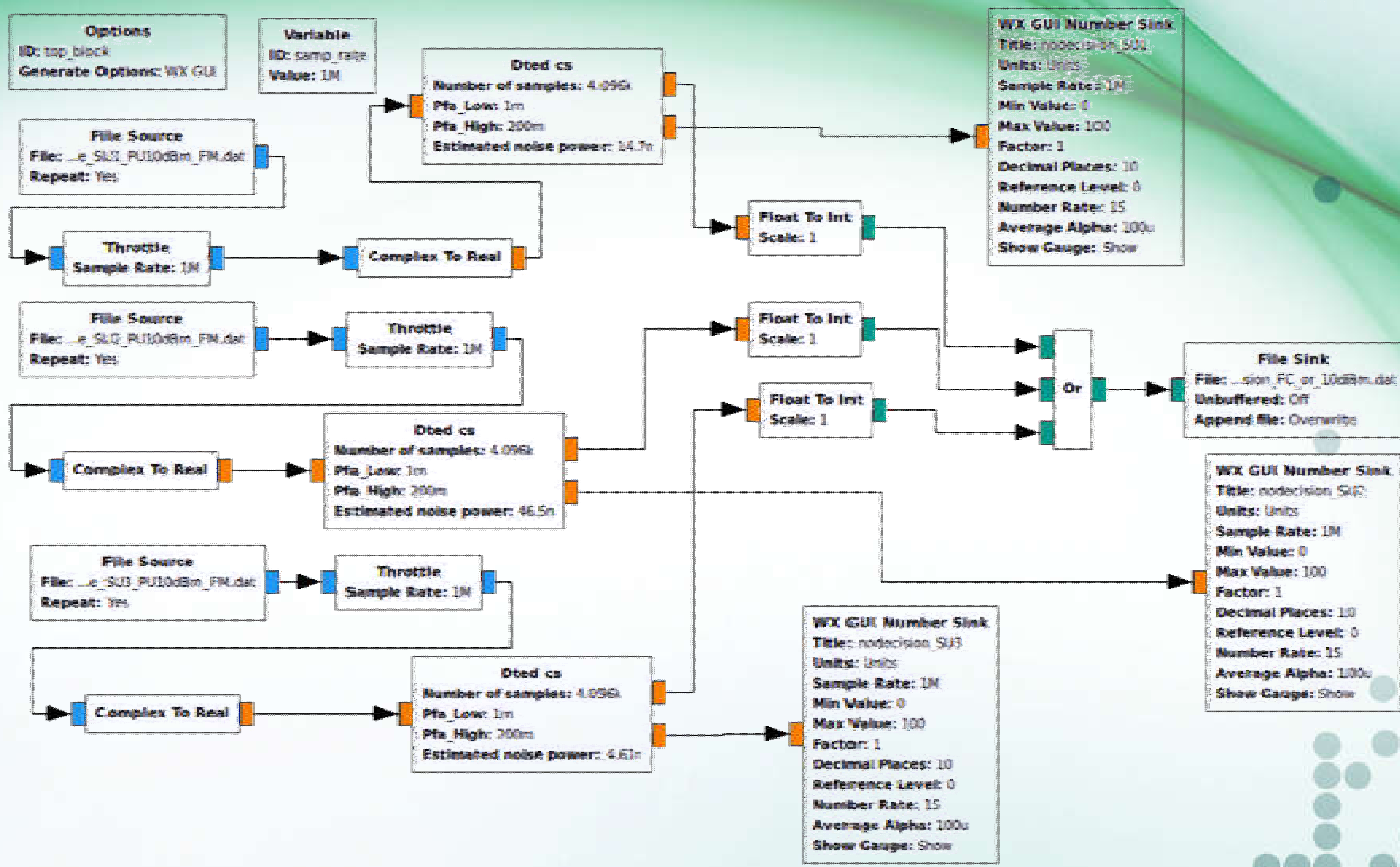
Analysis of results for 4 SUs

Good illustration of the need of **selection procedure** in the FC for security and reliability reasons. Outliers and sharply differing curves have to be discarded to avoid skewed result for the global decision.

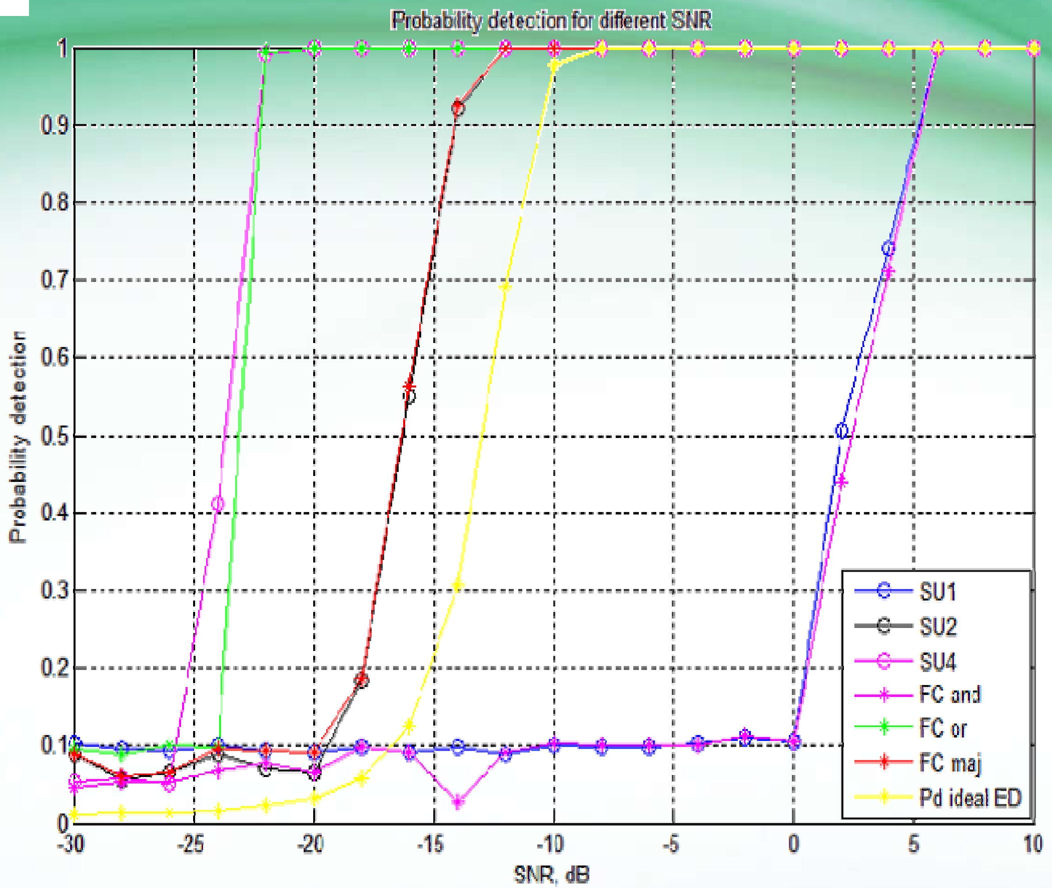
The criterion for discarding SUs with invariant curves by the FC, before decision making, is applied.
So, the global decision, taken by the FC is based on results from SU1, 2, 4.

Three SUs, often used in cooperative sensing experiments are enough to give meaningful results for MAJORITY function, which is not possible with 2 SUs .

Flowgraph in GNU radio for global decision taking in FC, using the function OR on the local decisions of SUs



Results for CSS



P_d(SNR) curves of the 3 SUs, selected by the FC and the P_d(SNR) curves of the FC when using functions OR, AND, MAJORITY on the local decisions of these 3 SUs. MATLAB simulation curve as reference.

The results obtained after 100 minutes long simulation on a notebook.

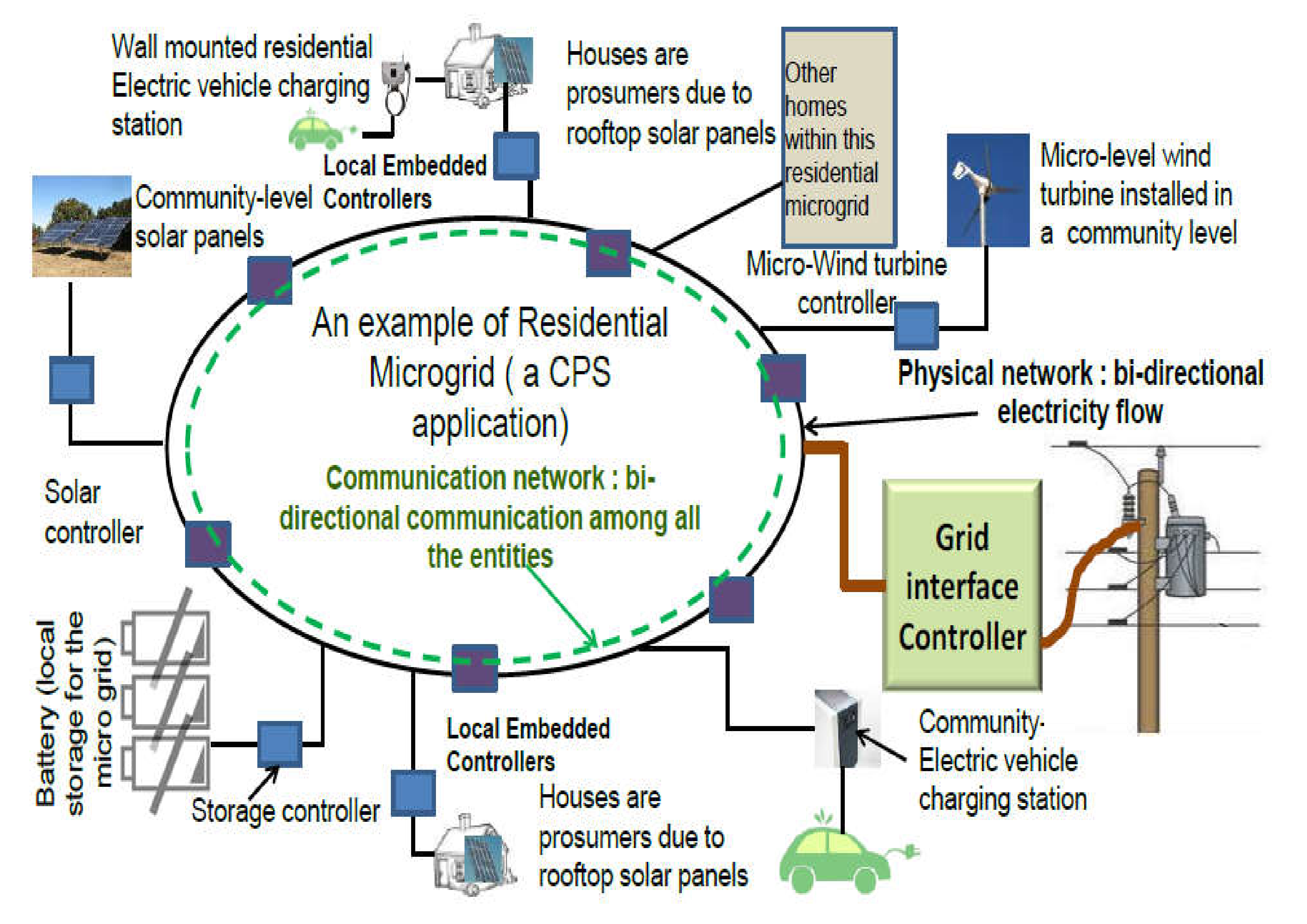
Analysis of results for CSS

OR function gives the best result in this particular experience.
The yellow curve comes from simulation in MATLAB and it's given as reference.
The results fully correspond to theory.

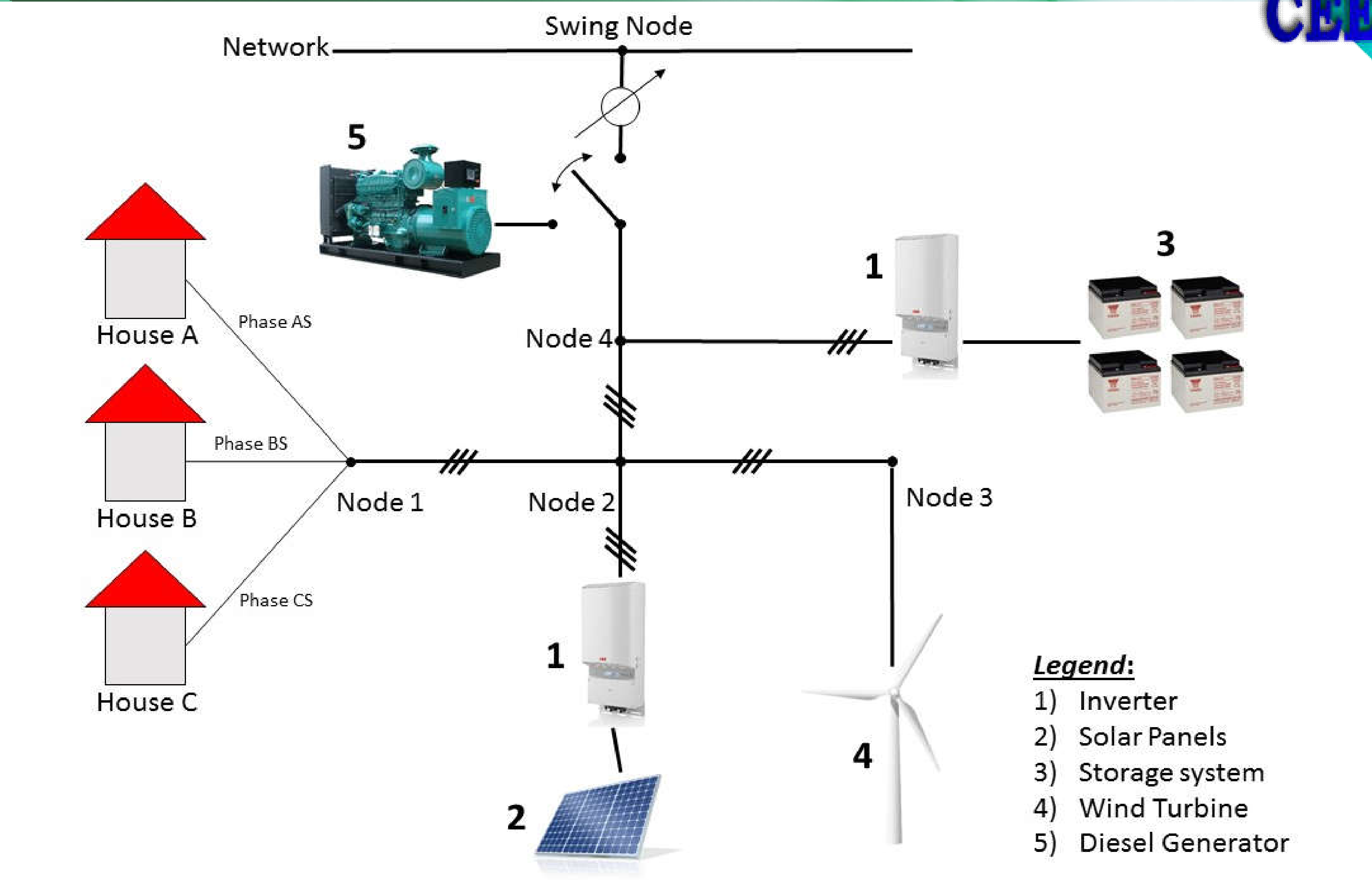
Functions OR and MAJORITY in FC decision allow to overcome the late detection from SU1 which is behind the screen.
The MAJORITY curve is the closest to the MATLAB simulation curve and it's the recommended function for the FC since the risk in the OR function is that in case of false alarm in only one SU, it will be transmitted to the FC decision.

Zdravka Tchobanova, Galia Marinova, Amor Nafkha, Cooperative Spectrum Sensing with Energy Detector Implemented on USRP and GNU Radio Platform, The Twelfth Advanced International Conference on Telecommunications. AICT 2016, May 22 - 26, 2016 - Valencia, Spain

4. Optimization algorithms for scheduling in Smart Microgrids

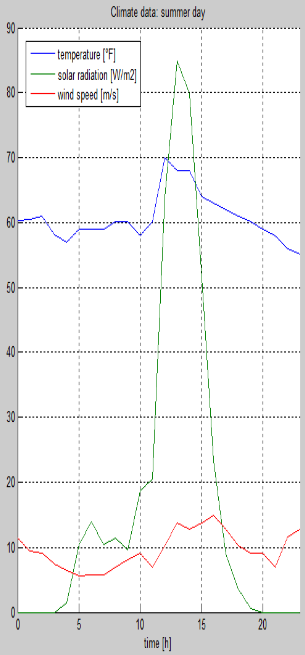


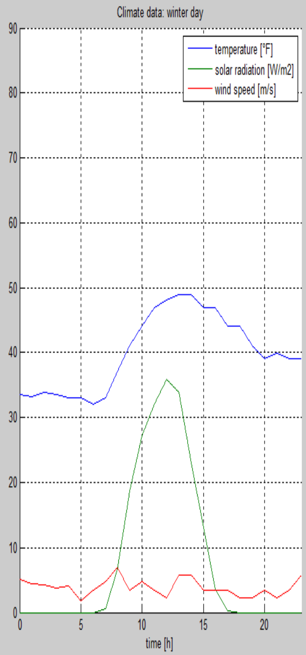
Microgrid

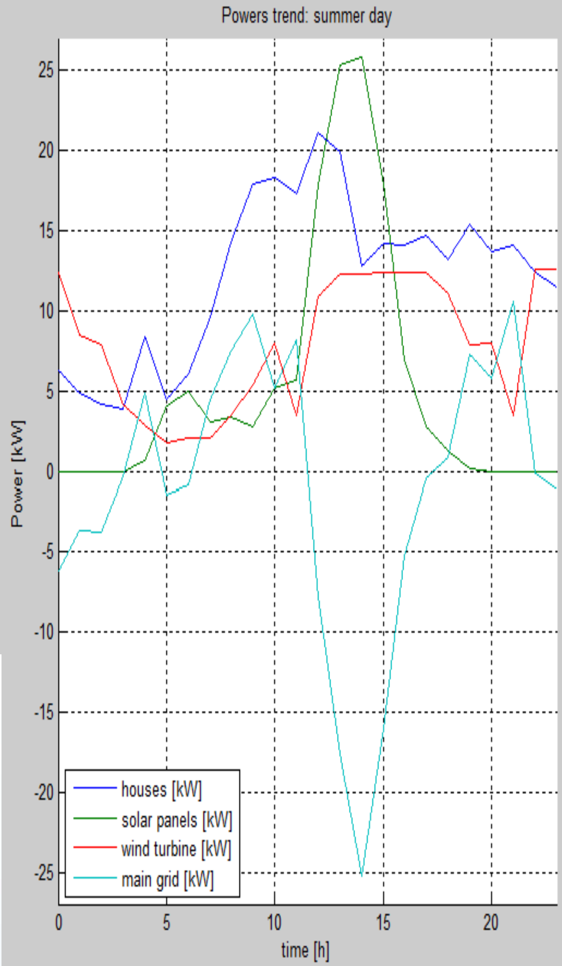


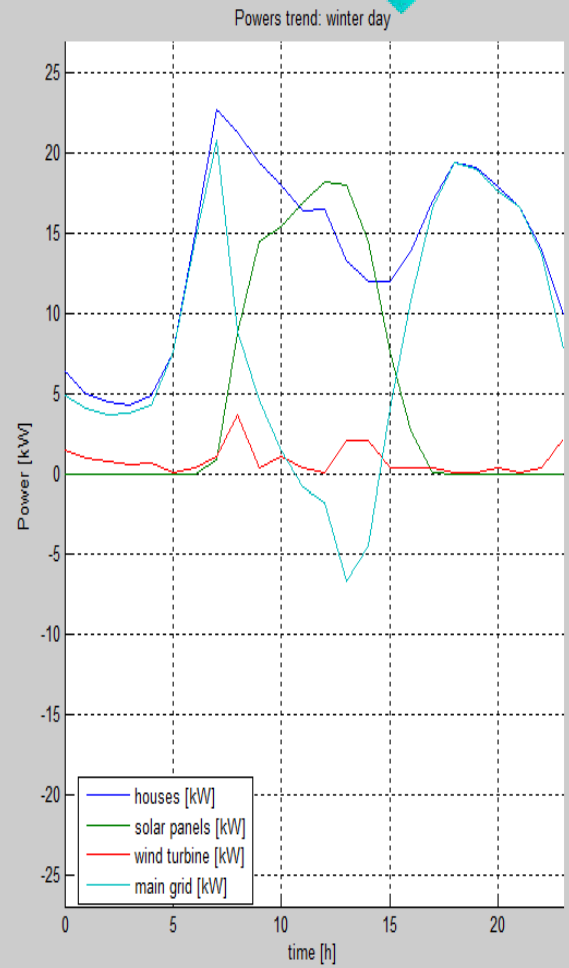
Network
Swing Node
5
House A
Phase AS
Node 4
1
3
House B
Phase BS
Node 1
Node 2
Node 3
House C
Phase CS
1
4
2
Legend:
1) Inverter
2) Solar Panels
3) Storage system
4) Wind Turbine
5) Diesel Generator

Results of Simulations with GridLab-D









Energy optimization of battery schedule

Economic optimization of battery schedule

Erasmus+
Students from India on internship in TUS

2015, US, Benevento

2016, US, Benevento

2015, Sofia, 2015


THANK
YOU!