UNIVERSIDADE FEDERAL DO CEARÁ

FEDERAL UNIVERSITY OF CEARÁ
OFFICE OF THE VICE PROVOST FOR UNDERGRADUATION (PROGRAD)
COORDINATION FOR PROJECT AND CURRICULUM DEVELOPMENT
CURRICULUM DEVELOPMENT DIVISION

1. Academic unit offering the curricular component (Faculty, Center, Institute, Campus)**:**

Center of Technology

2. Department offering the curricular component (when applicable)**:**

Teleinformatics Engineering Department

3. Undergraduate course(s) offering the curricular component

Code of the Course	Name of the Course	Course Degree[1]	Curriculum (Year/ Semester)	Nature of the Component[2]	Semester of Offer[3]	Habilitation[4]
91	Telecommunications Engineering	Bachelor	2015.1	Optional	-	-

4. Name of the curricular component:
Statistical Signal Processing

5. Code of the curricular component (filled by PROGRAD)**:**
TI0124

6. Prerequisites	No ( )	Yes (x)	
		Code	Name of the curricular component / activity
		TI0112	Stochastic Processes

7. Corequisite	No (x)	Yes ( )	
		Code	Name of the curricular component / activity

8. Equivalences	No ( )	Yes (x)	
		Code	Name of the curricular component / activity
		TI0088	Introduction to Statistical Signal Processing

9. Day period of the curricular component (more than one option can be selected)**:**
(x) Morning (x) Afternoon (x) Night

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1 **Fill with *Bachelor (Engineer), Licenciate,* or *Technologist.***
2 **Fill with *Mandatory, Optional,* or *Elective.***
3 **Fill when mandatory.**
4 **When elective, fill with the habilitation or emphasis to which the curricular component is linked.**

10. Regime of the curricular component:

(x) Semester ( ) Yearly ( ) Modular

11. Justificatory for the creation/regulamentation of this curricular component

The vast majority of sectors of Telecommunications Engineering are based on scientific, technological and professional observation, understanding, modeling, control and application of phenomena and random events. Based on the training acquired in probabilistic models and stochastic processes, this course will explore the concepts and applications of statistical processing of random signals in discrete time, which finds application not only in telecommunications but also in its related areas of biometrics, econometrics, automatic control, voice and image processing, among others.

12. Objectives fo the curricular component:

To provide students with the conceptualization, understanding and mastery of the use of techniques of statistical processing of random signals, with application in some dynamic systems of telecommunication engineering, based on methods of estimation, filtering, detection, prediction and adaptation.

13. Syllabus:

Analysis of second-order moments; estimation theory; optimum filtering; Prediction of stationary signals; Detection theory; Recursive methods in time; Adaptive filters.

14. Program:

1. **Analysis of second order moments:** Correlation and covariance functions; time-frequency transformations of random signals; the Karhunen-Loève transform; periodic and quasi-periodical processes; continuous and sampled processes; higher order statistics.
2. **Theory of estimation:** parameter estimation; Bayesian estimation; MAP criterion (maximum a posteriori); MMSE criterion (minimization of mean square error); maximum likelihood estimators (ML); properties of estimators (polarization, Fisher information matrix, Cramèr-Rao boundary); EM algorithm (expectation maximization); Kalman filters / estimators; Monte Carlo methods; non-linear filters.
3. **Optimum filtering:** Principle of orthogonality; linear prediction filtering; MMSE criterion; optimal filtering for FIR (finite impulse response) filters; optimal filtering for IIR (infinite impulse response) filters; Wiener filter, Wold decomposition; filtration with restriction; Yule-Walker equation.
4. **Prediction of stationary signals:** Prediction of AR processes; backward and forward prediction; Levinson-Durbin algorithm; Schur algorithm; minimum phase property of the prediction error.
5. **Detection theory:** Hypothesis testing; Neyman-Pearson's theorem; sufficient statistics; multivariate Gaussian model; detection of deterministic signals; detection of random signals; detection of linear statistical model with random parameters; maximum likelihood tests; Bayesian detectors (Bayes risk, minimax, multiple hypotheses).
6. **Recursive methods in time:** Time recurrence for normal equations; recursive least squares method; Kalman filters; introduction to adaptive filtering.

7. **Adaptive filters:** Classic adaptive filters; amplitude estimation; generalized adaptive filters.

15. Workload description

Number of Weeks:	Number of Credits:	Total Workload in Hours:	Theory Workload in Hours:	Practice Workload in Hours:
16	04	64	64	-

16. Basic bibliography:

1- Harry L. Van Trees, Kristine L Bell and Zhi Tian, Detection, Estimation and Modulation Theory, 2nd edition, Wiley, 2013

2- Steven M. Kay. Fundamentals of Statistical Signal Processing: Estimation Theory, Volume 1. Prentice Hall Signal Processing Series. Prentice-Hall, 1993.

3- Steven M. Kay. Fundamentals of Statistical Signal Processing: Detection Theory, Volume 2. Prentice Hall Signal Processing Series. Prentice-Hall, 1998.

17. Complementary bibliography:

1- Steven M. Kay, Fundamentals of Statistical Signal Processing: Practical Algorithm Development, Volume 3. Prentice Hall Signal Processing Series, Prentice Hall, 2013.

2- Dimitris Manolakis, Vinay K. Ingle, and Stephen M. Kogon. Statistical and Adaptive Signal Processing: Spectral Estimation, Signal Modeling, Adaptive Filtering and Array Processing. (Artech House Signal Processing Library). Artech House Publishers, 2005.

3- Mourad Barkat. Signal Detection and Estimation. (Artech House Radar Library). Artech House Publishers, 2nd edition, 2005.

4- Charles W. Therrien. Discrete Random Signals and Statistical Signal Processing. (Prentice-Hall Signal Processing Series). Prentice-Hall International, 1992.

5- Robert M. Gray and Lee D. Davisson. An Introduction to Statistical Signal Processing. Cambdrige University Press, 2004.

6- H. Vincent Poor, An Introduction to Signal Detection and Estimation, 2nd Ed., Springer, 1994.

7- Boaz Porat, Digital Processing of Random Signals: Theory and Methods, Dover, 1994.