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:
Analog and Digital Filter Design

5. Code of the curricular component (filled by PROGRAD)**:**
TI0126

6. Prerequisites	No ( )	Yes (x)	
		Code	Name of the curricular component / activity
		TI0119	Statistical Signal Processing Sinais
		TI0057	Electronic Circuits

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

8. Equivalences	No (x)	Yes ( )	
		Code	Name of the curricular component / activity

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

Signal filtering is present in all energy and information systems such as: telephony, power systems, imaging, video, telecommunications, communications, telemedicine, biomedical engineering, automation and robotics engineering, computer engineering, aerospace engineering, etc. Analog and digital signal processing techniques are the operations that give the filters functionalities in the various application domains. The telecommunications engineer must master them and develop skills and competencies to use these techniques to design analog and digital filters, active and passive, in order to be used to operate, maintain, design, audit telecommunication systems and other related applications, favoring a higher qualification in the training of human resources in order to promote innovation and scientific and technological development in the region.

12. Objectives fo the curricular component:

Introduce and develop the main tools used in analog and digital filter projects, active and passive, providing the student with complementary mathematical theory and the ability and competence to design and implement filters so that they can apply them to the various areas of telecommunications engineering and related areas.

13. Syllabus:

Introduction to filters and software-based filter design; approximation of functions for analog filters; low-pass, high pass, bandpass and band rejection analog filters; implementation of analog filters using active filters; introduction to discrete time systems; digital filter design with infinite impulse response; digital filter design with finite impulse response; implementation of digital filter using C; digital filtering using TFR.

14. Program:

1. **Introduction to filters and to software-based filter design:** filter selectivity; filter approximation; filter implementation; software-based filter design; examples.
2. **Analog filter approximation functions:** transfer functions for filters; Butterworth normalized approximation functions; Chebyshev normalized approximation functions; normalized inverse Chebyshev approximation functions; normalized elliptic approximation functions; comparison of approximation methods; examples.
3. **Low-pass, high pass, bandpass and band rejection analog filters:** non-normalized low pass approximation functions; non-normalized high-pass approximation functions; non-normalized band-pass approximation functions; non-normalized band rejection approximation functions; analog frequency response; criteria for decreasing filter parameters; examples.
4. **Implementation of analog filters using active filters:** implementation procedures for analog filters; low-pass, high pass, band-pass and band-reject analog active filters using operational amplifiers; implementation of complex zeros with active filters; sensitivity analysis and selection of components for the implementation of analog filters; use of WFilter in the implementation of active filters; examples.
5. **Discrete time systems:** Analog-digital conversion; review of discrete time systems, frequency

response and z-transform; waveforms scanned on computers; Examples.

6. **Infinite impulse response digital filter design:** filter designs based on sampling methods: impulsive invariance, step invariance and bilinear transform; C code for calculation of frequency response IIR; examples.
7. **Finite impulse response digital filter design:** FIR filter design using Fourier series; windowing techniques to improve projects; Parks-McClellan optimization procedures; C code for calculating the frequency response in FIR examples.
8. **Implementation of digital filters using C:** signal representation and digital filter coefficients representation; aspects of accuracy and stability; use of C code in the implementation of IIR and FIR filters for real-time and non-real-time applications; sound file filtering; examples.
9. **Digital Filtering using Fast Fourier Transform:** direct and inverse Discrete Fourier Transform and Fast Fourier Transform (FFT); C code for FFT and application of FFT in filtering; examples.

15. Workload description

Number of Weeks:	Number of Credits:	Total Workload in Hours:	Theory Workload in Hours:	Practice Workload in Hours:
16	04	64	48	16

16. Basic bibliography:

1- Les Thede, Practical Analog and Digital Filter Design, 1a Ed, Artech House, 2005.

2- Oppenheim, A.V., Schafer, R.W., Buck, J.R., Discrete-Time Signal Processing, 3rd edition, Prentice-Hall, 2009.

3- Diniz, P.S.R., da Silva, E.A.B., Netto, S.L., Digital Signal Processing: System Analysis and Design, 2nd edition, Cambridge University Press, 2010.

4- Proakis, J.G., Manolakis, D.G., Digital Signal Processing: Principles, Algorithms, and Applications, 4a Ed. Prentice-Hall, 2006.

17. Complementary bibliography:

1- Mitra, S.K., Digital Signal Processing: A Computer-Based Approach, McGraw Hill, 2006.

2- Ingle, V.K., J.G. Proakis, Digital Signal Processing Using MATLAB, 3rd edition, Cengage Learning, 2011.

3- Embree, Paul M., Danneli, D., C++ Algorithms for Digital Signal Processing, Prentice Hall, 1998.

4- Brigham, E. O., The Fast Fourier Transform and Its Applications, Prentice-Hall, 1988.

5- Arthur Williams, Fred J. Taylor, Electronic Filter Design Handbook: LC, Active, and Digital Filters, 4th edition, McGraw Hill