

# GNURadio as a digital signal processing environment: application to acoustic wireless sensor measurement and time & frequency analysis of periodic signals

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**Abstract**—The flexibility, reconfigurability and stability of software defined radio yield an attractive alternative to the analog strategy of probing acoustic transducers acting as passive sensors probed through a wireless link or to phase noise characterization of oscillators. However, developing processing blocks is a time consuming activity, yet metrology applications require a dedicated understanding of each processing step. We consider GNURadio as a means of exploiting opensource software as an optimum tradeoff between software re-usability yet compatible with an audit for assessing performance. This signal processing environment is demonstrated on two practical examples, FMCW probing of acoustic delay lines acting as sensors, and quartz tuning fork characterization. Both examples are considered as introductory setups for training and teaching yet a suitable environment for research activities.

## I. INTRODUCTION

Digital signal processing has been identified as a significant improvement over analog signal processing for a number of reasons [1], [2], including stability, flexibility and accuracy. Respectively, digital signal processing is not prone to component aging or drift over time; is reconfigurable in order to update algorithms or parameters in order to perform new functionalities on a given hardware; and provides a pre-defined, quantitative computation accuracy given the size of the handled datasets. Digital signal processing is nowadays ubiquitous and the mostly infinite computational power available yields to the trend of Software Defined Radio [3], in which general purpose radiofrequency source and sampling hardware is used for software processing of the recorded data for multiple application on a given experimental setup. Although processing power has been increasing continuously, the extensive bandwidth needed for radiofrequency (RF) sampling often remains beyond the general purpose hardware. On the other hand, most RF signal are narrowband and do not require full bandwidth sampling, so a common trend is to use an analog frontend with an amplifier and a mixer with a local oscillator to provide a zero-intermediate frequency (IF) configuration. We consider here the use of such a configuration in the context of time and frequency metrology signal processing, and most significantly consider the software environment needed to implement the associated processing algorithm, both from application and a teaching considerations since the skills for applying these concepts are mostly lacking.

## II. FMCW RADAR FOR PASSIVE WIRELESS SENSOR MONITORING

Acoustic transducers [4] have been demonstrated to be relevant alternatives to silicon-based radiofrequency identification (RFID) when harsh environments (temperatures above CMOS operating range) or long interrogation ranges (no threshold on the received power in the case of piezoelectric substrate) are needed. By patterning electrodes on single crystal substrates, a delay line configuration aims at providing a simple means to convert the incoming electromagnetic signal to a mechanical wave whose propagation velocity on the surface of the substrate is dependent on the physical property under investigation [5]. Through direct piezoelectric effect, the pulse reflected on a mirror patterned on the substrate generates a returned electromagnetic signal; the purpose of the readout unit is to allow for a measurement of this time of flight in order to recover the physical quantity value [6].

A classical pulsed-mode RADAR approach requires large measurement bandwidths  $B$  in order to achieve time resolution  $1/B$ : typical pulse widths and maximum time of flight durations are respectively 100 ns and 5  $\mu$ s, so that  $B > 10$  MS/s is needed. Although the pulsed mode, wideband RADAR approach provides some significant range and measurement speed advantages, a simpler approach has been favored in the literature through the use of the frequency-modulated continuous wave (FMCW) RADAR approach [7]. In the latter method, a local oscillator frequency  $f$  is linearly swept along a bandwidth  $B$  within the bandpass function of the acoustic delay line. The time delayed returned  $\tau$  signal is mixed and low pass filtered with the local oscillator, so that a beat signal  $\Delta f(\tau) = f(t) - f(t + \tau)$  is recorded after removal of the carrier. The resulting architecture is simple and only requires low frequency sampling rates, but also introduces multiple free parameters which are best tested in a software defined radio approach. Among the parameters are the central operating frequency  $f$  and the sweep rate  $T$ :  $\Delta f(\tau)/\tau = B/T$  since the frequency band  $B$  is swept linearly over a duration  $T$ .

Recently, a tutorial has been presented on the MIT Open-CourseWare web site [8] demonstrating a basic FMCW approach: this hardware platform is used as the starting point of this experiment, although the linear RF oscillator sweep and recording a no longer performed by dedicated hardware but by a personal computer sound card running GNURadio (<http://>

# Gnuradio As A Digital Signal Processing Environment

**Barrett Williams, ChatGPT**



## **Gnuradio As A Digital Signal Processing Environment:**

*Foundation of Cognitive Radio Systems* Samuel Cheng, 2012-03-16 The fast user growth in wireless communications has created significant demands for new wireless services in both the licensed and unlicensed frequency spectra Since many spectra are not fully utilized most of the time cognitive radio as a form of spectrum reuse can be an effective means to significantly boost communications resources Since its introduction in late last century cognitive radio has attracted wide attention from academics to industry Despite the efforts from the research community there are still many issues of applying it in practice This books is an attempt to cover some of the open issues across the area and introduce some insight to many of the problems It contains thirteen chapters written by experts across the globe covering topics including spectrum sensing fundamental cooperative sensing spectrum management and interaction among users

**Mastering the Airwaves** Barrett Williams, ChatGPT, 2025-05-04 Unlock the secrets of the airwaves and revolutionize your HAM radio experience with *Mastering the Airwaves* This groundbreaking eBook is your essential guide to diving deep into advanced homebrew HAM radio projects equipping you with detailed knowledge and practical skills to transform your radio setup into a state of the art communication station Begin your journey with a fascinating exploration of HAM radio s evolution and ignite your homebrewer s spirit by understanding the key concepts driving modern advancements Discover the power of niche digital modes and learn why they are capturing the imagination of radio enthusiasts worldwide Dive into the world of Software Defined Radio SDR with clear explanations of its fundamentals benefits and how you can construct your own SDR receiver and transmitter With step by step guidance and invaluable troubleshooting tips you ll navigate the complexities of design and compliance with confidence Elevate your transmission and reception capabilities with advanced antenna design tailored for digital modes Master the integration of computers in your setup utilizing vital software and even a Raspberry Pi for innovative radio projects Explore Digital Mobile Radio DMR technology and build your very own DMR hotspot unlocking new dimensions of communication From digital signal processing to scripting for advanced control each chapter equips you with practical tools and techniques ensuring you automate and enhance your radio functions with ease Dive into power amplification understanding critical safety and testing procedures to maximize your setup s performance Whether you re building a remote controlled HAM station experimenting with niche digital modes like FT8 and PSK31 or designing real world projects *Mastering the Airwaves* empowers you to advance your skills and make meaningful connections in the HAM community Embark on this compelling journey of creativity and innovation and master the art of HAM radio like never before Unleash your potential today

*Mastering Kali NetHunter* Sercan Akyuz, 2025-09-14 *Mastering Kali NetHunter* is your complete guide to turning an ordinary Android device into a full fledged hacking toolkit Built on Kali Linux NetHunter brings penetration testing power to your pocket Inside you ll learn how to Install and customize Kali NetHunter on supported devices Perform wireless Bluetooth and USB based attacks Use advanced tools like Metasploit Burp Suite and OWASP ZAP

Build and run real world attack simulations with step by step examples Stay on the legal side with guidelines for responsible testing Packed with diagrams case scenarios and practical exercises this book doesn't just teach you commands it trains you to think like a pentester Whether you're a beginner or an advanced red teamer this is your hands on playbook for mastering mobile hacking

**Software-Defined Radio for Engineers** Alexander M. Wyglinski, Robin Getz, Travis Collins, Di Pu, 2018-04-30 Based on the popular Artech House classic Digital Communication Systems Engineering with Software Defined Radio this book provides a practical approach to quickly learning the software defined radio SDR concepts needed for work in the field This up to date volume guides readers on how to quickly prototype wireless designs using SDR for real world testing and experimentation This book explores advanced wireless communication techniques such as OFDM LTE WLA and hardware targeting Readers will gain an understanding of the core concepts behind wireless hardware such as the radio frequency front end analog to digital and digital to analog converters as well as various processing technologies Moreover this volume includes chapters on timing estimation matched filtering frame synchronization message decoding and source coding The orthogonal frequency division multiplexing is explained and details about HDL code generation and deployment are provided The book concludes with coverage of the WLAN toolbox with OFDM beacon reception and the LTE toolbox with downlink reception Multiple case studies are provided throughout the book Both MATLAB and Simulink source code are included to assist readers with their projects in the field

**Applied Computer Sciences in Engineering** Juan Carlos Figueroa-García, Carlos Franco, Yesid Díaz-Gutierrez, Germán Hernández-Pérez, 2022-11-23 This book constitutes the proceedings of the 9th Workshop on Engineering Applications on Applied Computer Sciences in Engineering WEA 2022 which took place in Bogot Colombia in November December 2022 The 39 papers presented in this volume were carefully reviewed and selected from 143 submissions They were organized in topical sections as follows Artificial Intelligence Optimization Simulation and Applications

*LPWAN Technologies for IoT and M2M Applications* Bharat S Chaudhari, Marco Zennaro, 2020-03-17 Low power wide area network LPWAN is a promising solution for long range and low power Internet of Things IoT and machine to machine M2M communication applications The LPWANs are resource constrained networks and have critical requirements for long battery life extended coverage high scalability and low device and deployment costs There are several design and deployment challenges such as media access control spectrum management link optimization and adaptability energy harvesting duty cycle restrictions coexistence and interference interoperability and heterogeneity security and privacy and others LPWAN Technologies for IoT and M2M Applications is intended to provide a one stop solution for study of LPWAN technologies as it covers a broad range of topics and multidisciplinary aspects of LPWAN and IoT Primarily the book focuses on design requirements and constraints channel access spectrum management coexistence and interference issues energy efficiency technology candidates use cases of different applications in smart city healthcare and transportation systems security issues hardware software platforms challenges and future directions One stop guide to

the technical details of various low power long range technologies such as LoRaWAN Sigfox NB IoT LTE M and others Describes the design aspects network architectures security issues and challenges Discusses the performance interference coexistence issues and energy optimization techniques Includes LPWAN based intelligent applications in diverse areas such as smart city traffic management health and others Presents the different hardware and software platforms for LPWANs Provides guidance on selecting the right technology for an application *Proceedings of the 7th Brazilian Technology Symposium (BTSym'21)* Yuzo Iano, Osamu Saotome, Guillermo Leopoldo Kemper Vásquez, Claudia Cotrim Pezzuto, Rangel Arthur, Gabriel Gomes de Oliveira, 2022-07-20 This book presents the Proceedings of The 7th Brazilian Technology Symposium BTSym 21 The book discusses current technological issues on Systems Engineering Mathematics and Physical Sciences such as the Transmission Line Protein modified mortars Electromagnetic Properties Clock Domains Chebyshev Polynomials Satellite Control Systems Hough Transform Watershed Transform Blood Smear Images Toxoplasma Gondi Operation System Developments MIMO Systems Geothermal Photovoltaic Energy Systems Mineral Flotation Application CMOS Techniques Frameworks Developments Physiological Parameters Applications Brain Computer Interface Artificial Neural Networks Computational Vision Security Applications FPGA Applications IoT Residential Automation Data Acquisition Industry 4 0 Cyber Physical Systems Digital Image Processing Patterns Recognition Machine Learning Photocatalytic Process Physical chemical analysis Smoothing Filters Frequency Synthesizers Voltage Controlled Ring Oscillator Difference Amplifier Photocatalysis Photodegradation current technological issues on Human Smart and Sustainable Future of Cities such as the Digital Transformation Data Science Hydrothermal Dispatch Project Knowledge Transfer Immunization Programs Efficiency and Predictive Methods PMBOK Applications Logistics Process IoT Data Acquisition Industry 4 0 Cyber Physical Systems Fingerspelling Recognition Cognitive Ergonomics Ecosystem services Environmental Ecosystem services valuation Solid Waste and University Extension *Cognitive Radio Technology* Bruce A. Fette, 2006-08-08 Publisher description

### **Side-information Enhanced Localized Puncturing for Rate-adaptive, Reliable and Stable Wireless Protocols**

Ahmed Majeed Khan, 2010 [Hacking Exposed Wireless, Third Edition](#) Joshua Wright, Johnny Cache, 2015-03-19 Exploit and defend against the latest wireless network attacks Learn to exploit weaknesses in wireless network environments using the innovative techniques in this thoroughly updated guide Inside you ll find concise technical overviews the latest attack methods and ready to deploy countermeasures Find out how to leverage wireless eavesdropping break encryption systems deliver remote exploits and manipulate 802 11 clients and learn how attackers impersonate cellular networks Hacking Exposed Wireless Third Edition features expert coverage of ever expanding threats that affect leading edge technologies including Bluetooth Low Energy Software Defined Radio SDR ZigBee and Z Wave Assemble a wireless attack toolkit and master the hacker s weapons Effectively scan and enumerate WiFi networks and client devices Leverage advanced wireless attack tools including Wifite Scapy Pyrit Metasploit KillerBee and the Aircrack ng suite Develop and launch client side

attacks using Ettercap and the WiFi Pineapple Hack cellular networks with Airprobe Kraken Pytacle and YateBTS Exploit holes in WPA and WPA2 personal and enterprise security schemes Leverage rogue hotspots to deliver remote access software through fraudulent software updates Eavesdrop on Bluetooth Classic and Bluetooth Low Energy traffic Capture and evaluate proprietary wireless technology with Software Defined Radio tools Explore vulnerabilities in ZigBee and Z Wave connected smart homes and offices Attack remote wireless networks using compromised Windows systems and built in tools

**Annales des télécommunications**, 2002 The Future of HAM Radio Barrett Williams, ChatGPT, 2025-12-19 Unlock the world of amateur radio like never before with The Future of HAM Radio a revolutionary guide that bridges the gap between traditional practices and modern technology Dive into the captivating history of amateur radio and witness its transformation through the advent of digital and software innovations Discover the potential of Software Defined Radio SDR as you learn to differentiate it from traditional radios and unveil the power of Digital Signal Processing Explore open source SDR platforms that offer an array of software options and suitable hardware for both beginners and seasoned enthusiasts This comprehensive eBook delves into the digital era s impact on communication practices highlighting the seamless integration of the internet with radio technology From digital modes to internet assisted communication learn how to connect SDR to the global network and operate remotely Discover the vast opportunities and challenges presented by the Internet of Things in amateur radio ensuring your systems remain secure while you expand your horizons Harness the educational potential of SDR introducing young minds to the wonders of radio technology and providing learning platforms for future operators As the industry evolves gain insights into legal and ethical considerations ensuring compliance and maintaining integrity Explore advanced applications and experimentations with SDR from spectrum analyzers to digital modes pushing the boundaries of what s possible in amateur radio Learn from real world case studies showcasing both community projects and individual innovations that are shaping the future Whether you re a beginner eager to get started with essential tools and overcoming common challenges or a seasoned operator enhancing your setup this book provides invaluable tips and insights The Future of HAM Radio is your gateway to embracing a vibrant future encouraging a new generation of enthusiasts and fostering global collaboration within the amateur radio community Prepare to be inspired and connected like never before *Communication Systems Engineering with GNU Radio* Jean-Michel Friedt, Herve Boeglen, 2024-12-05 An approachable guide to an invaluable radiofrequency communication toolkit Software defined radio SDR which emerged in the 1990s has become a core development method in certain high profile fields including military and space communications High cost and problems with hardware availability however prevented this technology from being widely disseminated The advent of low cost hardware beginning in the 2010s however has made GNU Radio the leading open source software toolkit for developing SDR systems an increasingly viable and even critical tool for a new generation of radiofrequency communication engineers Communication Systems Engineering with GNU Radio provides an accessible overview of this

toolkit and its applications Beginning with the fundamentals of using GNU radio for digital signal processing the volume then moves to the practicalities of decoding data and the advantages of accessing raw data normally unavailable in hardware defined radiofrequency receivers The result is a potentially crucial tool for engineers looking to adopt this cost effective and flexible standard for transmitting and processing radiofrequency signals Readers will also find A careful balance of radio communications theory with GNU Radio practicalities Practical implementation examples employing well developed open source GNU Radio platforms Extensive accompanying documentation and explanation Communication Systems Engineering with GNU Radio is ideal for graduate and undergraduate students in communications systems courses as well as professionals working in SDR

[Using Digital Signal Processors in GNU Radio](#) ,2013 *Software Radio* Enrico Del Re,2012-12-06 Next generation mobile communications are likely to employ different techniques and standards The implementation in software of as many receiver functionalities as possible appears to be the most effective solution for coping with the multiplicity of communications alternatives The concept of software radio dating back to 1991 originally attracted commercial interest owing to the possibility that transmission layer functions could be fully software defined The same approach can be extended to protocols of the higher layers too thus conceiving a programmable hardware to implement the functionalities of several layers of protocols by resident software or software downloaded from the network Consisting of selected technical contributions to the Workshop on Software Radio this volume deals with state of the art surveys of the enabling technologies and the prospective services of software radio implementations for future mobile communications Original and state of the art research and development is presented in fields such as Software radio for universal wireless internet access Software radio for multimedia communications Software radio architecture Network architecture protocols and services Software radio technology towards pervasive appliance This volume on software radio is a valuable reference for both researchers and telecommunications professionals

**Unlocking the Airwaves** Barrett Williams,ChatGPT,2025-12-31 Unlocking the Airwaves is your gateway to the thrilling world of radio frequencies and software defined radio SDR This comprehensive guide dives into RTL SDR transforming everyday electronics into powerful versatile tools for exploring the unseen world of wireless communication Begin your journey with the basics as you unravel the fundamental concepts behind RTL SDR technology Discover the historical evolution of software defined radio and identify the key components that make up this cutting edge technology Whether you re setting up your first RTL SDR system or aiming to optimize your current setup this resource guides you every step of the way Venture into the realm of the radio frequency spectrum where you ll gain an in depth understanding of frequency bands and learn how to leverage spectrum analysis tools Explore the practical applications of frequency analysis in various communication domains From receiving FM and AM radio to decoding digital signals and capturing broadcast television the possibilities are as vast as the spectrum itself Unlock advanced reception techniques to enhance your signal capture abilities Master the art of noise reduction filtering and

antenna configuration for superior signal clarity With tools and strategies for decoding and analyzing data discover the modulation schemes and demodulation processes that power modern communications Dive into niche applications such as aviation monitoring amateur radio participation and weather satellite reception Unlock the intricacies of emergency services communication and explore the burgeoning field of IoT with RTL SDR This book also delves into the fascinating world of frequency hopping spread spectrum providing tools and insights for tracking and application Cap off your exploration with practical guidance on troubleshooting building custom tools and staying ahead with emerging trends in SDR technology Unlocking the Airwaves is not just a guide it s an exciting expedition into the dynamic future of wireless technology Embrace the SDR revolution today [Hertz to Bits](#) Barrett Williams,ChatGPT,2025-10-09 Unlock the hidden universe of radio waves with Hertz to Bits your ultimate guide to the revolutionary world of Software Defined Radio SDR Step into a domain where tradition meets innovation and explore how digital technology is transforming amateur radio breaking barriers and expanding horizons Embark on a journey through time starting with the evolution from analog to digital and delve into the fundamental concepts that define SDR Dive deep into the core components that make up SDR systems and discover the pivotal role of ADCs DACs and the software tools and platforms that bring them to life Witness the exciting impact of SDR on spectrum accessibility and learn how it surpasses the limitations of traditional bands For HAM radio enthusiasts a technical deep dive awaits unraveling the complexities of modulation demodulation and signal processing algorithms Are you ready to build your first SDR setup Our step by step guide will walk you through basic configurations software installation and your initial on air connection For the experts advanced techniques in customization and antenna modification promise to elevate your SDR experience Explore the future with SDR s integration into the Internet of Things and its role in bridging communication technologies while addressing security privacy concerns and common misconceptions Real world applications abound from emergency communications to scientific exploration proving the versatility of SDR Connect with a global community of enthusiasts engage with open source projects and stay informed about regulations and compliance Discover iconic projects and innovators through inspiring case studies and see how SDR is shaping the next generation of radio pioneers with educational programs and personal stories Hertz to Bits is not just a book it s a gateway to the future of radio technology Ready to transform your understanding and expand your potential Dive in and start your journey today

**Software Defined Radio** Walter H.W. Tuttlebee,2002-03-12 Over the past few years software radio has transitioned from an esoteric academic idea to a rapidly commercialising technology that in the coming decade will revolutionise the mobile telecommunications marketplace Written for industry professionals in engineering and commercial roles as well as those in academia and research this book will provide a comprehensive context for all those already active in or entering the field Walter Tuttlebee himself a pioneer of software radio in Europe has gathered contributions from many of the acknowledged world experts in software radio leaders operating at the heart of the software radio world today who share

their experience and insight into the background the present and the future evolution of the technology and the industry Contributions from North America Europe and Asia ensure a comprehensive overview of the global SDR scene The structured approach ensures that the book comprehensively addresses the key issues in the title the origins of software radio what has been and is driving its commercialisation and what is happening on the international scene The book includes a comprehensive review of the origins of software radio in the defence industry an insider's view of the origins evolution role and activities of the SDR Forum a summary of the MIT Sloan study into the drivers of global success in the mobile wireless marketplace a review of end user and mobile network operator perspectives of software radio and what the value it can offer insiders summaries of recent SDR research activities in Europe and Japan coverage of the regulatory issues associated with SDR and the current approaches being taken in North America and Europe with contributions from the regulators themselves a description of the first steps to SDR standards the ETSI MExE standard descriptions of some of the first commercial software defined radio products for both defence and commercial applications Endorsed with a foreword from Joseph Mitola III the father of software radio

Software Defined Radio Markus Dillinger, Kambiz Madani, Nancy Alonistioti, 2005-08-05

Software defined radio SDR is a hot topic in the telecommunications field with regard to wireless technology It is one of the most important topics of research in the area of mobile and personal communications SDR is viewed as the enabler of global roaming and a platform for the introduction of new technologies and services into existing live networks It therefore gives networks a greater flexibility into mobile communications It bridges the inter disciplinary gap in the field as SDR covers two areas of development namely software development and digital signal processing and the internet It extends well beyond the simple re configuration of air interface parameters to cover the whole system from the network to service creation and application development Reconfigurability entails the pervasive use of software reconfiguration empowering upgrades or patching of any element of the network and of the services and applications running on it It cuts across the types of bearer radio systems Paging to cellular wireless local area network to microwave terrestrial to satellite personal communications to broadcasting enable the integration of many of today's disparate systems in the same hardware platform Also it cuts across generation second to third to fourth This volume complements the already published volumes 1 and 2 of the Wiley Series in Software Radio The book discusses the requirements for reconfigurability and then introduces network architectures and functions for reconfigurable terminals Finally it deals with reconfiguration in the network The book also provides a comprehensive view on reconfigurability in three very active research projects as CAST MOBIVAS and TRUST SCOUT Key features include Presents new research in wireless communications Summarises the results of an extensive research program on software defined radios in Europe Provides a comprehensive view on reconfigurability in three very active research projects as CAST Configurable radio with Advanced Software Technology MOBIVAS Downloadable MOBILE Value Added Services through Software Radio and Switching Integrated Platforms TRUST

Transparently Reconfigurable Ubiquitous Terminal and SCOUT Smart User Centric Communication Environment **The Future of HAM Radio** Barrett Williams, ChatGPT, 2025-12-11

Unlock the Future of Radio Communication Dive into The Future of HAM Radio Are you ready to revolutionize your understanding of HAM radio and explore the cutting edge world of Software Defined Radio SDR The Future of HAM Radio is your comprehensive guide to the next era of radio communication This eBook opens the door to a world where technology meets tradition offering insights for both seasoned operators and passionate newcomers Explore the incredible journey from analog to digital radio in the detailed history of HAM radio technology Discover the powerful impact of SDR and how it integrates with modern computer technology to transform the amateur radio experience Understand the essentials of SDR with an in depth look at its hardware software and firmware components Learn how software integration is reshaping HAM operations setting the stage for developing custom applications that cater to your unique needs Delve into the infrastructure required for remote operation mastering the networking technologies and securing remote connections that keep your communications safe and sound Whether it s remote contesting or collaboration via cloud based SDRs find out how you can operate unbounded by distance Enhance your experience as you expand frequency ranges improve signal quality and interface with digital modes Face technical challenges head on with expert solutions for managing latency bandwidth and interference in SDR setups Peer into the future trends and innovations such as artificial intelligence and explore the vibrant and growing community of SDR and maker enthusiasts From setting up your own SDR station to understanding legal and ethical considerations this eBook covers all bases Join the frontier of radio communication and embrace the marriage of tradition and innovation The Future of HAM Radio is your ticket to becoming part of a dynamic community staying ahead of the curve and unlocking the limitless potential of modern HAM radio technology Take the leap your adventure into the future starts here

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