

1. Record Nr.	UNINA9910551839703321
Autore	Simrock Stefan
Titolo	Low-level radio frequency systems // Stefan Simrock and Zheqiao Geng
Pubbl/distr/stampa	Cham, Switzerland : , : Springer International Publishing, , [2022] ©2022
ISBN	3-030-94419-0
Descrizione fisica	1 online resource (396 pages)
Collana	Particle Acceleration and Detection
Disciplina	539.73
Soggetti	Particle accelerators - Experiments Radio frequency
Lingua di pubblicazione	Inglese
Formato	Materiale a stampa
Livello bibliografico	Monografia
Nota di contenuto	Intro -- Preface -- Contents -- Abbreviations -- Chapter 1: Introduction -- 1.1 RF Systems of Particle Accelerators -- 1.2 Principles of Beam Acceleration -- 1.2.1 Acceleration in Standing-Wave Cavities -- 1.2.2 Acceleration in Traveling-Wave Structures -- 1.3 Disturbances to RF Fields -- 1.3.1 Electronic Noise -- 1.3.2 Temperature and Humidity -- 1.3.3 Mechanical Vibrations -- 1.3.4 Beam Loading -- 1.4 LLRF Systems Overview -- 1.4.1 Requirements and Architecture -- 1.4.2 Context in Particle Accelerators -- 1.4.3 A Brief History -- 1.5 Summary -- References -- Chapter 2: RF Control Strategy -- 2.1 Feedback and Feedforward Control -- 2.2 Amplitude/Phase and In-Phase/Quadrature Control -- 2.3 RF Control Loop Architecture -- 2.3.1 Generator Driven Resonator -- 2.3.2 Self-Excited Loop -- 2.3.3 Phase-Locked Loop -- 2.4 Analog and Digital Control -- 2.5 Single-Cavity and Vector-Sum Control -- 2.6 Summary -- References -- Chapter 3: RF System Models -- 3.1 General Assumptions -- 3.2 RF Modeling Method -- 3.2.1 RF Signal Description -- 3.2.2 Principle of RF Signal Detection -- 3.2.3 Phasor Laplace Transform -- 3.3 Single-Cell Cavity Model -- 3.3.1 Parallel RLC Circuit Model -- 3.3.2 Cavity Phasor Transfer Function -- 3.3.3 Cavity Step Response -- 3.3.4 Cavity Response to RF Power -- 3.3.5 Cavity Response to a Single Bunch -- 3.3.6 Cavity Response to a Bunch Train -- 3.3.7 Cavity Equation with Voltage Drives -- 3.3.8 Interaction Between Cavity Voltage and Beam -- 3.3.9 Forward

and Reflected RF Power -- 3.3.10 Mechanical Model -- 3.4 Multi-cell Cavity Model -- 3.4.1 Coupled RLC Circuit Model -- 3.4.2 Multi-cell Cavity Phasor Equations -- 3.4.3 Passband Modes -- 3.4.4 Transient in Cavity Cells with RF Drive -- 3.5 Traveling-Wave Structure Model -- 3.5.1 Filling of Structures -- 3.5.2 Structure Phasor Transfer Function -- 3.6 Modeling of Important RF Devices. 3.6.1 Transmission Line Model -- 3.6.2 RF Amplifier Model -- 3.6.3 RF Pulse Compressor Model -- 3.7 Application of RF System Models -- 3.8 Summary -- References -- Chapter 4: RF Field Control -- 4.1 Requirements to RF Field Control -- 4.2 Generator Driven Resonator Control -- 4.2.1 Feedback Stability for Single-Cell Cavities -- 4.2.2 Feedback Stability for Multi-cell Cavities -- 4.2.3 Active Disturbance Rejection Control -- 4.2.4 Advanced Control Algorithms -- 4.2.4.1 Optimal Control -- 4.2.4.2 Robust Control and Adaptive Control -- 4.2.4.3 Model Predictive Control -- 4.3 Self-Excited Loop Control -- 4.3.1 Free-Running SEL -- 4.3.2 SEL with Amplitude Limiter -- 4.3.3 SEL with Feedback Control -- 4.4 Phase-Locked Loop Control -- 4.4.1 Introduction to PLL -- 4.4.2 Modeling of PLL for Cavity Control -- 4.4.3 Feedback Analysis of PLL -- 4.4.3.1 Control Goals Analysis -- 4.4.3.2 Controllability Analysis -- 4.5 Adaptive Feedforward -- 4.5.1 Adapt Feedforward with Feedback Actuation -- 4.5.2 Iterative Learning Control -- 4.5.2.1 FIR Model of RF System -- 4.5.2.2 ILC Algorithm -- 4.6 Cavity Resonance Control -- 4.6.1 Detuning Measurement -- 4.6.1.1 RF Frequency Scanning -- 4.6.1.2 Phase Slope at RF Pulse Decay -- 4.6.1.3 Solving Cavity Equation -- 4.6.1.4 Cavity Input-Output Phase Shift -- 4.6.2 Cavity Tuners -- 4.6.2.1 Motor Tuner -- 4.6.2.2 Piezo Tuner -- 4.6.2.3 Cooling Water Temperature -- 4.6.3 Tuning Control Scheme -- 4.6.3.1 Tuning Control with Feedback -- Coupling with Phase Feedback Loop -- Issues of Feedback with Piezo Tuners -- 4.6.3.2 Tuning Control with Adaptive Noise Cancellation -- 4.6.3.3 Feedforward Control for Pulsed Cavities -- 4.6.4 Ponderomotive Effects -- 4.6.4.1 Introduction to Ponderomotive Instability -- 4.6.4.2 Static Instability Analysis -- 4.6.4.3 Mitigation of Ponderomotive Instability -- 4.7 Summary -- References. Chapter 5: RF Detection and Actuation -- 5.1 RF Detection Schemes -- 5.1.1 Amplitude and Phase Detectors -- 5.1.2 Analog I/Q Demodulator -- 5.1.3 Down-Converter and IF Sampling -- 5.1.4 Direct RF Sampling -- 5.2 RF Detection Algorithms -- 5.2.1 I/Q Demodulation -- 5.2.1.1 I/Q Sampling and Demodulation Algorithm -- 5.2.1.2 Harmonics Aliasing of I/Q Sampling -- 5.2.2 Non-I/Q Demodulation -- 5.2.2.1 Non-I/Q Sampling -- 5.2.2.2 Harmonics Aliasing of Non-I/Q Sampling -- 5.2.2.3 Non-I/Q Demodulation Algorithm -- 5.2.2.4 Frequency Response of Non-I/Q Demodulation -- 5.2.2.5 Non-I/Q Demodulation for Transient RF Measurement -- 5.2.3 Digital Down-Conversion -- 5.2.4 Handling of Time-varying Frequency -- 5.2.5 RF Detection with Reference Tracking -- 5.2.5.1 Reference Tracking with PLL -- 5.2.5.2 Reference Tracking with Hilbert Transform -- 5.2.5.3 Direct Reference Phase Tracking -- 5.3 RF Actuation Schemes -- 5.3.1 Direct Up-Conversion -- 5.3.2 Single Sideband Up-Conversion -- 5.3.3 IF Up-Conversion -- 5.4 Summary -- References -- Chapter 6: Noise in RF Systems -- 6.1 General Description of Noise -- 6.1.1 Basic Concepts of Noise -- 6.1.2 Estimation of PSD and SNR -- 6.1.2.1 Discrete Fourier Transform -- 6.1.2.2 PSD and SNR Calculation -- 6.1.3 Correlation of Noise -- 6.1.3.1 Description of Correlation -- 6.1.3.2 PSD of the Sum of Two Noises -- 6.1.4 Additive Noise and Parametric Noise -- 6.1.5 White Noise and 1/f Noise -- 6.1.6 Noise Factor -- 6.1.7 Phase Noise and Amplitude Noise -- 6.1.7.1 Phase Noise -- 6.1.7.2 Amplitude Noise -- 6.1.7.3 Signal with Amplitude and Phase Noise -- 6.1.8

Additive Noise and RF Jitter -- 6.1.9 Frequency-Domain Meaning of RMS Value -- 6.1.10 Drift and Jitter -- 6.2 Noise Model of Basic RF Components -- 6.2.1 Two-Port Passive RF Components -- 6.2.2 Power Splitter and Combiner -- 6.2.3 RF Amplifier -- 6.2.4 Mixer. 6.2.5 Frequency Divider and Multiplier -- 6.2.6 Analog-to-Digital Converter -- 6.2.6.1 ADC Noise Model -- 6.2.6.2 Noise Added by ADC -- 6.2.6.3 Measurement of Noise Added by ADC -- 6.2.7 Digital-to-Analog Converter -- 6.2.7.1 DAC Noise Model -- 6.2.7.2 Noise Added by DAC -- 6.3 Noise Transfer in RF Control Loops -- 6.3.1 Noise Transfer in Feedback Control -- 6.3.2 Noise Transfer in Pulse-to-Pulse Control -- 6.4 RF System Noise Specification -- 6.4.1 Noise Specification Strategy -- 6.4.2 Accelerator Global Noise Model -- 6.4.2.1 Noise Specification of Linacs -- 6.4.2.2 Noise Specification of Synchrotrons -- 6.4.3 Specification of RF Reference Phase Noise -- 6.5 RF Station Noise Model -- 6.5.1 RF Station Noise Overview -- 6.5.2 RF Reference Phase Noise -- 6.5.3 RF Driving Chain Noise -- 6.5.4 RF Measurement Chain Noise -- 6.5.5 Estimation of RF Measurement Chain Noise -- 6.5.6 Estimation of RF Driving Chain Noise -- 6.5.7 Estimation of RF Field Noise -- 6.5.8 Validation of RF Station Noise Model -- 6.5.9 Specification of RF Component Noise -- 6.6 RF Detector Drift Correction -- 6.6.1 Reference Tracking -- 6.6.2 Drift Calibration -- 6.6.3 Beam-Based Feedback -- 6.7 Summary -- References -- Chapter 7: Nonlinearity in RF Systems -- 7.1 Basic Concepts -- 7.1.1 1-dB Compression Point -- 7.1.2 Third-Order Intercept Point -- 7.1.3 AM-PM Conversion -- 7.1.4 Nonlinearity Induced RF Detection Error -- 7.1.5 Nonlinearity Induced RF Driving Disturbances -- 7.2 Nonlinearity of RF Amplifiers -- 7.2.1 Look-Up Table Model -- 7.2.2 Analytical Model -- 7.2.3 Dynamical Model -- 7.3 Handling of Amplifier Nonlinearity in RF Control -- 7.3.1 RF Amplitude Control with High Voltage -- 7.3.2 Gain Scheduling -- 7.3.3 LUT-Based Linearization -- 7.3.4 Linearization Loop -- 7.4 Summary -- References -- Chapter 8: Timing and Synchronization -- 8.1 Overview -- 8.2 Master Oscillator. 8.2.1 RF and Laser Oscillator -- 8.2.2 Synchronization of Two Oscillators -- 8.3 Timing System -- 8.3.1 Timing Fiducial Generation -- 8.3.2 Common Subharmonic -- 8.3.3 Client Trigger Generation -- 8.4 Synchronization System -- 8.4.1 Synchronization Signal Distribution -- 8.4.2 Phase Drift Mitigation -- 8.4.2.1 Phase-Stable Coaxial Cable -- 8.4.2.2 Temperature and Humidity Stabilization -- 8.4.2.3 Active Drift Compensation -- 8.4.2.4 Phase-Averaging Coaxial Line -- 8.4.3 Client Synchronization -- 8.4.3.1 RF Signal Extraction -- 8.4.3.2 Frequency Synthesis -- 8.4.3.3 Synchronization of Laser Oscillator -- 8.5 Robust Timing Relations -- 8.5.1 Timing Relation Highlight -- 8.5.2 Timing Relation Uncertainty -- 8.5.3 Strategies for Robust Timing Relations -- 8.5.3.1 Frequency Selection -- 8.5.3.2 Timing Relation Diagnostics -- 8.5.3.3 Reference Tracking -- 8.5.3.4 Frequency Divider Resynchronization -- 8.5.3.5 Race Condition Handling -- 8.6 Summary -- References -- Chapter 9: LLRF Applications -- 9.1 Overview -- 9.2 Parameter Optimization -- 9.2.1 RF Pulse Shaping -- 9.2.2 DAC Offset Correction -- 9.2.3 Parameter Scanning -- 9.3 RF Calibration -- 9.3.1 Beam-Induced Transient -- 9.3.1.1 Physical Meaning of Beam-Induced Transient -- 9.3.1.2 Measurement of Beam-Induced Transient -- 9.3.2 Accelerating Voltage and Beam Phase Calibration -- 9.3.2.1 Accelerating Voltage Calibration with RF Drive Power -- 9.3.2.2 Accelerating Voltage and Beam Phase Calibration with Beam-Induced Transient -- 9.3.2.3 Accelerating Voltage and Beam Phase Calibration with Beam Energy -- 9.3.3 Cavity Input Power and Phase Adjustment -- 9.3.4 Vector-Sum Calibration -- 9.3.4.1 Vector-Sum Calibration Algorithm -- 9.3.4.2 Vector-Sum

Calibration Error -- 9.3.5 Cavity Forward and Reflected Signals
Calibration -- 9.3.6 RF Signal Power Calibration -- 9.4 RF System
Identification.
9.4.1 Cavity Input Coupling Factor Identification.
