

Contents

Introduction — V

Preface — VII

Chapter 1

Introduction to basic knowledge of communication electronic circuits — 1

- 1.1 Introduction to communication system — 1
 - 1.1.1 Composition of communication system — 1
 - 1.1.1.1 Signal source — 1
 - 1.1.1.2 Transmitting equipment — 2
 - 1.1.1.3 Channel — 2
 - 1.1.1.4 Noise — 2
 - 1.1.1.5 Receiving equipment — 2
 - 1.1.1.6 Destination — 2
 - 1.1.2 Classification of communication systems — 3
- 1.2 Basic components of communication system — 4
 - 1.2.1 Transmitting unit — 4
 - 1.2.2 Channel — 6
 - 1.2.2.1 Ground wave — 6
 - 1.2.2.2 Sky wave — 7
 - 1.2.2.3 Space wave — 7
 - 1.2.3 Receiving equipment — 8
- 1.3 Division of wireless communication frequency bands — 10
- 1.4 Frequency-selective circuits — 13
- 1.5 LC resonant circuits — 13
 - 1.5.1 Equivalent conversion of series-parallel circuit — 14
 - 1.5.2 Basic characteristics of LC parallel resonant circuit — 15
 - 1.5.2.1 LC parallel resonant circuit without load — 15
 - 1.5.2.1.1 Resonance condition of the parallel resonant circuit — 15
 - 1.5.2.1.2 Resonant characteristics — 16
 - 1.5.2.1.3 Impedance characteristic curves — 17
 - 1.5.2.1.4 Frequency-selective characteristics of LC parallel resonant circuit — 18
 - 1.5.2.1.5 Bandwidth — 19
 - 1.5.2.1.6 Rectangular coefficient — 21
 - 1.5.2.2 LC parallel resonant circuit with load — 22
 - 1.5.3 Basic characteristics of LC series resonant circuit — 23
 - 1.5.3.1 LC series resonant circuit without load — 23
 - 1.5.3.1.1 Resonance condition of series resonant circuit — 23
 - 1.5.3.1.2 Resonant characteristics — 23

1.5.3.1.3	Energy relationships — 24
1.5.3.1.4	Impedance characteristic curves — 25
1.5.3.1.5	Frequency-selective characteristics of <i>LC</i> series resonant circuit — 26
1.5.3.2	<i>LC</i> series resonant circuit with load — 26
1.6	Solid filters — 27
1.6.1	Quartz crystal filters — 27
1.6.2	Ceramic filters — 28
1.6.3	Surface acoustic wave filters — 29
1.7	Impedance conversion networks — 31
1.7.1	Autotransformer circuit — 31
1.7.2	Mutual transformer circuit — 33
1.7.3	Capacitor divider circuit — 34
1.7.4	Partial access of the signal source — 35
1.8	<i>LC</i> frequency matching networks — 35
1.8.1	L-type matching network — 35
1.8.2	T-type matching network — 38
1.8.3	π -Type matching network — 40
1.9	Basic characteristics of nonlinear devices — 42
1.9.1	Introduction — 42
1.9.2	Characteristics of nonlinear devices — 43
1.9.3	Frequency conversion by nonlinear devices — 45
1.9.3.1	Power series analysis — 46
1.9.3.2	Linear time-varying analysis — 47
1.9.3.3	Exponential function analysis method — 49
1.9.3.4	Switching function analysis method — 49
1.9.3.5	Hyperbolic function analysis — 52
1.10	Summary — 54
	Problems — 55

Chapter 2

Radio frequency amplifiers — 57

2.1	Introduction to radio frequency amplifiers — 57
2.2	Small signal tuned amplifier — 57
2.2.1	High-frequency model of transistor — 58
2.2.1.1	Y-parameter BJT equivalent circuit — 58
2.2.1.2	Hybrid π equivalent circuit of BJT — 59
2.2.1.3	High-frequency parameters of the transistor — 60
2.2.2	Performance of small signal amplifier — 63
2.2.2.1	Gain — 63
2.2.2.2	Bandwidth — 63
2.2.2.3	Rectangle coefficient — 64

2.2.3	Small signal tuned amplifier circuits — 64
2.2.3.1	Equivalent circuit of the amplifier and simplified circuit — 65
2.2.3.2	Amplifier technical specifications calculation — 67
2.2.3.3	Multistage single resonant circuit amplifiers — 69
2.2.4	Stability of small signal amplifiers — 70
2.2.5	Low noise variable gain broadband amplifiers — 71
2.2.5.1	Features of AD603 — 71
2.2.5.2	Theory of operation — 71
2.2.5.3	Gain control introduction — 72
2.3	Analysis of radio frequency power amplifier — 73
2.3.1	Performance of radio power amplifier — 74
2.3.2	Classification of power amplifier — 77
2.3.3	Analysis of periodic cosine pulses — 78
2.4	Radio frequency tuned Class C power amplifier — 81
2.4.1	Piecewise-linear approximation technique — 82
2.4.2	Operating principle of Class C power amplifier — 84
2.4.2.1	Amplifier characteristic — 86
2.4.2.2	Load characteristic — 86
2.4.2.3	Collector modulation characteristic — 87
2.4.2.4	Base modulation characteristic of Class C power amplifier — 88
2.4.3	Bias circuits — 90
2.4.3.1	Collector bias circuit — 90
2.4.3.2	Base bias circuit — 90
2.5	Class E power amplifier — 91
2.6	Class F power amplifier — 94
2.7	Summary — 97
	Problems — 97

Chapter 3

Sinusoidal oscillators — 99

3.1	Introduction — 99
3.2	Operational principle of feedback oscillators — 100
3.2.1	Basic principle and analysis of oscillation — 100
3.2.2	Oscillation conditions of feedback oscillators — 101
3.2.2.1	Startup condition of oscillation — 101
3.2.2.2	Balance condition of oscillation — 102
3.2.2.3	Stability condition of oscillation — 102
3.2.2.4	Discussion on oscillation conditions — 104
3.3	Feedback-type LC oscillators — 105
3.3.1	Principle of feedback-type LC oscillators composition — 105
3.3.2	Colpitts circuit — 107
3.3.3	Hartley circuit — 109

3.4	Improved capacitance feedback <i>LC</i> oscillators —	111
3.4.1	Clapp circuit —	112
3.4.2	Seiler circuit —	114
3.5	Frequency stability of oscillators —	116
3.5.1	Qualitative analysis of frequency stability —	116
3.5.1.1	Absolute frequency stability —	116
3.5.1.2	Relative frequency stability —	116
3.5.2	Factors causing frequency instability —	117
3.5.2.1	Unstable parameters of <i>LC</i> circuit —	117
3.5.2.2	Unstable parameters of transistor —	117
3.5.3	Measures for stabilizing frequency —	117
3.5.3.1	Reducing the impact from external factors —	118
3.5.3.2	Improving standardization of resonant circuit —	118
3.6	Quartz crystal oscillators —	119
3.6.1	Equivalent circuit and electrical properties of quartz crystal —	119
3.6.1.1	Piezoelectricity and the equivalent circuit of quartz crystal —	119
3.6.1.2	Impedance characteristic of quartz crystal —	121
3.6.1.3	Reasons of high-frequency stability of quartz crystal —	122
3.6.2	Quartz crystal oscillator circuits —	123
3.6.2.1	Crystal oscillators in parallel mode —	124
3.6.2.1.1	Pierce oscillator —	124
3.6.2.1.2	Miller oscillator —	126
3.6.2.1.3	Overtone crystal oscillator —	126
3.6.2.2	Crystal oscillators in series mode —	128
3.7	Negative resistance oscillators —	129
3.7.1	Basic characteristics of negative resistance device —	130
3.7.2	Negative resistance oscillator circuits —	132
3.8	Voltage-controlled oscillators —	134
3.8.1	Varactor diode —	134
3.8.2	Varactor diode voltage-controlled oscillators —	136
3.8.3	RF CMOS voltage-controlled oscillators —	137
3.9	Summary —	139
	Problems —	139

Chapter 4

Amplitude modulation, demodulation and frequency mixing — 145

4.1	Introduction —	145
4.2	Analysis of amplitude-modulated signal —	146
4.2.1	Standard AM wave —	146
4.2.1.1	Mathematical expressions of standard AM wave —	147
4.2.1.2	Waveform of standard AM wave —	147
4.2.1.3	Frequency spectrum of standard AM wave —	149

4.2.1.4	Average power of standard AM wave —	150
4.2.2	Double-sideband AM wave —	151
4.2.3	Single-sideband AM wave —	153
4.3	Amplitude-modulated circuits —	154
4.3.1	High-level amplitude-modulated circuits —	155
4.3.1.1	Base amplitude-modulated circuit —	155
4.3.1.2	Collector amplitude-modulated circuit —	157
4.3.2	Low-level amplitude-modulated circuits —	157
4.3.2.1	Integrated analog multiplier amplitude-modulated circuit —	158
4.3.1.2	Diode ring amplitude-modulated circuit —	159
4.4	Amplitude demodulation circuits —	161
4.4.1	Large signal peak envelope detection circuits —	162
4.4.1.1	Working principle —	162
4.4.1.2	Performance index —	164
4.4.1.2.1	Detection efficiency —	164
4.4.1.2.2	Input resistance —	166
4.4.1.3	Detection distortion —	167
4.4.1.3.1	Diagonal distortion —	167
4.4.1.3.2	Negative peak clipping distortion —	168
4.4.2	Synchronous detection circuits —	170
4.5	Mixers —	173
4.5.1	The basic principle of mixer —	174
4.5.2	The key technical indexes of mixer —	176
4.5.2.1	Mixing gain —	177
4.5.2.2	Selectivity —	177
4.5.2.3	Working stability —	177
4.5.2.4	Nonlinear distortion —	177
4.5.2.5	Noise figure —	177
4.5.2.6	Isolation —	178
4.5.3	The mixer circuits —	178
4.5.3.1	Transistor mixer circuits —	178
4.5.3.2	Diode ring mixer circuit —	180
4.5.3.3	Integrated analog multiplier mixer circuit —	182
4.5.4	Mixing interference and suppression methods —	182
4.5.4.1	Combined frequency interference (interference whistle) —	183
4.5.4.2	Side-channel interference —	184
4.5.4.3	Cross-modulation interference —	186
4.5.4.4	Intermodulation interference —	186
	Problems —	187

Chapter 5

Angle modulation and demodulation — 191

- 5.1 Introduction — **191**
- 5.2 Properties of angle modulation wave — **192**
 - 5.2.1 Instantaneous frequency and instantaneous phase — **192**
 - 5.2.2 Mathematical expression of FM and PM — **193**
 - 5.2.2.1 FM — **193**
 - 5.2.2.2 PM — **194**
 - 5.2.2.3 Comparison between FM and PM — **194**
 - 5.2.3 Frequency spectrum and bandwidth of FM and PM — **195**
 - 5.2.4 Power distribution of the angle modulation wave — **198**
- 5.3 Realization of FM — **198**
 - 5.3.1 Method of the frequency modulation — **198**
 - 5.3.2 Performance specifications of the FM circuit — **198**
- 5.4 FM circuit — **199**
 - 5.4.1 FM based on varactors — **199**
 - 5.4.1.1 Varactors — **199**
 - 5.4.1.2 Principle of varactor-based FM circuit — **200**
 - 5.4.1.3 Practical circuit of varactor-based FM — **202**
 - 5.4.2 FM circuit based on VCO — **202**
 - 5.4.3 FM circuit based on quartz crystal resonator — **203**
 - 5.4.3.1 Basic principle — **203**
 - 5.4.3.2 Practical circuit of quartz crystal FM — **203**
 - 5.4.4 Indirect FM circuit — **204**
 - 5.4.4.1 Principle of indirect FM — **204**
 - 5.4.4.2 PM circuit — **205**
- 5.5 Demodulation of FM — **208**
 - 5.5.1 Methods of frequency discrimination and the circuit model — **208**
 - 5.5.1.1 Methods of frequency discrimination — **208**
 - 5.5.2 Performance indices of frequency discriminators — **209**
 - 5.5.3 Slope of frequency discrimination — **210**
 - 5.5.4 Phase discriminator — **211**
 - 5.5.4.1 Phase detector — **212**
 - 5.5.4.1.1 Multiplier phase detector — **212**
 - 5.5.4.1.2 Adder phase detector — **213**
 - 5.5.5 Ratio discriminator — **219**
 - 5.5.6 Pulse-counting discriminator — **220**
- 5.6 Limiter — **222**
 - 5.6.1 Introduction — **222**
 - 5.6.2 Diode limiter — **223**
 - 5.6.3 Transistor limiter — **223**
- 5.7 Comparison of different modulation methods — **224**

- 5.7.1 Antiinterference ability — **224**
- 5.7.2 Bandwidth occupation — **225**
- 5.7.3 Transmitter power requirement — **225**
- 5.7.4 Strong signal blockage — **225**
- 5.8 Low-power FM receiver system based on digital IC — **226**
Problems — **227**

Chapter 6

Phase lock loop — 231

- 6.1 PLL introduction — **231**
- 6.2 Basic components and principle — **231**
- 6.3 Linear model — **232**
 - 6.3.1 Phase detector model — **232**
 - 6.3.2 Loop filter model — **234**
 - 6.3.3 VCO — **236**
 - 6.3.4 PLL model — **237**
- 6.4 Application of the PLL — **237**
 - 6.4.1 Frequency synthesizers — **238**
 - 6.4.2 Local oscillator — **238**
 - 6.4.3 Clock generation — **239**
- 6.5 Summary — **239**
Problems — **239**

References — 241

Index — 243