
Contents

Preface	xi
Chapter 1. The Transistor	1
1.1. Modeling of transistors	1
1.1.1. An input resistance and a linked source.	2
1.1.2. Giacoletto's equivalent diagram	3
1.1.3. Introduction of nonlinearities	4
1.1.4. Spice-type modeling	7
1.1.5. S or X parameters.	7
1.1.6. The Ebers-Moll model	10
1.1.7. Conclusion.	12
1.2. Amplification	12
1.2.1. Reminder about distortion	12
1.2.2. Reminder about feedback	14
1.2.3. Conclusion.	23
Chapter 2. Amplifiers	25
2.1. Common emitter amplifier	25
2.1.1. Calculation of the transfer function	25
2.1.2. Calculation of the distortion	26
2.1.3. Common emitter amplifier with CR feedback, calculation of the gain	30
2.1.4. Common emitter amplifier with CR feedback, distortion calculation.	32
2.1.5. Common emitter amplifier, calculation of the transfer function	36
2.1.6. Common emitter amplifier, Miller Effect.	39
2.2. Common base amplifier.	40

2.2.1. Calculation of the transfer function	40
2.2.2. Cascode amplifier.	41
2.3. Common collector amplifier	55
2.3.1. Calculation of the transfer function	56
2.3.2. Operation with a current source	56
2.3.3. Precautions and conclusions	57
Chapter 3. Differential Amplifiers.	61
3.1. Differential amplifier without a current source	62
3.2. Differential amplifier with a current source	65
3.2.1. Current sources and mirrors	66
3.2.2. Simulation of the differential stage	70
3.3. Cascode differential amplifier	75
3.3.1. Objective of the architecture of the differential cascode amplifier.	75
3.3.2. Simulation of the differential cascode amplifier	77
3.4. Differential cross-quad amplifier.	78
3.4.1. Inversion of the characteristic	78
3.4.2. Simulation around the linearity of the cross-quad differential amplifier.	83
3.5. Cascomp feedforward differential amplifier.	86
3.5.1. Calculating the gain of the cascomp differential amplifier.	86
3.5.2. Simulation of the cascomp differential amplifier.	88
3.5.3. Symmetrical cascomp differential amplifier	88
3.6. Differential cascomp feedback amplifier	95
3.7. Comparison of the different structures and conclusion.	96
3.7.1. Linearity	96
3.7.2. Bandwidth	96
3.7.3. Nature of the transfer function.	98
3.8. Exact calculation of transfer functions of differential stages	98
3.8.1. Generic amplifier stage.	98
3.8.2. Calculation of influential parameters	101
3.8.3. Elementary differential stage	103
3.8.4. Differential stage having two emitter resistors	106
3.8.5. Cascode differential stage	109
3.8.6. Cascomp feedforward differential stage, Tektronix patent	113
3.8.7. Differential cascomp feedback stage	118
3.8.8. Dimensioning procedure of the cascomp amplifier	121
3.9. Conclusion and comparison of differential stages	122

3.9.1. Comparison of the linearity of differential stages	122
3.9.2. Comparison of bandwidth at -3dB of the differential stages	126
3.9.3. Supplements to the cross-quad.	130
3.9.4. Cross-quad variants.	132
Chapter 4. Amplifier Output Stage	139
4.1. Class A amplifiers	140
4.2. Class B amplifiers	141
4.3. Class AB amplifiers	147
4.3.1. VBE multiplier	150
4.4. Example of output amplifier stages	154
4.4.1. Comparison of single transistor, Darlington or compound pair	155
Chapter 5. Study and Analysis of Certain Amplifiers	161
5.1. Study of the operational amplifier 741	161
5.2. Study of audio amplifiers	162
5.2.1. “1970s” type amplifier	162
5.2.2. “1980s” type amplifier	167
5.2.3. “2000s” type amplifier	172
5.3. Transimpedance amplifier	176
5.4. Class E amplifier.	183
5.5. Serial-shunt pair amplifier	192
5.5.1. Polarization and sizing of the amplifier	192
5.5.2. AC and transient simulation	195
5.5.3. S parameter simulation	198
5.5.4. Application to an oscillator	198
5.5.5. Variation with a differential stage	202
Chapter 6. Study and Analysis of Oscillators	205
6.1. Essential characteristics of oscillators	205
6.1.1. Oscillator phase noise	206
6.1.2. Oscillator pulling and pushing	209
6.1.3. Oscillator factor of merit, FOM	210
6.2. Theoretical Analysis of Oscillator Operations	210
6.2.1. Feedback and reaction	210
6.2.2. Calculation procedure	213
6.2.3. Example with a third-order transfer function.	214
6.2.4. Distortion in oscillators.	215
6.2.5. Validity of the linear model of the oscillator	216

Chapter 7. Low Frequency Oscillators	219
7.1. Wien bridge oscillators	219
7.1.1. Basic Wien bridge oscillator	219
7.1.2. Wien bridge oscillator with level regulation	223
7.1.3. Wien bridge oscillator with cascomp amplifier	225
7.2. Phase-shift oscillator	227
7.3. Oscillator around the state variable filter	230
7.3.1. Simple oscillator without regulation	230
7.3.2. Level-controlled oscillator	234
7.3.3. Oscillator with output recombination	237
7.3.4. Note on distortion rate and measurement	240
7.4. Other types of LF oscillators	241
7.4.1. Shunted T-filter oscillator	241
7.5. Conclusion on low frequency AOP oscillators	244
Chapter 8. High Frequency Oscillators	245
8.1. Colpitts oscillator	246
8.1.1. Analysis with a perfect amplifier	246
8.1.2. Analysis with the transistor model	248
8.1.3. Conclusions	254
8.1.4. Simulations	254
8.2. Colpitts series oscillator.	267
8.2.1. Analysis with a perfect amplifier	267
8.2.2. Model analysis of the transistor	268
8.2.3. Simulations	271
8.3. Vackar oscillator.	279
8.3.1. Analysis with a perfect amplifier	280
8.3.2. Model analysis of the transistor	282
8.3.3. Simulations	286
8.4. Parallel Clapp oscillator.	292
8.4.1. Analysis with a perfect amplifier	292
8.4.2. Model analysis of the transistor	294
8.4.3. Simulations	295
8.5. Clapp series oscillator.	301
8.5.1. Analysis with a perfect amplifier	301
8.5.2. Model analysis of the transistor	303
8.5.3. Conclusions	305
8.5.4. Simulations	305
8.6. SAW oscillator.	311
8.7. Comparison of the different oscillators	317
8.7.1. Oscillators with a single transistor.	317
8.7.2. Darlington and/or cascode oscillators	318

8.7.3. Complements on the oscillator Clapp resonance series	320
8.8. Transformation of oscillators into VCO	326
8.8.1. Variable capacity diodes	326
8.8.2. Colpitts VCO	327
8.8.3. Colpitts VCO, series resonance	330
8.8.4. Vackar VCO.	332
8.8.5. Clapp VCO	335
8.8.6. Clapp VCO, concrete realization	337
Chapter 9. Differential Oscillators	343
9.1. Simple differential oscillator	344
9.1.1. Influence of the base-emitter capacity	348
9.1.2. Influence of the base-collector capacity.	348
9.1.3. Simulations	349
9.2. Simple differential oscillator with SAW resonator	353
9.3. Simple differential oscillator, cascode	356
9.4. Differential oscillator, cross-coupled with buffer.	358
9.5. Differential oscillator, cross-coupled Colpitts.	362
9.6. Differential oscillator, bandpass filter	365
9.7. Variations of the differential oscillator.	368
9.8. Variations of unclassifiable oscillators.	371
9.9. Transformation of differential oscillators into VCO	376
9.9.1. Cross-coupled and buffer differential oscillators.	376
9.9.2. Differential cross-coupled cascode oscillators	382
9.9.3. Cross-coupled bandpass differential oscillators	384
Chapter 10. Bonus Oscillators	387
10.1. Parallel resonance oscillator	389
10.2. Series resonant oscillator	392
10.3. Differential oscillator, improvements.	395
10.3.1. Differential oscillator, basic diagram	396
10.3.2. Differential oscillator, Q increase	398
10.3.3. Differential oscillator, Q increase, improvements	400
10.4. Differential oscillator SAW, improvements	401
10.5. Conclusion	401
Bibliography.	403
Index	405