

<b>0.</b>	<b>Getting into the mood (Satire)</b>	<b>0-01</b>
0.1	Barking up the wrong tree	0-02
0.2	Signature guitars	0-11
0.3	Strings and the orcus (cf. Schiller)	0-15
0.4	Unamplified E-guitars	0-17
0.5	Noehle-Gluehstrumpf	0-23
<b>1.</b>	<b>The fundamentals of string oscillations</b>	<b>1-01</b>
1.1	Transversal waves	1-01
1.2	Wound strings	1-05
1.3	Inharmonic partials	1-10
	1.3.1 Dispersion in the time domain	1-10
	1.3.2 Dispersion in the frequency domain	1-18
1.4	Longitudinal waves / dilatational waves	1-20
1.5	Plucking a string	1-27
	1.5.1 Deconvolution of dispersion	1-27
	1.5.2 Plectrum influence	1-31
	1.5.3 String bounce	1-35
	1.5.4 String rattle	1-41
1.6	The decay of string oscillations	1-42
	1.6.1 Plane string oscillations	1-42
	1.6.2 Spatial string oscillations	1-46
	1.6.3 Partial level and summation level	1-51
	1.6.4 Worn out strings	1-53
1.7	String lifetime	1-54
<b>2.</b>	<b>The string as a waveguide</b>	<b>2-01</b>
2.1	Transversal waves	2-01
2.2	Image waves as a model for reflection	2-11
2.3	Standing waves	2-12
2.4	Transient phenomena	2-18
2.5	Reflection	2-20
	2.5.1 Reflection factor	2-20
	2.5.2 A resonator as string bearing	2-23
2.6	Internal dissipations	2-24
2.7	Dispersive bending waves	2-26
2.8	The generalized waveguide model	2-36
	2.8.1 Ideal string, bridge pickup	2-36
	2.8.2 String with singlecoil pickup	2-41
	2.8.3 String with humbucking pickup	2-47
	2.8.4 Dispersive waveguide components	2-50
2.9	Magnetic pickup with dilatational waves	2-52
<b>3.</b>	<b>String magnetics</b>	<b>3-01</b>
3.1	Steel, nickel, bronze	3-01
3.2	String loudness	3-04
3.3	Magnetic string parameter	3-08
	3.3.1 Measurements with a string loop	3-08
	3.3.2 The magnetic skin effect	3-10
	3.3.3 Measurements with a yoke	3-12

<b>4. The electromagnetic field</b>	<b>4-01</b>
4.1 Fundamentals of magnetostatics	4-02
4.2 The magnetic potentials	4-07
4.3 Materials in the magnetic field	4-10
4.3.1 Soft magnetic materials	4-14
4.3.2 Hard magnetic materials	4-14
4.3.3 Nonmagnetic materials	4-14
4.4 Pickup magnets	4-15
4.4.1 Alnico magnets	4-16
4.4.1.1 <i>Alnico-III and Alnico-I</i>	4-22
4.4.1.2 <i>Alnico-II</i>	4-23
4.4.1.5 <i>Alnico-V</i>	4-24
4.4.1.6 <i>Additional Alnico materials</i>	4-25
4.4.1.7 <i>Comparison of Alnico materials</i>	4-25
4.4.2 Cunife magnets	4-30
4.4.3 Ferrite magnets	4-31
4.5 Magnetic aging	4-32
4.6 The magnetic circuit	4-35
4.7 Depiction of magnetic fields	4-40
4.7.1 Magnetic field strength and flux density	4-41
4.7.2 Magnetic potentials	4-44
4.7.3 Spatial fields	4-45
4.8 Field geometry inside materials	4-46
4.9 Mathematic field theory	4-50
4.10 Magnetodynamics	4-57
4.10.1 Magnetic voltage induction	4-57
4.10.2 Self induction, inductivity	4-58
4.10.3 Permeability	4-61
4.10.4 Magnetic losses, magnetic skin effect	4-64
4.11 Magnetic field forces	4-72
4.11.1 Maxwell force	4-72
4.11.2 Field related pitch modulations	4-74
4.11.3 Field related level modulations	4-77
4.11.4 Field related dissipations	4-81
4.11.5 Indirect sound effects	4-85
4.11.6 Coulomb force	4-87
4.11.7 Lorentz force	4-87
4.12 Magnetic figures of merit (table)	4-88
<b>5. Magnetic pickups</b>	<b>5-01</b>
5.1 Singlecoil pickups	5-01
5.2 Humbucking pickups	5-09
5.3 Coaxial singlecoil pickups	5-13
5.4 The pickup's magnetic field	5-17
5.4.1 The static field without string	5-17
5.4.2 The static field with string	5-25
5.4.3 The alternating magnetic field	5-29
5.4.4 Magnetic window (aperture)	5-34
5.4.5 Absolute pickup sensitivity	5-43
5.4.6 Staggered and beveled polepieces	5-45
5.4.7 Fender Jaguar and Lace	5-48
5,4,8 DeArmond Pickups	5-52

5.5	Basic pickup parameters	5-56
5.5.1	DC resistance	5-56
5.5.2	Coil inductance	5-58
5.5.3	Coil capacity	5-61
5.5.4	Resonance quality	5-62
5.5.5	Polarity	5-64
5.5.6	Time variance	5-69
5.5.7	Wire coating, wax	5-70
5.5.8	Flatware	5-72
5.5.9	Absolute sensitivity, loudness	5-73
5.6	Pickup measurement devices	5-75
5.7	Hum sensitivity	5-79
5.8	Nonlinear distortions	5-86
5.9	Equivalent networks	5-91
5.9.1	Models and analogies	5-91
5.9.2	Impedance models	5-92
5.9.2.1	<i>Singlecoils with low eddy current losses</i>	5-94
5.9.2.2	<i>Eddy currents in the nonmagnetic conductor</i>	5-97
5.9.2.3	<i>Equivalent two-pole networks</i>	5-101
5.9.2.4	<i>Eddy currents in the magnetic conductor</i>	5-103
5.9.2.5	<i>Singlecoils with high eddy current losses</i>	5-106
5.9.2.6	<i>Gibson-Humbucker: screw-coil</i>	5-109
5.9.2.7	<i>Gibson-Humbucker: plug-coil</i>	5-118
5.9.2.8	<i>Gibson-Humbucker: coupling of the coils</i>	5-120
5.9.3	Equivalent transmission networks	5-122
5.9.4	Connected pickups	5-126
5.10	Analysis of the transfer behavior	5-129
5.10.1	Measurements with a shaker	5-129
5.10.2	Measurements with a Helmholtz coil	5-131
5.10.3	Measurements with a coaxial coil	5-133
5.10.4	Measurements with a tripole coil	5-134
5.10.5	Measurements with a laser-vibrometer	5-135
5.10.6	Measurement accuracy	5-145
5.10.7	Finite Element Modeling	5-148
5.11	Directional characteristic of pickups	5-150
5.11.1	String polarization	5-150
5.11.2	Wave polarization	5-153
5.12	Pickup noise	5-155
5.13	Pickup microphonics	5-157
5.14	Pickups with shorted turns	5-163
5.15	Database	5-167
5.16	Patents and Inventions	5-206
<b>6.</b>	<b>Piezoelectric pickups</b>	<b>6-01</b>
6.1	The piezoelectric process	6-01
6.2	Electric loading	6-03
6.3	The piezo pickup as a sensor	6-04
6.4	Reciprocity	6-08
6.5	The piezo pickup as an actuator	6-11
6.6	The disassembled pickup	6-14
6.7	Pickup noise	6-15
6.8	Piezo pickup vs. microphone	6-17
6.9	Microphonics	6-19
6.10	Differences compared to magnetic pickups	6-21
6.A	Supplement: Piezoelectric state equations	6-23

<b>7. Neck and body</b>	<b>7-01</b>
7.1 The guitar neck	7-01
7.2 The frets	7-04
7.2.1 Fret positions	7-04
7.2.3 Fret materials	7-10
7.2.3 The Buzz-Feiten-system	7-11
7.3 Neck and string geometry	7-15
7.3.1 Head and neck angle	7-15
7.3.2 String trees	7-17
7.4 String dynamics	7-18
7.4.1 Playing forces	7-18
7.4.2 Bearing forces	7-21
7.5 Reflection and absorption at the bridge/nut	7-25
7.5.1 Reflection and absorption parameter	7-26
7.5.2 Reflection analysis	7-27
7.5.3 The mechanical bridge impedance	7-39
7.5.4 Measurement results	7-45
7.6 Vibration measurement techniques	7-51
7.6.1 Impedance / admittance measurements	7-51
7.6.2 The spectrum of decaying tones (Volagramm)	7-56
7.6.3 The decay time $T_{30}$	7-64
7.7 Absorption of string oscillations	7-66
7.7.1 Radiation absorption	7-66
7.7.2 Internal dissipation	7-67
7.7.3 Winding attenuation of wound strings	7-69
7.7.4 Bearing absorption	7-71
7.7.4.1 <i>Coupling of transversal waves</i>	7-71
7.7.4.2 <i>Absorption of longitudinal waves</i>	7-75
7.7.4.3 <i>Residual absorption</i>	7-76
7.7.4.4 <i>Bearing conductance</i>	7-77
7.7.5 Finger-, hand- and capodaster-attenuation	7-84
7.7.6 String aging	7-85
7.7.7 Flatwound strings	7-86
7.8 "Specialized" literature	7-87
7.8.1 The fairytales of the primary tone	7-88
7.8.2 "Stratone"	7-92
7.8.3 BS-Journalists	7-100
7.9 Does the body wood affect the tone?	7-102
7.10 Special bridge constructions	7-117
7.10.1 Simple models	7-118
7.10.2 Bridges without vibrato (Gibson / Fender)	7-122
7.10.3 Bridges with vibrato (Fender / Bigsby / Rickenbacker)	7-132
7.11 Solid vs. semisolid body	7-139
7.12 Vibration – soundwaves – sound	7-142
7.12.1 Linear string oscillations	7-142
7.12.2 Nonlinear string oscillations	7-152
7.12.3 The causes of timbre	7-161
7.12.4 So what?	7-164
7.13 Neck curvature and fret/string distance ("action")	7-165
7.14 Damping reduction	7-170

<b>8.</b>	<b>Psychoacoustics</b>	<b>8-01</b>
8.1	Tone systems	8-02
8.1.1	Das Pythagorean tone system	8-03
8.1.2	Just intonation	8-07
8.1.3	Tempered intonation	8-10
8.1.4	Equal tempered intervals	8-13
8.1.5	Typical guitar mistuning	8-16
8.1.6	The stretched intonation	8-16
8.2	Frequency and pitch	8-17
8.2.1	Frequency measurement	8-17
8.2.2	Frequency and pitch accuracy	8-19
8.2.3	Pitch detection	8-23
8.2.4	Grouping of partials	8-25
8.2.5	Inharmonicity of partials	8-28
8.3	The character of keys	8-37
8.4	Consonance and dissonance	8-40
8.5	Timing and rhythm	8-47
8.6	Loudness and timbre	8-54
8.7	Listening tests	8-71
8.7.1	Psychometry	8-71
8.7.2	The unamplified E-Guitar	8-76
8.7.3	Tactile sensations	8-82
<b>9.</b>	<b>Guitar Circuits</b>	<b>9-01</b>
9.1	Potentiometers	9-01
9.2	Tone-Caps	9-05
9.3	Pickup cables	9-09
9.4	Guitar cables	9-10
9.5	Metal sheets	9-15
<b>10.</b>	<b>Guitar amplifiers</b>	<b>10-01</b>
10.1	<b>The input stage</b>	<b>10-01</b>
10.1.1	The input tube	10-02
10.1.2	The tube's input resistance	10-04
10.1.3	Triode charts	10-07
10.1.4	Nonlinearities, distortion	10-11
10.1.5	Cutoff frequencies	10-24
10.1.6	Time variances	10-28
10.1.7	Noise, hum, microphonics	10-30
10.1.8	Noise processes	10-32
10.1.9	Pentodes in the input stage	10-35
10.2	<b>The second stage</b>	<b>10-36</b>
10.2.1	Cathode-basis-circuit	10-37
10.2.2	Cathode follower	10-38
10.2.3	The mixing stage	10-46
10.3	<b>The filter section (Tone Stack)</b>	<b>10-49</b>
10.3.1	Bass-Middle-Treble	10-49
10.3.2	Equalizer	10-58
10.3.3	Presence-Control	10-61
10.4	<b>Phase reversal (Phase Splitter)</b>	<b>10-62</b>
10.4.1	Paraphase	10-62
10.4.2	Kathodyn	10-65
10.4.3	Difference amplifier	10-67
10.4.4	Halfewave antimetry	10-69

<b>10.5 The power stage</b>	<b>10-75</b>
10.5.1 Class-A, tetrode, pentode	10-76
10.5.2 Class-A push pull	10-85
10.5.3 Class-B	10-87
10.5.4 Class-AB, class-D	10-90
10.5.5 The impedance paradox	10-91
10.5.6 Negative feedback	10-92
10.5.7 The source resistance of the power stage	10-94
10.5.8 Biasing the power stage	10-98
10.5.9 Stress and aging	10-107
10.5.10 The magic sound of a 6L6	10-115
10.5.11 Match Point	10-119
10.5.11.1 <i>Selecting, matching (and leg pulling)</i>	10-119
10.5.11.2 <i>Tube testing</i>	10-122
10.5.12 Selected tube circuits VOX, Marshall, Fender	10-124
10.5.13 Comparing analysis: Power tubes	10-144
10.5.14 Pentode / triode / ultralinear	10-176
<b>10.6 The output transformer</b>	<b>10-157</b>
10.6.1 The linear model	10-157
10.6.2 Impedance matching	10-162
10.6.3 Winding capacitance	10-164
10.6.4 The nonlinear model	10-166
10.6.5 Comparing analyses	10-176
<b>10.7 Power supply</b>	<b>10-188</b>
10.7.1 Heating circuit	10-188
10.7.2 Filter capacitor	10-189
10.7.3 The internal resistance	10-193
10.7.4 Rectifier tubes	10-194
10.7.5 The smoothing filter	10-195
10.7.6 The mains transformer	10-196
<b>10.8 Effects</b>	<b>10-204</b>
10.8.1 Reverb	10-204
10.8.2 Vibrato / Tremolo	10-212
10.8.3 Phaser / Flanger / Chorus	10-218
10.8.4 Wah-wah-pedal	10-220
10.8.5 Fuzz-box	10-221
10.8.5.1 <i>Diodes</i>	10-227
10.8.5.2 <i>Transistors</i>	10-230
10.8.5.3 <i>Range Master (Dallas Arbiter)</i>	10-232
10.8.5.4 <i>Tube-Screamer (Ibanez)</i>	10-235
10.8.5.5 <i>Fuzz-Face (Dallas Arbiter)</i>	10-237
10.8.5.6 <i>Roaring semiconductors</i>	10-238
<b>10.9 Operational behavior</b>	<b>10-239</b>
10.9.1 Tube-sound vs. transistor-sound	10-239
10.9.2 Tube-Watt vs. transistor-Watt	10-244
10.9.3 Coupling capacitors	10-249
10.9.4 Sound event vs. listening event	10-267
<b>10.10 Comparing analyses</b>	<b>10-271</b>
10.10.1 Right you are if you think you are	10-271
10.10.2 Stage topology	10-275
10.10.3 Headroom charts	10-278
10.10.4 Comparison of nonlinear distortions	10-285
10.10.5 Audibility of nonlinear distortion	10-290
10.10.6 Comparison of Frequency responses	10-296
10.10.7 Comparison of VOX, Fender, Marshall	10-299
10.10.8 Modeling amps	10-316

<b>10.11 Tube data</b>	<b>10-325</b>
10.11.1 Nomenclature	10-325
10.11.2 Triodes	10-326
10.11.3 Power tubes	10-330
10.11.4 Tube parameters	10-338

<b>11. Guitar loudspeakers</b>	<b>11-01</b>
11.1 Construction and function	11-01
11.2 Electrical two-pole characteristic	11-07
11.3 Frequency response	11-11
11.4 Directional characteristic	11-29
11.5 Efficiency and maximum sound pressure	11-38
11.6 Nonlinear distortions	11-52
11.7 Alnico- vs. ferrite magnet	11-64
11.8 Loudspeaker cabinets	11-71
11.8.1 Basics	11-71
11.8.2 Comparison of cabinet materials	11-80
11.9 Beamblockers and Diffusers	11-86
11.10 Horn loudspeaker	11-91
11.11 Studio monitors	11-96
11.12 Loudspeaker cables	11-100
11.A Supplement: Measurement techniques	11-101
11.A.1 Measuring microphones	11-101
11.A.2 Reverberation time	11-101

<b>Supplement: Vibration and waves</b>	<b>A-01</b>
A.1 Oscillations vs. waves	A-01
A.1.1 Forced oscillations	A-02
A.1.2 Free oscillations	A-02
A.1.3 Forced waves	A-03
A.1.4 Free waves	A-05
A.1.5 Standing waves	A-05
A.2 Longitudinal waves	A-07
A.2.1 Pure longitudinal waves	A-07
A.2.2 Dilatational waves in strings	A-07
A.3 Transversal waves	A-10
A.3.1 Pure transversal waves	A-10
A.3.2 Transversal waves in strings	A-10
A.4 Bending waves	A-12
A.4.1 Bars under zero tension, pure bending waves	A-12
A.4.2 Vibrations of a stiff string	A-16
A.4.3 Eigenmodes of bending waves	A-17
A.5 Wave resistance	A-21
A.6 Stiffness	A-25
A.7 Impulses	A-27
A.8 Ultimate end: cryo...	A-28

## References

## Glossary

**Animations** (see [www.gitec-forum.de](http://www.gitec-forum.de), no download possible)