

Index

- absorption/gain spectra, 245
- absorption processes, 21–24
- acceptor, 19
- ACPR, *see* adjacent channel power ratio (ACPR)
- active baluns and unbals, 414–416
- active forward operation, 116
- adjacent channel power ratio (ACPR), 375–376
- amplifier configurations
 - common drain/common collector, 321–323
 - common gate/common base, 319–321
 - common source/common emitter, 316–318
 - Miller effect, 318
 - with two transistors, 329–336
 - Battjes f_T doubler, 333
 - cascode amplifier, 333–336
 - common-drain/common-source, 329–332
 - Darlington amplifier, 332–333
 - y matrix representation, 315–318
- amplifier linearity, 370–376
 - adjacent channel power ratio, 375–376
 - single-tone excitation, 370–372
 - two-tone excitation, 372–375
- ANN, *see* artificial neural networks (ANN)
- anti-guiding parameter, 244
- APD, *see* avalanche photodiodes (APDs)
- arbitrary terminations, 299–300
- Armstrong oscillator, 388
- artificial neural networks (ANN), 168–169
- associated gain, 312
- atomic bonding, 8
 - covalent bonding, 8–9
- atomic physics, 9
 - Bohr model, 10–11
 - photoelectric effects, 9–10
- avalanche photodiodes (APDs), 275, 276
 - input signal photocurrent for, 276
 - ionisation coefficient, 272–273
 - multiplication factors, 273–274
 - optical generation rate, 273
 - (SAM) separate absorption and multiplication, 275
- avalanching, 120
- bandgap energy, 222, 262
- band line-up, 38–39
- bandwidth
 - enhancement, 328
 - improvement, 326–329
- base design dilemma, 136–137
- base push out, 125
- base resistance, 128
- base transit time, 126
- base transport factor, 121
- Battjes f_T doubler, 333
- bipolar and hetero-bipolar transistors, 115
 - heterojunction
 - base design dilemma, 136–137
 - drift base, 139–140
 - HBT implementations, 140–143
 - III–V *versus* Si/SiGe HBTs, 146–147
 - Si/SiGe HBTs, 143–146
 - wide-gap emitter, 137–139
- homojunction, 115–116
 - collector current equation, 117–118
 - diffusion triangle, 116–117
 - Early effect, 122–124
 - ideal base current, 118–119
 - ideal current gain, 119
 - Kirk effect, 124–125
 - non-ideal current contributions, 119–120
 - non-ideal current gain, 120–121
 - saturation, 121–122
- large-signal modelling, 147
 - BJTs and HBTs, 155–156
 - Ebers–Moll model, 147
 - Gummel–Poon model, 147–150
 - MEXTRAM model, 152–153
 - VBIC95 model, 150
- microwave noise performance of bipolar transistors, 131–134
- small-signal dynamic behaviour, 125–129
 - maximum frequency of oscillation, 130–131
 - transit frequency, 129–130
- transit time optimisation
 - collector transit time optimisation, 135–136
 - drift field in base, 134–135
- bipolar junction transistors (BJT), 46
- BJT, *see* bipolar junction transistors (BJT)
- BJTs and HBTs, 155–156
- Bloch theorem, 16
- body-centred cubic lattice (BCC), 6
- Bohr formulation, 11
- Bohr model, 10–11
- Boltzmann’s constant, 222
- Bragg frequency, 356

- broadband amplifier techniques, 350–354
 - feedback techniques, 353–354
 - shunt peaking, 351–353
- building blocks for high-speed analogue circuits, 291
- baluns, unbaluns and hybrids
 - active baluns and unbaluns, 414–416
 - passive baluns and unbaluns, 412–414
 - quadrature generation, 417–419
- mixers, 396
 - diode-based, 406–407
 - double-balanced, 402–404
 - image-rejection mixer topologies, 407–410
 - micromixer, 404–405
 - noise figure, 411–412
 - resistive, 398–400
 - single-balanced, 401–402
 - transconductance multiplier, 397
- oscillators, 383
 - noise, 393–396
 - non-linearity in oscillators, 387–388
 - oscillator topologies, 388–392
 - resonators, 383–385
 - self-excitation criteria, 385–387
- transistor amplifiers, 313–314
 - broadband amplifier techniques, 350–354
 - configurations, 314–323
 - configurations with two transistors, 329–336
 - differential, 336–341
 - distributed amplification, 354–365
 - feedback, 323–329
 - linearity, 370–376
 - low-noise, 365–370
 - power, 376–383
 - source-coupled, 341–342
 - tuned, 342–350
- two-port networks, basic relations for
 - impedance matching, 297–298
 - Mason's unilateral gain, 305–306
 - maximum available gain and maximum stable gain, 305
 - maximum frequency of oscillation, 306
 - power gains for amplifier design, 298–302
 - scattering parameter theory, 291–295
 - Smith chart, 295–297
 - stability, 302–305
- built-in potential, 32
- bulk semiconductor, 257
- Burrus diode, 229
- CAD modelling of HEMTs, 88
 - MESFET *versus* HEMT, 91–92
 - non-linear capacitance equations, 90–91
 - static current equations, 88–90
- carrier confinement, 36
- carrier lifetime, 226, 240–241, 248
- carrier transport in semiconductors, 29
 - diffusion current, 29
 - drift current, 29
- cascode
 - amplifier, 333–336
 - topology, 368
- cavity photons, 252–253
- channel, 46
- channel length modulation, 103
- channel noise, 63
- COBRA current equation, 89
- collector
 - current equation, 117–118
 - resistance, 128
 - transit time optimisation, 134–136
- common-collector configuration, 321
- common-drain configuration, 321
 - common-source configuration, 329–332
- common-emitter configuration, 316
- common source configuration, 316
- confinement configuration, 230, 232, 236, 238, 239, 248, 257
- conformal mapping, 296
- constant-velocity approximation, 51–55
- constant-velocity model, 52–53
- cost function, 163–164
- Coulomb scattering, 67–69
- covalent bonding, 3, 8–9
- critical thickness, 39
- crystal directions, 7
 - and planes, 6–8
- crystal structure, 5–6
- current continuity, 50
- current–voltage characteristics, 33–34
- dark current flowing in slab, 263
- Darlington amplifier, 332–333
- de Broglie relation, 11–12
- density of states, 3, 19, 20, 35, 36
- depletion, 30
 - approximation, 30
 - capacitance, 33
 - layer width, 32–33
- device model optimisation, 163–164
- diamond, 8
- differential amplifiers, 336–341
 - common mode, 338–339
 - differential mode, 336–338
 - neutralisation of, 339
- diffusion components, 254
- diffusion current, 29
- diffusion triangle, 116–117
- diode-based mixers, 406–407
- diode responsivity, 270
- direct and indirect semiconductors, 20
 - absorption processes, 21–24
 - exciton absorption, 24–25
- direct bandgap semiconductors, 20

- distributed amplification, 354–365
 - amplifiers with cascode cell, 360–361
 - amplifier variations, 359–360
 - gain and loss in amplifiers, 358–359
 - general design procedure, 356–358
 - using Si/SiGe HBTs, 363–365
- distributed Bragg reflector (DBR) lasers, 253
- distributed feedback (DFB) laser, 253
- donor, 19
- double-balanced mixer, 402–404
- drain current, 50–51, 100–101
 - backgating, 102
 - constant-mobility model, 101–102
 - non-ideal effects in short-channel MOSFETs, 102–105
 - velocity saturation, 105–106
- drift base, 139–140
- drift current, 29
 - density, 268
- drift field in base, 134–135
- drift saturation velocity, 52
- Ebers–Moll model, 147
- edge-emitting LED, 228
- electrical pumping, 222
- electrons
 - and hole distribution, 19–20
 - in semiconductor, 16
- electrostatic theory, 67
- emission coefficient, 120
- emitter efficiency, 121
- emitter follower, *see* source follower
- epoch, 173
- exciton absorption, 24–25
- external power efficiency, 226
- extrinsic semiconductors, 18–19
- Fabry–Perot lasers, 248
- face-centred cubic lattice (FCC), 6
- facet mirror reflectivity, 230
- Fermi–Dirac distribution, 16
- fitness index, 180–181
- flat-band, 99
- FM signal, 372
- forward-biased emitter–base junction, 125
- free electron, 16
- f_T doubler, 332
- GaAs MESFET, 48
 - gain coefficient, 239–240
 - gain-guided lasers, 231–233
 - gain saturation sets, 371
 - gate length, 49
 - gate width, 49
 - generation-recombination noise, 265
 - gradual channel approximation, 49
 - Gummel–Poon model, 147–150
 - Hawkins’ theory, 133
 - HBT, *see* heterojunction bipolar transistors (HBT)
 - Heisenberg uncertainty principle, 12
 - heterojunction bipolar transistors (HBT)
 - base design dilemma, 46, 136–137
 - drift base, 139–140
 - III–V *versus* Si/SiGe HBTs, 146–147
 - implementations, 140–143
 - Si/SiGe HBTs, 143–146
 - wide-gap emitter, 137–139
 - heterojunction LED, 228
 - heterostructures, 35–37
 - band diagrams, 37–38
 - band line-up, 38–39
 - constructing heterostructure band diagrams, 37–38
 - lattice mismatch, 39–40
 - heterostructure bipolar transistor photodetector, 284
 - HICUM model, 153–155
 - high electron mobility, 80
 - high electron mobility transistor (HEMT), 67
 - CAD modelling, 88
 - MESFET *versus* HEMT, 91–92
 - non-linear capacitance equations, 90–91
 - static current equations, 88–90
 - charge control, 69–74, 69–75
 - channel current – constant mobility, 75–77
 - channel current – constant velocity, 77–78
 - Coulomb scattering, 67–69
 - high electron mobility, 80
 - non-ideal behaviour, 80–83
 - trapping effects, 83–85
 - small-signal parameters, 78–79
 - structural variations, 85
 - metamorphic, 87–88
 - pseudomorphic structure, 86–87
 - pulse-doped structure, 85–86
- high-speed lasers, 259–261
 - separate confinement (SC) region, 261
 - tunnelling injection laser, 261
- hill-climbing capability of SA, 166
- homojunction bipolar transistors, 115–116
 - collector current equation, 117–118
 - diffusion triangle, 116–117
 - Early effect, 122–124
 - ideal base current, 118–119
 - ideal current gain, 119
 - Kirk effect, 124–125
 - non-ideal current contributions, 119–120
 - non-ideal current gain, 120–121
 - saturation, 121–122
- Hopfield recurrent neural networks
 - energy function, 174
 - HBTs modelling of, 174–177

- image frequency, 407
- image-rejection mixer topologies, 407–410
- impedance inverters, 349
- impedance matching, 297–298
- index-guided lasers, 231–233
- indirect gap semiconductors, 223
- inductive source degeneration, 326
- input signal photocurrent, 270
- internal quantum efficiency, 225–226
- intrinsic and extrinsic base resistances, 193–195
- intrinsic semiconductors, 18
- ionic bonding, 8
- ion-implanted MESFET, 53

- JFET, *see* junction field effect transistor (JFET)
- Johnson noise, 265, 306
- junction field effect transistor (JFET), 47

- Kirchhoff's law, 50
- Kirk effect, 124–125
- knee voltage, 51
- Kronig–Penney model, 16–17
 - carriers in semiconductors, 18
 - effective mass, 17–18

- Langevin components, 254
- large-signal CAD model, 55–56
 - capacitance model, 56–57
 - parasitic circuit elements, 57–58
- laser noise, 253–255
- lattice, 5
- lattice constant, 5
- lattice mismatch, 39–40
- LED, *see* light-emitting diodes (LED)
- L–I curve, 242–244, 249
- light-emitting diodes (LED)
 - carrier dynamics for, 226
 - mechanisms for, 222
 - modulation response, 226–227
 - n^+ – p junction, 223–224, 226–227
 - optical power and, 225
 - recombination rate, 222–223
 - reflection coefficient, 225
 - responsivity of, 226
 - structure of, 227–229
 - usage of, 229
- light inversion, 98
- Lilienfeld's FET concept, 47
- linear regime, 51
- linewidth broadening factor, 252–253
- linewidth enhancement factor, *see* anti-guiding parameter
- local minimum trapping, 164
- lossless networks, 294
- lossy networks, 294
- low-frequency noise, 64
- low-noise amplifier, 365–370

- mapping, 296
- Mason's unilateral gain, 305–306
- massively distributed computing networks, 170–171
- maximum available gain, 344
 - and maximum stable gain, 305
- maximum frequency of oscillation, 112, 130–131, 306
- Meissner oscillator, *see* Armstrong oscillator
- MESFET, 46–50
 - constant-velocity approximation, 51–55
 - drain current, 50–51
 - large-signal CAD model, 55–56
 - capacitance model, 56–57
 - parasitic circuit elements, 57–58
 - noise performance, 62
 - low-frequency noise, 64
 - microwave noise, 62–64
 - small-signal equivalent circuit, 58–61
 - versus* large-signal model, 58
 - maximum frequency of oscillation, 61
 - transit frequency, 60–61
 - in third millennium, 64–66
- Metal-oxide-semiconductor field effect transistors (MOSFET), *see* MOSFET
- metal-semiconductor field effect transistor (MESFET), *see* MESFET
- metal–semiconductor–metal detectors, 277
 - capacitance of, 278
 - quantum efficiency, 279
- metamorphic HEMT, 87
- metastable region, 42
- MEXTRAM model, 152–153
- micromixer, 404–405
- microwave noise, 62–64, 112–114
 - performance of bipolar transistors, 131–134
- Miller capacitance, 58
- Miller effect, 318
- Miller indices, 7
- mirror reflectivity, 230
- mixer noise figure, 411–412
- mixers, 396
 - diode-based, 406–407
 - double-balanced, 402–404
 - image-rejection mixer topologies, 407–410
 - micromixer, 404–405
 - noise figure, 411–412
 - resistive, 398–400
 - single-balanced, 401–402
 - transconductance multiplier, 397
- mode suppression ratio (MSR), 242
- modulated cavity photons, 252
- modulated optical power, 227
- modulation response, 226–227
- MOS diode operation, 97–100

- MOSFET, 46
- MOS (metal oxide-semiconductor) diode, 96
- multiacronym device (MAD), 80
- multi-layer perceptron (MLP) neural networks, 171
 - backpropagation, 171–173
 - circuit design process, flow chart for, 173
 - epoch, 173
- neural networks and modelling, 168–179
 - ANN, 168–169
 - classes of, 169
 - Hopfield recurrent neural networks, 174–179
 - massively distributed computing networks, 170–171
 - multi-layer perceptron neural networks, 171–174
 - neuron, 169
 - physical implementation of, 171
 - structure of, 170
 - neural networks by genetic algorithm, optimisation of, 180
 - chromosomes and genes, 180
 - crossover, 180–181
 - fitness index, 180
 - flow chart for application of, 181
 - HBT
 - I–V characteristics of, 177–178
 - large-signal neural network model of, 177
 - mutation, 180
 - over-fitting, 181
 - neurons, 169–171
 - Neuron Transfer Function, 171
- noise, 393–396
 - noise in two-ports
 - figure, 307–309
 - figure with arbitrary generator admittance, 310–313
 - phenomena, 306–307
 - noise equivalent power (NEP), 265
 - noise figure, 307–313
 - with arbitrary generator admittance, 310–312
 - of cascaded two-ports, 309–310
 - noise in two-ports
 - noise figure, 307–309
 - noise figure with arbitrary generator admittance, 310–312
 - noise phenomena, 306–307
 - noise performance, 62
 - low-frequency noise, 64
 - microwave noise, 62–64
 - noise phenomena, 306–307
 - non-linearity in oscillators, 387–388
 - non-radiative recombination coefficient, 240
 - normalised detectivity, 265
 - $n^+ - p$ junction, 223–224, 226–227
 - optical generation rate, 273
 - optical sources, 221
 - light-emitting diodes, 222–229
 - preliminaries, 222
 - semiconductor lasers optical waveguides, 231–239
 - Optimisation and parameter extraction of circuit models
 - device models, 163–164
 - neural networks applied to modelling, 168–170
 - Hopfield recurrent neural networks, 174–179
 - massively distributed computing networks, 170–171
 - multi-layer perceptron neural networks, 171–174
 - neural networks by genetic algorithm, 180–184
 - semi-analytical device parameter extraction analysis, 184–198
 - parameter extraction results, 198–203
 - simulated annealing, 164–168
 - small-signal model of the collector-up (inverted) HBT, 212–214
 - small-signal parameter extraction, 209–211
 - Z-parameters at zero bias, 208–209
 - Z-parameters for HBT, theoretical approximations, 203–208
 - structured genetic algorithm, 181–184
 - oscillation frequency, 392
 - oscillators, 383
 - noise, 393–396
 - non-linearity in oscillators, 387–388
 - oscillator topologies, 388–393
 - resonators, 383–385
 - self-excitation criteria, 385–388
 - oscillator topologies, 388–393
 - over-fitting, 181
 - parasitic elements extraction of, 186–189
 - passive baluns and unbals, 412–414
 - photoconductor detector, 263, 266
 - generation-recombination noise, 265
 - with interdigitated fingers, 266
 - noise equivalent power (NEP), 265
 - normalised detectivity, 265
 - photoconductor slab, 263
 - signal-to-noise ratio, 265
 - photodetectors, 261–262
 - avalanche photodiodes, 271–277
 - heterostructure bipolar transistor photodetector, 284
 - metal–semiconductor–metal detectors, 277–279
 - photoconductor detector, 263–265
 - P–I–N diodes, 265–271
 - responsivity of, 262
 - travelling wave p–i–n photodiodes, 279–283
 - photoelectric effects, 9–10

- photon density, 240
- photon flux density, 267
- photon lifetime, 240–241
- photons, 9
- pinch-off voltage, 50–51
- P-I-N diodes, 265–271
 - conduction current density, 268–269
 - diffusion current density, 268
 - drift current density, 267–268
- p-i-n junction photodiode, 267
 - equivalent circuit of, 270
- Planck's constant, 9, 10
- p-n junction(s), 30–31, 222
 - under bias, 33
 - built-in potential, 32
 - current–voltage characteristics, 33–34
 - depletion capacitance, 33
 - depletion layer width, 32–33
 - photodiode, 267
- Poisson's equation, 54
- polycrystalline solids, 5
- poly-Si plug, 128
- port isolation, 400
- port matching, 325–326
- power amplifiers, 376–383
 - class D amplifier, 379–381
 - class E and F amplifiers, 381–383
 - classes of operation, 376–377
 - switched amplifiers, 377–379
- power gains
 - for amplifier design, 298–301
 - definitions, 301–302
- power output against current, 249
- powers at input and load, 300–301
- probability and uncertainty principle, 12–13
- propagation constant, 230
- pseudomorphic HEMT structure, 86–87
- pseudo-temperature, 165
- pulse-doped HEMT, 85–86
- pulse-doped MESFET, 53

- quadrature generation, 417–418
- quanta, 9
- quantum dot lasers, 255–261
- quantum mechanics, 12
 - probability and uncertainty principle, 12–13
 - wave equation, 13–15
- quantum well
 - lasers, 229, 255–259, 261
 - and quantum dot lasers, 258–261

- radial relaxation oscillation frequency, 250
- radiative recombination, 20
 - coefficient, 223, 240
 - rate, 222
- radio frequency MOSFETs, 95–96
 - drain current, 100–101
 - backgating, 102
 - constant-mobility model, 101–102
 - non-ideal effects in short-channel MOSFETs, 102–104
 - velocity saturation, 105–106
- large-signal modelling, 106–109
- MOS diode operation, 97–100
- small-signal model and RF performance, 109–110
 - maximum frequency of oscillation, 112
 - microwave noise, 112–114
 - transit frequency, 110–112
- structure, 96
- reciprocal mixing, 393
- reciprocity, 294
- recombination rate, 222–223, 241
- reference planes, 294–295
- relative intensity noise (RIN), 253
- relaxation frequency, 251
- relaxation oscillation frequency, 221, 249–251, 254, 260–261
- resistive mixer, 398–404
- resonators, 383–385
 - quality factor, 384–385
- ridge laser, 232–233, 237
- Rollet factor, 304, 305

- SA, *see* simulated annealing (SA)
- SAM, *see* separate absorption and multiplication (SAM)
- saturated regime, 51
- saturation, 122
- scattering parameter theory, 291–295
- Schottky diode, 34–35, 49
- Schrödinger wave equation, 14
- second medium index, 231
- second-order intermodulation, 396
- self-excitation criteria, 385–386
- semi-analytical device parameter extraction
 - equivalent circuit elements, extraction of
 - base–collector capacitance, 189–190
 - base–collector resistance, 190–192
 - base contact lead inductor, 193
 - collector contact lead inductor, 190
 - collector extrinsic resistance, 192–193
 - emitter lead inductor and base–emitter capacitance, 195–196
 - emitter resistance and base–emitter resistance, 195
 - intrinsic and extrinsic base resistances, 193–195
 - parasitic elements extraction of, 186–189
 - transport factor, 196–198
- parameter extraction results, 198, 201–202
 - bias-dependent parameters, 200–201
 - bias-independent parameters, 199
 - optimisation error, 199–200

- semiconductors
 - band diagrams, 22
 - carriers in, 18
 - elemental and binary compound, 4
 - in equilibrium
 - electron and hole distribution, 19–20
 - extrinsic, 18–19
 - intrinsic, 18
 - materials, 4
 - in periodic table, 4
 - recombination and radiation in, 25–26
 - spontaneous and stimulated emission, 26–28
 - ternary and quaternary, 4
- semiconductor heterostructures, central design
 - principle of, 40
- semiconductor lasers, 229
 - absorption, emission and gain, calculation of, 244
 - classification, 231–232
 - concepts of, 229–231
 - confinement factor, 230–231
 - emission characteristics of, 238
 - carrier lifetime, 240
 - gain coefficient, 239–240
 - L–I curves, 242
 - photon lifetime, 240–241
 - high-speed lasers, 259–261
 - laser noise, 253–255
 - mirror reflectivity, 230
 - optical waveguides in, 231–238
 - quantum well and quantum dot lasers, 255–259
 - rate equations, 244–248
 - steady-state and dynamic characteristics, 248–253
 - cavity photons, 252–253
 - linewidth broadening factor, 252–253
 - power output against current, 249
 - radial relaxation oscillation frequency, 250, 251
- separate absorption and multiplication (SAM), 275
- separate confinement (SC) region, 261
- series–series feedback, 324
- Shockley–Read–Hall recombination, 26
- short-base diode condition, 117
- shunt–shunt feedback, 324
- signal-to-noise ratio, 265, 271
- silicon–germanium heterostructures, 40–43
- simulated annealing (SA), 164
 - hill-climbing capability of, 166
 - modelling of HEMT, application of, 166–168
 - pseudo-temperature, 165
- single-balanced mixer, 401–402
- single quantum well vertical cavity laser, 259
- single-sideband noise figure, 411
- single-tone excitation, 370–371
- Si/SiGe HBTs, 143–146
- III–V *versus* Si/SiGe HBTs, 146–147
- slab waveguide, 232
- small-signal amplifiers, 324–325
- small-signal dynamic behaviour, 125–129
 - maximum frequency of oscillation, 130–131
 - transit frequency, 129–130
- small-signal equivalent circuit, 58–61
 - versus* large-signal model, 58
 - maximum frequency of oscillation, 61
 - transit frequency, 60–61
- small-signal model and RF performance, 109–110
- small-signal model of the collector-up (inverted) HBT, 212–214
- small-signal parameter extraction, expressions
 - approximation at $R_{bi} = 0$, 212
 - parameter extraction, 209–211
 - Z-parameters
 - for HBT, theoretical approximations, 203–208
 - at zero bias, 208–209
- small-signal photons in cavity, 252–253
- Smith chart, 295–297
- solids, types of, 5
- source-coupled amplifier, 341–342
- source follower, 322
- space charge region, 30
- spontaneous emission, 26–28
 - factor, 247
- spreading resistance, 113
- stability, 308–305
 - circles, 303–305
 - Rollet's stability factor, 304–305
 - unconditional, 303
- statistical mechanics
 - Fermi–Dirac distribution, 16
 - free electron, 16
- stimulated emission, 26–28
- stimulated transition, 27
- strong inversion, 98
- structured genetic algorithm (SGA)
 - modelling of HEMT amplifier, application of, 182
 - parameters for, 184
 - for neural networks, 183
 - simplified power amplifier schematic, 183
- supply layer, 75
- surface-emitting LED, 229
- surface recombination, 223
- thermal noise, *see* Johnson noise
- three-layer slab symmetric guide, 232, 237
- threshold current density, 240
- total cavity photons, 252
- transconductance multiplier, 397
- transistor amplifiers, 313–314
 - broadband amplifier techniques, 350–354
 - configurations, 314–323
 - configurations with two transistors, 329–336
 - differential amplifiers, 336–341
 - distributed amplification, 354–365
 - feedback, 323–326

- transistor amplifiers (cont.)
 - linearity, 370–376
 - low-noise amplifier, 365–370
 - power amplifiers, 376–383
 - source-coupled amplifier, 341–342
 - tuned amplifiers, 342–350
- transit frequency, 60–61, 110–112, 129–130
- transit time optimisation
 - collector, 135–136
 - drift field in base, 134–135
- transmission line, 382–383
- transport factor α , 196–198
- transverse electric field, 24
- trapezoidal Germanium profile, 145
- trapping effects, 83–85
- travelling wave p–i–n photodiodes
 - with coplanar electrodes, 280
 - equivalent circuit of, 282
 - and p–i–n structure, 281–282
 - velocity mismatch, 282–283
 - waveguide photodetector (WPD), 280
- tuned amplifiers, 342–350
 - input and output matching networks, 344–350
 - resonant loads, 342–344
- tunnelling injection laser, 261
- two-dimensional electron gas (2DEG), 70
- two-port networks, basic relations for
 - impedance matching, 297–298
 - Mason's unilateral gain, 305–306
 - maximum available gain and maximum stable gain, 305
 - maximum frequency of oscillation, 306
 - power gains for amplifier design, 298–299
 - scattering parameter theory, 291–295
 - Smith chart, 295–303
 - stability, 302–305
- two-tone excitation, 372–375
- two-tone second-order intermodulation products, 373
- two-tone third-order intermodulation products, 373
- ultrafast lasers, 229
- under bias, 33
- unilateral gain, 305
- unilateralisation, 325
- unloaded Q , 385
- VBIC95 model, 150
- Vertical cavity surface emitting lasers (VCSELs), 258, 259, 270
- virtual ground, 337
- wall plug efficiency, *see* external power efficiency
- wave equation, 13–15
- waveguide mode refractive index, 238
- waveguide photodetector (WPD), 280
- wide-gap emitter, 137–139
- WPD, *see* waveguide photodetector (WPD)
- zero-gap configuration, 39
- Z-parameters
 - for HBT, theoretical approximations, 203–208
 - at zero bias, 208–209