

Index

- 1/f noise, 43–44
- absorption coefficient, 10
- absorption length, 10
- acousto-optical modulator, 287
- acousto-optical spectrometer, 293
- Allan time, 335
- antenna theorem, 296
- AOM
- see acousto-optical modulator
- AOS
- see acousto-optical spectrometer
- avalanche photodiodes, 79–82
- noise, 79
- backend spectrometer, 304
- backends
- autocorrelation, 330
 - discrete Fourier transform, 330
- backshort, 307
- bandpass filter, 6
- BCS theory of superconductivity, 215
- bipolar junction transistor, 99
- blackbody, 2
- blocked impurity band detectors, 84–91
- bolometer examples
- Herschel PACS, 269
 - hot electron, 272
 - Planck HFI, 268
 - room-temperature microbolometer, 247
 - SCUBA-2, 270
- bolometer noise
- Johnson, 256–257
 - thermal, 257–259
- bolometer, basic operation, 245–247
- heat capacity, 264–266
 - NEP, 256
 - quantum efficiency, 267–268
 - simple thermal model, 245
- thermal link, 266–267
- thermal time constant, 246
- Bose–Einstein statistics, 22
- Bragg cell
- LO frequency shift, 287
 - in AOS, 293
- capacitance and inductance, complex representation, 106
- CCD, 134–162
- anti-blooming gates, 147
 - backside illumination, 155
 - backside treatments, 156
 - basic operation, 134–143
 - buried channel, 143–148
 - charge summing, 150
 - charge transfer, 137
 - charge transfer architectures, 149–150
 - charge transfer efficiency, 140–143
 - deep depletion, 157, 161
 - electron multiplying, 154
 - fat zero, 143
 - floating diffusion readout, 152
 - floating gate readout, 153
 - frame transfer, 149
 - frontside illumination, 154
 - frontside pinning, 148
 - interface trapping, 139, 143–144
 - interline transfer, 149
 - line address, 149
 - orthogonal transfer, 150
 - overclocking, 154
 - quantum efficiency, 154
 - quantum yield, 159
 - readout, 150
 - skipper readout, 154
 - thinning, 155
 - time-delay integration, 150
 - UV and IR performance, 157

- X-ray energy resolution, 159
- X-ray performance, 158–162
- charge coupled device
 - see CCD
- classical mixer, 287
- CMOS arrays, 125–127
 - active pixel sensors, 127
 - backside illumination, 127
 - Bayer pattern pixels, 126
 - comparison with CCDs, 126
 - passive pixel sensors, 127
- coherent and incoherent performance comparison, 337
- coherent detectors, 9
- conversion gain, 314
- conversion gain (mixer), 286
- coplanar waveguide, 225
- CTIA
 - see integrating amplifiers
- D*
 - see detectivity
- D^* , 166, 277
- Debye temperature, 265
- DEPFET
 - see depleted P-channel FET
- depleted P-channel FET, 127
 - sideways depletion, 128
- detectivity, 166
- DFT
 - see discrete Fourier transform
- Dicke radiometer equation, 334
- dielectric relaxation, 38–39
- diffusion, 68–70
- diffusion length, 70
- diode
 - contact potential, 60
 - diode equation, 72
 - Fermi level, 60
 - principles, 59–61
- diode equation, 94–97
- diode mixers, 309–315
- diplexer, 283
- discrete Fourier transform, 330
- DQE*
 - see quantum efficiency
- dynamic range, 10
- effective wavelength, 6
- Einstein relation, 70
- electron optics, 187–206
 - in image intensifier, 198–206
 - in photomultiplier, 188–191
- emissivity, 4
- epitaxial growth, 65
- extrinsic photoconductors, 48–54
 - background-dependent response, 53
 - impurity concentration limits, 49
 - ionizing radiation effects, 51
- nonequilibrium response, 51
- spiking, 53
- stressed detectors, 50
- Fano factor, 159
- field effect transistor, 99–101
 - junction field effect transistor, 100
 - metal–oxide–semiconductor field effect transistor, 100
- Fourier transforms, 17
- Fourier transforms, table, 17
- frequency bandwidth, 41
- frequency multiplication for LO, 329
- frequency response, 17–19
- future improvements in submm- and mm-wave receivers, 336
- Geiger mode photodiodes, 82–83
- generation–recombination noise, 40–41
- germanium CCDs, 162
- Gunn diode, 325
- Gunn oscillator, 324
- HEMT, 289
- heterodyne, 303
- heterodyne basics, 280–283
 - double sideband, 282
 - image signal, 282
 - intermediate frequency, IF, 282
 - local oscillator, LO, 281
 - mixer, 280
 - sidebands, 282
 - single sideband, 282
 - square law mixer, 281
- heterodyne detector stage, 291
- heterodyne receiver
 - total power detector, 292
- heterodyne receiver definition, 279
- heterodyne spatial arrays, 336
- heterodyne system test procedures, 335
 - Y*-factor, 335
- heterodyne, spectral bandwidth, 294
- high electron mobility transistor
 - see HEMT
- high-energy X-ray detectors, 129
- hot electron bolometer, 272–275
 - InSb, 272
 - superconducting, 273–275
- hot electron bolometer mixers, 322–324
- IBC detectors
 - dopants and spectral range, 84
 - gain, 90
 - operational properties, 89–91
 - quantum efficiency, 86–89
 - spectral response, 89
 - ideality factor, 75, 311
 - IF amplifier, 289

image intensifier, 196–206
 delay line readout, 203
 electron bombardment CCD, 203
 electronic readout, 202
 fiber optic bundles, 201
 Gen I, 199
 Gen II, 198
 ion events, 202
 magnetically focused, 199
 phosphor, 196
 proximity focused, 197
 resolution, 201
 source induced background, 201
 imaging properties, 10, 13–17
 line pairs per millimeter, 13
 modulation transfer function, 14–17
 optical transfer function, 14
 spatial frequency, 14
 IMPATT diodes, 327
 impurity band conduction detectors, 84–91
 indirect energy band, 30
 infrared detector arrays, 120–125
 backside illumination, 122
 construction challenges, 122–123
 direct hybrid array, 121
 indium bump bonding, 120
 reference pixels, 116
 Z-plane technology, 121
 integrating amplifiers, 109–120
 capacitive transimpedance amplifier, 112–114
 crosstalk, 118
 CTIA linearity, 113
 direct injection, 112
 double correlated sampling, 115
 dynamic range, 119
 electronic noise, 117–120
 Fowler sampling, 118
 kTC noise, 115–117
 multiaccum, 118
 nondestructive readout, 118
 read noise, 110
 readout strategies, 114–117
 reset noise, 115
 sampling up the ramp, 118
 simple source follower, 109–112
 source follower linearity, 111
 well depth, 110, 119
 interpixel capacitance, 167
 intrinsic photoconductors, 32–47
 material properties, 36
 spectral response, 37
 IPC
 see interpixel capacitance
 irradiance, 5
 JFET, 100
 Johnson noise, 42
 junction field effect transistor
 see JFET

kTC noise, 43
 LADAR, 283
 Lambertian, 2
 LIDAR, 283, 287
 linearity, 10
 load resistor readout, 102–103
 local oscillators
 CO₂ laser, 288
 continuous wave laser, 283, 287–288
 Gunn diode, 324–327
 IMPATT diodes, 327
 MMICs, 328–329
 MAMA
 see multi-anode microchannel array
 MCP
 see microchannel plate
 MESFET, 213, 289
 metal oxide semiconductor field effect transistor
 see MOSFET
 metal semiconductor field effect transistor
 see MESFET
 microchannel plate, 195
 microstrip, 225
 microwave kinetic inductance detectors
 see MKIDs
 millimeter-wave monolithic integrated circuit
 see MMIC
 minimum detectable power, 299
 mixer figure of merit, 308
 MKIDs, 223–235
 λ/4 waveguide, 226
 applications, 235
 backshort, 232
 circuit behavior, 226
 detector arrays, 229
 lumped element, 224
 performance measurement, 234
 quality factor, Q , 226
 quantum efficiency, 231
 scattering matrix description, 228
 two-port device representation, 228
 MMIC, 324, 328
 MMIC local oscillators, 328
 molecular beam epitaxy, 65
 MOSFET, 100
 MTF
 see imaging properties
 multi-anode microchannel array, 203
 multiplexer, 124
 MUX
 see multiplexer
 NEA
 see photocathode, negative electron affinity
 NEP
 see noise equivalent power
 noise, 10–13

- noise combinations, 44–45
- noise equivalent power, 166, 256
- noise temperature, 300, 331–335
 - receiver performance summary, 331
 - system characterization, 332–335
- Norton equivalent circuit, 105
- Nyquist noise, 42
- op-amp
 - see operational amplifier
- operational amplifier, 101–102
- optical/infrared detector test procedures, 162–170
 - calibrated sources, 163
 - crosstalk, 169
 - imaging performance, 168
 - integrating amplifiers, 166
 - laboratory blackbody sources, 163
 - MTF*, 168
 - NEP*, 166
 - pixel gain, 166
 - quartz tungsten halogen lamp, 163
 - standard noise source, 166
 - tunnel-trap diode configuration, 164
 - waveform factor, 165
- phosphor, 196
- photocathode, 181–188
 - dark current, 186–187
 - electron affinity, 182
 - negative electron affinity, 184
 - quantum efficiency, 182, 184
- Richardson–Dushman equation, 186
- spectral response, 185
- work function, 181
- photoconductors
 - dielectric relaxation, 39
 - frequency response, 38
 - generation–recombination noise, 40
 - latent images, 40
 - photoconductive gain, 37
 - responsivity, 36
- photodetectors, 9
- photodiode, 58–77
 - capacitance, 76
 - current and impedance, 72–75
 - HgCdTe, 65–68
 - materials, 64–65
 - physics of operation, 68–77
 - principles, 61–64
 - quantum efficiency, 71–72
 - response, 75
 - ultraviolet, 64
 - visible and infrared, 64
- photoemissive detectors, 180–206
- photography, 174–180
 - color, 178
 - detective quantum efficiency, 177
 - development, 177
 - dye sensitization, 178
- Gurney–Mott hypothesis, 176
- latent image, 177
- orthochromatic emulsions, 178
- panchromatic emulsions, 178
- photographic plate, 175
- photomixer, 280
- photomultiplier, 188–194
 - detective quantum efficiency, 192
 - dynode chain, 188–192
 - electron multiplier, 190
 - image dissector scanner, 190
 - ion events, 187
 - pulse counting, 192–193
 - signal degradation in dynode chain, 190–192
 - stability and linearity, 193–194
- PIN photodiodes, 78
- PMT
 - see photomultiplier
- pnCCD, 160
- point spread function, 15
- Poisson statistics, 11
- polyphase filter bank, 330
- primary antenna, 305
- PSF*
 - see point spread function
- pyroelectric detector, 249
- QCD
 - see quantum capacitance detector
- QCL
 - see quantum cascade laser
- quantum capacitance detector, 241–242
- quantum cascade laser, 288
- quantum efficiency, 10–13
 - detective, 12
 - photon limited, 12
- quantum limit, 298
- quantum mixer, 286
- quantum well detectors, 206–213
 - bound-to-quasibound operation, 210
 - heterojunction, 206
 - MESFET readout, 213
 - quantum well infrared photodetector, 207
 - QWIP, 207
 - spectral response, 211
 - superlattice, 210
 - quantum yield, 129
- $R_0 A$ product, 166
- radiance, 2
- radiant exitance, 2, 4
- radiometric quantities, table, 7
- random access, 125
- reset noise, 43
- room-temperature bolometer, 247–250
 - Golay cell, 250
 - microbolometer array readout, 248
 - microbolometer arrays, 247–249

- room-temperature bolometer (Cont.)
 - pyroelectric detectors, 249
 - thermopiles, 249
- scalloping loss, 330
- Schottky diode
 - design, 309
 - operation, 310
- Schottky diode mixers, 309–315
 - conversion loss, 314
 - ideality factor, 311–312
 - performance, 312
 - performance limitations, 315
 - photolithographic, 309
 - point contact, 309
- secondary antenna, 305
- semiconductor bolometer, 250–260
 - electrothermal feedback, 253
 - neutron transmutation doped germanium, 251
 - readout, 260
 - responsivity, 253
 - temperature sensing, 251–252
 - time response, 252
- semiconductors, 24–32
 - absorption coefficient, 30
 - band diagrams, 26
 - band gap, 26
 - compound semiconductors, 27
 - direct and indirect electron transitions, 30
 - electroluminescence, 30
 - Fermi level, 45
 - holes, 27
 - intrinsic and extrinsic, 27
 - traps and recombination centers, 29
 - valence and conduction bands, 26
- single-mode detector, 306
- SIS mixers, 315–322
 - construction, 315
 - conversion gain, 318
 - frequency bandwidth, 318–320
 - high-frequency limit, 320–321
 - I*–*V* curve, 315–318
- SNSPD
 - see superconducting nanowire single-photon detector
- solar blind detectors, 65
- solid angle, 4–5
- solid state photomultiplier, 91
- spectral bandwidth, 10
- spectral radiance, 2, 4
- spectral response, 10
- SQUID, 222–223
- Stefan–Boltzmann law, 4
- STJ, 235–240
 - energy resolution, 238
 - Fano factor, 238
- readout electronics, 239
- superconducting bolometer, 260–264
 - electrothermal feedback, 262
 - frequency domain multiplexing, 263
 - multiplexing, 262–264
 - SQUID readout, 262
 - temperature sensing, 260–262
 - time domain multiplexing, 263
 - transition edge sensor, 260
- superconducting electronics, 222–223
- superconducting nanowire single-photon detector, 240–241
- superconducting photodetectors, 9
- superconducting quantum interference device
 - see SQUID
- superconducting tunnel junction
 - see STJ
- superconductivity principles, 215–221
 - “bandgap”, 216
 - Cooper pair, 216
 - critical temperature, 215
 - electrical resistance, 218–220
 - kinetic inductance, 220–221
 - London penetration depth, 219
 - Meissner effect, 218
 - quasiparticles, 216
- superheterodyne, 303
- SUR
 - see integrating amplifiers, sampling up the ramp
- TDI
 - see CCD, time-delay integration
- TES
 - see superconducting bolometer, transition edge sensor
- Thévenin equivalent circuit, 105
- thermal detectors, 9
- thermal excitation, 45–47
- thermal limit, 298
- thermopile, 249
- TIA
 - see transimpedance amplifier
- time response, 10
- transimpedance amplifier, 103–109
 - bias stability, 105
 - frequency response, 105–109
 - linearity, 104, 107
- tunable diode laser LO, 288
- vacuum photodiode, 180
- waveguide, 307
- white noise, 118
- Wiedeman–Franz relation, 266
- X-ray calorimeters, 271–272