

Index

- ABCD noise correlation matrix, 382–83
 - bipolar transistors, 384
- Active device modelling, 198–205
 - active region, 7, 33, 166
 - device transconductance, 4, 45, 128, 223, 318, 323, 371, 413, 423
 - pinch-off region, 4, 6, 319, 321
 - pinch-off voltage, 4, 45, 154
 - saturation mode, 173, 213, 308
 - temperature voltage, 88, 136
- Admittance Y -matrix
 - common terminal, 38–39
 - three-port network, 38
 - two-port matrices, 38
 - Y -parameters, 38–39, 60, 66, 73, 129
- Amplitude stability, 46–49
 - condition, 47, 103
 - stable, 49
 - unstable, 49
 - hysteresis region, 102
 - intercept point, 49–50
 - oscillation build-up
 - hard, 36, 50, 113
 - soft, 49
 - regeneration factor, 48, 50, 424
- Amplitude-to-phase conversion, 239–41
- Bipolar transistors, 16–19, 203–5, 379
 - base resistance, 203
 - base-emitter capacitance
 - diffusion, 373
 - junction, 373
 - collector capacitance, 359, 373, 380
 - transconductance
 - average, 16–19
 - large-signal, 16, 18, 146–47
 - small-signal, 19–20, 45, 78, 99, 121
 - transition frequency, 16, 53, 63, 324, 359–60, 380, 412
- Class A, 33, 320
- Class AB, 44, 320, 412
- Class B, 6, 44, 173, 234, 320, 325
- Class C, 44, 162–65, 320
- Class DE oscillator, 170–72
- Class E oscillators, 165–70
- Class F mode, 172–77
- CMOS voltage-controlled oscillators, 299–342
 - differential cross-coupled oscillator, 325–26
 - flicker noise, 310–13
 - phase noise, 305–9
 - quadrature VCO, 331–33
 - wideband tuning, 326–31
- Computer-aided analysis
 - analysis, 24–28
 - convergence, 26–27
 - degenerate solution, 24, 26
 - error function vector, 26
 - goal error, 27
 - group, 27–28
 - Hessian matrix, 27
 - initial estimate, 24, 26
 - injected current, 24–25
 - Kirchhoff's current law, 24
 - Monte-Carlo approach, 27

438 INDEX

- Computer-aided analysis (*cont.*)
 - optimization, 24, 26–27
 - goal, 26–28
 - phrase, 27–28
 - process, 26–27
 - search
 - gradient, 27
 - minimax, 27–28
 - random, 27
 - steady-state condition, 24
- Dual mode varactor tuning, 381–87
- Dual transistor oscillators, 55–60
 - bipolar transistor, 59
 - cascode connection, 58
 - common terminal, 55
 - first stage, 55–56
 - Franklin oscillator, 55–57
 - frequency stability, 56
 - HEMT, 59–60
 - JFET, 56–58
 - LC-circuit, 56
 - microstrip line, 59–60
 - oscillator locking, 59
 - output impedance, 56–57, 60
 - resonant circuit, 56
 - parallel, 55
 - series, 56, 57f
 - resonator, 59
 - second stage, 56
 - source follower, 56, 58
 - source-coupled differential oscillator, 56, 58f
 - two-stage power amplifier, 56, 58f
- Evtyanov approach, 22
 - complex amplitude, 23
 - Maclaurin series expansion, 23
 - polynomial functions, 23
 - small parameter, 23
 - symbolic equation, 22–23
- Filtering technique, 399, 416–23
- Frequency modulation, 258–62
- Gummel-Poon SPICE model, 63, 143
 - bipolar, 63
 - early effect, 63, 144
- Harmonic tuning, 172–77, 394, 419
- High-efficiency design technique, 162–77
- Impedance Z-parameters, 39, 60, 129, 145, 153, 191, 321
 - common terminals, 39
 - gate (base), 39–40
 - drain (collector), 38–40
 - source (emitter), 38–39
 - three-port network, 38–39
- Loaded quality factor, 56, 59, 166, 169, 172, 208, 210, 212, 213, 215, 223, 230, 235–40, 245, 274, 283, 289, 309, 320, 372, 387, 390, 392, 403–4, 407–10, 419, 423–29
- Matrix technique, 50–55, 321
 - boundary conditions, 53
 - feedback elements, 53, 55
 - feedback oscillator
 - parallel, 50–53
 - series, 53–55
 - matrix equation, 51, 54
 - one-port oscillator, 86f, 91
 - negative conductance, 51, 52
 - negative resistance, 54
 - parameters
 - active device, 60
 - resonant circuit, 52, 55, 308, 323
 - two-port network, 12, 22, 29, 30f, 50–53, 60, 62, 66, 73, 83, 113–16, 127, 136–38, 143, 189–95, 360–61, 390
 - Y-parameters, 60, 321–22
 - Z-parameters, 60, 321–22
- MESFET transistors
 - charging time constant, 154
 - gate charging resistance, 18, 154
 - gate-drain capacitance, 137, 157–58, 230
 - gate-source capacitance, 154, 200, 223, 229–30, 369
 - saturation current, 154
 - Schottky barrier, 154, 198, 389
 - transconductance, 128–29, 154, 203, 223, 230
- MOS transistors, 310–12, 330–31, 334, 337, 340–42
- Newton-Raphson algorithm, 12–15
 - algebraic equation, 12
 - initial guess, 12–14
 - iteration, 14–15
 - iterative algorithm, 14–15

- Jacobian matrix, 13
- Taylor series expansion, 12–13
- two-port network, 12
- Noise in oscillators, 187–245
 - Colpitts oscillator, 216–19
 - flicker noise, 196–98
 - impulse response model, 224–34
 - Kurokawa approach, 219–24
 - linear model, 205–19
 - noise figure, 187–95
 - nonlinear model, 219–45
- Noise modelling, 198–205
 - bipolar transistor, 203–5
 - MESFET device, 203
 - MOSFET device, 198
- Noise reduction techniques, 399–433
 - feedback optimization, 410–16
 - feedback loop, 413–14
 - filtering technique, 416–23
 - impedance noise matching, 426–30
 - low-frequency loading, 410–16
 - lumped elements, 400–2
 - noise-shifting technique, 423–26
 - transmission lines, 402–10
- Nonlinear feedback loop noise suppression, 430–33
- Optimum design, 127–82
 - analytic approach, 138, 150, 155, 157
 - computer-aided design, 157–62
 - empirical approach, 128–36
 - MOSFET oscillator, 139–42
 - oscillation condition, 138–39
 - quasilinear approach, 146–52
- Oscillator circuit equivalent representation, 41, 198, 203
 - negative resistance circuits, 430
 - parallel feedback oscillator, 205
 - series feedback oscillator, 137
- Oscillator operation principles, 29–79
 - self-bias condition, 43–50
 - start-up conditions, 31–36
 - steady-state operation mode, 29–31
- Oscillator with delay line, 75–79
 - degeneration, 79
 - delay line, 75–79
 - eigenvector, 78
 - feedback circuit, 76–79
 - multi-frequency oscillations, 77
 - noise improvement, 79
 - open-loop gain, 79
 - phase shift, 77
 - self-injection lock technique, 79
 - stability conditions, 77, 79
 - time delay, 75–78
 - transformer-coupled resonant circuit, 75–79
 - transmission line, 75–79
- Oscillators
 - Armstrong oscillator, 36, 288
 - Clapp oscillator, 40, 41
 - Colpitts oscillator, 37, 38, 40, 52, 216–19, 233, 234, 322, 337–39, 423
 - grounded gate, 38–40, 423–24
 - grounded drain, 37, 38
 - grounded source, 37, 38
 - common base, 143–46, 181, 261, 276, 281, 424
 - common collector, 65, 96, 273, 284, 293, 355, 373–75, 379, 389, 394, 428–30
 - common emitter, 59, 284, 286, 384, 392, 427, 429, 433
 - differential-pair oscillators, 42–43, 56, 288, 307, 308, 336, 416
 - dual transistor oscillators, 55–60, 285
 - feedback factor, 12, 339, 384
 - strong, 12
 - small, 12, 384
 - Gouriet-Clapp oscillator, 40
 - Hartley oscillator, 36–37, 339
 - LC-circuit, 22, 34, 36, 55–57, 106–111, 299, 319
 - parallel, 22, 36
 - series, 235, 238
 - Meissner oscillator, 36, 43, 230
 - oscillator with delay line, 75–79
 - push-pull oscillator, 43, 65–66
 - push-push oscillator, 65–72, 394
 - resonant circuit, 87–91, 96, 125, 259
 - Seiler oscillator, 40–43, 322, 384
 - single-resonant circuit oscillators, 87–89
 - transformer-coupled oscillator, 36, 42, 43, 98, 112, 120, 427
 - transmission-line oscillator, 60–65, 275
 - triple-push oscillator, 72–75
 - two coupled resonant circuits, 91, 94–105, 356–57, 359
 - coupling factor, 97, 339
 - Vackar oscillator, 41
- Parallel resonant circuit oscillator with nonlinear load, 88–89

440 INDEX

- Phase plane method, 105–113, 224
 - aperiodic process, 110–12
 - free-running oscillations, 106–7, 112
 - lossless resonant *LC*-circuit, 106–8
 - lossy resonant *LC*-circuit, 108–12
- π - to *T*-circuit transformation, 41–42
 - π -circuit, 42
 - T*-circuit, 41–42
- Pulling figure, 241–45
- Push-pull oscillator, 65–72
 - balanced oscillator, 66
 - centre point, 66, 68
 - equal amplitudes, 66
 - load resistors, 66
 - operation mode, 66–69
 - even, 67–68
 - odd, 68–69
 - resonant circuit, 65–71
 - parallel, 66
 - series, 65, 68, 71
 - symmetry, 67
 - virtual ground, 67, 389
- Push-push oscillator, 65–72, 394–96
 - capacitive feedback, 70
 - frequency doubler, 69
 - half wavelength, 69
 - load pulling, 69, 394
 - microstrip line, 69, 72
 - null point, 69
 - odd operation mode, 68–69
 - open-circuited resonator, 69
 - quarter wavelength, 70
- Quasilinear method, 15–20, 99
 - Barkhausen-Moeller method, 15
 - voltage-ampere characteristic, 19
 - voltage-capacitance characteristic, 15
- Resonant circuit, 10, 19, 24, 33, 36, 45, 52, 61, 66–72, 76, 83–104, 119, 166, 173, 207–215, 230, 235, 238–42, 259, 266–69, 272–79, 292–93, 306, 322–24, 348–66, 392, 394, 399–410, 427, 429
 - amplitude of oscillations, 100
 - dissipation factor, 20, 22, 23
 - oscillation frequency, 30–31, 36, 70–72, 98, 104, 150–53, 230, 400, 402
 - phase, 24–26, 52, 66–72, 92, 99, 102, 230
- Self-bias condition, 43–50
 - amplitude stability, 46–49
 - bias voltage, 45, 49–50, 178
 - discharging process, 45
 - self-bias circuit, 45, 47, 50, 178
 - self-bias resistor, 43–45, 146–49, 179
 - self-modulation, 45–50
 - self-pulse modulation, 45–46, 50
 - Taylor series, 46
 - time constant, 45
 - of resonant circuit, 45
 - of self-bias circuit, 45
 - transient response, 45, 50
- Series resonant circuit oscillator with constant load, 87–88
- Spectral-domain analysis, 1–9
 - Bessel functions, 2, 8–9
 - conduction angle, 5, 6
 - current coefficient, 6
 - Fourier series expansion, 4, 6, 8
 - harmonic balance technique, 2
 - large signal, 4
 - piecewise-linear approximation, 2, 4–6
 - power series, 2–3
 - transfer characteristic, 2–4
 - trigonometric identities, 1–3
 - voltage-ampere characteristic, 19
- Stability of oscillations, 95, 101, 270
 - general multi-frequency stability criterion, 91–3
 - general single-frequency stability condition, 86–87
 - Nyquist stability criterion, 113–18
 - two coupled resonant circuits, 350, 356–59, 83, 91, 101–3
 - two-frequency oscillation mode, 93–94
- Start-up conditions, 31–36
 - bias voltage, 31
 - build-up of self-oscillations, 33
 - hard, 33
 - soft, 19
 - collapse of the oscillation, 35
 - equilibrium, 35
 - stable, 35
 - unstable, 35
 - hysteresis, 35–36
 - mutual-coupling coefficient, 35
 - nonlinear transfer function, 33
 - polynomial approximation, 33
 - threshold voltage, 32
 - transfer function, 31–34
 - feedback, 31
 - forward, 31, 33

- Steady-state operation mode, 29–31
 - balance condition, 30
 - amplitude, 30
 - phase, 30
 - Barkhausen criterion, 29
 - complex loop gain, 29
 - oscillation frequency, 30–31
 - quality factor, 31
 - resonant circuit impedance, 29
 - transfer function, 29, 31
 - feedback, 29
 - forward, 29, 31
 - voltage feedback coefficient, 29
- Tank inductor, 40, 68, 74, 288, 291, 313–17, 336, 374, 424
- Time-domain analysis, 9–12
 - Taylor series expansion, 12–13
 - Transient response, 11
- Transmission-line oscillator, 60–65
 - characteristic impedance, 62, 64
 - even mode, 62
 - odd mode, 62
 - coupling coefficient, 62–65
 - electrical length, 62–65
 - input reactance, 64–65
 - microwave, 61
 - negative resistance, 60–61, 64, 65
 - reflection coefficients, 60
 - resonator, 61, 65
 - S-parameters, 60
 - stability factor, 60, 65
 - transmission lines, 61–63, 65
 - coupled, 61, 62, 65
 - open-circuited, 61, 62
 - quarter-wave, 62
 - Z-parameters, 60
- Triple-push oscillator, 72–75
 - 120° phase shift, 73
 - cascode configuration, 75
 - fundamental oscillator, 72, 74, 75
 - negative conductance, 73
 - three identical circuits, 73
 - three modes, 73
 - virtual ground, 73–74
 - Y-parameters, 73
- Tuning linearity, 104–5, 267–76, 349, 350, 353, 359
 - lumped elements, 267–73
 - reactance compensation technique, 276–80
 - transmission lines, 273–76
- Van der Pol method, 20–24, 77
 - oscillation period, 21
 - slowly varying, 20–24
 - amplitude, 21
 - phase, 21
 - truncated equation, 22
- Varactor, 251–96
 - abrupt junction, 241, 252
 - anti-series pair, 262–66
 - hyperabrupt junction, 252–54
 - MOS varactor, 299–305, 316, 327–30, 336
- Varactor modelling, 251–54
 - initial capacitance, 251–54
 - junction potential, 251–52
 - junction sensitivity, 252, 253
- Varactor nonlinearity, 255–58, 266
- Voltage-controlled oscillator (VCO), xiii, xiv, 79, 89, 240, 251, 262, 299, 414
 - differential, xiv, 286–92, 295, 311, 326, 330, 417–22, 429
 - push-push, 292–96, 394
- Wideband voltage-controlled oscillators, xiii, 347–96
 - double-resonant circuit, 356–60
 - dual mode varactor tuning, 381–87
 - lumped elements, 351–56
 - main requirements, 347–51
 - microwave monolithic design, 391–94
 - multi-section transmission line, 365–69
 - nonlinear design, 378–81
 - oscillators, 394–96
 - parallel resonant circuit, 353–56
 - push-push oscillators, 394–96
 - series resonant circuit, 351–53, 355
 - uniform transmission line, 360–364, 365