

Index

- Acoustic noise, 2
- Active power, 10, 21, 36
 - control, 14, 202
- Air density, 4
 - stream, 5
- Air-gap, 39, 40
- Ampere-turns, 41
- Anemometer, 7
- Asynchronous generator, 7
- Automatic voltage regulation, 53, 139

- Base values, 46
- Betz's limit, 5
- Blade, 3, 7
 - angle, 228
 - bending modes, 122, 123
 - dynamics, 122
 - mass, 122
 - stiffness, 122, 123
 - twist angle, 122

- Capacitor, 23
- Carrier waveform, 25
- Chopper, 34, 237
- Climate change, 1
- Commutation, 21
- Complex plane, 136, 152, 177, 186
- Connection, 15
 - conditions, 15
 - requirements, 15
- Controlled rectifier, 54
- Controller, 11, 21, 84, 90
- Converter, 19
 - designs, 19
 - systems, 19, 22, 34
- Crowbar, 9, 130, 229
 - active, 230
 - protection, 9
 - single-shot, 230
 - soft, 229
- Current, 21
- Current-mode control, 84

- Damper, 49
 - current, 49, 139
 - windings, 49, 139
- Damping, 137, 139
 - Coefficient, 138
 - Factor, 138, 139
 - Power, 137
 - Power coefficient, 138
- DC field current, 44
- DC link, 33, 34, 83, 110
- Diode, 33, 34, 102
- Direct axis, 43
- Direct-drive synchronous generator, 100

- Doubly fed induction generator (DFIG), 8, 77, 149
- Drive train, 122
- Droop, 55
 - characteristic, 55
 - control, 55
- Efficiency, 60, 62
- Eigenvalue, 150, 249
- Eigenvalue analysis, 136, 150, 169
- Eigenvectors, 249
- Electrical torque, 47, 59, 79
- Energy conversion, 64
- Energy storage, 197
- Environmental issues, 2
- Equivalent circuit, 48, 58, 77
- Excitation, 139
 - current, 54
 - control, 53
 - dynamics, 52
 - voltage, 52, 53
- Fast pitching, 228
- Fault clearance time, 74
- Fault current, 11
- Fault Ride-Through, 13, 16, 228
- Firing angle, 29
- Fixed-speed induction generator (FSIG), 7, 8, 11, 57, 61, 149
- Flux linkage, 45
- Flux Magnitude and Angle Controller (FMAC), 89, 160
- Fourier spectrum, 26, 29
- FRC wind turbine, 8, 9, 99, 149
- Frequency, 13, 15
 - regulation, 217
 - response, 15
 - support, 13, 14
- Fundamental frequency, 25
- Gearbox, 3, 7
- Generic network, 149
- Governor, 55, 143
- Grid connection, 14
- Grid Code, 14, 15
- Harmonic distortion, 11, 12
- Harmonic voltage distortion, 11, 12
- High voltage alternating current (HVAC), 198
- High voltage direct current (HVDC), 200, 201
 - Line-commutated converter, 200
 - Voltage Source Converter, 201
 - Multi-terminal, 203
- Horizontal axis windmills, 7
- Inductance, 45
 - leakage, 45
 - mutual, 45
 - self-, 45
- Induction generator, 7, 57
 - slip, 8
 - squirrel-cage, 11, 58
 - wound-rotor, 58
- Inertia constant, 68, 139
- Infinite bus, 70, 91
- Instability, 13
- Insulated-Gate Bipolar Transistor (IGBT), 9, 23
- Internal voltage, 81, 82, 89
- International Energy Agency, 1
- Kinetic energy, 3
- Lead-lag compensation, 90
- Leakage
 - flux, 42, 45
 - reactance, 59, 78

- Linearisation, 255
- Load, 36, 53, 135
 - angle, 36
 - angle control, 103, 112
 - compensation, 55
- Losses, 25, 80, 204
- Low-carbon energy sources, 1

- Magnetic field, 39, 40, 64
- Modulation ratio, 26
 - amplitude, 26
 - frequency, 26
 - scheme, 24
- Moment of inertia, 68

- Nacelle, 3
- Negative sequence, 49
- No-load current, 88
- Non-salient pole rotor, 39

- Offshore wind farm, 2
- Operating point, 84
- Optimum wind power extraction, 83
- Oscillation, 139
- Oscillation damper, 49
- Over-modulation, 26

- Penetration level, 13
- Per unit system, 46, 60, 67, 86
- Permanent magnet synchronous generator, 9, 101
- Phase-Locked Loop (PLL), 21, 22
- Phasor representation, 48
- PI controller, 85, 90
- Pitch, 84, 222
 - angle, 222
 - control, 84, 222
 - regulation, 84
- Pole Amplitude Modulation (PAM), 63

- Positive sequence, 49
- Power, 4
 - coefficient, 4
 - curve, 5, 6
 - factor, 83, 87
 - rated, 84
- Power factor correction capacitors, 8
- Power in the airflow, 3
- Power quality, 11, 12
- Power system, 13
 - dynamics, 13
 - stability, 13, 135
- Power System Stabiliser (PSS), 55, 167
- Power-angle characteristic, 138
- Primary control, 218, 219
- Primary reserves, 218, 219
- Prime mover control, 55
- Protection, 11
 - scheme, 11
- Pulse-Width Modulation (PWM), 24
 - carrier-based, 24, 25
 - elimination, 24, 29
 - hysteresis, 24, 33
 - non-regular sampled, 24, 28
 - optimal, 24, 27
 - regular sampled, 24, 28
 - selective harmonic, 24, 29
 - square-wave, 24
 - switching frequency, 25

- Quadrature axis, 43

- Reactance, 59, 78
- Reactive power compensation, 8, 14, 64, 193
- Reactive power, 8, 14
- Rectifier, 10
- Reference frame, 43, 44

- Regulator, 54
- Renewable energy, 1, 135
- Resistance, 139
- Rotational speed, 5, 8
- Rotor, 3
 - angle, 140, 155
 - angular velocity, 57
 - blade, 3
 - current, 59, 66
 - flux, 42, 66, 81
 - mechanics equation, 67
 - oscillations, 49, 144
 - speed, 5, 58
 - speed runaway, 13, 73
 - structural dynamics, 127
 - swept area, 3, 4
 - voltage, 65
- Rural electrification, 3
- Safety, 6
- Salient pole, 39
- Secondary reserve, 218, 219
- Shaft, 122, 123
- Short circuited rotor, 58
- Short-circuit, 73, 159
- Slip, 57
 - frequency, 9, 57
 - rings, 8, 58
- Soft-starter, 8, 21
- Stability, 135
 - dynamic, 135, 150
 - limits, 136
 - transient, 135, 145
- State matrix, 244
- State variable, 242
- State-space, 241
- Static compensator (STATCOM),
 - 14, 195
- Static Var Compensator (SVC), 14,
 - 194
- Stator, 42
 - flux, 42, 65
 - voltage, 65
- Stator Flux Oriented (SFO), 85
- Steady, 48
 - operation, 15
- Sub synchronous mode, 77, 79
- Super synchronous mode, 77, 79
- Superposition, 41
- Switchgear, 11, 139
- Switching frequency, 25
- Switching losses, 25
- Synchronising power, 137, 140
- Synchronous generator, 39
 - armature, 39
 - cylindrical-pole, 39, 49
 - field, 39
 - rotor, 39
 - stator, 39
 - salient-pole, 39, 49
- Synchronous rotating reference
 - frame, 44, 45
- Synchronous speed, 9, 40, 57
- Thyristor-controlled reactor, 194
- Thyristor-switched capacitor, 194
- Tip-speed ratio, 5
- Torque, 47, 59, 79, 85
 - accelerating, 49
 - controller, 84
 - counteracting, 49
 - pull-out, 60
- Torque-slip characteristic, 60, 61,
 - 79, 84
- Transmission System
 - Operator, 15
- Turbine, 7
 - design, 7
 - output, 6
 - torque, 121

- Two-mass model, 122, 125
- Two-speed wind turbine, 62

- Variable rotor resistance, 60, 63
- Variable slip, 63
- Variable speed wind turbine, 8, 11, 77
- Vector, 81, 243
 - diagram, 81
- Visual intrusion, 11
- Voltage, 11
 - control, 87, 89, 106, 113
 - flicker, 11, 13
 - response, 89
 - stability, 147
- Voltage behind a transient reactance, 85, 65
- Voltage Source Converter (VSC), 9, 21

- Weak grid, 11, 19
- Wind, 3
 - energy, 1
 - farm, 2
 - power, 1
 - speed, 2
 - velocity, 90

- Wind energy technology, 3
- Wind power capacity, 1
- Wind speed, 5
 - average, 6
 - cut-in, 6, 7
 - cut-out, 6, 7
 - rated, 6, 7
- Wind turbine, 3, 4
 - architectures, 7
 - blades, 3
 - effective two-mass, 126
 - fixed-speed, 7, 8
 - gearbox, 3, 7
 - generator, 3
 - high-speed shaft, 7
 - horizontal axis, 7
 - inertia, 218
 - low-speed shaft, 7
 - nacelle, 3
 - power output, 5
 - rotor, 5
 - transformer, 3
 - two-mass model, 122, 125
 - variable-speed, 3, 5
- Wind turbulence, 2, 7
- World Energy Outlook, 1