Index

Accelerometer, 226–230 AGC, 176 Amplifier, 40–44, 54–56, 154–169, 239 Bi-MOS, 188 bootstrap, 159 direct, DC 51 discrete, 160–162, 166 feedback, 44, 55, 164, 205 FET input, 166 headroom, 219 high-Z, 41, 54, 154–162, 204, 244 high-Z, guarded, 155 input resistance, 155 inverting, 204 low-Z, 40, 55, 63, 162–164 MOS, 189 noise, 167–169 operational, 169 rise time, 159 saturation, 76 slew rate, 160 stray capacitance, 156 T configuration, 164 transient response, 157 Amplitude sensitivity, 108 Analog Devices, 226 Applications	computer graphic input, 5 electret microphone, 221 keypad, 135–138 liquid level sense, 140–144 measurement, 4, 243–249 micrometer, 45, 61–65 motion detect, 45 motion detect, 45 motion sense, 83–104, 124–129 motor commutator, 129–131 pressure sensor, 122–124, 279–281 proximity detector, 37, 45, 66–82, 236–242 six-axis transducer, 144–145 spacing measurement, 139 StudSensor, 231 switches, 4 touch switch, 134 touchpad, 138–139 water/oil mixture probe, 131–134 Area variation, 39 B Bandpass filter, 50, 60 BiCMOS, 180, 228 Bridge, 52, 63 Brushless motors, 129 C
Applications	
accelerometer, 226, 281 clinometer, 145–146, 265–270 communications, 5	Capacitance, 13 analytical solutions, 20 approximate solutions, 24

Capacitance (continued)	D
bridge, 39	
cocylindrical plates, 23	DC restoration, 56 Debounce, 110, 110–112
concentric cylinders, 15	
coplanar plates, 22	Demodulator, 173–176, 193–196, 240, 246
coplanar plates with shield, 23	180° drive, 173, 228, 244
cylinder and plane, 16	90° drive, 175
measuring, 49	Dielectric absorption, 148
multielectrode capacitors, 17	Dielectric constant, 70, 283–291
overlapped plates, 21	Dielectric constant of air, 73
parallel cylinders, 15	Dielectric models, 147
parallel plates, 14, 48	Dielectric substrate, 118
reference capacitors, 17	Digital signal processing, 177–178
single plate, 37	Displacement current, 9
sketching field lines, 24	Dissipation factor, 148
small gaps, 20	Doppler, 128
two cylinders and plane, 16	_
two strips and plane, 16	E
Capacitance bridge, 57	Earth ground, 71
Capacitor dielectrics, 147–152	Edge effects, 61
Capacitor measurement, 152	Electret, 221–225
Capacitor models, 152	Electric, 8
Carrier, 171–173, 219	Electric potential sensor, 87
frequency, 171	Electrode configuration, 45
sine wave, 172	Electrostatic force, 62, 230
square wave, 173	Electrostatics ,6–36
Carrier; see also Excitation	Encoder
Charge coupled device, 178	absolute, 83
Charge images, 12	incremental, 83
Charge injection, 188, 192–194	optical stripe, 84
Charges, 7	Equipotential surfaces, 24
Circuit	ESD, 136, 138, 217
bandpass filter, 60, 240	Excess charge, 149
bridge, 52, 57	Excess noise, 198, 199, 200
capacitance bridge, 57	Excitation, 58, 219
capacitance measurement, 49	pseudorandom carrier, 77
limit switch, 80	Excitation; see also Carrier
lowpass filter, 59	
micrometer, 62–65	F
proximity detector, 75	FET noise, 200
single-ended, 57, 58	
synchronous demodulator, 54, 187, 193-196	Field lines, 74
Clinometer, 145	Finite element analysis, 27
CMOS ASIC, 247	Fringe, 29
Component accuracy, 179	G
Conductive films, 115	G
Convolution, 92	Gage factor, 65, 241
2-D, 93, 97–98	Gauss, 10
integral, 92	Ghost keys, 137
inverse, 94, 94–97	Ground, 72, 209
Coulomb, 7	ideal ground, 209
Crossover resistance, 167	Guard, 42, 44, 52, 54, 56, 64, 101, 102, 214
Crosstalk, 31, 198, 219	Guard, bulk leakage, 215
Current noise, 167	Guard, surface leakage, 215

Hall effect, 68, 130 Heerens, 11, 20, 21, 22, 43, 127, 133 Humidity, 213, 217 IEEE Trans. on Dielectrics and Electrical Insulation, 147 Induced charge, 11 Inductive sensors, 67 Insulation resistance, 150 Integration, 2 Invar, 212 Ilinearity, 39 moving shield, 40 multiplate, 127, 244 plate geometry, 99–101 six axis, 144–145 spacing change, 100 spacing variation, 49 vernier caliper, 243–249 Motion sense, x-y, 138–139 Motor commutator, 129 Moving shield, 34 Multiple plate systems, 105–121 N	Н	Motion sense, 38, 83–104 area variation, 49
Isix axis, 144–145 IREE Trans. on Dielectrics and Electrical Insulation, 147 Induced charge, 11 Inductive sensors, 67 Insulation resistance, 150 Integration, 2 Invar, 212 J Molones and Richards, 61 K Kelvin, 12 Keypad, 135 L L. S. Starrett, 243 Laplace's equation, 10 Leakage, 214 Levelite Store, 140 Limit switch, 78, 78–82 Limiting displacement, 205 Linear encoder, 108 Linearity, 48, 53, 62, 91 Liquid level sense, 140–144 conductive liquids, 141 dielectric liquids, 140 Liquid level switch, 143 Loss tangent, 148, 150 Low-Z amplifier; see Amplifier LVDT, 84 Motion sense, x-y, 138–139 Motion commutator, 129 Moving shield, 34 Multiple plate systems, 105–121 N NAMUR, 67 Neutralizing, 102–103 Neutralizing apacitor, 102 Noise, 46, 50, 76, 87, 197–211 circuit, 168 current, 167 FET, 222–223 high-Z amplifier, 204 proximity detector, 241 thermal, 168 transformer, 206 transistor, 200–204 Noise resistance, 167 Noise, transistor, 202 Optical encoder, 109 Optical encode	Hall effect, 68, 130 Heerens, 11, 20, 21, 22, 43, 127, 133 Humidity, 213, 217	linearity, 39 moving shield, 40 multiplate, 127, 244
### Induced charge, 110 Insulation, 147 Induced charge, 150 Insulation resistance, 150 Integration, 2 Invar, 212 ### Notion sense, x-y, 138–139 Motor commutator, 129 Moting shield, 34 Multiple plate systems, 105–121 ### N #	1	
Inductive sensors, 67 Insulation resistance, 150 Integration, 2 Invar, 212 Moving shield, 34 Multiple plate systems, 105–121 N Jones and Richards, 61 K Kelvin, 12 Keypad, 135 L L. S. Starrett, 243 Laplace's equation, 10 Leakage, 214 Levelite Store, 140 Limit switch, 78, 78–82 Limiting displacement, 205 Linear encoder, 108 Linearity, 48, 53, 62, 91 Liquid level sense, 140–144 conductive liquids, 141 dielectric liquids, 140 Liquid level switch, 143 Loss tangent, 148, 150 Low-Z amplifier; see Amplifier LVDT, 84 Motion sense, x-y, 138–139 Motor commutator, 129 Moving shield, 34 Multiple plate systems, 105–121 N NAMUR, 67 Neutralizing, 102–103 Neutralizing capacitor, 102 Noise, 46, 50, 76, 87, 197–211 circuit, 168 current, 167 FET, 222–223 high-Z amplifier, 204 low-Z amplifier, 204 proximity detector, 241 thermal, 168 transformer, 206 transistor, 200–204 Noise resistance, 167 Noise, transistor, 202 O Optical encoder, 109 Optical sensors, 68 Oscillator, 49, 51 gated, 75 LC, 51 RC, 52 M P Magnetic sensors, 68 Market, 1 Maxwell's capacitor, 13 Metal-filled paint, 117 Micrometers, 61 limiting resolution, 62, 205 Micrometers, 61 limiting resolution, 61 Popcorn noise, 198 Position transducer, 86	IEEE Trans. on Dielectrics and Electrical Insulation, 147	spacing change, 100
Insulation resistance, 150 Integration, 2 Invar, 212 Moving shield, 34 Multiple plate systems, 105–121 N NAMUR, 67 Neutralizing, 102–103 Neutralizing capacitor, 102 Noise, 46, 50, 76, 87, 197–211 circuit, 168 current, 167 FET, 222–223 high-Z amplifier, 204 low-Z amplifier, 204 low-Z amplifier, 204 proximity detector, 241 thermal, 168 transformer, 206 transistor, 200–204 Noise resistance, 167 Noise, transistor, 200–204 Noise resistance, 167 Noise, transistor, 2002 Moy 2 amplifier, 204 low-Z amplifier, 205 Noise, transistor, 202 O Optical encoder, 109 Optical sensors, 68 Oscillator, 49, 51 gated, 75 LC, 51 RC, 52 M P Magnetic sensors, 68 Market, 1 Maxwell's capacitor, 13 Maxwell's capacitor, 14 Microphone, electret, 221 Miller capacitance, 224 MOS vs. bipolar, 179 Plate counting, 109 Poisson, 24 Poisson's equation, 10 Popcorn noise, 198 Position transducer, 86	Induced charge, 11	vernier caliper, 243-249
Integration, 2 Invar, 212 Moving shield, 34 Multiple plate systems, 105–121 N N NAMUR, 67 Neutralizing, 102–103 Neutralizing capacitor, 102 Noise, 46, 50, 76, 87, 197–211 circuit, 168 current, 167 FET, 222–223 high-Z amplifier, 204 low-Z amplifier, 204 proximity detector, 241 thermal, 168 transformer, 206 transistor, 200–204 Noise resistance, 167 Noise, transistor, 200–204 Noise resistance, 167 Noise, transistor, 200 Optical encoder, 109 Optical sensors, 68 Oscillator, 49, 51 gated, 75 LC, 51 RC, 52 M P Magnetic sensors, 68 Market, 1 Maxwell's capacitor, 13 Metal-filled paint, 117 Micrometer, 45, 61–65 I mitting resolution, 62, 205 Micrometers, 61 Microphone, electret, 221 Miller capacitance, 224 MOS vs. bipolar, 179 Motion detect spacing variation, 61 Moving shield, 34 Multiple plate systems, 105–121 N NAMUR, 67 Neutralizing, 102–103 Neutralizing capacitor, 10 Noutralizing, 102–103 Neutralizing capacitor, 10 Optical, encoder, 109 Optical encoder, 1	Inductive sensors, 67	
Invar, 212 Multiple plate systems, 105–121 N Jones and Richards, 61 K Kelvin, 12 Keypad, 135 L L. S. Starrett, 243 Laplace's equation, 10 Leakage, 214 Levelite Store, 140 Limit switch, 78, 78–82 Limiting displacement, 205 Linear encoder, 108 Linearity, 48, 53, 62, 91 Liquid level sense, 140–144 conductive liquids, 141 dielectric liquids, 140 Liquid level switch, 143 Loss tangent, 148, 150 Low-Z amplifier; 204 Noise resistance, 167 Noise, transistor, 200–204 Noise resistance, 167 Noise, transistor, 202 O Optical encoder, 109 Optical encode	Insulation resistance, 150	
N NAMUR, 67 Neutralizing, 102–103 Neutralizing capacitor, 102 Noise, 46, 50, 76, 87, 197–211 circuit, 168 current, 167 FET, 222–223 high-Z amplifier, 204 low-Z amplifier, 204 proximity detector, 241 thermal, 168 transformer, 206 transistor, 200–204 Noise estistance, 167 Noise, 178–82 Limiting displacement, 205 Linear encoder, 108 Linearity, 48, 53, 62, 91 Liquid level sense, 140–144 conductive liquids, 141 dielectric liquids, 140 Liquid level switch, 143 Loss tangent, 148, 150 Low-Z amplifier; see Amplifier LVDT, 84 M P Magnetic sensors, 68 Market, 1 Maxwell's capacitor, 13 Metal-filled paint, 117 Micrometer, 45, 61–65 limiting resolution, 62, 205 Micrometers, 61 Microphone, electret, 221 Miller capacitance, 224 MOS vs. bipolar, 179 Motion detect spacing variation, 61 NAMUR, 67 Neutralizing, 102–103 Noise, 46, 50, 76, 87, 197–211 circuit, 168 current, 167 FET, 222–223 high-Z amplifier, 204 low-Z amplifier, 204 low-Z amplifier, 204 Noise resistance, 167 Noise, transistor, 202 Optical encoder, 109 Optical encoder, 109 Optical sensors, 68 Oscillator, 49, 51 gated, 75 LC, 51 RC, 52 M P P Parallel plates, 38, 61 Parasitic capacitance, 132, 133 Paschen's threshold, 217, 221 Phase detector, 76 Photopot, 85 Piezoresistive, 122, 228 Plastic plating, 117 Plate counting, 109 Poisson, 24 Poisson's equation, 10 Pooporn noise, 198 Position transducer, 86	Integration, 2	=
Jones and Richards, 61 K Kelvin, 12 Keypad, 135 L L. S. Starrett, 243 Laplace's equation, 10 Leakage, 214 Levelite Store, 140 Limit switch, 78, 78–82 Limiting displacement, 205 Linear encoder, 108 Linearity, 48, 53, 62, 91 Liquid level sense, 140–144 conductive liquids, 140 Liquid level sense, 140–144 conductive liquids, 140 Liost tangent, 148, 150 Low-Z amplifier; see Amplifier LVDT, 84 M P Magnetic sensors, 68 Market, 1 Maxwell's capacitor, 13 Maxwell's capacitor, 13 Metal-filled paint, 117 Micrometer, 45, 61–65 Limiting resolution, 62, 205 Micrometers, 61 Microphone, electret, 221 Miller capacitance, 224 MOS vs. bipolar, 179 Motion detect spacing variation, 61 Noise, resistance, 167 Noise, transistor, 202 Optical encoder, 109 Optical encoder, 109 Optical sensors, 68 Oscillator, 49, 51 gated, 75 LC, 51 RC, 52 M P Parallel plates, 38, 61 Parasitic capacitance, 132, 133 Paschen's threshold, 217, 221 Phase detector, 76 Photopot, 85 Piezoresistive, 122, 228 Plastic plating, 117 Plate counting, 109 Poisson, 24 Poisson's equation, 10 Popcorn noise, 198 Position transducer, 86	Invar, 212	Multiple plate systems, 105–121
Kelvin, 12 Keypad, 135 L L L. S. Starrett, 243 Laplace's equation, 10 Leakage, 214 Levelite Store, 140 Limit switch, 78, 78–82 Limiting displacement, 205 Linear encoder, 108 Linear incoder, 108 Linearity, 48, 53, 62, 91 Liquid level sense, 140–144 conductive liquids, 141 dielectric liquids, 140 Liquid level switch, 143 Loss tangent, 148, 150 Low-Z amplifier; see Amplifier LVDT, 84 M P Magnetic sensors, 68 Market, 1 Maxwell's capacitor, 13 Maxwell's capacitor, 13 Metal-filled paint, 117 Micrometer, 45, 61–65 Limiting resolution, 62, 205 Micrometers, 61 Microphone, electret, 221 Miller capacitance, 224 MOS vs. bipolar, 179 Motion detect spacing variation, 61 Noise, transistor, 202 Noise resistance, 167 Noise, transistor, 202 Optical encoder, 109 Opti	J	N
Kelvin, 12 Kelvin, 12 Keypad, 135 L L. S. Starrett, 243 Laplace's equation, 10 Leakage, 214 Levelite Store, 140 Limiting displacement, 205 Linear encoder, 108 Linearity, 48, 53, 62, 91 Liquid level sense, 140–144 conductive liquids, 141 dielectric liquids, 140 Liquid level switch, 143 Loss tangent, 148, 150 Low-Z amplifier; see Amplifier LVDT, 84 M Magnetic sensors, 68 Market, 1 Maxwell's capacitor, 13 Metal-filled paint, 117 Micrometer, 45, 61–65 limiting resolution, 62, 205 Micrometers, 61 Micrometer, 5, 61 Micrometer, 421 Miler capacitance, 224 MOS vs. bipolar, 179 Motion detect spacing variation, 61 Noise, transitor, 202 Linearity, 48, 53, 62, 91 Coptical encoder, 109 Optical encoder,	Jones and Richards, 61	NAMUR, 67
Kelvin, 12 Keypad, 135 L L L S. Starrett, 243 Laplace's equation, 10 Leakage, 214 Levelite Store, 140 Limit switch, 78, 78–82 Limiting displacement, 205 Linear encoder, 108 Linearity, 48, 53, 62, 91 Liquid level sense, 140–144 conductive liquids, 141 dielectric liquids, 140 Liquid level switch, 143 Loss tangent, 148, 150 Low-Z amplifier; see Amplifier LVDT, 84 M P Magnetic sensors, 68 Market, 1 Maxwell's capacitor, 13 Metal-filled paint, 117 Micrometer, 45, 61–65 limiting resolution, 62, 205 Micrometers, 61 Microphone, electret, 221 Miller capacitance, 224 MOS vs. bipolar, 179 Motion detect spacing variation, 61 Noise, transistor, 200 Popical encoder, 109 Optical encoder, 109 Optical encoder, 109 Optical sensors, 68 Oscillator, 49, 51 gated, 75 LC, 51 RC, 52 P Parallel plates, 38, 61 Parasitic capacitance, 132, 133 Paschen's threshold, 217, 221 Phase detector, 76 Photopot, 85 Piezoresistive, 122, 228 Plastic plating, 117 Plate counting, 109 Poisson, 24 Poisson, 24 Poisson, 24 Poisson's equation, 10 Popcorn noise, 198 Position transducer, 86		
Keypad, 135 L L. S. Starrett, 243 Laplace's equation, 10 Leakage, 214 Levelite Store, 140 Limit switch, 78, 78–82 Limiting displacement, 205 Linear encoder, 108 Linearity, 48, 53, 62, 91 Liquid level sense, 140–144 conductive liquids, 141 dielectric liquids, 140 Liquid level switch, 143 Loss tangent, 148, 150 Low-Z amplifier; see Amplifier LVDT, 84 M P Magnetic sensors, 68 Market, 1 Maxwell's capacitor, 13 Maxwell's capacitor, 13 Metal-filled paint, 117 Micrometer, 45, 61–65 limiting resolution, 62, 205 Micrometers, 61 Microphone, electret, 221 Miller capacitance, 224 MOS vs. bipolar, 179 Motion detect spacing variation, 61 Circuit, 168 current, 167 FET, 222–223 high-Z amplifier, 204 proximity detector, 241 thermal, 168 transformer, 206 transistor, 200–204 Noise resistance, 167 Noise, transistor, 202 Optical encoder, 109 Optical encoder, 109 Optical encoder, 109 Optical sensors, 68 Oscillator, 49, 51 gated, 75 LC, 51 RC, 52 M P Magnetic sensors, 68 Parallel plates, 38, 61 Parasitic capacitance, 132, 133 Paschen's threshold, 217, 221 Phase detector, 76 Photopot, 85 Piezoresistive, 122, 228 Plastic plating, 117 Plate counting, 109 Poisson, 24 Poisson, 24 Poisson, 24 Poisson's equation, 10 Popcorn noise, 198 Position transducer, 86	K	<u> </u>
Keypad, 135 L L. S. Starrett, 243 Laplace's equation, 10 Leakage, 214 Levelite Store, 140 Limit switch, 78, 78–82 Limiting displacement, 205 Linear encoder, 108 Linearity, 48, 53, 62, 91 Liquid level sense, 140–144 conductive liquids, 141 dielectric liquids, 140 Liquid level switch, 143 Loss tangent, 148, 150 Low-Z amplifier; see Amplifier LVDT, 84 M P Magnetic sensors, 68 Market, 1 Maxwell's capacitor, 13 Metal-filled paint, 117 Micrometer, 45, 61–65 limiting resolution, 62, 205 Micrometers, 61 Miller capacitance, 224 MOS vs. bipolar, 179 Motion detect spacing variation, 61 Current, 167 FET, 222–223 high-Z amplifier, 204 low-Z amplifier, 204 low-E amplifier, 206 limiting detector, 21 loss transforme, 206 low-E amplifier, 204 low-E amplifier, 206 limiting detector, 21 loss transforme, 206 low-E amplifier loss transforme, 206 loss transitor, 20 loss transitor, 2	Kelvin, 12	
L. S. Starrett, 243 Laplace's equation, 10 Leakage, 214 Levelite Store, 140 Limit switch, 78, 78–82 Limiting displacement, 205 Linear encoder, 108 Linearity, 48, 53, 62, 91 Liquid level sense, 140–144 conductive liquids, 140 Liquid level switch, 143 Loss tangent, 148, 150 Low-Z amplifier; see Amplifier LVDT, 84 M P Magnetic sensors, 68 Market, 1 Maxwell's capacitor, 13 Metal-filled paint, 117 Micrometer, 45, 61–65 limiting resolution, 62, 205 Miller capacitance, 224 MOS vs. bipolar, 179 Motion detect spacing variation, 61 Porximity detector, 204 low-Z amplifier, 204 low-E amplifier, 204 low-Z amplifier, 204 low-E amplifier lop-potential, 18 los-potential, 18 los-pot		
L. S. Starrett, 243 Laplace's equation, 10 Leakage, 214 Levelite Store, 140 Limit switch, 78, 78–82 Limiting displacement, 205 Linear encoder, 108 Linearity, 48, 53, 62, 91 Liquid level sense, 140–144 conductive liquids, 141 dielectric liquids, 140 Liquid level switch, 143 Loss tangent, 148, 150 Low-Z amplifier; see Amplifier LVDT, 84 M P Magnetic sensors, 68 Market, 1 Maxwell's capacitor, 13 Metal-filled paint, 117 Micrometer, 45, 61–65 limiting resolution, 62, 205 Miller capacitance, 224 MOS vs. bipolar, 179 Motion detect spacing variation, 61 high-Z amplifier, 204 low-Z amplifier, 204 proximity detector, 241 thermal, 168 transfier, 204 proximity detector, 241 thermal, 168 transformer, 206 transistor, 200–204 Noise resistance, 167 Noise, transistor, 202 O Optical encoder, 109 Optical encoder, 109 Optical sensors, 68 Oscillator, 49, 51 gated, 75 LC, 51 RC, 52 M P Magnetic sensors, 68 Parallel plates, 38, 61 Parasitic capacitance, 132, 133 Paschen's threshold, 217, 221 Phase detector, 76 Photopot, 85 Piezoresistive, 122, 228 Plastic plating, 117 Plate counting, 109 Poisson, 24 Poisson's equation, 10 Popcorn noise, 198 Position transducer, 86	71	
L. S. Starrett, 243 Laplace's equation, 10 Leakage, 214 Levelite Store, 140 Limit switch, 78, 78–82 Limiting displacement, 205 Limiting displacement, 205 Limear encoder, 108 Linearity, 48, 53, 62, 91 Liquid level sense, 140–144 conductive liquids, 141 dielectric liquids, 140 Liquid level switch, 143 Loss tangent, 148, 150 Low-Z amplifier; see Amplifier LVDT, 84 M P Magnetic sensors, 68 Market, 1 Maxwell's capacitor, 13 Maxwell's capacitor, 13 Maxwell's capacitor, 14 Micrometer, 45, 61–65 limiting resolution, 62, 205 Micrometers, 61 Miler capacitance, 224 MOS vs. bipolar, 179 Motion detect spacing variation, 61 liw-Z amplifier, 204 proximity detector, 241 thermal, 168 transformer, 206 transitor, 240 Ootical encoder, 109 Optical	L	
Laplace's equation, 10 Leakage, 214 Levelite Store, 140 Limit switch, 78, 78–82 Limiting displacement, 205 Linear encoder, 108 Linearity, 48, 53, 62, 91 Liquid level sense, 140–144	I S Starrett 243	
Leakage, 214 Levelite Store, 140 Limit switch, 78, 78–82 Limiting displacement, 205 Linear encoder, 108 Linearity, 48, 53, 62, 91 Liquid level sense, 140–144 conductive liquids, 141 dielectric liquids, 140 Liquid level switch, 143 Loss tangent, 148, 150 Low-Z amplifier; see Amplifier LVDT, 84 M P Magnetic sensors, 68 Market, 1 Maxwell's capacitor, 13 Maxwell's capacitor, 13 Micrometer, 45, 61–65 limiting resolution, 62, 205 Micrometers, 61 Miller capacitance, 224 MOS vs. bipolar, 179 Motion detect spacing variation, 61 tthermal, 168 transformer, 206 transistor, 200–204 Noise resistance, 167 Noise, transistor, 202 O Optical encoder, 109 Optical enc		
Levelite Store, 140 Limit switch, 78, 78–82 Limiting displacement, 205 Linear encoder, 108 Linearity, 48, 53, 62, 91 Liquid level sense, 140–144 conductive liquids, 141 dielectric liquids, 140 Liquid level switch, 143 Loss tangent, 148, 150 Low-Z amplifier; see Amplifier LVDT, 84 M P Magnetic sensors, 68 Market, 1 Maxwell's capacitor, 13 Maxwell's capacitor, 13 Metal-filled paint, 117 Micrometer, 45, 61–65 limiting resolution, 62, 205 Micrometers, 61 Miller capacitance, 224 MOS vs. bipolar, 179 Motion detect spacing variation, 61 transformer, 206 transistor, 200–204 Noise resistance, 167 Noise resistance, 167 Noise resistance, 169 Noise, transistor, 200 Coptical encoder, 109 Optical encode		
Limit switch, 78, 78–82 Limiting displacement, 205 Linear encoder, 108 Linearity, 48, 53, 62, 91 Liquid level sense, 140–144 conductive liquids, 141 dielectric liquids, 140 Liquid level switch, 143 Loss tangent, 148, 150 Low-Z amplifier; see Amplifier LVDT, 84 Magnetic sensors, 68 Market, 1 Magnetic sensors, 68 Market, 1 Maxwell's capacitor, 13 Metal-filled paint, 117 Micrometer, 45, 61–65 limiting resolution, 62, 205 Micrometers, 61 Microphone, electret, 221 Miller capacitance, 224 MOS vs. bipolar, 179 Motion detect spacing variation, 61 Liquid level switch, 143 Optical encoder, 109 Op		•
Limiting displacement, 205 Linear encoder, 108 Linearity, 48, 53, 62, 91 Liquid level sense, 140–144 conductive liquids, 141 dielectric liquids, 140 Liquid level switch, 143 Loss tangent, 148, 150 Low-Z amplifier; see Amplifier LVDT, 84 M P Magnetic sensors, 68 Market, 1 Maxwell's capacitor, 13 Metal-filled paint, 117 Micrometer, 45, 61–65 limiting resolution, 62, 205 Micrometers, 61 Microphone, electret, 221 Miller capacitance, 224 MOS vs. bipolar, 179 Motion detect spacing variation, 61 Noise resistance, 167 Noise, transistor, 202 O Optical encoder, 109 Optical		
Linear encoder, 108 Linearity, 48, 53, 62, 91 Liquid level sense, 140–144 conductive liquids, 141 dielectric liquids, 140 Liquid level switch, 143 Loss tangent, 148, 150 Low-Z amplifier; see Amplifier LVDT, 84 M P Magnetic sensors, 68 Market, 1 Maxwell's capacitor, 13 Metal-filled paint, 117 Micrometer, 45, 61–65 limiting resolution, 62, 205 Micrometers, 61 Microphone, electret, 221 Miller capacitance, 224 MOS vs. bipolar, 179 Motion detect spacing variation, 61 Noise, transistor, 202 O Optical encoder, 109 Optical encode		
Linearity, 48, 53, 62, 91 Liquid level sense, 140–144		Noise, transistor, 202
Liquid level sense, 140–144 conductive liquids, 141 dielectric liquids, 140 Liquid level switch, 143 Loss tangent, 148, 150 Low-Z amplifier; see Amplifier LVDT, 84 M P Magnetic sensors, 68 Market, 1 Maxwell's capacitor, 13 Maxwell's capacitor, 13 Micrometer, 45, 61–65 Iimiting resolution, 62, 205 Micrometers, 61 Microphone, electret, 221 Miller capacitance, 224 MOS vs. bipolar, 179 Motion detect spacing variation, 61 Optical encoder, 109 Optical encod		
dielectric liquids, 140 Liquid level switch, 143 Loss tangent, 148, 150 Low-Z amplifier; see Amplifier LVDT, 84 M P Magnetic sensors, 68 Market, 1 Maxwell's capacitor, 13 Maxwell's capacitor, 13 Micrometer, 45, 61–65 Ilimiting resolution, 62, 205 Micrometers, 61 Microphone, electret, 221 Miller capacitance, 224 MOS vs. bipolar, 179 Motion detect spacing variation, 61 Optical sensors, 68 Oscillator, 49, 51 gated, 75 LC, 51 RC, 52 P Parallel plates, 38, 61 Parasitic capacitance, 132, 133 Paschen's threshold, 217, 221 Phase detector, 76 Photopot, 85 Piezoresistive, 122, 228 Plastic plating, 117 Plate counting, 109 Poisson, 24 Poisson's equation, 10 Popcorn noise, 198 Position transducer, 86	Liquid level sense, 140–144	0
dielectric liquids, 140 Liquid level switch, 143 Loss tangent, 148, 150 Low-Z amplifier; see Amplifier LVDT, 84 M P Magnetic sensors, 68 Market, 1 Market, 1 Market, 1 Micrometer, 45, 61–65 limiting resolution, 62, 205 Micrometers, 61 Micrometers, 61 Microphone, electret, 221 Miller capacitance, 224 MOS vs. bipolar, 179 Motion detect spacing variation, 61 Optical sensors, 68 Oscillator, 49, 51 gated, 75 LC, 51 RC, 52 P Parallel plates, 38, 61 Parasitic capacitance, 132, 133 Paschen's threshold, 217, 221 Phase detector, 76 Photopot, 85 Piezoresistive, 122, 228 Plastic plating, 117 Plate counting, 109 Poisson, 24 Poisson, 24 Poisson's equation, 10 Popcorn noise, 198 Position transducer, 86	conductive liquids, 141	Optical encoder, 109
Loss tangent, 148, 150 Low-Z amplifier; see Amplifier LVDT, 84 M P Magnetic sensors, 68 Market, 1 Maxwell's capacitor, 13 Metal-filled paint, 117 Micrometer, 45, 61–65 Iimiting resolution, 62, 205 Micrometers, 61 Micrometers, 61 Microphone, electret, 221 Miller capacitance, 224 MOS vs. bipolar, 179 Motion detect spacing variation, 61 Magnetic sensors, 68 Parallel plates, 38, 61 Parasitic capacitance, 132, 133 Paschen's threshold, 217, 221 Phase detector, 76 Photopot, 85 Piezoresistive, 122, 228 Plastic plating, 117 Plate counting, 109 Poisson, 24 Poisson, 24 Poisson's equation, 10 Popcorn noise, 198 Position transducer, 86		•
Low-Z amplifier; see Amplifier LVDT, 84 M P Magnetic sensors, 68 Market, 1 Maxwell's capacitor, 13 Metal-filled paint, 117 Micrometer, 45, 61–65 Iimiting resolution, 62, 205 Micrometers, 61 Microphone, electret, 221 Microphone, electret, 221 Miller capacitance, 224 MOS vs. bipolar, 179 Motion detect spacing variation, 61 M Parallel plates, 38, 61 Parasitic capacitance, 132, 133 Paschen's threshold, 217, 221 Phase detector, 76 Photopot, 85 Piezoresistive, 122, 228 Plastic plating, 117 Plate counting, 109 Poisson, 24 Poisson, 24 Poisson's equation, 10 Popcorn noise, 198 Position transducer, 86	-	Oscillator, 49, 51
LVDT, 84 RC, 52 M P Magnetic sensors, 68 Market, 1 Maxwell's capacitor, 13 Metal-filled paint, 117 Micrometer, 45, 61–65 Iimiting resolution, 62, 205 Micrometers, 61 Microphone, electret, 221 Microphone, electret, 221 Miller capacitance, 224 MOS vs. bipolar, 179 Motion detect spacing variation, 61 P P Parallel plates, 38, 61 Parasitic capacitance, 132, 133 Paschen's threshold, 217, 221 Phase detector, 76 Photopot, 85 Piezoresistive, 122, 228 Plastic plating, 117 Plate counting, 109 Poisson, 24 Poisson, 24 Poisson's equation, 10 Popcorn noise, 198 Position transducer, 86		2
Magnetic sensors, 68 Market, 1 Parasitic capacitance, 132, 133 Maxwell's capacitor, 13 Metal-filled paint, 117 Micrometer, 45, 61–65 Iimiting resolution, 62, 205 Micrometers, 61 Micrometers, 61 Microphone, electret, 221 Microphone, electret, 221 Microphone, electret, 224 MOS vs. bipolar, 179 Motion detect spacing variation, 61 Parasitic capacitance, 132, 133 Paschen's threshold, 217, 221 Phase detector, 76 Photopot, 85 Piezoresistive, 122, 228 Plastic plating, 117 Plate counting, 109 Poisson, 24 Poisson, 24 Poisson's equation, 10 Popcorn noise, 198 Position transducer, 86		
Magnetic sensors, 68 Market, 1 Parasitic capacitance, 132, 133 Maxwell's capacitor, 13 Metal-filled paint, 117 Micrometer, 45, 61–65 Iimiting resolution, 62, 205 Micrometers, 61 Microphone, electret, 221 Microphone, electret, 221 Miller capacitance, 224 MOS vs. bipolar, 179 Motion detect spacing variation, 61 Parallel plates, 38, 61 Parasitic capacitance, 132, 133 Paschen's threshold, 217, 221 Phase detector, 76 Photopot, 85 Piezoresistive, 122, 228 Plastic plating, 117 Plate counting, 109 Poisson, 24 Poisson, 24 Poisson's equation, 10 Popcorn noise, 198 Position transducer, 86	LVD1, 64	RC, 52
Market, 1 Maxwell's capacitor, 13 Maxwell's capacitor, 13 Metal-filled paint, 117 Micrometer, 45, 61–65 Ilimiting resolution, 62, 205 Micrometers, 61 Microphone, electret, 221 Microphone, electret, 221 Miller capacitance, 224 MOS vs. bipolar, 179 Motion detect spacing variation, 61 Parasitic capacitance, 132, 133 Paschen's threshold, 217, 221 Phase detector, 76 Photopot, 85 Piezoresistive, 122, 228 Plastic plating, 117 Plate counting, 109 Moiller capacitance, 224 Poisson, 24 Poisson's equation, 10 Popcorn noise, 198 spacing variation, 61 Position transducer, 86	M	P
Market, 1 Parasitic capacitance, 132, 133 Maxwell's capacitor, 13 Paschen's threshold, 217, 221 Metal-filled paint, 117 Phase detector, 76 Micrometer, 45, 61–65 limiting resolution, 62, 205 Piezoresistive, 122, 228 Micrometers, 61 Plastic plating, 117 Microphone, electret, 221 Plate counting, 109 Miller capacitance, 224 Poisson, 24 MOS vs. bipolar, 179 Poisson's equation, 10 Motion detect spacing variation, 61 Position transducer, 86	Magnetic sensors, 68	Parallel plates, 38, 61
Maxwell's capacitor, 13 Metal-filled paint, 117 Micrometer, 45, 61–65 limiting resolution, 62, 205 Micrometers, 61 Microphone, electret, 221 Miller capacitance, 224 MOS vs. bipolar, 179 Motion detect spacing variation, 61 Paschen's threshold, 217, 221 Phase detector, 76 Photopot, 85 Piezoresistive, 122, 228 Plastic plating, 117 Plate counting, 109 Poisson, 24 Poisson, 24 Poisson's equation, 10 Popcorn noise, 198 spacing variation, 61 Position transducer, 86		
Micrometer, 45, 61–65 limiting resolution, 62, 205 Micrometers, 61 Microphone, electret, 221 Miller capacitance, 224 MOS vs. bipolar, 179 Motion detect spacing variation, 61 Photopot, 85 Piezoresistive, 122, 228 Plastic plating, 117 Plate counting, 109 Poisson, 24 Poisson, 24 Poisson's equation, 10 Popcorn noise, 198 spacing variation, 61 Position transducer, 86	Maxwell's capacitor, 13	
limiting resolution, 62, 205 Piezoresistive, 122, 228 Micrometers, 61 Plastic plating, 117 Microphone, electret, 221 Plate counting, 109 Miller capacitance, 224 Poisson, 24 MOS vs. bipolar, 179 Poisson's equation, 10 Motion detect spacing variation, 61 Position transducer, 86		Phase detector, 76
Micrometers, 61 Microphone, electret, 221 Miller capacitance, 224 MOS vs. bipolar, 179 Motion detect spacing variation, 61 Plastic plating, 117 Plate counting, 109 Poisson, 24 Poisson's equation, 10 Popcorn noise, 198 spacing variation, 61 Position transducer, 86		Photopot, 85
Microphone, electret, 221 Miller capacitance, 224 MOS vs. bipolar, 179 Motion detect spacing variation, 61 Plate counting, 109 Poisson, 24 Poisson's equation, 10 Popcorn noise, 198 Position transducer, 86	•	
Miller capacitance, 224 MOS vs. bipolar, 179 Motion detect spacing variation, 61 Poisson, 24 Poisson's equation, 10 Popcorn noise, 198 Position transducer, 86		
MOS vs. bipolar, 179 Motion detect spacing variation, 61 Poisson's equation, 10 Popcorn noise, 198 Position transducer, 86		
Motion detect Popcorn noise, 198 spacing variation, 61 Position transducer, 86		
spacing variation, 61 Position transducer, 86		

Power factor, 148 Precision, 46–47 Pressure sensor, 122–124, 193 silicon, 123 Pressure sensors absolute, 123 differential, 122 linearity, 124 Printed circuit board, 113–115, 244 photoplot, 113 Proximity, 35, 37, 45 Proximity detector, 66–82, 236–242 limit switch, 78 limiting resolution, 72 noise, 241 target, 75 Pseudorandom number, 77 Puers, R., 279 Q Quadrature, 110 Quadrature encoder, 109	Spacing measurement, 139 Spacing variation, 38 Stability, 46, 211–213 Static charge, 219 Static discharge, 217 Stray capacitance, 44, 50, 55, 62, 87, 99, 101 Stray fields, 75 StudSensor, 231–234 Superposition, 11, 18 Surface micromachining, 226 Switched capacitor circuits, 177–196 accuracy, 191 balanced demodulator, 193 components, 188 demodulator, 187 filter, 178, 182–185 instrumentation ampilfier, 186 integrator, 185 operational amplifier, 189 Symbios/Scriptel, 138 Synaptics, 138 Synaptics, 138 Synchronous demodulator, 54, 76
Rectangular to polar conversion, 98 Resistive thick films, 116 Resistive thin films, 116 Resistor, 171 high value, 171 Resistor noise, 199 Resolvers, 84 Ripple torque, 129 Rotary encoder, 106–108 angle demodulation, 107 Rotary motion, 40 Rotary transducer, 89	T Teledeltos paper, 25 Thermal noise, 168, 197, 199 Thick films, 115 Thin films, 115 Three-phase drive, 113 Tilt, 88 Tiltmeter, 146 Tin oxide, 117 Touch switch, 134 Touchpad, 138 Transistor noise, 202 Turck, 70
Sampling, 181 Schering bridge, 153 Sensor, 3 Sensor bus Fieldbus, 3 TC-9 committee, 3 Shield, 42, 54, 64, 76, 87, 101, 164, 207 Shot noise, 197, 200 Shunt resistance, 50, 81 Silicon accelerometer, 226–230 crosstalk, 219 pressure sensor, 123–124 Skin depth, 207	U Ultrasonic sensors, 68 Units, 7 V Vernier caliper, 243–249 Von Hippel, 147, 148, 151, 283–291 W Water, 151 Water/oil probe, 129 Westerlund, 150 Wheatstone bridge, 57 Wireless coupling, 103, 165