

Contents

1	What to Build and How to Plan for it	5
1.1	Discovering Product Requirements	5
1.2	Writing Specifications	11
1.3	Writing the Test Plan	13
1.4	Accurate Schedule Prediction	14
1.5	How Manufacturing Works	17
2	Selecting Components	23
2.1	How to buy parts	23
2.2	Passive Components	36
2.2.1	Capacitors	36
2.2.2	Resistors	47
2.2.3	Inductors	49
2.2.4	Ferrite beads	51
2.2.5	Connectors and cables	54
2.2.6	Circuit protection	65
2.3	Active components	83
2.3.1	Oscillators and crystals	84
2.3.2	Power supplies	85
2.3.3	Microcontrollers	88
2.3.4	RF	90
2.3.5	Transistors	92
2.3.6	Diodes	96
2.3.7	Batteries	96

3	Prototyping	101
3.1	Hardware Prototyping Principles	101
3.2	How to Develop Hardware Quickly	105
3.3	Modules & Eval Boards	114
3.4	Breadboards	115
3.5	Prototyping Platforms	117
3.5.1	Arduino	117
3.5.2	Raspberry Pi et al	118
3.5.3	RF Prototyping	119
3.6	Lab Notebooks	121
4	Schematic Design	129
4.1	Conventions	130
4.2	Avoiding mistakes	137
4.3	Debugging	141
4.4	Ensuring performance	143
5	Layout Design	149
5.1	General	149
5.2	Performance	161
5.3	Stackup	171
5.4	DFx	188
5.5	Mechanical	204
5.6	Avoiding mistakes	213
5.7	EMC and EMI	217
6	Cost engineering	227
6.1	Cost Reduction in your Schematic	229
6.2	Cost Reduction in your Layout	231
6.3	Cost Reduction in your Assembly	235
7	Fabrication and Assembly	237
7.1	Preparing for Fabrication	237
7.2	Buying parts	245
7.3	Finding and working with CMs	247

7.4	PCB fabrication	254
7.5	How Assembly Works	261
7.6	Soldering techniques	262
7.7	Tips for Assembly	272
7.8	Enclosures	284
7.9	Thermal considerations	290
7.10	Quality and Manufacturing Processes	293
8	Testing	297
8.1	Regulatory testing	299
8.1.1	Approval marks	299
8.1.2	Electromagnetic compatibility	300
8.1.3	Medical devices	302
8.1.4	Getting standards	303
8.2	PCB functionality tests	303
8.2.1	Board Bring up	304
8.2.2	Test fixtures	306
8.3	Designing Tests	308
8.4	Avoiding Testing Problems	321
9	Building a Lab	323
9.1	Lab furniture	324
9.2	Soldering equipment	325
9.2.1	Choosing a Soldering Iron	329
9.3	Organization	331
9.4	Test equipment	336
9.4.1	Test Leads	337
9.4.2	Power Supplies	338
9.4.3	Multimeters	339
9.4.4	Oscilloscopes	340
9.4.5	Logic analyzer	341
9.4.6	Spectrum analyzer	342
9.4.7	Vector Network Analyzer	343
9.5	Small Hand Tools	344

10 Troubleshooting	349
10.1 How Electronics Fail	350
10.2 Tools for Troubleshooting	352
10.3 The Medical Model for Troubleshooting	353
10.4 Narrative Based Troubleshooting	358
10.5 Scientific Troubleshooting	359
11 Appendix A: Design Principals	361
12 Appendix B: Rules of Thumb	373
13 Appendix C: How to Give a Demo	379
14 Appendix E: Companies that can help your startup	387
14.1 Tools	387
14.2 PCB Fabrication and Assembly	388
14.3 Part Fabrication	388
14.4 Materials	391
14.5 Paperwork	391
14.6 Shipping and Logistics	391
14.7 Design Services	392
Bibliography	395