

Mike Holt's Solar Photovoltaics Video Library

This document includes the Table of Contents from each book included, so you can see the full scope of this library.



Title	page #
Solar PV and Energy Storage Systems	2
Understanding Electrical Theory	11
Electrical Estimating	16
Business Management Skills.....	20

Understanding NEC® Requirements for Solar Photovoltaic and Energy Storage Systems

TABLE OF CONTENTS

About This Textbook	xv	Part II. 1,000V, Nominal, or Less	63		
Additional Products to Help You Learn	xviii	110.26 Spaces About Electrical Equipment.....	63		
How to Use the <i>National Electrical Code</i>	1	110.28 Enclosure Types	72		
Article 90—Introduction to the <i>National Electrical Code</i>	7	CHAPTER 2—WIRING AND PROTECTION	73		
90.1 Purpose of the <i>NEC</i>	7	Article 200—Use and Identification of Grounded Conductors	75		
90.2 Scope of the <i>NEC</i>	8	200.1 Scope	76		
90.3 <i>Code Arrangement</i>	10	200.2 General.....	76		
90.4 Enforcement	11	200.4 Neutral Conductor.....	76		
90.5 Mandatory Requirements and Explanatory Material	13	200.6 Identification of Grounded Conductors.....	77		
90.7 Examination of Equipment for Product Safety.....	14	200.7 Use of White or Gray Color	79		
CHAPTER 1—GENERAL RULES	15	Article 210—Branch Circuits	81		
Article 100—Definitions	17	Part I. General Provisions	81		
100 Definitions	17	210.1 Scope	81		
Article 110—Requirements for Electrical Installations	45	210.4 Multiwire Branch Circuits.....	82		
Part I. General Requirements	45	210.5 Identification for Branch Circuits	84		
110.1 Scope	45	210.7 Multiple Branch Circuits	85		
110.2 Approval of Conductors and Equipment.....	45	Part II. Branch-Circuit Ratings	86		
110.3 Use and Product Listing (Certification) of Equipment.....	46	210.18 Branch-Circuit Rating.....	86		
110.4 Voltage Rating of Electrical Equipment	46	210.19 Conductor Sizing	86		
110.5 Conductor Material	46	210.20 Overcurrent Protection	88		
110.6 Conductor Sizes	46	210.21 Receptacle Rating	89		
110.7 Wiring Integrity	47	210.23 Permissible Loads, Multiple-Outlet Branch Circuits	90		
110.8 Suitable Wiring Methods	47	 			
110.9 Interrupting Rating (Overcurrent Protective Devices).....	47	Article 215—Feeders	91		
110.10 Equipment Short-Circuit Current Rating	48	215.1 Scope	91		
110.11 Deteriorating Agents.....	49	215.2 Conductor Sizing	92		
110.12 Mechanical Execution of Work	50	215.3 Overcurrent Protection Sizing	96		
110.13 Mounting and Cooling of Equipment.....	52	215.10 Ground-Fault Protection of Equipment	97		
110.14 Conductor Termination and Splicing.....	52	215.12 Conductor Identification	97		
110.15 High-Leg Conductor Identification.....	59	 			
110.16 Arc Flash Hazard Warning.....	59	Article 225—Outside Branch Circuits and Feeders	99		
110.21 Markings	61	Part I. General	99		
110.22 Identification of Disconnecting Means	62	225.1 Scope	99		
110.24 Available Fault Current	63	225.6 Minimum Conductor Size and Support	99		
110.25 Lockable Disconnecting Means	63	225.16 Attachment of Overhead Conductors	100		
		225.17 Masts as Supports	100		

225.18	Clearance for Overhead Conductors.....	101	Part VI. Service Disconnect—Disconnecting Means	124	
225.19	Clearances from Buildings	102	230.70	Service Disconnect Requirements	124
225.22	Raceways on Exterior Surfaces of Buildings or Other Structures.....	103	230.71	Number of Service Disconnects.....	125
225.26	Trees for Conductor Support	103	230.72	Grouping of Disconnects	125
225.27	Raceway Seals	104	230.76	Manually or Power Operated	126
Part II. Buildings or Other Structures Supplied by a Feeder		104	230.79	Rating of Disconnect	126
225.30	Number of Supplies	104	230.82	Connected on Supply Side of the Service Disconnect.....	126
225.31	Disconnecting Means	105	230.85	Emergency Disconnects.....	128
225.32	Disconnecting Means Location	105	Part VII. Service Disconnect Overcurrent Protection.....		128
225.33	Maximum Number of Disconnects.....	105	230.90	Overload Protection—Where Required.....	128
225.34	Grouping of Disconnects	106	230.91	Location	129
225.37	Identification of Multiple Supplies	106	230.95	Ground-Fault Protection of Equipment	129
225.39	Rating of Disconnecting Means.....	106	Article 240—Overcurrent Protection		131
Article 230—Services		107	Part I. General		132
Part I. General		107	240.1	Scope	132
230.1	Scope	107	240.2	Definitions	132
230.2	Number of Services	107	240.3	Other Articles (Overcurrent Protection of Equipment).....	133
230.3	Not to Pass Through a Building	109	240.4	Overcurrent Protection of Conductors.....	133
230.6	Conductors Considered Outside a Building.....	109	240.5	Protection of Flexible Cords, Flexible Cables, and Fixture Wires	137
230.7	Service Conductors Separate from Other Conductors	109	240.6	Standard Ampere Ratings.....	137
230.8	Raceway Seals	110	240.10	Supplementary Overcurrent Protection.....	138
230.9	Clearances on Buildings.....	110	240.13	Ground-Fault Protection of Equipment	138
230.10	Vegetation as Support.....	110	240.15	Phase Conductor Overcurrent Device.....	139
Part II. Overhead Service Conductors		111	Part II. Location		140
230.23	Overhead Service Conductor Size and Rating	111	240.21	Location in Circuit	140
230.24	Vertical Clearance for Overhead Service Conductors.....	112	240.24	Location of Overcurrent Protective Devices at Premises	145
230.26	Point of Attachment.....	112	Part III. Enclosures		147
230.27	Means of Attachment.....	113	240.33	Vertical Position	147
230.28	Service Masts as Support.....	113	Part IV. Disconnecting and Guarding		147
Part III. Underground Service Conductors		114	240.40	Disconnecting Means for Fuses	147
230.30	Installation	114	Part V. Plug Fuses, Fuseholders, and Adapters		147
230.31	Underground Service Conductor Size and Rating	114	240.51	Edison-Base Fuses	147
230.32	Protection Against Damage	114	Part VI. Cartridge Fuses and Fuseholders		148
Part IV. Service-Entrance Conductors		115	240.60	General	148
230.40	Number of Service-Entrance Conductor Sets.....	115	240.67	Arc Energy Reduction—Fuses	149
230.42	Conductor Sizing	115	Part VII. Circuit Breakers		149
230.43	Wiring Methods	119	240.81	Indicating	149
230.46	Spliced Conductors.....	119	240.83	Markings	149
230.50	Protection Against Physical Damage	120	240.85	Applications	150
230.51	Cable Supports.....	120	240.86	Series Ratings	151
230.53	Raceways to Drain	121	240.87	Arc Energy Reduction—Circuit Breakers	152
230.54	Overhead Service Locations	121	240.88	Reconditioned Equipment.....	153
230.56	High-Leg Conductor Identification.....	122	Article 250—Grounding and Bonding		155
Part V. Service Disconnect—General		122	Part I. General		155
230.62	Service Equipment—Enclosed or Guarded	122	250.1	Scope	155
230.66	Marking for Service Disconnect	123	250.4	Performance Requirements for Grounding and Bonding	156
230.67	Surge Protection	123			

250.6	Objectionable Current.....	162	Part VII. Methods of Equipment Grounding Conductor Connections	226
250.8	Connection of Grounding and Bonding Connectors.....	166	250.134 Equipment Connected by Permanent Wiring Methods.....	226
250.10	Protection of Ground Clamps and Fittings	166	250.136 Equipment Secured to Grounded Metal Supports	227
250.12	Clean Surfaces	166	250.138 Cord-and-Plug-Connected	227
Part II. System Grounding and Bonding		167	250.140 Frames of Ranges, Ovens, and Clothes Dryers.....	227
250.20	Systems Required to be Grounded	167	250.142 Neutral Conductor for Effective Ground-Fault Current Path	228
250.21	Ungrounded Systems	168	250.146 Connecting Receptacle Grounding Terminal to an Equipment Grounding Conductor.....	229
250.24	Grounding	168	250.148 Continuity and Attachment of Equipment Grounding Conductors in Boxes.....	232
250.25	Grounding for Supply Side of the Service Disconnect	172		
250.28	Main Bonding Jumper and System Bonding Jumper.....	173		
250.30	Separately Derived Systems	174		
250.32	Buildings Supplied by a Feeder	183		
250.34	Generators—Portable and Vehicle- or Trailer-Mounted	185		
250.36	High-Impedance Grounded Systems.....	186		
Part III. Grounding Electrode System and Grounding Electrode Conductor		186	CHAPTER 3—WIRING METHODS AND MATERIALS	235
250.50	Grounding Electrode System	186	Article 300—General Requirements for Wiring Methods and Materials	239
250.52	Grounding Electrode Types	187	Part I. General Requirements	239
250.53	Grounding Electrode Installation Requirements.....	190	300.1 Scope	239
250.54	Auxiliary Grounding Electrodes	195	300.3 Conductors	240
250.58	Common Grounding Electrode	196	300.4 Protection Against Physical Damage	243
250.62	Grounding Electrode Conductor	196	300.5 Underground Installations.....	246
250.64	Grounding Electrode Conductor Installation.....	196	300.6 Protection Against Corrosion and Deterioration	250
250.66	Sizing Grounding Electrode Conductor.....	200	300.7 Raceways Exposed to Different Temperatures.....	251
250.68	Grounding Electrode Conductor and Bonding Jumper Connection to Grounding Electrodes	201	300.9 Raceways in Wet Locations Above Grade	251
250.70	Grounding Electrode Conductor Termination Fittings.....	203	300.10 Electrical Continuity	252
Part IV. Enclosure, Raceway, and Service Cable Connections		204	300.11 Securing and Supporting	252
250.80	Service Raceways and Enclosures	204	300.12 Mechanical Continuity	254
250.86	Other Enclosures	204	300.13 Mechanical and Electrical Continuity of Conductors—Splices and Pigtails	255
Part V. Bonding for Fault Current		204	300.14 Length of Free Conductors	256
250.90	General	204	300.15 Boxes or Fittings	257
250.92	Bonding Equipment Containing Service Conductors	204	300.17 Number and Size of Conductors in a Raceway	259
250.94	Bonding Communications Systems	207	300.18 Inserting Conductors in Raceways	261
250.96	Bonding Other Enclosures.....	208	300.19 Supporting Conductors in Vertical Raceways	261
250.97	Bonding Metal Parts Containing 277V and 480V Circuits	209	300.20 Induced Alternating Currents in Ferrous Metal Parts	262
250.98	Bonding Loosely Jointed Metal Raceways.....	209	300.21 Spread of Fire or Products of Combustion	264
250.102	Neutral Conductor, Bonding Conductors, and Bonding Jumpers	210	300.22 Wiring in Ducts and Plenum Spaces	265
250.104	Bonding of Piping Systems and Exposed Structural Metal	212	300.23 Panels Designed to Allow Access	267
250.106	Lightning Protection Systems.....	216	300.25 Exit Enclosures (Stair Towers).....	267
Part VI. Equipment Grounding and Equipment Grounding Conductors		216	Article 310—Conductors for General Wiring	269
250.109	Metal Enclosures.....	216	Part I. General	269
250.114	Equipment Connected by Cord and Plug	216	310.1 Scope	269
250.118	Types of Equipment Grounding Conductors	218	310.3 Conductors	269
250.119	Identification of Equipment Grounding Conductors	221	Part II. Construction Specifications	270
250.120	Equipment Grounding Conductor Installation	222	310.4 Conductor Construction and Application	270
250.121	Restricted Use of Equipment Grounding Conductors	223	310.6 Conductor Identification	273
250.122	Sizing Equipment Grounding Conductors.....	223		

Part III. Installation	273	320.15	Exposed Work.....	318	
310.10	Uses Permitted.....	273	320.17	Through or Parallel to Framing Members.....	318
310.12	Single-Phase Dwelling Services and Feeders.....	276	320.23	In Accessible Attics or Roof Spaces	319
310.14	Ampacities for Conductors Rated 0V to 2,000V	279	320.24	Bending Radius	319
310.15	Ampacity Tables.....	280	320.30	Securing and Supporting	319
310.16	Ampacities of Insulated Conductors in Raceways, Cables, or Buried	287	320.40	Boxes and Fittings.....	321
			320.80	Conductor Ampacity.....	321
Article 312—Cabinets	289				
Part I. Scope and Installation	289				
312.1	Scope	289			
312.2	Damp or Wet Locations	289			
312.3	Position in Walls	290			
312.4	Repairing Gaps in Noncombustible Surfaces	290			
312.5	Enclosures	290			
312.6	Deflection of Conductors.....	292			
312.8	Overcurrent Device Enclosures	292			
Part II. Construction Specifications	294				
312.10	Material	294			
Article 314—Outlet, Pull, and Junction Boxes; Conduit Bodies; and Handhole Enclosures	295				
Part I. Scope and General	295				
314.1	Scope	295			
314.3	Nonmetallic Boxes	295			
314.4	Metal Boxes	296			
Part II. Installation	296				
314.15	Damp or Wet Locations	296			
314.16	Sizing Outlet Boxes	296			
314.17	Conductors That Enter Boxes or Conduit Bodies	304			
314.20	Flush-Mounted Box Installations	304			
314.21	Repairing Noncombustible Surfaces	305			
314.22	Surface Extensions	306			
314.23	Support of Boxes.....	306			
314.25	Covers and Canopies	308			
314.27	Outlet Box Requirements	309			
314.28	Sizing Pull and Junction Boxes.....	311			
314.29	Wiring to be Accessible	314			
314.30	Handhole Enclosures.....	315			
Article 320—Armored Cable (Type AC)	317				
Part I. General	317				
320.1	Scope	317			
320.2	Definition.....	317			
320.6	Listing Requirements	317			
Part II. Installation	318				
320.10	Uses Permitted.....	318			
320.12	Uses Not Permitted.....	318			
Part III. Construction Specifications	322				
320.100	Construction	322			
320.108	Equipment Grounding Conductor.....	322			
Article 330—Metal-Clad Cable (Type MC)	323				
Part I. General	323				
330.1	Scope	323			
330.2	Definition	323			
330.6	Listing Requirements	324			
Part II. Installation	324				
330.10	Uses Permitted	324			
330.12	Uses Not Permitted.....	325			
330.15	Exposed Work.....	325			
330.17	Through or Parallel to Framing Members.....	325			
330.23	In Accessible Attics or Roof Spaces	326			
330.24	Bending Radius	326			
330.30	Securing and Supporting	326			
330.80	Conductor Ampacities	328			
Part III. Construction Specifications	329				
330.108	Equipment Grounding Conductor.....	329			
Article 334—Nonmetallic-Sheathed Cable (Type NM)	331				
Part I. General	331				
334.1	Scope	331			
334.2	Definition	331			
334.6	Listing Requirements	331			
Part II. Installation	332				
334.10	Uses Permitted	332			
334.12	Uses Not Permitted.....	333			
334.15	Exposed Work.....	333			
334.17	Through or Parallel to Framing Members.....	334			
334.23	Accessible Attics and Roof Spaces.....	335			
334.24	Bending Radius	335			
334.30	Securing and Supporting	336			
334.40	Boxes and Fittings.....	337			
334.80	Conductor Ampacity	337			
Part III. Construction Specifications	338				
334.108	Equipment Grounding Conductor.....	338			

Article 336—Power and Control Tray Cable (Type TC)	339	342.24	Bends	348
Part I. General	339	342.26	Number of Bends (360°)	348
336.1 Scope	339	342.28	Reaming	348
336.2 Definition	339	342.30	Securing and Supporting	349
336.6 Listing Requirements	339	342.42	Couplings and Connectors	350
Part II. Installation	339	342.46	Bushings	350
336.10 Uses Permitted	339	342.60	Equipment Grounding Conductor	351
336.12 Uses Not Permitted	340			
336.24 Bending Radius	340			
Article 338—Service-Entrance Cable (Types SE and USE)	341			
Part I. General	341			
338.1 Scope	341	344.1 Scope	353	
338.2 Definitions	341	344.2 Definition	353	
338.6 Listing Requirements	342	344.6 Listing Requirements	354	
Part II. Installation	342	Part II. Installation	354	
338.10 Uses Permitted	342	344.10 Uses Permitted	354	
338.12 Uses Not Permitted	343	344.14 Dissimilar Metals	354	
338.24 Bending Radius	343	344.20 Trade Size	354	
Article 340—Underground Feeder and Branch-Circuit Cable (Type UF)	345	344.22 Number of Conductors	354	
Part I. General	345	344.24 Bends	355	
340.1 Scope	345	344.26 Number of Bends (360°)	355	
340.2 Definition	345	344.28 Reaming	355	
340.6 Listing Requirements	345	344.30 Securing and Supporting	355	
Part II. Installation	345	344.42 Couplings and Connectors	357	
340.10 Uses Permitted	345	344.46 Bushings	358	
340.12 Uses Not Permitted	346	344.60 Equipment Grounding Conductor	358	
340.24 Bends	346			
340.80 Ampacity	346			
Part III. Construction Specifications	346			
340.108 Equipment Grounding Conductor	346			
340.112 Insulation	346			
Article 342—Intermediate Metal Conduit (Type IMC)	347			
Part I. General	347			
342.1 Scope	347	348.1 Scope	359	
342.2 Definition	347	348.2 Definition	359	
342.6 Listing Requirements	347	348.6 Listing Requirements	359	
Part II. Installation	348	Part II. Installation	359	
342.10 Uses Permitted	348	348.10 Uses Permitted	359	
342.14 Dissimilar Metals	348	348.12 Uses Not Permitted	359	
342.20 Trade Size	348	348.20 Trade Size	360	
342.22 Number of Conductors	348	348.22 Number of Conductors	360	
		348.24 Bends	361	
		348.26 Number of Bends (360°)	361	
		348.28 Trimming	361	
		348.30 Securing and Supporting	361	
		348.60 Equipment Grounding and Bonding Conductors	362	
Article 350—Liquidtight Flexible Metal Conduit (Type LFMC)	363			
Part I. General	363			
350.1 Scope	363			
350.2 Definition	363			
350.6 Listing Requirements	363			

Part II. Installation	363	Article 358—Electrical Metallic Tubing (Type EMT).....	381
350.10 Uses Permitted.....	363	358.1 Scope	381
350.12 Uses Not Permitted.....	364	358.2 Definition.....	381
350.20 Trade Size	364	358.6 Listing Requirements	381
350.22 Number of Conductors	364	Part II. Installation	382
350.24 Bends	365	358.10 Uses Permitted	382
350.26 Number of Bends (360°).....	365	358.12 Uses Not Permitted.....	382
350.28 Trimming	365	358.20 Trade Size	382
350.30 Securing and Supporting	365	358.22 Number of Conductors	383
350.60 Equipment Grounding and Bonding Conductors	366	358.24 Bends	383
Article 352—Rigid Polyvinyl Chloride Conduit (Type PVC).....	369	358.26 Number of Bends (360°).....	383
Part I. General	369	358.28 Reaming.....	383
352.1 Scope	369	358.30 Securing and Supporting	384
352.2 Definition.....	369	358.42 Couplings and Connectors	385
Part II. Installation	369	358.60 Equipment Grounding Conductor.....	385
352.10 Uses Permitted.....	369	Article 362—Electrical Nonmetallic Tubing (Type ENT).....	387
352.12 Uses Not Permitted.....	370	Part I. General	387
352.20 Trade Size	371	362.1 Scope	387
352.22 Number of Conductors	371	362.2 Definition.....	387
352.24 Bends	372	362.6 Listing.....	387
352.26 Number of Bends (360°).....	372	Part II. Installation	387
352.28 Trimming	372	362.10 Uses Permitted	387
352.30 Securing and Supporting	372	362.12 Uses Not Permitted.....	389
352.44 Expansion Fittings.....	373	362.20 Trade Sizes.....	389
352.46 Bushings	373	362.22 Number of Conductors	389
352.48 Joints.....	374	362.24 Bends	390
352.60 Equipment Grounding Conductor.....	374	362.26 Number of Bends (360°).....	390
Article 356—Liquidtight Flexible Nonmetallic Conduit (Type LFNC).....	377	362.28 Trimming	390
Part I. General	377	362.30 Securing and Supporting	390
356.1 Scope	377	362.46 Bushings	391
356.2 Definition.....	377	362.48 Joints	391
356.6 Listing Requirements	377	362.60 Equipment Grounding Conductor.....	391
Part II. Installation	377	Article 376—Metal Wireways.....	393
356.10 Uses Permitted.....	377	Part I. General	393
356.12 Uses Not Permitted.....	378	376.1 Scope	393
356.20 Trade Size	378	376.2 Definition.....	393
356.22 Number of Conductors	378	Part II. Installation	393
356.24 Bends	379	376.10 Uses Permitted	393
356.26 Number of Bends (360°).....	379	376.12 Uses Not Permitted.....	394
356.30 Securing and Supporting	379	376.20 Conductors Connected in Parallel.....	394
356.42 Fittings	379	376.22 Number of Conductors and Ampacity	394
356.60 Equipment Grounding Conductor.....	379	376.23 Wireway Sizing	395

Part III. Construction Specifications.....	398	400.10	Uses Permitted.....	414
376.100 Construction.....	398	400.12	Uses Not Permitted.....	415
		400.14	Pull at Joints and Terminals.....	416
		400.17	Protection from Damage	417
Article 380—Multioutlet Assemblies.....	399			
Part I. General	399			
380.1 Scope	399			
Part II. Installation	399			
380.10 Uses Permitted.....	399	404.1	Scope	419
380.12 Uses Not Permitted.....	399	404.2	Switch Connections	419
380.76 Through Partitions	399	404.3	Switch Enclosures.....	421
		404.4	Damp or Wet Locations.....	422
		404.7	Indicating	422
		404.8	Accessibility and Grouping	423
		404.9	General-Use Snap Switches, Dimmers, and Control Switches	425
Article 386—Surface Metal Raceways.....	401	404.10	Mounting of Snap Switches, Dimmers, and Control Switches	426
Part I. General	401	404.12	Grounding of Enclosures	427
386.1 Scope	401	404.14	Rating and Use of Snap Switches	427
386.2 Definition.....	401			
386.6 Listing Requirements	402			
Part II. Installation	402			
386.10 Uses Permitted.....	402	404.20	Switch Marking	427
386.12 Uses Not Permitted.....	402	404.22	Electronic Control Switches.....	428
386.21 Size of Conductors.....	402			
386.22 Number of Conductors	402			
386.30 Securing and Supporting	403			
386.56 Splices and Taps	403			
386.60 Equipment Grounding Conductor.....	403			
386.70 Separate Compartments.....	403			
Article 392—Cable Trays.....	405			
Part I. General	405			
392.1 Scope	405	408.1	Scope	429
392.2 Definition.....	405	408.3	Arrangement of Busbars and Conductors.....	429
Part II. Installation	405	408.4	Field Identification.....	430
392.10 Uses Permitted.....	405	408.5	Clearance for Conductors Entering Bus Enclosures	431
392.12 Uses Not Permitted.....	407	408.6	Short-Circuit Current Rating.....	432
392.18 Cable Tray Installations	407	408.7	Unused Openings.....	432
392.20 Cable and Conductor Installation	408	408.8	Reconditioning of Equipment	432
392.30 Securing and Supporting	408			
392.44 Expansion Splice Plates	408	Part II. Switchboards and Switchgear	432	
392.46 Bushed Conduit and Tubing	408	408.18	Clearances	432
392.56 Cable Splices	408	Part III. Panelboards	432	
392.60 Equipment Grounding Conductor.....	409	408.36	Overcurrent Protection	432
		408.37	Panelboards in Damp or Wet Locations	433
		408.40	Equipment Grounding Conductor.....	433
		408.41	Neutral Conductor Terminations	434
		408.43	Panelboard Orientation.....	434
CHAPTER 4—EQUIPMENT FOR GENERAL USE	411			
Article 400—Flexible Cords and Flexible Cables.....	413			
400.1 Scope	413	Article 445—Generators.....	435	
400.3 Suitability	413	445.1	Scope	435
400.4 Types of Flexible Cords and Flexible Cables.....	414	445.6	Listing.....	435
400.5 Ampacity of Flexible Cords and Flexible Cables	414	445.11	Marking	435
		445.13	Ampacity of Conductors.....	436
		445.18	Disconnecting Means and Emergency Shutdown.....	436

Article 450—Transformers	439	Part VI. Markings and Labels	481
450.1 Scope	439	690.53 Direct-Current PV Circuit Label.....	481
450.3 Overcurrent Protection	439	690.54 Interactive System Point of Interconnection.....	482
450.9 Ventilation	440	690.55 Energy Storage.....	482
450.10 Grounding and Bonding.....	440	690.56 Identification of Power Sources.....	482
450.13 Transformer Accessibility.....	440	Part VII. Connections to Other Sources	483
450.14 Disconnecting Means	441	690.59 Connection to Other Power Sources.....	483
Article 480—Storage Batteries	443	Part VIII. Energy Storage Systems	483
480.1 Scope	443	690.71 Energy Storage Systems.....	483
480.2 Definitions	443	690.72 Self-Regulated PV Charge Control.....	484
480.4 Battery and Cell Terminations	444	Article 691—Large-Scale Photovoltaic (PV) Electric Supply Stations	485
480.5 Wiring and Equipment Supplied from Batteries	445	691.1 Scope	485
480.7 Direct-Current Disconnect Methods	445	691.2 Definitions	485
480.8 Insulation of Batteries	445	691.4 Special Requirements for Large-Scale PV Electric Supply Stations	485
480.9 Battery Support Systems	445	691.5 Equipment.....	486
480.10 Battery Locations.....	446	691.6 Engineered Design.....	486
480.12 Battery Interconnections.....	446	691.7 Conformance of Construction to Engineered Design.....	486
480.13 Ground-Fault Detection	446	691.8 Direct-Current Operating Voltage	486
CHAPTER 6—SPECIAL EQUIPMENT	447	691.9 Disconnect for Isolating Photovoltaic Equipment.....	486
Article 690—Solar Photovoltaic (PV) Systems	449	691.10 Arc-Fault Mitigation.....	486
Part I. General	449	691.11 Fence Bonding and Grounding	486
690.1 Scope	449	CHAPTER 7—SPECIAL CONDITIONS	487
690.2 Definitions	451	Article 705—Interconnected Electric Power Production Sources	489
690.4 General Requirements.....	454	Part I. General	489
690.6 Alternating-Current Modules and Systems	455	705.1 Scope	489
Part II. Circuit Requirements	456	705.2 Definitions	489
690.7 Maximum PV System Direct-Current Circuit Voltage	456	705.6 Equipment Approval	490
690.8 Circuit Current and Conductor Sizing.....	460	705.8 System Installation	490
690.9 Overcurrent Protection	465	705.10 Identification of Power Sources.....	490
690.10 Stand-Alone Systems	467	705.11 Supply-Side Source Connections	491
690.11 Arc-Fault Circuit Protection	467	705.12 Load-Side Source Connections	493
690.12 Rapid Shutdown.....	467	705.13 Power Control Systems	499
Part III. Disconnect	469	705.16 Interrupting and Short-Circuit Current Rating.....	500
690.13 PV System Disconnect	469	705.20 Disconnect	500
690.15 PV Equipment Disconnecting Means to Isolate PV Equipment.....	470	705.25 Wiring Methods	500
Part IV. Wiring Methods	472	705.28 Circuit Sizing and Current	500
690.31 Wiring Methods	472	705.30 Overcurrent Protection	501
690.32 Component Interconnections	477	705.32 Ground-Fault Protection	502
690.33 Connectors (Mating)	477	705.40 Loss of Utility Power	502
690.34 Access to Boxes	478	705.45 Unbalanced Interconnections	502
Part V. Grounding and Bonding	478	Part II. Microgrid Systems	504
690.43 Equipment Grounding and Bonding	478	705.50 System Operation	504
690.45 Size of Equipment Grounding Conductors	479	705.60 Primary Power Source Connection	504
690.47 Grounding Electrode System	480		

Article 706—Energy Storage Systems	505	Practice Questions	517
Part I. General	505	Final Exam A—Straight Order	551
706.1 Scope	505	Final Exam B—Random Order	563
706.2 Definitions	506	INDEX	573
706.3 Qualified Personnel.....	506		
706.4 System Requirements	506		
706.5 Listing.....	507	About the Author	583
706.6 Multiple Systems.....	507	About the Illustrator	584
706.8 Storage Batteries.....	507	About the Mike Holt Team	585
706.9 Maximum Voltage	507		
Part II. Disconnect	507		
706.15 Disconnect.....	507		
Part III. Installation Requirements	508		
706.20 General.....	508		
706.21 Directory (Identification of Power Sources).....	509		
Part IV. Circuit Requirements	509		
706.30 Circuit Sizing and Current.....	509		
706.31 Overcurrent Protection	510		
706.33 Charge Control.....	510		
Part V. Flow Battery Energy Storage Systems.....	511		
Article 710—Stand-Alone Systems	513		
710.1 Scope	513		
710.6 Equipment Approval	513		
710.10 Identification of Power Sources.....	514		
710.12 Stand-Alone Inverter Input Circuit Current.....	514		
710.15 General.....	514		

Mike Holt's Illustrated Guide to
Understanding Electrical Theory
for NEC Applications

TABLE OF CONTENTS

About This Textbook	ix	4.7 Secondary Distribution Voltage	23
Additional Products to Help You Learn	xii	4.8 Service Drop and Service Lateral.....	23
Chapter 1—Practice Questions25			
CHAPTER 1—ELECTRICAL FUNDAMENTALS1			
Unit 1—Atomic Structure	3	CHAPTER 2—USES AND DANGERS OF ELECTRICITY33	
1.1 Introduction	3	5.1 Introduction	35
1.2 Atomic Theory	3	5.2 Uses of Electricity.....	35
1.3 Electrostatic Field	4	5.3 Electrochemical Processes.....	35
1.4 Atomic Charge of an Atom	5	5.4 Electromagnetism.....	35
1.5 Electrostatic Charge and Discharge.....	6	5.5 Photoelectricity	36
1.6 Lightning	7	5.6 Electric Heating	37
1.7 Lightning Protection System.....	8	5.7 Lighting	39
Unit 2—Electron Theory and Chemical Bonding	9	Unit 5—Uses of Electricity35	
2.1 Introduction	9	5.1 Introduction	35
2.2 Electron Orbitals.....	9	5.2 Uses of Electricity.....	35
2.3 Valence Electrons.....	9	5.3 Electrochemical Processes.....	35
2.4 Freeing Valence Electron(s) from an Atom.....	10	5.4 Electromagnetism.....	35
2.5 Conductance	10	5.5 Photoelectricity	36
2.6 Insulators	12	5.6 Electric Heating	37
2.7 Semiconductors.....	12	5.7 Lighting	39
2.8 Chemical Bonding	13	Unit 6—Dangers of Electricity41	
Unit 3—Electrical Circuits and Power Sources	15	6.1 Introduction	41
3.1 Introduction	15	6.2 <i>National Electrical Code (NEC)</i>	41
3.2 The Electrical Circuit.....	15	6.3 Electrical Fire	41
3.3 Electric Current Flow (Electricity).....	15	6.4 Electric Shock	42
3.4 Electrical Power Sources	16	6.5 Electric Arc Flash and Arc Blast	43
Unit 4—The Electrical System	21	6.6 Arc Flash Incident Energy	44
4.1 Introduction	21	6.7 Electrically Safe Work Condition	45
4.2 Source of Electrical Generation.....	21	6.8 Personal Protective Equipment	46
4.3 Step-Up Transmission Voltage	21	Chapter 2—Practice Questions49	
4.4 High-Voltage Transmission Lines.....	22	CHAPTER 3—MAGNETISM AND ELECTROMAGNETISM55	
4.5 Primary Distribution Voltage	22	Unit 7—Basics of Magnetism	57
4.6 Primary Distribution Wires	22	7.1 Introduction	57
		7.2 The Natural Magnet	57
		7.3 Magnetic Polarities	57
		7.4 Theory of Magnetism	58
		7.5 Permanent and Temporary Magnets	58
		7.6 Magnetizing and Demagnetizing Magnets	58

Table of Contents |

7.7	Magnetic Lines of Force	59
7.8	Law of Attraction and Repulsion of Magnets.....	59
Unit 8—Electromagnetism		61
8.1	Introduction	61
8.2	Electromagnetism in a Wire	61
8.3	Electromagnet Field Interaction	62
8.4	Electromagnetic Field Interaction of Wire Loops.....	62
8.5	Electromagnetic Core	63
Unit 9—Uses of Electromagnetism		65
9.1	Introduction	65
9.2	Motors	65
9.3	Generators	66
9.4	Relays.....	66
9.5	Transformers	66
Chapter 3—Practice Questions		67
CHAPTER 4—MATHEMATICS		71
Unit 10—Basic Math		73
10.1	Introduction	73
10.2	Whole Numbers.....	73
10.3	Fractional Numbers	73
10.4	Decimal Numbers.....	73
10.5	Percentages.....	74
10.6	Parentheses.....	75
10.7	Squaring a Number.....	75
10.8	Square Root.....	75
10.9	Kilo	76
10.10	Rounding	76
10.11	Surface Area of a Rectangle or Square	76
10.12	Surface Area of a Circle.....	77
10.13	Volume	79
10.14	Reciprocal.....	79
10.15	Testing Your Answer	79
Unit 11—Trigonometry		81
11.1	Introduction	81
11.2	Triangles.....	81
11.3	Right Triangle	81
11.4	Pythagorean Theorem	82
11.5	Practical Use of Trigonometry	83
Chapter 4—Practice Questions		85
CHAPTER 5—OHM'S LAW AND WATT'S LAW		91
Unit 12—Ohm's Law		93
12.1	Introduction	93
12.2	The Electrical Circuit.....	93
12.3	Electromotive Force (Pressure).....	93
12.4	Circuit Resistance	94
12.5	Circuit Intensity	95
12.6	Ohm's Law	95
12.7	Ohm's Law Formula Circle	96
Unit 13—Watt's Law		99
13.1	Introduction	99
13.2	Watt's Law	99
13.3	Power Formula Circle.....	100
13.4	Power Changes with the Square of the Voltage.....	101
Chapter 5—Practice Questions		103
CHAPTER 6—ELECTRICAL CIRCUIT TYPES		107
Unit 14—Series Circuits		109
14.1	Introduction	109
14.2	Series Circuits.....	109
14.3	Understanding Series Circuits	109
14.4	Series Circuit Summary.....	113
14.5	Series-Connected Power Supplies	113
14.6	Applications of Series Circuits.....	114
Unit 15—Parallel Circuits		117
15.1	Introduction	117
15.2	Understanding Parallel Circuits	117
15.3	Parallel Circuit Resistance Calculations	119
15.4	Parallel Circuit Summary.....	122
15.5	Parallel-Connected Power Supplies	122
15.6	Practical Uses of Parallel Circuits.....	123
Unit 16—Series-Parallel Circuits		125
16.1	Introduction	125
16.2	Understanding Series-Parallel Circuits	125
16.3	Calculating Resistance in Series-Parallel Circuits	126
Chapter 6—Practice Questions		129

CHAPTER 7—ALTERNATING CURRENT	137	CHAPTER 8—MOTORS, GENERATORS, RELAYS, AND TRANSFORMERS	177
Unit 17—Alternating Current Fundamentals	139	Unit 21—Motors	179
17.1 Introduction	139	21.1 Introduction	179
17.2 How Alternating Current is Produced	139	21.2 Alternating-Current Motor Principles	179
17.3 Waveforms	140	21.3 Motor Horsepower Rating	180
17.4 Frequency	143	21.4 Motor Amperes	181
17.5 In-Phase Waveforms	143	21.5 Motor Nameplate Amperes	182
17.6 Out-of-Phase Waveforms	143	21.6 Dual-Voltage Motors	184
17.7 Alternating-Current Waveform Values	144	21.7 Reversing the Rotation of Alternating-Current Motors	185
Unit 18—Inductance	147	21.8 Alternating-Current Motor Types	186
18.1 Introduction	147	Unit 22—Generators	187
18.2 How Inductance Works	147	22.1 Introduction	187
18.3 Self-Inductance	147	22.2 Generator Prime Mover	187
18.4 Mutual Inductance	148	22.3 Alternating-Current Generators	187
18.5 Inductive Reactance	149	22.4 Generator Output Current	188
18.6 Uses of Induction	150	22.5 Single-Phase and Three-Phase Generator Voltages	189
Unit 19—Capacitance	151	22.6 Electrical Industry Voltages	189
19.1 Introduction	151	Unit 23—Relays	191
19.2 Capacitance in Capacitors	151	23.1 Introduction	191
19.3 Capacitor Charge and Discharge	152	23.2 How Relays Operate	191
19.4 Capacitive Reactance	152	23.3 Relay Contacts	192
19.5 Uses of Capacitors	153	Unit 24—Transformers	193
Unit 20—True Power, Power Factor, and Apparent Power	155	24.1 Introduction	193
20.1 Introduction	155	24.2 Types of Transformers	193
20.2 True Power	155	24.3 Primary versus Secondary	193
20.3 Power Losses of Wires	156	24.4 Transformer Mutual Induction	194
20.4 Power Losses at Terminals	156	24.5 Secondary Induced Voltage	194
20.5 Equipment Efficiency	157	24.6 Transformer Turns Ratios	194
20.6 Cost of Power	158	24.7 Isolation Transformer (1:1)	196
20.7 Power Factor	159	24.8 Autotransformer	197
20.8 Apparent Power	160	24.9 Transformer kVA Rating	197
20.9 Apparent Power versus True Power	161	24.10 Transformer Current Flow	197
20.10 Effects of Power Factor on Circuits	162	24.11 Transformer Current Rating	197
Chapter 7—Practice Questions	165	24.12 Transformer Configurations	200
		24.13 Delta/Wye Transformers	201
		24.14 Delta/Delta (High-Leg) Transformer	203
Chapter 8—Practice Questions	205		

CHAPTER 9—PROTECTIVE DEVICES	215	Unit 28—Multiwire Circuits	249
Unit 25—Overcurrent Protection.....	217	28.1 Introduction	249
25.1 Introduction	217	28.2 Neutral Wire.....	249
25.2 Overcurrent Protection.....	217	28.3 Grounded Wire	250
25.3 Fuses	219	28.4 Current Flow on the Neutral Wire.....	250
25.4 Circuit Breakers.....	221	28.5 Multiwire Branch Circuits	251
25.5 Overcurrent Protective Devices, Time-Current Curves	222	28.6 Dangers of Multiwire Circuits	253
25.6 Available Short-Circuit Current	223	28.7 NEC Requirements	254
25.7 Overcurrent Protective Devices, Interrupting Rating.....	225		
25.8 Equipment Short-Circuit Current Rating (SCCR).....	225		
25.9 Coordination of Overcurrent Protective Devices.....	226		
UNIT 26—GFCIs, GFPEs, AFCIs, AND SPDs	229	Unit 29—The Formula Wheel	255
26.1 Introduction	229	29.1 Introduction	255
26.2 Ground-Fault Circuit Interrupters (GFCIs).....	229	29.2 Formula Wheel Quadrants	255
26.3 Special Purpose Ground-Fault Circuit Interrupters (SPGFClis).....	231	29.3 Using the Formula Wheel	256
26.4 Ground-Fault Protection of Equipment (GFPEs)	231		
26.5 Arc-Fault Circuit Interrupters (AFCIs).....	232		
26.6 Clearing Arcing Faults	232		
26.7 Surge Protective Devices (SPDs)	233		
26.8 How Surge Protective Device Functions.....	234		
Chapter 9—Practice Questions	235	Chapter 10—Practice Questions	259
CHAPTER 10—GENERAL KNOWLEDGE	241	FINAL EXAM	267
Unit 27—Wire Resistance and Voltage Drop	243	INDEX	279
27.1 Introduction	243		
27.2 Wire Sizes	243		
27.3 Direct-Current Wire Resistance	243		
27.4 NEC Wire Direct-Current Resistance	244		
27.5 Alternating-Current Wire Resistance	245		
27.6 Alternating-Current Resistance versus Direct-Current Resistance	246		
27.7 Wire Voltage Drop—Ohm's Law Method	246		
About the Author	283		
About the Illustrator	284		
About the Mike Holt Team	285		

CHAPTER 6—MOTORS, GENERATORS, AND TRANSFORMERS	265
Unit 20—Motors.....	267
Introduction	267
Part A—Motor Basics	267
20.1 Motor Principles.....	267
20.2 Dual-Voltage AC Motors	267
20.3 Motor Horsepower Ratings.....	268
20.4 Motor Current Ratings.....	269
20.5 Calculating Motor FLA.....	269
20.6 Motor Starting Current	271
20.7 Motor Running Current.....	271
20.8 Motor Locked-Rotor Current (LRC)	271
20.9 Motor Overload Protection.....	271
Part B—Direct-Current Motors.....	272
20.10 Direct-Current Motor Principles.....	272
20.11 Direct-Current Motor Types	273
20.12 Reversing the Rotation of a DC Motor.....	273
Part C—Alternating-Current Motors.....	273
20.13 AC Induction Motor	273
20.14 Alternating-Current Motor Types	274
20.15 Reversing the Rotation of an AC Motor	274
Summary	276
Conclusion.....	278
Practice Questions	279
 Unit 21—Generators.....	283
Introduction	283
21.1 Direct-Current Generator	283
21.2 Alternating-Current Generator	284
21.3 Three-Phase Generator	284
Summary	285
Conclusion.....	285
Practice Questions	286
 Unit 22—Transformers	287
Introduction	287
22.1 Transformer Basics	287
22.2 Secondary Induced Voltage.....	287
22.3 Autotransformers	288
22.4 Power Losses	289
22.5 Harmonic Current	290
22.6 Efficiency	291
22.7 Transformer Turns Ratio	291
22.8 Transformer kVA Rating.....	293
22.9 Current Flow	294
22.10 Current Rating	294
Summary	296
Conclusion.....	297
Practice Questions	298
 Chapter 6 Final Exam Questions	300
 BASIC ELECTRICAL THEORY CONCLUSION ..	305
 BASIC ELECTRICAL THEORY FINAL EXAM ..	307
 ANNEX A—GROUNDING AND BONDING ..	323
 INDEX	345

Mike Holt's Illustrated Guide to

Electrical Estimating, 2nd Edition

TABLE OF CONTENTS

About This Textbook	ix
About the Author	xiv
Mike Holt Enterprises Team	xvi

CHAPTER 1—INTRODUCTION 1

Introduction	1
1.1 Estimating versus Bidding	2
1.2 A Good Estimating System	3
1.3 Objectives and Purpose of an Electrical Contractor	3
1.4 Why So Many Electrical Contractors Are Unsuccessful	3
1.5 Project Management	4
1.6 Can I Be Competitive?	5
1.7 The Electrical Market	10
1.8 Negotiated Work	10
1.9 Best Value	10
Summary	11
Conclusion	14
Essay Questions	15
Multiple-Choice Questions	17

CHAPTER 2—ABOUT ESTIMATING 23

Introduction	23
2.1 Qualities of a Good Estimator	23
2.2 Duties and Responsibilities of the Estimator	24
2.3 The Estimating Workspace and Tools	25
2.4 Types of Bids	27
2.5 What an Accurate Estimate Must Include	29
2.6 Improper Estimating Methods	29
2.7 The Detailed Estimating Method	30
2.8 How Accurate Can an Estimate Be?	32
2.9 Manual Estimate, Estimating Software, or an Estimating Service?	33
Summary	37
Conclusion	40
Essay Questions	41
Multiple-Choice Questions	43

Table of Contents | Electrical Estimating

CHAPTER 3—UNDERSTANDING LABOR UNITS	49
Introduction	49
3.1 What Is a Labor Unit?	50
3.2 How Labor Units Are Expressed	51
3.3 Using Work Experience	51
3.4 What Is Included in the Labor Unit?	54
3.5 Labor Units Do Not Include.....	55
3.6 Labor-Unit Manuals	56
3.7 How to Develop Your Own Labor Units.....	56
3.8 Your Labor Units as Compared to Your Competitors	57
3.9 Knowing Your Competitors' Labor Units.....	58
3.10 Variables That Affect Labor Units.....	59
3.11 Are You for Real?.....	69
Summary	70
Conclusion.....	73
Essay Questions	74
Multiple-Choice Questions	76
CHAPTER 4—THE ESTIMATING PROCESS	83
Introduction	83
4.1 Job Selection.....	84
4.2 Understanding the Scope of Work	86
4.3 Preparing for the Estimate	87
4.4 Plans and Specifications Review	89
4.5 Estimate and Bid Notes.....	93
4.6 Estimating Forms and Worksheets	94
4.7 The Take-Off	94
4.8 Determining the Bill-of-Material (Manual Estimate)	100
4.9 Pricing and Laboring	103
4.10 Extensions and Totals.....	106
Summary	108
Conclusion.....	112
Essay Questions	113
Multiple-Choice Questions	115
CHAPTER 5—DETERMINING BREAK-EVEN COST	121
Introduction	121
5.1 Labor Hours (Step A)	123

Table of Contents | Electrical Estimating

5.2 Labor Cost (Step B)	128
5.3 Labor Rate per Man-Hour	128
5.4 Labor Burden	130
5.5 Total Material Cost (Step C)	130
5.6 Direct Job Expenses (Step D)	133
5.7 Estimated Prime Cost (Step E)	136
5.8 Overhead (Step F)	136
5.9 Overhead Calculation Methods	138
5.10 Break-Even Cost (Estimated Cost) (Step G)	140
Summary	141
Conclusion	144
Essay Questions	145
Multiple-Choice Questions	147
 CHAPTER 6—THE BID PROCESS	151
Introduction	151
6.1 Profit (It Is Not a Dirty Word)	152
6.2 Profit to Prime Cost	153
6.3 Other Bid Cost Considerations	154
6.4 Bid Accuracy	156
6.5 Bid Analysis	157
6.6 Bid Proposal	159
Summary	162
Conclusion	165
Essay Questions	166
Multiple-Choice Questions	168
 CHAPTER 7—UNIT PRICING	171
Introduction	171
7.1 What Is Unit Pricing?	171
7.2 Advantages and Disadvantages of Unit Pricing	171
7.3 Unit Price Example	172
Summary	174
Conclusion	175
Essay Questions	176
Multiple-Choice Questions	177

Table of Contents | Electrical Estimating

CHAPTER 8—SOFTWARE-BASED ESTIMATING	179
Introduction	179
8.1 Computer Estimating System Functions.....	179
8.2 Advantages and Benefits.....	181
8.3 Pre-Purchase Considerations.....	183
8.4 Hardware Considerations.....	184
8.5 Cost of Software	185
8.6 Technical Support	185
8.7 Can I Afford it?	186
8.8 Software Vendors.....	187
8.9 Training and Support.....	188
8.10 Pricing Services	188
8.11 Frequently Asked Questions.....	189
Summary	191
Conclusion.....	195
Essay Questions	196
Multiple-Choice Questions	198
CHAPTER 9—THE BID PROCESS REVIEW	203
Introduction	203
9.1 Pre-Estimate.....	203
9.2 Estimate Process	206
9.3 Determining Break-Even Cost	207
9.4 The Bid Process	210
FINAL EXAM.....	213

Business Management Skills Workbook

TABLE OF CONTENTS

About the Author	viii
How to Use This Workbook	ix
INTRODUCTION	x
CHAPTER 1—BUSINESS MANAGEMENT	1
Advertising and Branding	5
Appearance	8
Balance (Life)—All Things in Proportion	10
Burnout	12
Business Forecasting	14
Business Image and Reputation	16
Change	19
Communication	21
Computers and Technology	23
Confidence and Positive Attitude	26
Conduct	28
Creative Tension and Personal/Position Power	30
Creativity/Innovation	33
Crisis Management	35
Customers	37
Delegation	40
Goal Setting	43
Groups and Associations	47
Leadership	49
Legal	54
Listening and Learning	56
Management's Role	58
Marketing	60
Mistakes	63
Motivation	65
"No"—The Most Difficult Word	68
Peer Pressure	70
Planning and Organizing	72

Problem Solving.....	74
Procrastination	77
Reading	80
Schools of Management Thought.....	83
Self-Confidence	85
Stress.....	88
Success and/or Mortality Rate	92
Teamwork.....	94
Theories—Your Attitude Toward Your Employees.....	96
The Pareto Principle or the 80:20 Rule	98
Thinking/Thinking Out Loud	101
Time Management.....	103
Training	107
Weaknesses	109
Websites and Internet Marketing.....	111
 CHAPTER 2—FINANCIAL MANAGEMENT	 115
Accounting	117
Bad Debt	121
Bankers/Line of Credit	123
Billing and Collecting	125
Bonding.....	128
Break-Even Point.....	130
Budgeting.....	132
Contracts.....	135
Debt Free.....	137
Equipment Rental/Leasing/Purchase.....	139
Expansion, Growth and Stability	141
Insurance	143
Job Costing (Estimating Analysis).....	145
Markup.....	149
Payment Schedule	151
Profit	153
Record Keeping	155
Selling the Job at Your Price.....	157
Service and/or Shop Charge Determinations	160
Taxes.....	162

CHAPTER 3—JOB MANAGEMENT (PROJECT).....	165
Bid Analysis	167
Change Orders (Extras)	169
Codes and Standards.....	172
Cost Overrun.....	174
Estimating vs. Bidding	177
Estimating Process	180
Inventory	184
Job Schedule	186
Job Selection.....	188
Labor-Units.....	190
Plans	193
Project Manager’s Role	195
Proposals.....	198
 CHAPTER 4—LABOR MANAGEMENT (EMPLOYEES)	 201
Appearance of Office	205
Basic Needs.....	207
Company Policy	209
Company Procedures.....	213
Dress Code	217
Forms	219
Hiring and Firing	221
Job Descriptions and Responsibility	224
Meetings	228
Peter Principle	230
Salary	232
 ANNEX—ACTION PLAN	 235
Business Model	236
Business Development Worksheet	250
Daily Log Example	253
Organizational Chart Example	254
Customer Survey Example	255
Employee Survey Example	256
Proposal for Electrical Work—Example 1	257
Proposal for Electrical Work—Example 2	260