

Show Networks and Control Systems

Table of Contents

Foreword	v
Table of Contents	vii
Preface	xv
I Wonder	xv
Why Does This Book Exist?	xv
What's New in This Edition?	xvi
For Whom Is This Book Written?	xvii
How Should This Book Be Used?	xvii
What Is Included?	xviii
Conventions	xviii
Disclaimers	xix
Website	xix
Special Thanks to My Production Team	xix
Chapter 1: Introduction	1
What Is Entertainment Control?	1
What Is Show Control?	2
What Is a System?	2
What Is a Network?	3
What Is a Standard?	4
Moving On	9
Part 1: Entertainment Discipline Overview	11
Chapter 2: Lighting	13
Lighting Control Equipment	13
Lighting Control Approaches	20
Chapter 3: Lasers	23
Laser System Control Equipment	23
Laser Control Approaches	25

Chapter 4: Audio	27
Audio Control Equipment	27
Audio Control Approaches	31
Chapter 5: Image Presentation	35
Image Presentation Control Equipment	35
Image Presentation Control Approaches	37
Chapter 6: Stage Machinery	41
Machinery Control Systems	41
Sensing/Feedback	42
Control	44
Drive Devices	46
Emergency Stop	47
Commercial Entertainment Machinery Control Systems	48
Machinery Control Approaches	48
Chapter 7: Animatronics	51
Animatronic Effects	51
Animatronic Control Systems	52
Animatronic Control Approaches	54
Chapter 8: Fog, Smoke, Fire, and Water	57
Fog and Smoke Equipment	57
Fire and Water Control Systems	58
Fog Smoke Fire and Water Control Approaches	58
Chapter 9: Pyrotechnics	61
Pyrotechnic Control Systems	61
Pyrotechnic Control Approaches	63
Part 2: Entertainment Control	65
Chapter 10: Entertainment Control Basics	67
Show Types	67
Cues	68
Cueing Methods	69
Operational Modes	72
Commands/Data	73
Data Relationships	74
Feedback	78
Control Structures	80
System Control Architectures	81

Physical Topologies	83
Variables	85
Logical Operators	86
Chapter 11: Electrical Control System Basics	89
Sensors and Switches	89
Contact Closures	93
Contact Nomenclature	94
Isolation	97
Chapter 12: Numbering Systems	99
Base 10 (Decimal) Notation	99
Base 2 (Binary) Notation	100
Base 16 (Hexadecimal) Notation	101
Binary-Coded Decimal Notation	103
Math with Binary and Hex	103
Bitwise Operation	104
Converting Number Bases	105
Sample Numbers in Different Formats	108
Storing Numbers in Computers	108
Chapter 13: System Design Principles	111
Principle 1: Ensure Safety	111
Principle 2: The Show Must Go On	115
Principle 3: Simpler Is Always Better	117
Principle 4: Strive for Elegance	118
Principle 5: Complexity Is Inevitable, Convolution Is Not	118
Principle 6: Make It Scalable, and Leave Room for Unanticipated Changes	118
Principle 7: Ensure Security	118
System Troubleshooting	119
Part 3: Data Communication and Networking	123
Chapter 14: Data Communication	125
An Introduction to Communications Layering	125
Character Encoding	126
Data Rate	127
Bandwidth	127
Multiplexing	127
Communications Mode	129
Error Detection	129
Flow Control	132
Electricity for Data Transmission	133

Transmission/Modulation Methods	140
Light for Data Transmission	141
Radio for Data Transmission	143
Chapter 15: Point-to-Point Interfaces	145
Parallel Interfaces	145
Serial Interfaces	146
TIA/EIA Serial Standards	147
Practical Serial Connections	151
Serial Connection Example	152
High-Speed Serial Point-to-Point Interconnects	154
Moving On	156
Chapter 16: Networking Basics	157
Open Systems Interconnect (OSI) Layering Scheme	157
Packet Switching	159
Encapsulation	159
Packet Forwarding Schemes	160
Network Types	161
Ethernet	162
Ethernet Implementations	166
Ethernet Hardware	169
IEEE 802.11 “Wi-Fi”	175
Ethernet in Our Industry	179
Chapter 17: Show Networks	181
TCP, UDP, and IP	181
Transmission Control Protocol (TCP)	182
User Datagram Protocol (UDP)	183
Internet Protocol (IP)	183
Dynamic Host Configuration Protocol (DHCP)	185
ipconfig/ifconfig Command	186
Example Network Using DHCP and ipconfig	187
Link-Local Addresses	189
Static/Fixed IP Addresses	189
ping Command	190
Example Network Using Fixed IP Addresses and ping	191
Subnets and Network Masks	194
Example Network with Two Subnets	197
Address Resolution Protocol (ARP)	200
Ports and Sockets	203
Testing Networks	204
Moving On	209

Chapter 18: Advanced Show Network Topics	211
Broadcast Domain	213
Network Topology and Broadcast Storms	216
Default Gateway	219
Layer 3 Routing	220
Virtual LANs (VLAN)	221
Example Network with VLANs and Managed Switches	226
Other Network System Protocols	232
IPv6	233
Part 4: Standards and Protocols Used in Entertainment	239
Chapter 19: Digital MultipleX (DMX512-A)	241
DMX's Repetitive Data Approach	241
Addressing	242
Universes	243
Controlling Equipment Other Than Dimmers	243
Physical Connections	245
Data Transmission	247
DMX Distribution and Termination	249
DMX Patching/Merging/Processing/Test Equipment	250
Alternate Start Codes	251
Enhanced Function	251
DMX Over a Network	252
Network Over DMX?	257
DMX in the Entertainment Control Market	257
Chapter 20: Remote Device Management (RDM)	259
Basic Structure	259
RDM Message Structure	260
The Discovery Process	263
RDM Messages	265
RDM and Networks	268
RDM in the Entertainment Control Market	268
Chapter 21: Architecture for Control Networks (ACN)	269
A Bit of Blue Sky Thinking	269
Background and Mandate	270
Overview	270
ACN's Acronym Soup	271
Protocol Structure	274
Identifiers and Addresses	274
Discovery	276

Control of Devices	278
ACN Implementations	279
ANSI E1.31: Streaming ACN (sACN)	280
ACN in the Entertainment Control Market	280
Chapter 22: Musical Instrument Digital Interface (MIDI)	281
Basic Structure	281
Physical Connections	282
MIDI Messages	283
Channel Messages	283
System Messages	285
Active Sensing	287
MIDI Sync	287
System-Exclusive Messages	287
MIDI Running Status	291
General MIDI	292
MIDI Processors/Routers/Interfaces	292
Recommended MIDI Topologies	294
Common MIDI Problems	294
MIDI over Networks	296
MIDI in the Entertainment Control Market	299
Chapter 23: MIDI Show Control (MSC).....	301
MSC Command Structure	301
Recommended Minimum Sets	306
MSC Commands	306
Limitations of MIDI Show Control	312
MSC in the Entertainment Control Market	314
Chapter 24: MIDI Machine Control (MMC)	315
MMC Systems	315
Command/Response Structure of MMC	315
MMC Motion Control	316
MMC Message Structure	316
Common MMC Commands	318
MMC in the Entertainment Control Market	319
Chapter 25: SMPTE and MIDI Time Code (MTC)	321
Background	321
Time Code Addresses	321
Traditional Audio/Visual Synchronization	321
Live Entertainment Time Code Applications	323
Time-Code Types	324

Practical Time Code For Live Shows	325
SMPTE Time-Code	327
SMPTE Time Code Hardware	329
SMPTE Linear Time Code in the Entertainment Control Market	330
MIDI Time Code	330
MIDI Time Code in the Entertainment Control Market	332
Other Time Codes	333
Chapter 26: Open Sound Control (OSC)	335
OSC Overview	335
OSC in the Entertainment Control Market	338
Chapter 27: Other Control Protocols	341
Open Control Alliance (OCA)	341
MIDI Visual Control (MVC)	343
Network Time Protocol (NTP)	343
Simple Network Management Protocol (SNMP)	344
Virtual Network CoNtrol (VNC)	344
Industrial I/O Systems	345
Legacy Video Connection Standards	347
Part 5: Show Control	355
Chapter 28: Show Control	357
Evolution of Show Control	357
Why Show Control?	360
What Is a Show Controller?	361
My Show Control Design Process	362
Question 1: What are the safety considerations?	362
Question 2: What type of show is it?	363
Question 3: Is the show event-based, time-based, or a hybrid?	363
Question 4: What is the control information source?	363
Question 5: What is the type of user interface required?	363
Question 6: What devices must be controlled/connected?	365
Other Concerns	366
Finally	367
Moving On to Some Examples	367
Chapter 29: A Theatrical Thunderstorm	369
The Mission	369
Design Considerations	369
The Systems	370

Show Control Script	372
Approach 1	373
Approach 2	374
Approach 3	376
Chapter 30: Put on a Happy Face	379
The Mission	379
Design Considerations	379
The Systems	380
Approach 1	382
Approach 2	384
Chapter 31: Ten-Pin Alley	387
The Mission	387
Design Considerations	388
The Systems	389
The Approach	393
Chapter 32: Comfortably Rich	397
The Mission	397
Design Considerations	397
The Systems	398
Show Control Script	400
Approach 1	401
Approach 2	403
Chapter 33: It's an Itchy World after All	407
The Mission	407
Design Considerations	408
The Systems	408
The Approach	412
Conclusion	421
Contact Info and Blog	422
Acknowledgments	423
Appendix: Decimal/Hex/Binary/ASCII Table	427
Glossary	435
Index	453