

Show Networks and Control Systems, Second Edition

Table of Contents, October 31, 2017

<i>Foreword</i>	v
<i>Table of Contents</i>	vii
<i>Preface</i>	xv
I Wonder	xv
Why Does This Book Exist?	xv
What’s Included and Not Included?	xvi
For Whom Is This Book Written?	xvi
How Should This Book Be Used?	xvii
Edition History	xviii
Conventions	xix
Disclaimers	xix
Special Thanks to My Production Team	xx
Website	xx
<i>Chapter 1: Introduction</i>	1
What Is Entertainment Control?	1
What Is Show Control?	1
What Is a System?	1
What Is a Network?	3
What Is a Standard?	4
Moving On	8
Part 1: Entertainment Discipline Overview	9
<i>Chapter 2: Lighting</i>	11
Lighting Control Equipment	11
Lighting Control Approaches	15
<i>Chapter 3: Lasers</i>	19
Laser System Control Equipment	19
Laser Control Approaches	20
<i>Chapter 4: Audio</i>	23
Audio Control Equipment	23
Audio Control Approaches	26
Audio Transmission Networks	27

Other Digital Audio Transmission Methods	28
Chapter 5: Video	31
Video Control Equipment	31
Video Control Approaches	33
Chapter 6: Stage Machinery	35
Machinery Control Systems	36
Sensing/Feedback	36
Control	38
Drive Devices	40
Emergency Stop	42
Commercial Entertainment Machinery Control Systems	42
Machinery Control Approaches	43
Chapter 7: Animatronics	45
Animatronic Effects	45
Animatronic Control Systems	46
Animatronic Control Approaches	48
Chapter 8: Fog, Smoke, Fire, and Water	51
Fog and Smoke Equipment	51
Fire and Water Control Systems	52
Fog, Smoke, Fire, and Water Control Approaches	52
Chapter 9: Pyrotechnics	55
Pyrotechnic Control Systems	55
Pyrotechnic Control Approaches	57
Part 2: Entertainment Control	59
Chapter 10: Entertainment Control Basics	61
Show Types	61
Cues	62
Cueing Methods	63
Operational Modes	66
Commands/Data	66
Data Relationships	68
Feedback	72
Control Structures	73
System Control Architectures	74
Physical Topologies	77
Variables	78

Logical Operators	79
Chapter 11: Basic Inputs and Outputs	83
Contact Closures for Input or Output	83
Inputs	85
Outputs	90
Electrical Isolation	92
Chapter 12: Numbering Systems	95
Base 10 (Decimal) Notation	95
Base 2 (Binary) Notation	96
Base 16 (Hexadecimal) Notation	97
Binary-Coded Decimal Notation	99
Math with Binary and Hex	99
Bitwise Operation	100
Converting Number Bases	101
Sample Numbers in Different Formats	104
Chapter 13: System Design Principles	105
Principle 1: Ensure Safety	105
Principle 2: The Show Must Go On	109
Principle 3: Simpler Is Always Better	112
Principle 4: Strive for Elegance	112
Principle 5: Complexity Is Inevitable, Convolution Is Not	113
Principle 6: Make It Scalable, and Leave Room for Unanticipated Changes	113
Principle 7: Ensure Security	113
System Troubleshooting	114
Part 3: Data Communication and Networking	117
Chapter 14: Data Communication	119
An Introduction to Communications Layering	119
Character Encoding	120
Data Rate	121
Bandwidth	121
Determinism	121
Multiplexing	122
Communications Mode	123
Error Detection	124
Flow Control	126
Electricity for Data Transmission	127
Transmission/Modulation Methods	135
Light for Data Transmission	136

Radio for Data Transmission	137
Chapter 15: Point-to-Point Interfaces	139
Parallel Interfaces	139
Serial Interfaces	140
TIA Serial Standards	141
Universal Serial Bus (USB)	146
Moving On	147
Chapter 16: Networking Basics	149
Open Systems Interconnect (OSI) Model	149
Packet Switching	151
Encapsulation	152
Packet Forwarding Schemes	152
Network Types	153
Ethernet	154
Ethernet Implementations	158
Ethernet Hardware	159
IEEE 802.11 “Wi-Fi”	164
Why Ethernet Is Good for Our Industry	167
Chapter 17: Show Networks	169
TCP, UDP, and IP	169
Transmission Control Protocol (TCP)	170
User Datagram Protocol (UDP)	171
Internet Protocol (IP)	171
Dynamic Host Configuration Protocol (DHCP)	173
ipconfig/ifconfig Command	174
Example Network Using DHCP and ipconfig	175
Link-Local Addresses	177
Static/Fixed IP Addresses	177
ping Command	177
Example Network Using Fixed IP Addresses	178
Subnets and Network Masks	181
Example Network with Two Subnets	186
Address Resolution Protocol (ARP)	189
Ports and Sockets	191
Free Network Testing Tools	192
Moving On	194
Chapter 18: Advanced Show Network Topics	195
Traffic Forwarding and Broadcast	195
Network Topology	201

Simple Layer 3 Routing	204
Virtual LANs (VLAN)	206
Example Network with Managed Switches, VLANs, and Simple Routing	212
Other Network System Protocols	217
IPv6	219
Entertainment Networking Best Practices	222
Moving On	225
Part 4: Standards and Protocols Used in Entertainment	227
<i>Chapter 19: Digital MultipleX (DMX512-A)</i>	229
DMX's Repetitive Data Approach	229
Addressing	230
Universes	231
Controlling Equipment Other Than Dimmers	231
Physical Connections	234
Data Transmission	236
DMX Distribution and Termination	238
DMX Patching/Merging/Processing/Test Equipment	239
Alternate Start Codes	240
Enhanced Function	240
DMX Over a Network	241
DMX in the Entertainment Control Market	245
<i>Chapter 20: Remote Device Management (RDM)</i>	247
Basic Structure	247
RDM Message Structure	248
The Discovery Process	251
RDM Messages	252
RDM and Networks	255
RDM in the Entertainment Control Market	255
<i>Chapter 21: Architecture for Control Networks (ACN).....</i>	257
Background and Mandate	257
Overview	258
ACN's Acronym Soup	258
Protocol Structure	261
Identifiers and Addresses	261
Discovery	263
Control of Devices	264
ACN Implementations	266
ANSI E1.31: Streaming (sACN)	266
ACN in the Entertainment Control Market	266

Chapter 22: Musical Instrument Digital Interface (MIDI)	267
Basic Structure	267
Physical Connections	268
MIDI Messages	269
Channel Messages	270
System Messages	272
Active Sensing	273
System-Exclusive Messages	273
MIDI Running Status	276
General MIDI	278
MIDI Processors/Routers/Interfaces	278
Recommended MIDI Topologies	279
Common MIDI Problems	279
MIDI over Networks	281
MIDI in the Entertainment Control Market	283
Chapter 23: MIDI Show Control (MSC)	285
MSC Command Structure	285
Recommended Minimum Sets	290
MSC Commands	290
Limitations of MIDI Show Control	297
MSC in the Entertainment Control Market	298
Chapter 24: MIDI Machine Control (MMC)	301
MMC Systems	301
Command/Response Structure of MMC	301
MMC Motion Control	302
MMC Message Structure	302
Common MMC Commands	304
MMC in the Entertainment Control Market	305
Chapter 25: SMPTE and MIDI Time Code (MTC)	307
Time Code Basics	307
Live Entertainment Time Code Applications	309
Time Code Types	309
SMPTE Time Code	311
SMPTE Time Code Hardware	313
MIDI Time Code	314
Practical Time Code For Live Shows	316
Other Ways to Sync Systems	319
Time Code in the Entertainment Control Market	320

Chapter 26: Open Sound Control (OSC)	321
OSC Overview	321
OSC in the Entertainment Control Market	324
Chapter 27: Other Control Approaches	327
AES70/Open Control Architecture (OCA)	327
Network Time Synchronization Protocols	329
Precision Time Protocol (PTP)	330
Simple Network Management Protocol (SNMP)	330
Virtual Network CoNtrol (VNC)	331
Positional Tracking and Interchange	331
Industrial I/O Systems	332
Consumer Electronics Control (CEC)	334
Bluetooth	334
Sony 9-Pin Protocol (Obsolete)	334
Moving On	339
Part 5: Show Control	341
Chapter 28: Show Control	343
Evolution of Show Control	343
Why Show Control?	348
What Is a Show Controller?	348
My Show Control Design Process	349
Question 1: What are the safety considerations?	350
Question 2: What type of show is it?	350
Question 3: Is the show event-based, time-based, or a hybrid?	350
Question 4: What is the control information source?	350
Question 5: What is the type of user interface required?	350
Question 6: What devices must be controlled/connected?	353
Budget and Time	353
Finally	354
Moving on to Some Examples	354
Chapter 29: A Theatrical Thunderstorm	355
The Mission	355
Design Considerations	355
The Systems	356
Show Control Script	358
Approach 1	359
Approach 2	360
Approach 3	362

<i>Chapter 30: Put on a Happy Face</i>	363
The Mission	363
Design Considerations	363
The Systems	364
Approach 1	366
Approach 2	368
<i>Chapter 31: Ten-Pin Alley</i>	371
The Mission	371
Design Considerations	372
The Systems	373
The Approach	376
<i>Chapter 32: Comfortably Rich</i>	381
The Mission	381
Design Considerations	381
The Systems	382
Show Control Script	384
The Approach	385
<i>Chapter 33: It's an Itchy World after All</i>	387
The Mission	387
Design Considerations	388
The Systems	388
The Approach	391
<i>Conclusion</i>	399
Contact Info and Blog	400
<i>Acknowledgments</i>	401
<i>Appendix: Decimal/Hex/Binary/ASCII Table</i>	407
<i>Glossary</i>	415
<i>Index</i>	435