Understanding DMX

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What can DMX do?

• DMX is simple – it is designed to control devices, usually lights
• This may also mean just turning on and off a device
• Work with desperate devices and software applications
Where did “DMX” Come From?

• DMX was designed as a public standard to allow hardware and software vendors to all be able to design interoperation devices
• Designed in the early 90’s
• Developed by USITT – United States Institute for Theatre Technology
• Designed to be very reliable (but not guaranteed – no error checking)
What is DMX?

- DMX is a protocol
- DMX is a public standard
  - E1.11 (ANSI)
  - Just a set of rules
- DMX runs “over” other protocols or wiring systems
What DMX isn’t

• DMX isn’t a wiring standard
• DMX isn’t a physical “thing”
• DMX isn’t complicated
• DMX isn’t the perfect protocol
RS485 and DMX

- It is important to understand that RS485 ISN’T DMX and vice-versa
- RS485 is the most common method of DMX transmission

<table>
<thead>
<tr>
<th>CAT5 Cable</th>
<th>CAT5 Cable</th>
<th>CAT5 Cable</th>
<th>Freeway</th>
</tr>
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<tr>
<td>RS-485</td>
<td>Ethernet</td>
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<td>DMX</td>
<td>TCP/IP</td>
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<tr>
<td>DMX (E1.31)</td>
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RS485

- RS485 is the “road” on which DMX runs
- Very robust – designed for industrial environments back in the 1970’s
- Differential signaling system (positive and negative voltages)
RS485

• Able to handle speeds up to 35 Mbit/s depending on cabling
• Cable lengths up to several thousand feet
• Two wires + ground (optional)
• Allows for a variety of wiring topologies
  • RS485 is the basis for DMX (E1.11), LOR, Pixelnet and Renard protocols
RS485 Termination – Yes or no?

• **PRO:** Termination “dampens” the reflections of the signal in the cable

• **CON:** Termination “sucks up” power on the line, lowering the voltage and thus the distance

• The RS485 (DMX) specs call for termination (100-120 ohms) with standard DMX cable
Termination Cont.

• LOR Controllers don’t use termination
• No one best answer – sometimes it is necessary…sometimes not
• A scope is the best tool for looking at the quality of the signal
• For video showing the effects of termination:
  http://www.holidaycoro.com/kb_results.asp?ID=17
Splitting RS485

• Some controllers passively split the connection (LOR/LE Express) and some actively split and then repeat the signal (LE Express)
• Splitting DMX can be as simple as using 3-way splitters
• Keep “stubs” as short as possible
Connectors and Cable (E1.11)

- The E1.11 DMX standard says to use 5 PIN “XLR” plugs
- Many lighting industry devices use 3 PIN “microphone” cable with XLR plugs instead as it is more common
- The holiday lighting world uses CAT5 cable and connections almost exclusively – as they are cheap
RS485 Wiring

• Chart showing wiring interconnections:

<table>
<thead>
<tr>
<th>CAT5 Pin # (T568B)</th>
<th>Wire Color (T568B)</th>
<th>Function</th>
<th>3/5 Pin XLR</th>
<th>LOR Wiring</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>White/Orange</td>
<td>DMX Data +</td>
<td>Pin 3</td>
<td>Blue</td>
</tr>
<tr>
<td>2</td>
<td>Orange</td>
<td>DMX Data -</td>
<td>Pin 2</td>
<td>White/Blue</td>
</tr>
</tbody>
</table>

• Ground wire often not connected in holiday lighting controllers
Controller Count per line

• Technical limit to the number of devices on a single DMX line is 32 but many more are possible depending on the line load per controller

• Controller counts can be increased with the use of repeaters
DMX over Ethernet (E1.31)

- No RS485 - DMX is instead sent over standard Ethernet/Wireless using TCP/IP
- Allows many universes over a single network connection
- Used when distances are far or channel counts are high
- EtherCongateway (J1SYS)
DMX Channels and universes

- There are 512 channels (9 bits) in a DMX universe
- One transmitter (RS485) per universe
- One transmitter (E1.31) for many universes
- Universes are effectively unlimited
- Universes are not “connected” to another universe
DMX Protocol Internals

- DMX runs at 250Khz or 4 micro seconds widths/"slices" of time
  - 1 Microsecond (µs) = .001 milliseconds (ms) / 1000 ms = 1 second
- MTBP – Mark Time Between Packets (idle)
- Break – Starts with 88 µs low/ 22 pulses (get ready… I’m about to send data)
- MAB – Mark After Break ~12 µs high / 2 pulses
- Channel Data - 44 µs / 11 pulses for each channel (shown in red below)
  - Start bit– 1 bit low
  - Data bits – 8 bits (0-255 that define the level of light intensity)
  - End bits – 2 bits high
- First channel zero, has the start code of binary 00000000 (zero)
- MTBF - Mark Time Between Frames 0-1 seconds high (the next channel is coming up)
- All 512 channels are sent one after another until the next MTBP and the process restarts
DMX Packet Timing

- **Timing References**
  - 1 Microsecond (µs) = .001 milliseconds (ms)
  - 1 Second = 1000ms
- \([(88)+(12)+(44)+(\text{channels} \times 44)+(\text{channels} \times \text{MTBF})+(\text{MTBP})]\) µs
- \(88+12+44+22528+0+50 = 22,722\) µs
- \(1,000,000\) µs (1 second) / 22,722µs = 44.01 Hz or 44(times per second)
- This means that as long as your sequences contain timing no smaller than 22ms or .022 seconds, the timing of the display will be as expected
Output Adapters / Dongles

• DMX must be generated by a device
• Devices can be “smart” or “Dumb”
  – **Smart** – Command is sent to device from the sequencing software (say…Channel 1 at 128 bits) once and the devices keeps repeating it 44 times/sec. This way the PC doesn’t need to keep repeating it.
  – **Dumb** – Commands from the sequencing software have to be re-sent over and over 44 times/sec. This puts a larger load on the PC

• Adapters/Dongles
  – Smart – Enttec Pro, DIYLA Dongle
  – Dumb – Enttec Open, generic RS-485 Adapters
Levels of Fading

• Each channel in a universe carries 8 bits of data, allowing up to 256 (FF hex) levels of fading per channel.
• 0 = Off
• 128 = Half on
• 255 = Full on
• Fading “quality” can be affected by lighting curves, linear lighting output
  • http://vimeo.com/19615787
  • http://vimeo.com/13703416
DMX Effect Generation

- DMX Devices don’t generate any local effects, unlike the LOR protocol which generates its effects in the controller hardware
- Effects are generated in software
- This means that effects can be changed easily as they are created in the sequencing software
LOR Users – How get DMX

- LOR S2 Users – Upgrade to LOR S3
- Native in LOR S3 using Enttec Open/Pro (supported by LOR)
- Native in LOR S3 using Lynx Dongle
- iDMX-1000 – converts LOR protocol to DMX (not recommended)
- Play sequences in xLights – better output support and less moving parts
Misc

• LOR Controllers can listen to LOR and DMX allowing you to run all your controllers as DMX (DIY and LOR)

• There is “to spec” and there is “it works” – this is Christmas lights after all
Resources

• DMX Standards:
  – Recommended Practice for DMX512 from USITT – book, purchase only
  – BSR E1.11 Standard from USITT, book, purchase only

• RS-485
DEMO

• Capturing DMX signals using logic analyzer
Q&A