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The Impact and Benefits of SHoW DMX™ High Data Fidelity

In November 2007, CTI commissioned testing of SHoW DMX and three other competitors' wireless DMX systems with regard to DMX data fidelity and potential interference with WiFi systems[1]. The results proved that SHoW DMX's patent pending technologies provided dramatically improved performance in both areas; in fact, the results were so dramatic that some people wondered how the other tested systems were even usable under any circumstances.

What causes the differences in fidelity?

SHoW DMX is an acronym for Synchronized Hopping of Wireless DMX. Before the development of SHoW DMX, RF based wireless DMX distribution systems were forced to treat their radios and the associated conversion point from wired DMX 512 to or from a wireless signal as a black box. DMX went in, somehow was changed to a wireless broadcast, was received and then somehow changed back into DMX. Along the way, the DMX data sometimes got lost or changed, either through RF loss from wireless interference, or due to timing differences between the DMX source and the wireless system. This affected the wireless system's DMX output in a variety of ways:

- **FHSS Fragment Loss:** Conventional Frequency Hopping Spread Spectrum radio offers a durable and aggressive delivery method that usually delivers most of the DMX data, but it is not immune to interference and related loss. When the incoming DMX is not completely synchronized with the radio broadcast method, the DMX packet must be broken up and sent as packet fragments through the air on multiple hops, and then those fragments must be re-assembled at the receiver. Sometimes interference appears on one of the hopping channels and a fragment is lost. The conventional FHSS based system would compensate by substituting a previously received fragment that corresponded with the lost fragment's position in the DMX serial data sequence. In other words, the system would replace lost DMX slots with older data from a previous refresh.

- **Inadequate Output Refresh Rate:** If the wireless system can't convert and transmit at the fastest possible DMX data rate (44Hz refresh, 250Kb data), then some whole DMX packets are lost. In one of the competitor systems tested, the DMX data is transmitted via radios that can't keep up with the incoming DMX and so the system compensates with a data compression scheme that tries to broadcast only moving slots. If large numbers of slots are moving, this system bogs down and considerable packet loss and fragmentation results.

- **Fixed Output Refresh Rate:** If the wireless system receiver outputs the reconstituted DMX at single constant refresh rate and the incoming DMX to the transmitter is slower, then the system will create extra copies of received DMX packets. It is important to note that this is still a problem even if the wireless system's output refresh rate is full speed (44Hz refresh), because many consoles output at less than full speed.

[1] This CTI White Paper discusses the issue of data fidelity. For more about reducing and eliminating interference with WiFi systems, please see *The Impact and Benefits of SHoW DMX RF Interference Reduction.*

All of these issues contribute to DMX errors. In the ETL testing, the competitor products demonstrated from 32% total errors up to 99% total errors, including from 18% up to 63% fragment errors, and from ~30% to ~90% packet loss (dropped packets). SHoW DMX is the only wireless DMX system that is specifically designed to address all of these problems, and was the only system tested that demonstrated 0 errors and 0 dropped packets. SHoW DMX is also the only system that matches the receiver's output refresh rate to the transmitter's input refresh rate.

Finally, it is important to note that City Theatrical's ETL testing was performed in the ideal RF environment of ETL's Semi-Anechoic Chamber, so the systems under test were protected from the myriad of environmental issues that can appear in a real world setting, such as competing RF sources, reflective interference, radio barriers, powerful electrical fields, and so forth. The problems demonstrated in some wireless DMX systems in the ideal lab setting would be even worse in the real world conditions of a show.

Why should you care?

To understand how these inaccuracies affect show performance, it can be useful to consider a few hypothetical case studies involving packet loss, fragment loss and mismatched refresh rate.

Case 1: A conventional SCR dimmer driving a 1KW PAR 64 fading from full to black in 5 seconds. In this case the filament warm up and cool down time is probably measured in hundreds of milliseconds/DMX refreshes, so the accuracy and even the practical refresh rate of the incoming DMX data is probably not too important. Early (1980's) DMX consoles often had relatively slow DMX refresh rates of a little as 8Hz, and DMX output might be interrupted occasionally for many milliseconds without much problem for end users, as the consoles were still faster than the lights they controlled. Any of the tested systems would be adequate in this least demanding case.

Case 2: A single 50W MR16 fading from full to black in 5 seconds. This incandescent load is still pretty slow but does not have the filament inertia of the 1K mentioned above. Fragment errors of 2 or 3 points would not be visible in this case, but 90% packet loss would result in a very step-y fade. Still, if there were only one or two of these units being run wirelessly in the show, any of the systems would probably be adequate.

Case 3: A single RGB LED luminaire cross-fading back and forth from Blue to Yellow in 5 seconds. LEDs are instantaneously responding loads with none of the inertia found in large or small incans. In this case, fragment errors would be visible as steps or shivers in the color change, and any significant packet loss would turn the color change into randomly occurring steps between colors. Multiple arrays of these fixtures running the same program on different DMX addresses would compound the problems, as fragment errors would be slot specific and so would affect individual units differently. Low error rates might be acceptable in this case, but once error rates passed a certain threshold, the result would be highly disruptive.

Case 4: A moving light executing a rapid 120 degree pan. Fragment errors, packet loss or the extra packets resulting from mismatched refresh rate could confuse this unit's acceleration and deceleration algorithms resulting in jerking, lurching motions. Again, low error rates might be acceptable in this case, but once error rates passed a certain threshold, the result would be highly disruptive.

Case 5: A large array of direct view LED tiles displaying detailed changing geometric imagery. Modest packet loss will cause the image changes to start, stop and generally appear jumpy, and extra packets will have much the same effect. Fragment errors will cause the images to break up and smear, with some pixels falling behind and then catching up as their DMX slots are loaded with old data due to fragment losses. Even low error rates would degrade this effect.

Conclusion:

There are low tech applications where even the most basic wireless DMX system might work. As the technical demands of the application rise, such as use of moving lights and LEDs, longer broadcast distances, and higher levels of competing radio interference on shows, the need for high DMX data fidelity becomes more critical, and the highest available DMX fidelity is mandatory if the result must match wired DMX performance.