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# SHoW DMX™ 16 Universe Saturation Testing

There are times when lighting users may want to control multiple DMX universes wirelessly, so it is valuable to know how many universes a given system can reliably transmit, and what limitations are likely to be encountered. It is reasonable to assume that for any radio technology, there must be some limit to the number of transmitter/receiver systems that can operate well in the same environment, because all of the transmitters take up some portion of their assigned radio band, and that bandwidth is limited. Above that limit the radio environment will become *saturated*. In the past, manufacturers may have claimed all sorts of things, but no data has been provided to support such claims. City Theatrical's proprietary SHoW DMX (Synchronized Hopping of Wireless DMX) Radio Transceivers are designed to support 16 different hopping patterns and so, in theory, up to 16 different Transmitter/Universes could be broadcast simultaneously. City Theatrical decided to design and perform some tests to help predict how SHoW DMX systems would perform in multiple universe configurations, and what limitations might be encountered. We referred to these tests as *Saturation Tests*, and the details of our testing procedure and results are provided in this report.

We were pleased to learn from our saturation testing that SHoW DMX can support 16 Universes of DMX with less than 25% packet loss. This means that very large systems of conventional incandescent lighting or moving lights can be controlled wirelessly with SHoW DMX and operate with close to wired performance.

25% packet loss will result in an effective drop in refresh rate of the same amount, so a 44Hz DMX refresh rate would be effectively reduced to 33Hz. Because of the random nature of the loss, it may or may not be distributed evenly. In practice, when compared to wired performance, the effect would be visible in moving lights as occasional slight delays in motion, and incandescent fixtures might show some occasional small delays or slight roughness in fades. The effect of the data loss would be most evident in quick moves or level changes, while there would be little or no effect on slow changes.

SHoW DMX is the first and only wireless DMX system to offer adjustable broadcast power. We tested our 16 Transmitter/Universe system at all 5 available power levels, and found that all except the lowest (5mW) level gave us less than 25% packet loss.

Packet loss in the different test cycles varied from unit to unit and test to test. This is consistent with the way that frequency hoppers create interference when operated in groups. Since the multiple units cannot be intentionally synchronized together, there will be differences in how their hopping patterns overlap every time they are setup and run together, so different interference patterns will occur with each use. It is therefore only meaningful to look at *ranges* of interference-based loss, and to plan for the worst case.

**The Saturation Tests**

Evaluate the performance of 16 Transmitter/Universes broadcasting in full bandwidth, over a range of 736ft/224 meters

**Methodology**

Setup: The tests were performed on a public baseball field in Lyndhurst, NJ. This provided a very large flat area with no overhanging power or telephone lines, no trees and no nearby buildings. The area is bounded on all sides by open land. The large area of the test site allowed a test broadcast range of 736ft/224m.

16 CTI # 5600 SHoW DMX Transmitters were mounted on two 8ft/2.44m lengths of triangle truss. These two sections of truss were then mounted atop A frame ladders, to form a truss assembly that was 8ft/2.44m long, with one row positioned at 7ft/2.1m and the second row positioned below it at 5ft/1.5m. This truss assembly was installed at one end of the field. The target Receiver was mounted on top of a 7ft/2.1m telescoping stand located down the field, 736ft/224m from the truss assembly. The Transmitters were configured sequentially with unique hopping patterns (1-16). The Receiver was configured to communicate with one of the Transmitters (see below). All units were equipped with standard SHoW DMX 7" omni-directional antennas and all antennas were oriented identically in the vertical position.

The DMX output of a City Theatrical 5690 Wireless DMX Tester was connected to the DMX input of the Transmitter under test, and the target Receiver's DMX output was connected via a 1000ft/304.8m DMX cable to the DMX input of the 5690 Wireless DMX Tester. The system setup is shown below in figure 1.

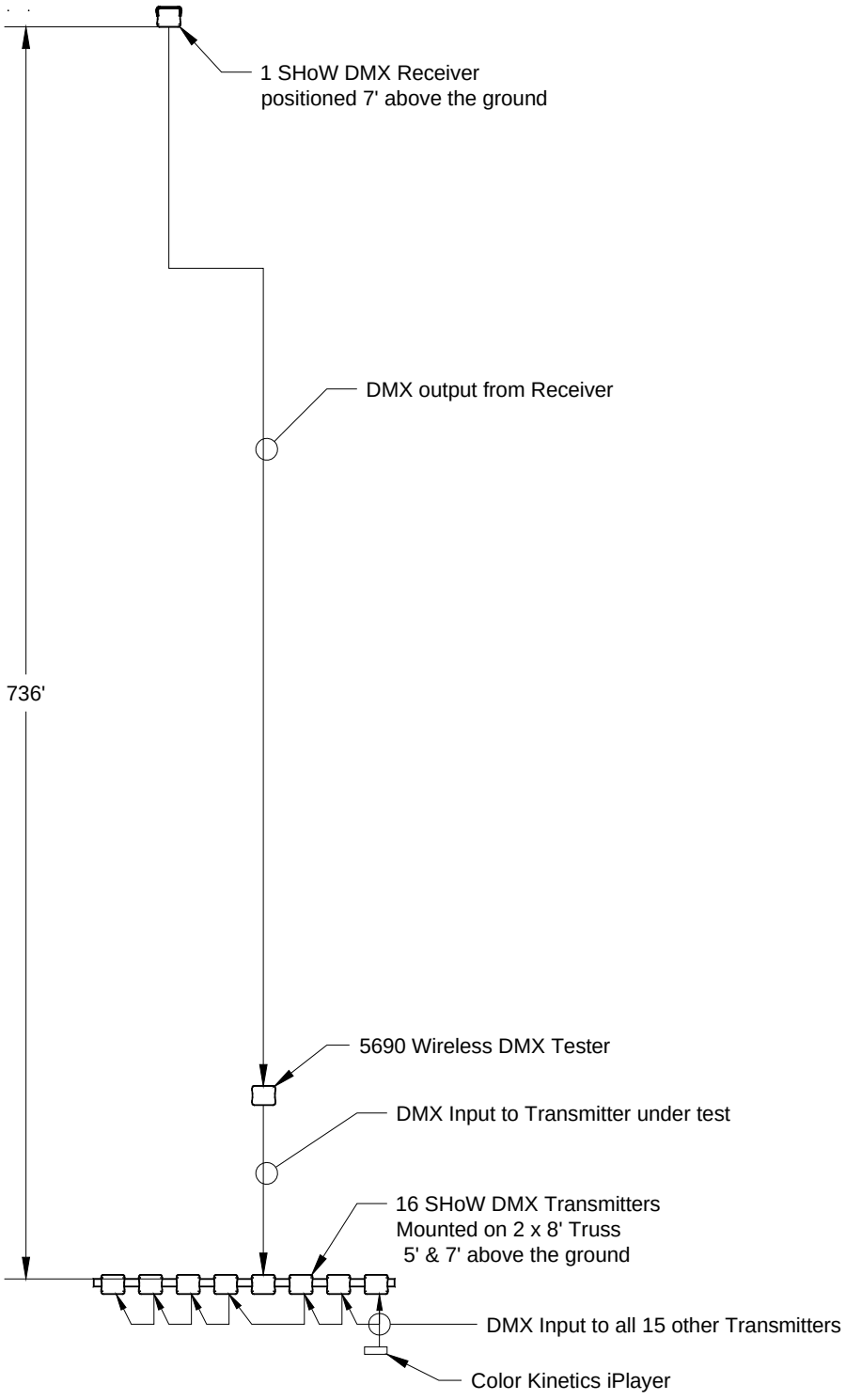


**Figure 1, Saturation Test Setup**

The 5690 Tester is designed to perform a range of data loss and fidelity tests by generating unique DMX packets, sending them to its DMX output, and then monitoring its DMX input to see if the packets are returned. In this case, the Account Test was used to measure DMX packet loss Below is a detailed explanation of the 5690 wireless DMX tester account test[1]:

**1 Account Test [`Account test`]**

This test measures the number of packets that are lost during data transmission as they pass through the System Under Test. This test is structured as follows:

a. The SHoW DMX Wireless DMX Tester outputs 10 packets containing all **`0s`** to prime the System Under Test.
b. The SHoW DMX Wireless DMX Tester outputs 256 packets with first byte in each packet containing the packet number (1-256), the next 509 bytes as random data and the last two bytes as checksum.
c. The SHoW DMX Wireless DMX Tester receives the data from the Receiver Under Test and compares the results with the originally transmitted data.
d. After the 256 packets have been sent and the results received and checked, the SHoW DMX Wireless DMX Tester presents the following result data:
    - Packet Errors **`[Pkt errs:]`** Number of packets received where the checksums were incorrect
    - Extra packets **`[Extra:]`** Number of duplicate packets received
    - Dropped Packets **`[Dropped:]`** Number of packets lost (missing packet ID number)

This test continues to repeat until stopped. Each repetition of this takes ~ 6 seconds to complete and update the display.
The other 15 SHoW DMX Transmitters were then connected to a Color Kinetics iPlayer, which was used to provide them with continuous DMX data that was completely different from the data being broadcast and received by the system under test.

A baseline test was performed to check system performance without interference from simultaneously operating multiple transmitters. A single Transmitter was tested with the Account Test for 2 minutes at 5mW and at 125mW. Packet loss at 5mW was 15 (out of 5280) and packet loss at 125mW was 0 (out of 5280).

Procedure: Transmitters were initially configured with a broadcast power of 5mW (minimum power).
A two minute Account Test was performed at the maximum refresh rate of 44Hz, so 5280 DMX packets were output to the Transmitter under test in that 2 minute period. At the end of each test period the measured packet loss was recorded. The test was performed three times with Transmitters located at different points in the set (Transmitters 2, 7 and 13). Then all 16 Transmitters were set to the next highest broadcast power level and the Test cycle was repeated, so that the test cycle was performed at 5mW, 10mW, 50mW, 100mW and 125mW FCC. The system was shut down, powered back up, and the complete test cycle was repeated.

The WiSpy Frequency Analyzer screen shots below show RF activity for one SHoW DMX Transmitter and for 16 SHoW DMX Transmitters:

[1] Reprinted from *the 5690 Wireless DMX Tester User's Manual, Rev 0.6* © 2007, City Theatrical Inc.

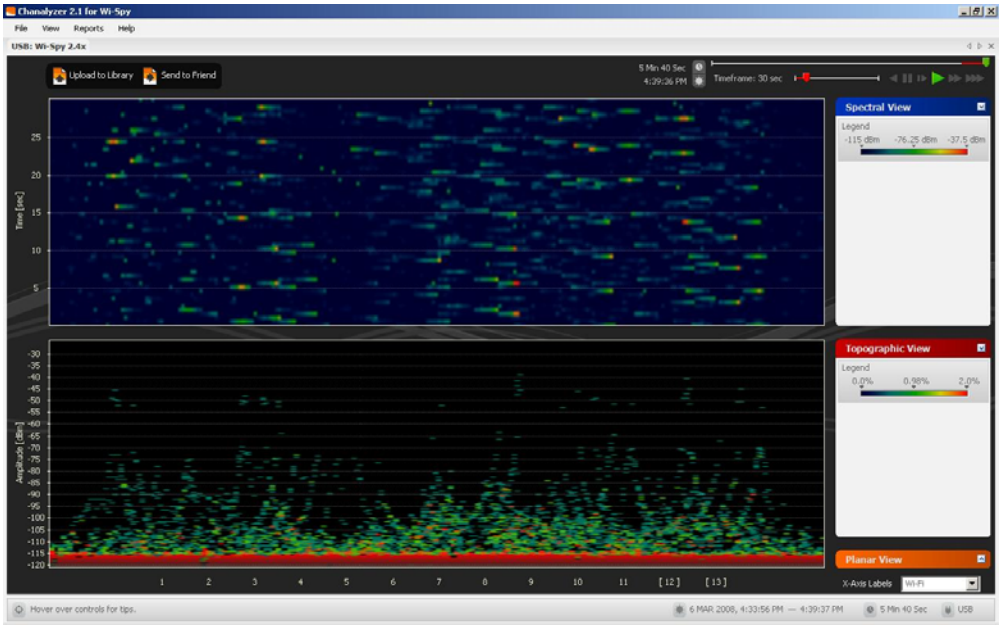


**Figure 2, RF Activity, One SHoW DMX Transmitter, 125mW, Full Bandwidth**

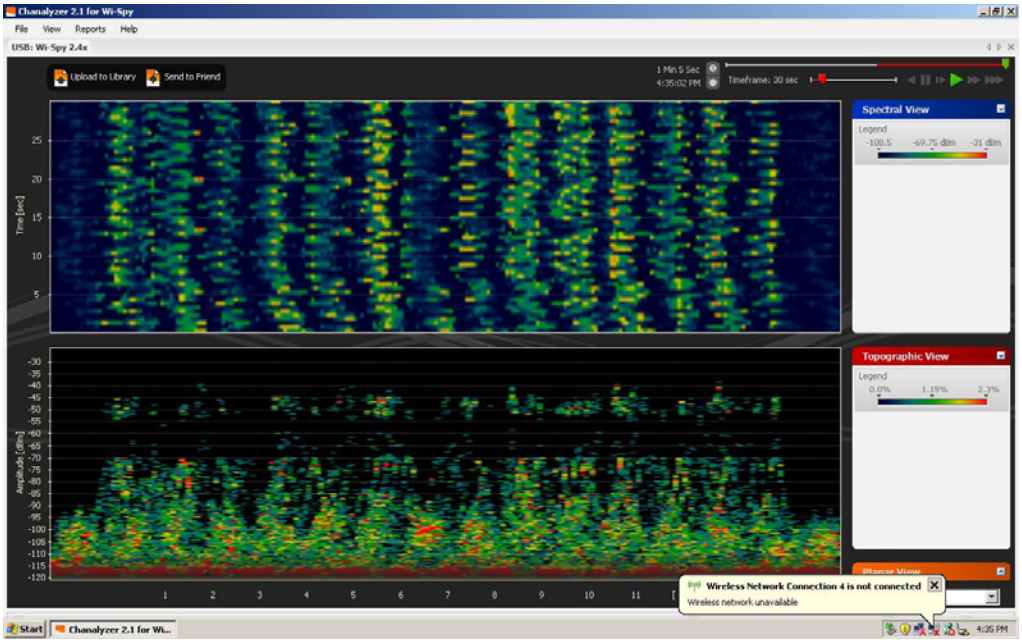


**Figure 3, RF Activity, 16 SHoW DMX Transmitters, 125mW, Full Bandwidth**

Results are shown in the table below:

| Test 1 | | | | | | |
|---|---|---|---|---|---|---|
| **Packet Loss count (out of 5280 packets sent)** | | | | **Packet Loss %** | | |
| **Broadcast Power** | **Tx2** | **Tx7** | **Tx13** | **Tx2** | **Tx7** | **Tx13** |
| **5 mW** | 1935 | 853 | 732 | 36.65% | 16.16% | 13.86% |
| **10 mW** | 938 | 666 | 607 | 17.77% | 12.61% | 11.50% |
| **50 mW** | 1060 | 530 | 896 | 20.08% | 10.04% | 16.97% |
| **100 mW** | 1135 | 729 | 1067 | 21.50% | 13.81% | 20.21% |
| **125 mW** | 972 | 449 | 156 | 18.41% | 8.50% | 2.95% |
| **Test 2** | | | | | | |
| **Packet Loss count (out of 5280 packets sent)** | | | | **Packet Loss %** | | |
| **Broadcast Power** | **Tx2** | **Tx7** | **Tx13** | **Tx2** | **Tx7** | **Tx13** |
| **5 mW** | 1692 | 489 | 510 | 32.05% | 9.26% | 9.66% |
| **10 mW** | 500 | 362 | 854 | 9.47% | 6.86% | 16.17% |
| **50 mW** | 1010 | 346 | 222 | 19.13% | 6.55% | 4.20% |
| **100 mW** | 771 | 373 | 860 | 14.60% | 7.06% | 16.29% |
| **125 mW** | 1165 | 422 | 229 | 22.06% | 7.99% | 4.34% |

## Conclusions

The testing showed that 16 Transmitter/Universes of SHoW DMX equipment can be operated simultaneously with less than 25% packet loss, and in many cases with much less packet loss than that.

Figure 3 shows the significant increase in RF activity produced by 16 Transmitter/Universes operating simultaneously, resulting in many potential opportunities for hopping collision-based interference. SHoW DMX's redundant data delivery scheme (main copy on one hop, backup on the next) helps to reduce packet loss when a large amount of potential interference is encountered, by creating two opportunities for each packet to be successfully transmitted.

SHoW DMX's unique Synchronized Hopping of Wireless DMX data management technology prevents any DMX fragmentation from occurring during wireless transmission, even if there is interference resulting in data loss, so all DMX slots in any given packet remain synchronized and continue to track together.

## Recommendations

For best results, it is recommended that the transmit power settings be optimized for the range required. Transmit power should be set high enough to produce receiver signal strength readings in the -50 to -70dBm range.

CTI will continue to perform SHoW DMX performance testing and will publish those results as they become available.