



**BSR E1.68 - 202x**  
**Recommended Practice for Compliance and Interoperability in DMX512-A  
Systems**

Approved by the ANSI Board of Standards Review on \_\_\_\_\_

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**Voting members:****Observer (non-voting) members:****Interest category codes:**

CP = custom-market producer    DE = designer  
DR = dealer rental company    G = general interest  
MP = mass-market producer    U = user

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## 1 Introduction

### 1.1 Intent

This Recommended Practice includes information for the entire base of DMX512 users, from end users to product developers, and from the earliest version of the protocol in 1986 to the current ANSI E.11 standard. Individuals interact with DMX512 in different ways, and this document has been structured to allow people to use as much or as little of the information as they need.

Section 5 is intended for a general audience, and contains both descriptions of common issues and recommended practices to prevent these issues.

Section 6 is intended for electricians, designers, system integrators, product developers and testing laboratories that need to have specific technical tests to determine whether a device is compliant with the DMX512-A standard, or to troubleshoot a system. Tests in Section 6 have in general been grouped by complexity, with physical tests that can be done through readily available tools such as a volt or ohm meter in section 6.2, protocol tests that can be done with many DMX512 test tools and software tools in section 6.3, and timing tests that require more expensive tools such as an oscilloscope in section 6.4.

Section 7 is intended primarily for product developers, though it may be useful for others as well. The section includes recommendations that are much tighter than those needed for basic compliance with the DMX512 standard, but which are known to be highly interoperable across a wide range of devices. Any device that follows the suggestions in section 7 will not only pass the tests in Section 6, but will also be interoperable with a majority of DMX512 devices.

**table 1: User group applicability**

User Group	Section 5	Section 6	Section 7
General Audience	X		
Stagehands	X		
Stage Electricians	X		
Senior Electricians	X	X	
Technical Directors	X	X	
Lighting Designers	X	X	
System Integrators	X	X	
Testing Laboratories	X	X	
Product Manufacturers	X	X	X
Product Developers	X	X	X

## 2 Normative References

[DMX] **ANSI E1.11 – 2008 (R2018)**, *Entertainment Technology – USITT DMX512-A Asynchronous Serial Digital Data Transmission Standard for controlling lighting equipment and accessories.*

[RDM] **ANSI E1.20 – 2010**, *Entertainment Technology – Remote Device Management over DMX512 networks.*

**ANSI E1.27-1 – 2006 (R2021)**, *Entertainment Technology - Standard for Portable Control Cables for Use with ANSI E1.11 (DMX512-A) and USITT DMX512/1990 Products*

**ANSI E1.27-2 – 2009 (R2019)**, *Recommended Practice for Permanently Installed Control Cables for Use with ANSI E1.11 (DMX512-A) and USITT DMX512/1990 Products*

[RDMnet] **ANSI E1.33 – 2019**, *Entertainment Technology – (RDMnet) Message Transport and Device Management of ANSI E1.20 (RDM) over IP Networks*

[sACN] **ANSI E1.31 – 2018**, *Entertainment Technology - Lightweight streaming protocol for transport of DMX512 using ACN*



[PIDS-1] **ANSI E1.37-1 - 2012 (R2017)**, *Entertainment Technology - Additional Message Sets for ANSI E1.20 (RDM) – Part 1, Dimmer Message Sets*

[EIA485] **TIA-485-A-1998** *Electrical Characteristics of Generators & Receivers for Use in Balanced Digital Multipoint Systems*

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Note: EIA-485-A is compatible with: ISO/IEC 8482:1993 Information Technology - Telecommunications and information exchange between systems - Twisted pair multipoint interconnections.

### 3 Definitions

All definitions included in ANSI E1.11 – USITT DMX512-A are included here by reference.

**3.1 Compliance:** Compliance with a standard means a Device Under Test has passed all applicable tests without any exceptions or variances.

**3.2 Conformance:** Conformance with a standard means a Device Under Test has passed all applicable tests but may have minor exceptions or variances due to interpretations of the standard.

**3.2 Data Loss Behavior:** Data Loss Behavior is the state or condition that a device enters when it loses a valid DMX512 signal having previously received at least one properly formatted DMX512 packet.

**3.4 Device, Device Under Test (DUT):** A product with at least one DMX512 connection, including controllers, responders, data consumers, networking products and inline products.

**3.5 DMX512:** A general reference to any revision of ANSI E1.11 or the predecessor USITT standards.

**3.6 DMX512-A:** A general reference to any revision of ANSI E1.11.

**3.7 E1.11:** A specific reference to the current revision of ANSI E1.11 as of the publication date of this document.

**3.8 Earth-Grounding:** The common, zero potential available from the mains electricity supply and usually connected to the metal chassis of equipment. Earth Ground is referred to as Earth in Europe and Ground in the USA.

**3.9 Termination, Data:** The resistance required at the end(s) of an EIA-485 transmission line.

**3.10 Termination, Physical:** The field connection of a conductor to a Device, particularly on a terminal block of a Device with internal connections.

## 4 DMX512 Overview

### 4.1 History of DMX512-A

In the early 1980's, several manufacturers developed digital and analog multiplex dimming control protocols. These replaced various analog protocols which generally used one wire per dimmer. Mixing different analog protocols in a system could be done with simple converters, though it was sometimes a bit tedious. As the new digital and analog multiplex protocols grew, converters to allow multiple types of protocols in one system were hard to come by or non-existent. And, with the growing size of shows, more costly.

In April of 1986, a group of manufacturers met in a public session at the USITT Annual conference in Oakland, California. At the end of that session, a project to develop a new digital standard was begun – a lowest common denominator which everyone could implement while manufacturers could still retain their proprietary protocols. In August 1986, USITT DMX512 was published. A minor update was done in 1990 and use of the standard increased dramatically, including non dimmer applications. Many manufacturers dropped their proprietary protocols in favor of DMX512/1990. In 2004 ESTA updated the standard and it became an American National Standard, ANSI E1.11. The 2004 version included a Protocol Implementation Conformance Statement for manufacturers, but due to a lack of use, this was removed in later revisions.

Despite the relatively straightforward nature of the ANSI E1.11 standard, compatibility issues still exist due to a lack of compliance and conformance with E1.11 requirements. This Recommended Practice strives to address those compatibility issues for users, designers, and developers.

#### **4.2 OSI 7-layer Model As It Relates to DMX512**

Using the traditional network model, DMX512 largely sits on Layer 1 and 2, though it was not designed to fit this model neatly. ANSI E1.11 defines the Layer 1 Physical layer in detail, and the protocol structure can be considered to fit in Layer 2 to some extent. Higher levels of the model are implemented in other protocols such as E1.31 (sACN), and in products such as lighting consoles.

#### **4.3 Initial Start-Up Considerations**

Using Section 6 of this document, it is possible to determine whether devices are compliant with E1.11, which goes a long way towards providing a reliable system. Section 5 discusses best practices for installing systems. When compliant products are used according to best practices, a successful system start-up is assured.

When starting up a system, one of the most important considerations is the quality of the data cabling and any wireless communications in use. Poor cabling, either due to use of an inappropriate cable or poor installation, is a major cause of system issues. Grounding is another major cause of issues, in particular ground loops. Use of compliant devices built according to the preferred grounding topology alleviates many of the issues caused by ground loops.

#### **4.4 Re-certification Considerations**

Even a well designed system that has been properly started up should be periodically tested for issues over time. Device drift, power supply droop, and changes in grounding can all affect system performance. Using the information in Sections 5 and 6, it is possible to evaluate system condition after years of use and take corrective action, such as preventative maintenance or device replacement.

Adding RDM to an existing system can be complicated, and doing a thorough evaluation of system condition prior to adding RDM can save time and frustration. A system that has degraded over time may still be functional with DMX512 but fail immediately with RDM. Evaluating the cabling and existing devices in a system will reveal problems, such as devices that fail to properly filter START Codes.

### **5 DMX512-A Known Issues**

#### **5.1 Overview of Known Issues**

This section is intended for general DMX512 users, including stagehands, lighting designers, system integrators, manufacturers, consultants, and product developers. It describes the issues commonly encountered during the use of DMX512. Most often, issues are due to failure of a particular device or installation to properly implement the DMX512 standard or the associated E1.27 cabling standard.

DMX512 has evolved into applications that were never envisioned when it was first developed. While the continuing use of the protocol shows how effective the original design was, there are some known

implementation issues to be aware of. This section details the nature of each issue as well as generally accepted practices to provide resolution.

Physical layer errors are generally the easiest to prevent, but they can also be very difficult to correct. Using good quality cabling that is properly installed will prevent many physical layer issues, but everyone involved with running the cable must be aware of this. Specific technical discussion of each known physical layer issue can be found in Section 5.2, and additional discussion of physical layer issues is in Sections 5.5 and 5.6.

Protocol issues fall into two categories. Encode/Decode issues are described in Section 5.3, while Timing issues are described in Section 5.4. Unlike Physical Layer issues, protocol issues often involve individual product designs. Preventing protocol level incompatibilities with current products is the focus of the Compliance testing described in Section 6, and reducing protocol level incompatibilities in the future is the focus of the Interoperability descriptions in Section 7.

## 5.2 Physical Layer Issues

This section provides a general description of physical layer issues. Each subsection includes section numbers for related clauses in Section 5, as well as the related compliance tests in Section 6 and the interoperability considerations in Section 7.

### 5.2.1 Pinout

DMX512 specifies the connectors that can be used with physical transport of DMX512-A. Connectors not specified by the standard should be avoided and implementers should, instead, use 5-Pin XLR (or acceptable alternate connector if there is not space for 5-Pin XLRs) for portable equipment, or the appropriate connectors for fixed equipment. Use of compliant connectors will have the best results for any installed system.

### 5.2.2 EIA-485 Compatibility

DMX512 is based on the industry standard EIA485 physical layer. Its wide acceptance can be attributed in great part to the low cost of implementation and the general reliability of EIA485. Low cost comes from wide use of EIA485 in many industries, and the resulting large number of available transceiver chips. Reliability comes from the use of a differential signal over a twisted pair of wires. When properly installed, differential signals run over twisted pairs have a very high noise immunity - any external noise affects both halves of the signal the same way and does not change the difference between the signal levels.

In lighting control, there are several practical considerations when using EIA485.

- Using a cable with the appropriate characteristics
- Proper shielding techniques
- Correct connection of signal and common
- Proper end-of-line terminations

When each of these considerations is met, the signal range of transmitters and receivers is consistent and the data is clean.

Other types of control such as HVAC may use EIA485 differently, and may use different practices suitable for those applications. Using the practices described here will provide the best results for DMX512 controlled lighting.

### 5.2.3 Single Ended Signals (including TTL-DMX)

Single ended signals are also known as *unbalanced*, as they use only a single signal line and a common reference, as opposed to a differential signal.

One special case of DMX512 compatibility is in products that convert the differential signal of DMX512 to single ended data by dropping the Data (-) connection. Such a signal is explicitly not DMX512, and further discussion of troubleshooting such a signal is beyond the scope of this document.

The differential signal of EIA485, when used with twisted pair cable, provides most of the noise immunity and reliability of DMX512. A receiver measures the difference between the signal lines to determine whether the signal is high or low, and using just the Data (+) line is a single ended signal that often allows interference to

cause communication failure. Simply dropping the minus lead may prevent the rest of the system from working correctly.

Going back to the original standard, and reaffirmed in all versions of ANSI E1.11, all DMX512 systems should have at a minimum a Data Link Common, a Data Link True, and a Data Link Complement, often identified as **Com**, **Data (+)**, and **Data (-)**. Any time the Data Link Complement, Data (-), is missing, the product is not in compliance with DMX512-A. This is also true for the optional second data link.

#### 5.2.4 Missing Data Link Common

Another special case of DMX512 compatibility is lack of a Data Link Common. Data Link Common is necessary to provide a voltage reference between the transmitter and all receivers on the line. Without this voltage reference, it is possible for one or both signal lines to fall outside the Common Mode voltage range of the receiver sensitivity, leading to a loss of data and potential equipment damage.

A missing Data Link Common at the transmitter is the worst case for data loss, as there will be no common reference for any receiver. If the problem is internal to the transmitter, it may be difficult to correct in the field, and checking for a DMX512 compliant transmitter is the only way to prevent this problem.

A missing Data Link Common in the wiring, either due to installation error or failure of a product to pass through Data Link Common, will affect all the devices downstream of the missing connection. Devices upstream of the missing connection could still operate normally.

A missing Data Link Common at any receiver should affect only that device, so long as the remaining devices have Data Link Common connected. Since many installations use multiple fixtures of the same type, if a fixture does not have an internal Data Link Common connection, the results can be inconsistent.

Fixtures at certain locations may operate properly most of the time, while other fixtures on the same Data Link may not operate at all. As with transmitters, the only way to prevent this problem is to select DMX512 compliant products.

#### 5.2.5 Receiver End-of-line Terminations

DMX512 defines connections that together create an EIA-485 transmission line. This line is defined by its electrical characteristics. The far end of the transmission line must be terminated with a resistor whose value matches the impedance of the line itself. Products that include the capability to set end-of-line termination make it easier for users to properly set the termination, but users and designers should check product specifications and understand how to set terminations in their system. A few products have automatic termination, but most require the user to set the termination for the last device in line. In some cases, this may be done using a separate terminator connector.

Double termination, where more than one device has the termination resistor active, reduces signal strength and can cause reception errors. Users should confirm that only the end-of-line device has termination enabled. Devices that automatically terminate the line may be particularly difficult to identify if there is no external indication of termination status. Passive Wyes should be avoided in general as they can create double termination as well as other problems. If a passive Wye exists in a system and cannot be easily corrected through addition of an active distribution amplifier, the best practice is to terminate the longest run.

#### 5.2.6 Transmitter End-of-Line Data Termination

When using a simple DMX512 system that uses only NULL START Code data, there is a single DMX512 transmitter and one or more DMX512 receivers. In this case, the controller is the only transmitter. It is always driving the line, so lack of a termination resistor at the transmitter may not affect signal quality. However, some systems have been installed with transmitters in the middle of the line, and so termination resistors should be used at both ends of the line in those cases.

When using RDM, any device on the line may be a transmitter, so a termination resistor is required at the controller as well as at the far end of the line. It is entirely possible for a system to work flawlessly with only NULL START code data for many years, but fail when using an RDM controller. Duplicate controller termination is a likely reason for this situation, possibly at the DMX512 input connector, and any duplicate termination should be removed.

### 5.2.7 Transmitter Grounding

In the preferred DMX512 topology, Data Link Common is connected to earth ground at the transmitter. This requirement is included in the Section 6 tests, to ensure that products are correctly labeled for the topology used.

When receivers are floating or isolated, the grounded transmitter is a single point ground. This provides the best protection against ground loops and common conductor current flow. Some devices, such as PoE devices, may not have an earth-ground connection. While devices with floating transmitters are compliant with DMX512-A if properly labeled, devices without an earth-ground connection will not have an *earth-grounded* transmitter without separate grounding of the transmitter by the user. It is common for entertainment systems to have a single earth-ground for lighting power, and with isolated or floating receivers a floating transmitter may function properly so long as the Data Link Common connections are good. Grounded receivers, which may be found in legacy products, could experience ground loops, particularly when receivers are installed on rigging or ground supported positions. Excessive ground loop currents can cause interference or even heating and damage to the cable in extreme cases. Users should check the device topology for all devices in a system, especially when using floating transmitters.

Ground loops aside, it is possible for flickering to occur in systems with all floating devices that use separately derived DC power. Flickering occurs when the DC power supplies of a transmitter and receiver(s) in a floating system exceed a threshold common mode difference. Common mode differences attenuate the received signal, causing receive errors that generally appear as flickering. These problems can occur even when the distance between the transmitter and receiver is very short, making them difficult to troubleshoot.

Though originally intended for entertainment applications, DMX512 has found widespread use in architectural applications. Growing use of tunable lighting and dynamic color changing in architecture is driving demand for DMX512-A compliant products. Architectural systems often have power derived from multiple sources, one example being lights on multiple buildings controlled from a single location. Separate power sources can have large ground potential differences that cause excess current flow in the Data Link Common which can damage wiring or equipment. Such systems may require the use of floating or isolated transmitters and receivers. Though not using the preferred DMX512-A topology, architectural systems can have different considerations from entertainment systems and therefore require use of other topologies.

System design for both entertainment and architectural applications should consider transmitter grounding regardless of device architecture, and ensure the appropriate topology is used.

### 5.2.8 Earth-Grounded Receivers

If any receivers are *earth-grounded* and the transmitter is also *earth-grounded*, ground loops may occur that introduce noise into the signal instead of shielding against it. DMX512's preferred topology discourages any receiver grounding, but some legacy [DMX512] or low cost products may have *earth-grounded* receivers. The trend toward distributed dimming systems leads to longer cable runs and the potential for receivers to be *earth-grounded* to different parts of the building structure. In some cases, *earth-grounded* receivers can cause damage to equipment.

Note: Symptoms of receiver *earth-grounding* issues typically involve uncontrollable flickering, that sometimes changes as building electrical loads change.

### 5.2.9 Shielded Cable Grounding

Some jurisdictions require shielded Category cable (STP) to be grounded at all connection points. This can create ground loops in DMX512-A systems - so, in locations where STP must be grounded, use of Unshielded Twisted Pair (UTP) cable is preferred.

### 5.2.10 Cable Characteristics

Characteristics for DMX512 cable are described in ANSI E1.27-1 and E1.27-2. When cables meet these recommended characteristics, the system is likely to work well. As the cable characteristics move farther and farther away from the recommended values, signal integrity issues are more likely to occur and may not be consistently observable. For example, increased capacitance or mismatched impedance are known to reduce the maximum effective cable length. A system that requires longer cable runs, but does not use an appropriate cable type can have serious problems with data integrity.

## 5.2.11 Network Compatibility

### 5.2.11.1 Legacy Systems with Added RDM Receivers

Legacy systems, such as those installed prior to the publication of the ANSI E1.20 RDM standard, may have special considerations when adding RDM devices. Some legacy systems will function with legacy devices but the addition of RDM devices creates unexpected issues. The following sections describe well-known conditions and their resolutions.

### 5.2.11.2 RDM Controller With Legacy Receivers

Per E1.11, transmitters must be able to drive a line of up to 32 RDM devices. When legacy devices and RDM devices are mixed in a system, legacy devices may not perform the same as they did prior to the addition of the RDM devices.

A range of conditions may exist in the physical plant that do not present problems for Null START Code DMX512, but do have problems with RDM. One example is an unterminated signal line that may have standing waves in the signal at certain points. If the DMX512 system is just a console and dimmer rack, standing waves in the middle of the line may not interfere with operation, but when RDM devices are added in the middle of the line, it could cause problems.

START code filtering is a widespread problem with non-compliant receivers that do not check the DMX512 START Code. For detailed discussion of START Codes see ANSI E1.11 Section 8.5. When an RDM Controller is added to the system the RDM messages are received as dimmer level data and often appear as flickering.

### 5.2.11.3 RDM Controller With Both Legacy and RDM Receivers

When an RDM controller is used with a combination of legacy and RDM receivers it may be necessary to separate legacy devices onto their own data link. For example, if legacy devices in the system do not have proper START Code filtering, using a distribution amplifier or network manager that filters RDM messages for data links to those legacy devices will allow use of RDM on other data links.

## 5.2.12 RDM Bias Resistors

The required RDM line bias circuit provides appropriate bias voltages on the line, so voltages required in Section 6 are met for 5 volt and 3.3 volt systems. Values in RDM are examples for 5V and should not be used for other voltages.

## 5.2.13 Data Through Connections

*Data Through* or *loop-through* refers to a non-isolated output intended for connection of additional fixtures on a continuous data link.

DMX512 does not speak to the requirements for a loop-through, and, as such, loop-through topologies are irregularly implemented in different products. While many products use a passive loop-through where Data Link Common, Data (-), and Data (+) are wired directly from the input connector to the loop-through connector, some products use an active buffer. Some active loop-throughs will prevent downstream RDM operation.

Series resistance on through connections will degrade the signal, and should be kept to a minimum in internal wiring or PCB traces.

## 5.2.15 Noise Susceptibility

Testing for noise susceptibility is beyond the scope of this standard, as it applies to installed systems and not just products. Though not specifically tested in Section 6, the tests for signal level, encode/decode, and timing can all affect device noise susceptibility. Using compliant products will reduce problems with noise susceptibility.

## 5.2.16 Product Documentation Issues

E1.11 requires certain declarations and disclosures, which are also included in the product compliance tests in Section 6. In addition to those disclosures, there are other items that users should look for in product documentation.

Loop-through should be properly documented with regard to active vs passive, as RDM cannot communicate upstream through an active loop-through that is not bi-directional.

Self termination operation could result in multiple line data terminations if not properly set up. If a device is marketed as self-terminating, users should ensure they understand how the self-termination works when using the device.

Some EIA-485 transceivers are slew rate limited to reduce electromagnetic emissions. Users should note if product specifications include slew rate limited transceivers. Cascading of slew rate limited transceivers may degrade the signal more rapidly than other transceivers and users should follow manufacturers' recommendations for use of distribution amplifiers.

### 5.3 Encode/Decode Issues

This section describes data encoding and decoding issues. Encoding and decoding data relate to data format, while timing issues can be found in Section 5.4.

#### 5.3.1 START Code

The first byte of a DMX512 packet is known as the START Code, which defines the type of the remaining data in the packet. The default data type sent using a START code of 0x00 is Dimmer Level Data. Since the value is 0 the packet is also referred to as a NULL START Code (NSC) packet. (Reference Section 8.5.1)

Early on, very few devices used anything other than NSC data; as a result, some non-compliant products do not check the value of the START Code. This causes a problem with RDM, which uses an Alternate START Code (ASC). If a device does not check the START Code, it will receive both NSC packets and RDM packets as Dimmer Level Data. Receivers should never process RDM data, or any Alternate START Code data, as if it were Dimmer Level Data.

Symptoms of START code mishandling typically manifest as some degree of flickering, since ASC data often has different levels than the NSC data, and the receiver responds as though a legitimate level change has occurred. If the ASC data is intermittent, the flickering will also be intermittent, but if the ASC data is sent more than once a second, it can be very difficult to distinguish flickering due to START code filtering from that due to noise or reflections from an improperly terminated line.

A receiver that does not check START Codes often requires either a firmware upgrade or an additional upstream device that filters ASC packets.

#### 5.3.2 Stop Bits

DMX512 requires two stop bits.

Transmitters that do not send two stop bits cannot communicate properly with compliant receivers, as the receiver would interpret a single stop bit and a subsequent start bit as a framing error.

Receivers that accept a slot with a single stop bit, treating it as valid data, will experience very unstable data reception. This condition can be exacerbated if transmitters have variable slot timing, which is allowed by DMX512. Any slot with fewer than two stop bits should be rejected per DMX512, along with the rest of the packet, until the next Break.

Symptoms of a single stop bit include flickering or complete failure of reception.

#### 5.3.4 Data Slot Count Issues

DMX512 has always allowed variable packet length containing between 0 and 512 data slots. Some receivers drop packets with data slot counts less than 512, but this is not in compliance with the standard.

Some transmitters send more than 512 data slots, though that is also not in compliance with the standard. Receivers vary in how they respond to this condition - some dropping the whole packet, others processing only the first 512 data slots. The best approach is for receiver manufacturers to disclose in user documentation how they handle packets with more than 512 data slots.

Addresses 256 and above can have reception problems if an 8-bit processor does not encode the number correctly. For example, it may not respond to addresses above 256, even though the device allows an address to

be set above 256. A symptom of this issue is a device responding to address 1 when it is set to address 256. Other addressing problems above 256 may also exist.

### 5.3.5 Slot Footprint Issues

DMX512 requires the slot footprint be disclosed in the user documentation. Some devices can be set to different slot footprints, all of which must be disclosed. Changing the slot footprint in operation may affect other devices if the slot footprints overlap.

Trying to set a DMX512 starting address value so that the Address + Slot Footprint is greater than 512 is not recommended. For RDM compatibility there may be additional issues, such as failure of responses from device attributes outside the address range. There is no requirement that a device limit its addressing range based on the slot footprint, so users should always check the documentation.

Devices whose slot footprint spans multiple universes can have very complex operating requirements, and are best used by experienced users.

Products deliberately limited to certain addresses should be documented along with the slot footprint.

### 5.3.6 Failure at Valid Addresses

A DMX512 receiver should provide a valid output to valid data at any valid address the device can process. If a device fails to respond to valid data at a valid address, it may not be possible to integrate that device into systems. An example of this would be a fixture that fails to respond at certain addresses, meaning that a series of fixtures cannot be used at consecutive addresses.

Receivers are allowed to drop full packets if they need time to process the previously received data, but they are not allowed to drop or skip individual slots that fall within their addressing range. Some receivers operate on non-contiguous data address ranges, so it can be difficult to tell whether those devices are not receiving correctly or just set up incorrectly. Users should review the product documentation carefully to ensure they understand any complex addressing modes a device might support.

### 5.3.7 Failure with Different Slot Values

Data errors that occur on attributes corresponding to slots with values that are not changing can be indicative of reception errors by the receiver. The receiver may not be reliably counting addresses, or might not be synchronizing with the transmitter properly.

Data errors on attributes corresponding to slots with values that are not changing are typically due to receiver errors such as miscounting slots. Setting a staircase of dimmer levels, such as 100%, 75%, 50%, 25%, 0%, is a quick test for this sort of error.

### 5.3.8 Failure with Slot Value Changes

Data errors when slots are changing values simultaneously are different from the errors described in 5.3.7. Slot value errors are more likely due to system timing issues than receiver problems, and may be related to cabling issues. If excessive noise is getting into a signal chain or the signal is being attenuated by large numbers of connections, long cable runs, or improperly selected cable, the signal quality is degraded. Under conditions of marginal signal quality, repeated data with the same levels may be received properly but changing values may not.

## 5.4 Timing Issues

Timing issues can be very difficult to identify without network test tools. Some of the issues described in 5.2 and 5.3 may interact with the timing issues described in this section. For example, a marginal cable combined with devices that have marginal timing could result in a system failure, while other devices or other cabling work acceptably. Correcting device timing issues will lead to better systems overall. In many cases, it is not difficult to find and correct timing issues during product development.

### 5.4.1 Receiver Fails To Reject an Invalid Packet Length

Packets that are either too long or too short can affect DMX512 system performance, for different reasons.

Common timing issues are described in the next sections.



#### 5.4.1.1 Receiver Fails To Reject Too Long a Packet

In section 5.3.4, issues with too many bytes are discussed, but it is also possible for a transmitter to send the correct number of bytes yet have a packet that is too long overall. DMX512 specifies a maximum transmitter packet length of 1.00 second, as measured from the falling edge of one Break to the falling edge of the next Break. Receivers are specified to allow a maximum of 1.25 seconds as a maximum packet length, allowing for some tolerance on the part of the transmitter. Any packet longer than 1.25 seconds must be treated as data loss, and, while the standard does not require a particular loss of data handling procedure, it does require that the manufacturer state their data loss handling in the product documentation.

#### 5.4.1.2 Receiver Fails To Reject Too Short a Packet

DMX512 requires that a receiver reject packets that are too short, however that requirement is only with regard to timing, not data. A packet consisting of a Reset sequence including a START Code, but no data, is compliant with the standard as long as it meets the timing requirements through some combination of Break, Mark After Break (MAB), and Mark Before Break (MBB) timing. Receivers that accept packets shorter than the minimum timing could have unstable operation, such as treating noise as if it were valid data. (Devices exist that send only a Reset sequence under certain conditions, to keep receivers from entering a sleep mode. This can be important with fixtures that use discharge lamps, as repeated lamp strikes reduce the life of the lamp.)

Short packet lengths result in high refresh rates when packets are sent with minimum inter-packet timing. Receivers must be able to operate at a refresh rate up to approximately 836Hz, based on the minimum packet length. Receivers that fail to synchronize to properly-formatted packets at high refresh rates will exhibit unstable behavior.

#### 5.4.2 Receiver Loses Synchronization Due to Inter-Packet Timing

Some transmitters use the MBB and Break time for processing. In particular it is possible for transmitters to have variable Break timing, which is compliant with DMX512 when it is between 92 microseconds and 999,944 microseconds. Receivers must be able to handle this variable timing without going into data loss behavior. In addition, receivers must be able to recover from multiple Breaks between packets. Though transmitters producing multiple Breaks between packets are not compliant with the standard, it is possible that noise could cause receivers to detect multiple Breaks.

Some receivers go into data loss behavior with less than the maximum allowable Break time. This is a difficult problem for manufacturers, as a compliant device may appear to be at fault while a non-compliant device appears to operate correctly. If a transmitter sends a long, but compliant, Break (for example 5ms) but receivers enter data loss behavior after 2ms, it is the receiver that is non-compliant. Troubleshooting by trying a different transmitter (say one with less than a 2ms Break) will make it appear that the transmitter is at fault, though. The real problem is the receiver that does not accept the required range of Break timing. Field experience has shown this to be an occasional problem, one that would not be revealed without a test tool.

#### 5.4.3 Receiver Loses Synchronization Due to Inter-Slot Timing

Inter-Slot timing is allowed to vary between 0us and 1s, within the allowed overall packet timing. While it is good practice to maintain consistent timing, it is not required. Receivers must be able to handle variable Inter-Slot timing without losing addressing or going into data loss behavior, so long as overall timing is within requirements.

#### 5.4.4 Receiver Does Not Respond Correctly To Data Pair Reversal

Under normal data transmission, data pair reversal should not be received as valid data. However, some devices will still receive data with reversed pairs, outputting inverted levels.

Symptoms of data pair reversal vary from intermittent flickering to full reception of inverted values. If lights are full when control levels are at 0, and fade out as levels are increased, it is most likely a combination of a data pair reversal and a device that does not properly reject a reversed pair.

#### 5.4.5 Receiver Loses Sync With Varying Update Rate

Transmitters often do certain tasks during the Break and MBB times, and may do tasks that affect the update rate at any time. Changes in the Break, MAB, MBB, and inter-slot timing affect the update rate, and receivers are required to properly receive data even as the timing parameters change. A receiver should never enter data loss behavior while the timing parameters remain within those allowed by DMX512, even though the allowable timing is quite wide.

A more difficult condition occurs when receivers drop packets, which they are allowed to do. It is possible, though highly unlikely, for a compliant transmitter with widely varying timing, and a compliant receiver that intentionally drops some packets, to exhibit unwanted behavior such as flickering. It may be necessary to add an inline processing device to resolve this issue.

While it is very difficult to test all conditions that can produce a varying update rate, compliance tests in 6.3 and 6.4 can be used to evaluate whether a device responds correctly to each parameter.

#### **5.4.6 Receiver Shows Inconsistent or Incorrect Behavior On Data Loss**

Receivers are required to disclose their data loss behavior in product documentation.

Typical behaviors may include:

- Holding the last received data, either indefinitely or for a defined interval
- Switching or fading out
- Selecting a lower priority data source that is still present
- Playing an internally recorded preset

It is possible for receivers to support multiple data loss behaviors, selectable by users. If receivers do not follow a consistent behavior or do not note that behavior in the user documentation, they are not in compliance with the standard. Testing for data loss behavior can be complicated for products that support multiple data loss behaviors.

Users should review the product documentation and familiarize themselves with all data loss behaviors a device supports, and, where possible, select the one best suited to their needs.

#### **5.4.7 Receiver Shows Inconsistent Behavior on Data Presence**

Receivers should respond to the data present on boot or after a data loss. If a fixture immediately goes into a sleep mode after data loss, it can have inconsistent behavior, or even require a power cycle, to come back to full operation. On a power cycle or cold boot, the device should always exhibit the same behavior.

It is beneficial if receivers remain in an operating condition for 60 seconds or longer after data loss, in case data is restored. For example, a fixture with an arc lamp would benefit from riding through a 30 second loss of data, as it would not extinguish and re-strike the lamp. Though not required by the standard, receiver behavior should be consistent for interoperability. If data is restored within 60 seconds, the receiver should start responding to data with the first valid packet.

The receiver must follow the data loss behavior in the user documentation, from which the user should be able to discern behavior on data restoration, such as lamp strike status.

#### **5.4.8 Receiver Shows Inconsistent Behavior on Boot**

Receivers should always respond properly to the data present. If no data is present, receivers should enter the data loss behavior described in the user documentation.

A receiver's behavior on boot should always be consistent. Receivers configured to persistently hold the last data received may falsely appear to be non-compliant if they continue to hold those data after a reboot in the presence of no new data. However, as long as this behavior is properly disclosed in the user documentation, it is compliant. This may or may not be desirable operation for the user. System designers should take this into account and ensure that appropriate power and data sequencing is done to meet user requirements.

#### **5.4.9 RDM Responder Goes Into Transmit at Incorrect Times**

Though outside the scope of the compliance tests in this document, users should be aware that an RDM responder that either boots in transmit or goes into transmit at incorrect times can cause disruption of the DMX512 signal. RDM requires devices to boot in receive mode, and describes specific cases where a responder is allowed to transmit. Any transmit operation outside of those conditions is a failure and the device may need to be removed from the system to allow normal operation of other devices.

### **5.5 System Design Issues**

### 5.5.1 Grounding Topology

Appropriate grounding is important for a reliable installed system. Initial system design should assume that the transmitting devices and receiving devices have the data link common grounded at the transmitting devices and that there are no connections between earth ground and data connections at the receiving devices.

Most twisted pair cables used for DMX512 utilize the shield or drain wire from the shield for data link common. Permanently installed cables generally should not be grounded except at the transmitter, in order to maintain isolation between data link common and earth ground. Cables with shielding that is not connected to the data link common, such as shielded Category cables and specially-constructed multi-shielded cables, should be Earth Grounded at the transmitter end, but not both ends. If the transmitter is portable a permanent earth ground connection may not exist in the cabling.

Portable cables should be constructed such that the connector shell is not connected to the data link common.

Grounding issues will often manifest as unpredictable behavior in DMX512 receivers exhibiting unstable voltage reference. Testing for grounding issues can often be achieved by checking for continuity with Earth ground while the transmitter is disconnected from the system and all receiving devices are un-powered. Since the cabling should only be Earth grounded at the transmitter, when the transmitter is disconnected there should be no continuity between Data Link Common and Earth ground.

### 5.5.2 Noise Immunity

Noise immunity in DMX512 systems comes from the use of EIA-485 over a twisted pair. A tighter twist on the twisted pair will provide higher noise immunity. It is because of the tighter twist (shorter lay length) of Category (5, 5e, 6, 6a, 7) cable that the E1.27-2 DMX512-A permanent cabling standard does not require shielding when using Category cable – the inherent noise immunity of the pairs at DMX512-A data speeds is sufficient in most applications.

Shielding has a varied effect on noise immunity. Foil shields are generally only effective above 5MHz, so will filter Radio Frequency Interference (RFI) but not ElectroMagnetic Interference (EMI) from line voltage sources. Braid shields are typically effective above 1kHz, and so will prevent EMI from line voltage harmonics. Properly *earth-grounded* conduit has a shielding effectiveness similar to a braid shield.

#### 5.5.2.1 Parallel Data Pairs

The practice of paralleling data pairs or "doubling up" conductors by using a second pair to carry the same signal as the first pair should always be avoided, because it alters the impedance of the cable and decreases noise immunity. Doubling up pairs changes the impedance of the cable. When a cable with doubled pairs is connected in line with an E1.27-1 compliant cable, the mismatch of impedance will cause attenuation of the signal and may cause signal reflections that interfere with data reception.

Any data that uses a twisted pair (DMX512, Ethernet, etc.) depends on the voltage difference between the individual conductors, not the absolute voltage. All of the noise immunity, and therefore signal quality, comes from this differential signal traveling on a single twisted pair. The characteristics of the transmitter, cable, and receiver are all designed to operate within a particular range, and paralleling pairs changes these characteristics. It is possible for the parallel pairs to reduce the quality of the signal to the point that receivers do not reliably receive data.

Paralleling pairs does not protect against individual broken wires. Instead, the remaining wire in the pair becomes an antenna that increases the potential for interference. Capacitance is also increased by parallel pairs, which increases distortion of the signal. Reducing DC resistance does not make a stronger DMX512 signal. The impedance of the data line has been designed to work with the transmitter and receiver, and changing the impedance reduces the signal strength.

### 5.5.3 Cabling Type and Properties

E1.27-1 and E1.27-2 define cable properties for different types of cable. Following E1.27 standards will ensure reliable operation when used properly. Other cable types may work in some limited cases, but will not be suitable in all cases.

### 5.5.4 Cable Length

Maximum cable length will vary with the type of cable used and the number of unit loads. In general, the worst case, particularly when RDM is in use, is a group of receivers close together at the end of a long cable run. This

topology is common in some applications, and the best way to address it is to limit the number of devices, or to add a distribution amplifier near the end of the main cable run.

### 5.5.5 Cable Lay Length

Shorter lay length, the length of each twist of the cable, will provide better noise immunity. This is the primary reason E1.27-2 uses both cables designed for EIA485 and Category cables, as all the pairs in Category 5 and higher cables have a shorter lay length than the typical EIA485 cable. The only issue with Category cable is that the conductors are often solid and may break after only a few cycles of flexing. A remedy for this is to punch down Category cable on a connector designed for the solid wire, and then use a patch cable with stranded wire to make the final connection to the device.

### 5.5.6 Inline Devices

Inline devices, such as distribution amplifiers, data mergers, or network managers, may alter the characteristics of the DMX512 signal, either intentionally or unintentionally. Depending on the quality, design, or intended use of the inline device this may include, timing, refresh rate, data content, or signal level.

For example, a data merger with two inputs merged to one output may select slots from one source or another for the output. If the input data streams to the merger are different lengths the refresh rate on the output may be different than the refresh rate on either input. Timing between input and output may be different depending on the processing in the data merger, possibly due to user settings. If the output drivers are 3.3V and the input signal is from a 5V source the signal levels may be different as well.

Using devices that pass all the compliance tests in Section 6 will alleviate many issues, but if a particular device is dependent on a characteristic such as refresh rate the user should ensure that inline devices will provide the necessary signal characteristics.

Inline devices are required to disclose their packet processing behavior, including dropping or modifying Null Stare Code packets and processing latency.

System designers should carefully evaluate inline devices to ensure they have the desired effect in the system, without introducing unwanted effects. This may be particularly important if specific refresh rates are used.

### 5.5.7 Multiple Power Supplies

If there are multiple power supplies with different grounding topologies, there may exist leakage current between the devices that will affect the DMX512 signal. It is recommended to test any configuration including devices with multiple power supplies before using them.

## 5.6 Practices to Mitigate Known Issues

### 5.6.1 Cable Infrastructure Acceptance Testing

Cabling is one of the most difficult parts of any DMX512 system. While following E1.27-2 will help alleviate issues due to selecting an appropriate cable, that cable still needs to be installed properly, and properly grounded or isolated. Requirements for grounding shields vary around the world, and installations have to follow local codes. Acceptance testing is the best way to ensure that cabling has been installed properly.

It is beyond the scope of this standard to provide a procedure for acceptance testing, however some good practices are:

A) A physical check of the installed cable against the cable specified by the consultant, manufacturer, or other responsible party. If the installed cable is not one already called out or approved, the best practice is to obtain a copy of the specification sheet for the cable and compare key properties of physical construction, impedance and capacitance against the values in E1.27-2. If the impedance and capacitance are within the ranges in E1.27-2, check the lay length of the cable. Shorter lay lengths, (such as those under 50mm), will offer greater noise immunity. If the cable complies with E1.27-2 and has a reasonably short lay length, it should be sufficient. Different cables have different properties for different applications, and a microphone cable might be very high quality when it comes to carrying analog audio signals, but it does not have the right properties to carry DMX512.

B) Verification of the cable run lengths and connected devices. DMX512 has some limitations on long runs. In particular, long runs from a transmitter to a group of receivers can limit the maximum run length. Each

receiver adds a small amount of load to the line, and at the end of a long run, all the loads together can reduce the signal strength. This is a particular concern when using RDM, as the fixtures must be able to drive a signal back to the controller.

C) Verification of appropriate signal distribution. DMX512 is a bus topology, which must run in a daisy chain from device to device for best performance. Large "Y" splits in cable runs will likely have flickering issues. If RDM is being used, the signal distribution devices must be able to support the bi-directional signal.

D) Verification of grounding. Depending on the location, contractor, and other factors, there could be multiple grounding points on data runs. If the shields are grounded at multiple points, it is possible that ground loops will affect the DMX512 signal. Measurement of ground potential can require specialized equipment, so, if the cable is grounded at multiple points, it is best to document the ground topology and then do the active testing in 5.6.2.E to assess whether a problem exists.

E) Active testing and measurement. When doing acceptance testing, the best practice is to send data down each line, placing a typical fixture load on the line, and then measure the signal at the end of line, and in the middle, if possible. It is best to use an oscilloscope to measure the line, to see whether there is any distortion of the signal. An oscilloscope will show sources of interference, such as ground loops, radio frequency interference, and electromagnetic interference, as distortions of the high and low signal levels. It will also show whether the end-of-line termination is correctly set, as reflections will show up on top of the signal. For long runs, an oscilloscope will show the differential signal level, which must be greater than 0.2V. If there is a concern about the cable, an oscilloscope will also show over- and undershooting of signal transitions which are typical of cables that do not have the correct impedance and capacitance for DMX512. If an oscilloscope is not available, a DMX test tool will at least show whether the data is consistent.

While acceptance testing is always advisable when starting up a new or replacement system, it is also useful to perform periodic checks on existing systems to ensure they are reliable, and that nothing has changed. Changes to building equipment may impact lighting systems in unanticipated ways, such as adding new sources of interference. Periodic tests of the lighting system may identify issues before they become problematic.

### 5.6.2 Hazardous Application Implementation

Section 1.5 of ANSI E1.11 prohibits the use of DMX512 for hazardous applications. It does not just limit the use of NULL START Code data. These applications include any application that has life safety concerns, or the potential for injury in the case of failure. Such applications include but are not limited to:

- Moving scenery
- Moving rigging
- Pyrotechnic effects
- Safety, security, or emergency lighting

NULL START Code data was designed as a quick and simple communication of dimmer level data. The packet does not include error checking or any other reliable delivery mechanism. In-line equipment, such as processing equipment, is allowed to drop or modify NULL START Code packets, and receivers are not required to receive all NULL START Code packets. These are all reasons stated in E1.11 why NULL START Code data is not suitable for hazardous applications.

## 6 DMX512-A Compliance Testing

(System Designers, Product Developers, Integrators, Advanced End Users)

### 6.1 Compliance Tests

#### 6.1.1 Compliance Overview and History

**Compliance** means that a device complies with all applicable requirements of a standard. The requirements themselves may represent worst case conditions, and do not necessarily guarantee performance of a device, unless specifically required by the standard. DMX512 has wide ranges allowed for many parameters, and sometimes devices operate well within one range of parameters, but not others. Such devices are not compliant with the standard, but may still be interoperable with other devices that function within the same range of parameters. This section deals with compliance, including tests that can be used by a testing laboratory to determine whether a device is compliant. Section 7 addresses interoperability, and the values of parameters that

are known to be interoperable with the largest number of devices. Adhering to the values in Section 7 will make a device compliant with the standard, as well as interoperable with many devices that are not fully compliant.

Some of the tests in this section may be useful for users troubleshooting systems, but some tests do require equipment that is likely not available in the field. It is recommended to review any test before starting it to ensure that it can be completed properly and provide a useful result.

Developers and evaluators should review the most current revision of ANSI E1.11 prior to conducting the tests in this section, and should refer to DMX512 if there are any questions about the intent of a test. DMX512 was developed to provide the widest range of interoperability. Since this wide interoperability is sometimes hard to understand in the context of a specific implementation of the standard, referring to DMX512 can be helpful when conducting some of these tests.

When DMX512-A was made an ANSI standard in 2004 it included a Protocol Implementation Conformance Statement (PICS), which could be used as a checklist by developers to ensure compliance with the standard. This was a voluntary process, and was removed from later versions for a variety of reasons. The tests in this section are based on those PICS, and the experience of many who have used the standard.

### **6.1.2 Measurement Devices**

Throughout this section there are references to measurement devices. Some tests will have several possible measurement devices. For example, an LED driver with a current output could be measured with an ammeter, or by connecting an LED and measuring the light output. For tests where a specific measurement device is not required, the tester may select one that suits their needs, but shall declare the device and describe the test conditions in the test report.

#### **6.1.2.1 Expected Output**

Devices using DMX512 take many forms, and have a wide range of outputs. More complex devices, such as moving lights, may have outputs that depend on the interaction of multiple data slots. When the term Expected Output is used to evaluate a test it means that a device provides the output that is described in the documentation for a given input, and that the output does not vary beyond a reasonable degree for that device. For the tests in this section it is recommended to configure the device for the most recognizable output state. It is the responsibility of the tester to determine the appropriate device settings for each test where Expected Output is used to measure device performance. Any device settings used shall be noted on the test report.

#### **6.1.2.2 Data Loss Behavior for Device Evaluation**

Data Loss Behavior varies from device to device and is not specified in DMX512 other than to say that the behavior must be declared. When using Data Loss Behavior to evaluate a device under test, it is recommended to configure the device for the most recognizable indicator of data loss. It is the responsibility of the tester to determine the appropriate device settings for each test where Data Loss Behavior is used to measure device performance. Any device settings used shall be noted on the test report.

For devices with a dedicated data status indicator, such as an LED or screen symbol, the setup is usually as simple as ensuring that the indicator is enabled.

For devices without a dedicated data status indicator, the most recognizable change is to have all outputs go to a predetermined state at a predetermined rate, though this capability will vary between devices. Devices with configurable data loss behavior should be set to the shortest delay time (0 seconds if possible) and the fastest fade rate. Devices without a configurable data loss behavior can only be evaluated within the resolution of that behavior. For example, if the fixed data loss behavior of a device is to hold the last data received for three minutes and then fade out in five seconds, the only way to test that is to wait for the fade out. So long as a device behaves according to the description in the documentation, it is compliant with DMX512.

If a device always holds the last data received, and there is no data status indicator, there is no way to determine whether a device has gone into Data Loss Behavior, and this shall be reported as "Not Possible to Test".

#### **6.1.2.3 Devices With Multiple Ports**

Devices with multiple transmitter or receiver ports, or both, shall test each port individually, and each port shall be reported separately on the test report.

NOTE: All inline devices have multiple ports, as a minimum of one input and one output is required to make a device inline.

Some devices, such as data mergers or Ethernet gateways, should be configured for a typical application when performing tests. For example, when testing the output transmitter port of a device that merges two input data links on two receiver ports, two separate streams of data with different timing parameters should be used, as well as testing with identical data on both ports.

#### **6.1.2.4 Wireless Devices**

Wireless devices may be difficult to test without specialized equipment to generate or decode the wireless signal. Wireless devices may be tested as a single device with multiple transmitter and/or receiver ports, according to 6.1.2.3.

#### **6.1.3 Test Report**

A test report showing the result of all tests shall be provided to the entity or individual requesting the test. A sample compliance test report is included in informative Annex A.

It is recommended that the default test values provided in this standard are included in the Test Report. Test reports that include the described default test values should also indicate that the included value is a default value.

Settings and parameters that are not included in this standard, but that affect the test results, shall be noted on the test report.

#### **6.1.4 Test Procedures**

Tests may be combined at the tester's discretion only if the test equipment is capable of separately verifying the results of each test.

### **6.2 Physical Device Tests**

#### **6.2.1 Documentation and Marking**

Section 10 of DMX512 describes the requirements for product documentation and specific marking of products. Devices that do not include the required disclosures and markings do not comply with DMX512, though, in certain cases, they may still conform.

Conformance applies to conditions where a device operates in a manner not described in DMX512, but which does conform to the intent.

All devices that comply or conform to DMX512 may be labeled as having passed the tests outlined in this standard.

If a device does not comply or conform to DMX512 marking and disclosures, testers may stop device evaluation, or continue to conduct all remaining tests at their discretion.

##### **6.2.1.1 Markings**

###### **6.2.1.1.1 Port Marking**

A marking shall exist on any device in compliance with Section 10.2 of (DMX512 port marking). If this marking does not exist, it will not be possible to conduct other tests in this section, and it may be necessary to stop evaluation of the device.

###### **6.2.1.1.2 Termination Marking**

If termination switches are present on the device, a marking shall exist on the device, in compliance with Section 10 of E1.11 (Data Line termination marking).

###### **6.2.1.1.3 Ground/Isolation Marking**

A marking shall exist on the device in compliance with Section 10.4 of DMX512 (Ground/Isolation marking). If this marking does not exist, it will not be possible to conduct other tests in this section, and it may be necessary to stop evaluation of the device.

### 6.2.1.2 Disclosures

#### 6.2.1.2.1 Port Disclosure

A declaration shall exist in the product documentation in compliance with Section 10.2, 10.5.1, and 10.5.2 of DMX512 regarding port disclosures. Devices with documentation that fully complies with these requirements are compliant. Devices with documentation that generally conforms to these requirements are conformant.

Examples of conformant documentation are notations of port pins that are not described in table 8 of E1.11, but that do effectively convey the signal descriptions, and descriptions of grounding topologies not described in DMX512.

#### 6.2.1.2.2 Loss of Data Handling Declaration

A declaration shall exist in the product documentation in compliance with Section 10.5.3 of DMX512 (Loss of data handling procedure). If this declaration does not exist; it will not be possible to conduct other tests in this section, and it may be necessary to stop evaluation of the device.

#### 6.2.1.2.3 Packet Processing Latency

A declaration shall exist in the product documentation in compliance with Section 10.5.4 of DMX512 (Packet processing latency).

#### 6.2.1.2.4 NULL START Code

A declaration shall exist in the product documentation in compliance with Section 10.5.5 of DMX512 (NULL START Code functionality).

#### 6.2.1.2.5 Slot Footprint

A declaration shall exist in the product documentation in compliance with Section 10.5.6 of DMX512 (Slot footprint). If this declaration does not exist, it will not be possible to conduct other tests in this section, and it may be necessary to stop evaluation of the device.

#### 6.2.1.2.6 Hazardous Applications

No device using DMX512 data intended for hazardous application(s) may be deemed compliant or conformant under this standard. If the documentation lists any of the following applications, or shows the device being used in any other potentially hazardous manner, it shall fail the test.

**table 2: Hazards**

<b>Application</b>	<b>Result</b>
Moving Scenery	Fail
Moving Rigging	Fail
Pyrotechnics	Fail
Safety Lighting	Fail
Security Lighting	Fail
Emergency Lighting	Fail

### 6.2.2 Connectors

This document only provides evaluation of connectors that comply with DMX512-A. Evaluation of connections that do not comply with E1.11 is at the discretion of testing laboratories and manufacturers. Connections shall only be marked as compliant if they meet the requirements of this document. Connections that do not meet the requirements of this document shall not be marked as compliant even where they are adjacent to compliant connections.

#### 6.2.2.1 Portable Equipment with 5-Pin XLR Connectors

Portable devices with 5-Pin XLR plugs for inputs and 5-Pin XLR receptacles for outputs are compliant.



Portable devices with 5-pin XLR receptacles for inputs or 5-Pin XLR plugs for outputs are not compliant.

Portable devices with correct 5-Pin XLR connectors and connectors of any other type wired in parallel are conformant but not compliant. Tests are not required by this standard on the parallel connectors, but may be done at the discretion of the tester. Should other connectors be tested, the test report shall note all tests performed on the parallel connectors.

Portable devices with separately wired XLR connectors that are not 5-pin XLRs are not compliant.

Due to decreasing product size and the introduction of products that did not exist when E1.11 was drafted, devices intended for permanent or semi-permanent mounting that use IEC 60603-7 (RJ45) connectors may be considered in conformance despite the requirements of E1.11 7.3. Examples of conformant products include tunable downlights, track lights, LED drivers, and similar products that do not require frequent connection and disconnection. Any lights designed to be regularly connected and disconnected as part of normal use are neither compliant or conformant. Pinout for the IEC 60603-7 connector shall be the pinout specified in E1.11, and any other pinout shall not be accepted as compliant or conformant. This allowance is specific to connector(s) allowed on portable equipment and does not mean any other requirement of E1.11 may be violated.

Portable devices with non-compliant connectors should identify the pinout per clause 6.2.1.2.1.

### **6.2.2.2 Fixed Equipment**

#### **6.2.2.2.1 Equipment with 5-Pin XLR Connectors**

Fixed equipment with 5-Pin XLRs shall comply with the requirements for Portable Equipment in 6.2.2.1.

#### **6.2.2.2.2 Equipment with IEC 60603-7 Connectors**

Fixed equipment with IEC 60603-7 connectors shall comply with the requirements of E1.11, section 7.3, including the connector connection schedule shown in E1.11, table 4.

#### **6.2.2.2.3 Equipment with Internal Connections**

Fixed equipment with internal connections are not required to use any specific connectors. Examples include, but are not limited to, equipment with terminal blocks, interior or exterior rated fixed luminaires with connectors intended for regularly spaced interconnections, and equipment provided with pigtailed for direct wiring.

At a minimum the internal connections shall include Data Link Common, Data Link 1 (-), and Data Link 1 (+). Data Link 2 is optional but if it is used internally by the device it shall be tested to all the requirements of 6.2.3 and should be tested to the installation instructions provided by the manufacturer. Connections shall be marked per E1.11 10.2.

#### **6.2.2.3 NCC connectors on Portable Equipment**

This section applies to any devices not already covered in 5-Pin XLR Connectors on Portable Equipment (6.2.2.1), or Fixed Equipment (6.2.2.2).

DMX512 requires a 5-pin XLR connector for all portable equipment. A concession is provided in Section 7.1.2 of DMX512 for products where it is physically impossible to mount a 5-pin XLR. While this is generally understood to mean a device that is too small to mount a 5-Pin XLR, it may also mean a device with connectors suitable for harsh environments.

See the current revision of E1.11 for the exact requirements, but in general all five of the following criteria must be met for compliance:

- A) The connector is not an XLR type connector
- B) The connector is not an IEC 60603-7 type connector
- C) An adapter to a 5-Pin XLR is available with appropriate markings
- D) Required NCC marking in addition to other required markings
- E) Required disclosures exist in product documentation

If the requirements of E1.11 7.1.2 are not met, it will not be possible to complete other tests in this section and it may be necessary to stop evaluation of the device. If conforming with the exception of E1.11 7.1.2 item 2

(allowing the use of an IEC 60603-7 (aka RJ45) connector for certain fixed equipment) use of an adapter (required per item 4) is necessary.

### **6.2.3 Receiver Physical Tests**

These tests are primarily intended as laboratory or bench tests, as some tests require tools or access to internal circuit elements that will not be readily available in many field conditions. Opening enclosures in the field may expose individuals to hazardous voltages and should only be done by qualified individuals. Users are responsible for determining the appropriate use of each test for their application, and ensuring any necessary safety precautions are taken.

Prior to starting physical tests, it is recommended that the tester review the product schematics to determine necessary test points including the following.

- Receiver isolated common
- Main circuit common
- Data Link test points

Some tests require measurement of circuit elements that are not accessible from outside the unit. When providing units for third party testing, the device manufacturer shall provide for access to the internal circuitry or provide a specially modified device where the necessary test points have been brought out via wire harness or similar means. If necessary test points are not available, the tester shall report failure of that test on the test report.

#### **6.2.3.1 Receiver Preferred Topology Test**

DMX512 describes a preferred topology of an isolated receiver. Unless the device is marked with an alternate receiver grounding topology per 6.2.1.1.3 Ground/Isolation Marking, it shall pass all of the applicable tests in this section.

Where pin numbers are referenced, they refer to the pins of a 5-pin XLR. It is the responsibility of the tester to determine the appropriate connection points for other connectors.

Resistance tests shall be conducted with the Device Under Test (DUT) unpowered. Testing laboratories shall use test equipment capable of resistance testing at an applied voltage of 42V, though field tests may use readily available equipment that operates at a lower voltage. Voltage tests shall be conducted with the DUT powered from a power supply supplied with the DUT or recommended by the manufacturer for use with the device. Devices with external power supplies may have different earth-grounding topologies depending on the power supply used.

Tests 11, 14 and 15, described in figure 1 apply only to devices where the second data link is implemented. For devices without a second data link, the test report shall show that these tests were not applicable. figure 1 Tests 5 and 6 apply to all devices, regardless of whether the second data link is implemented, and the test result shall be shown on the test report.

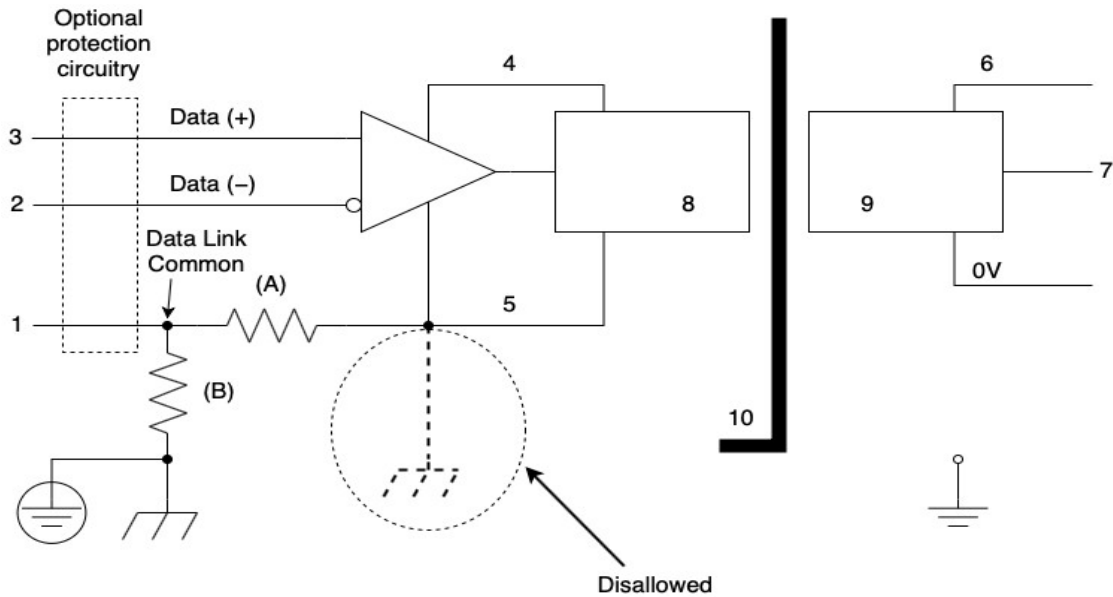


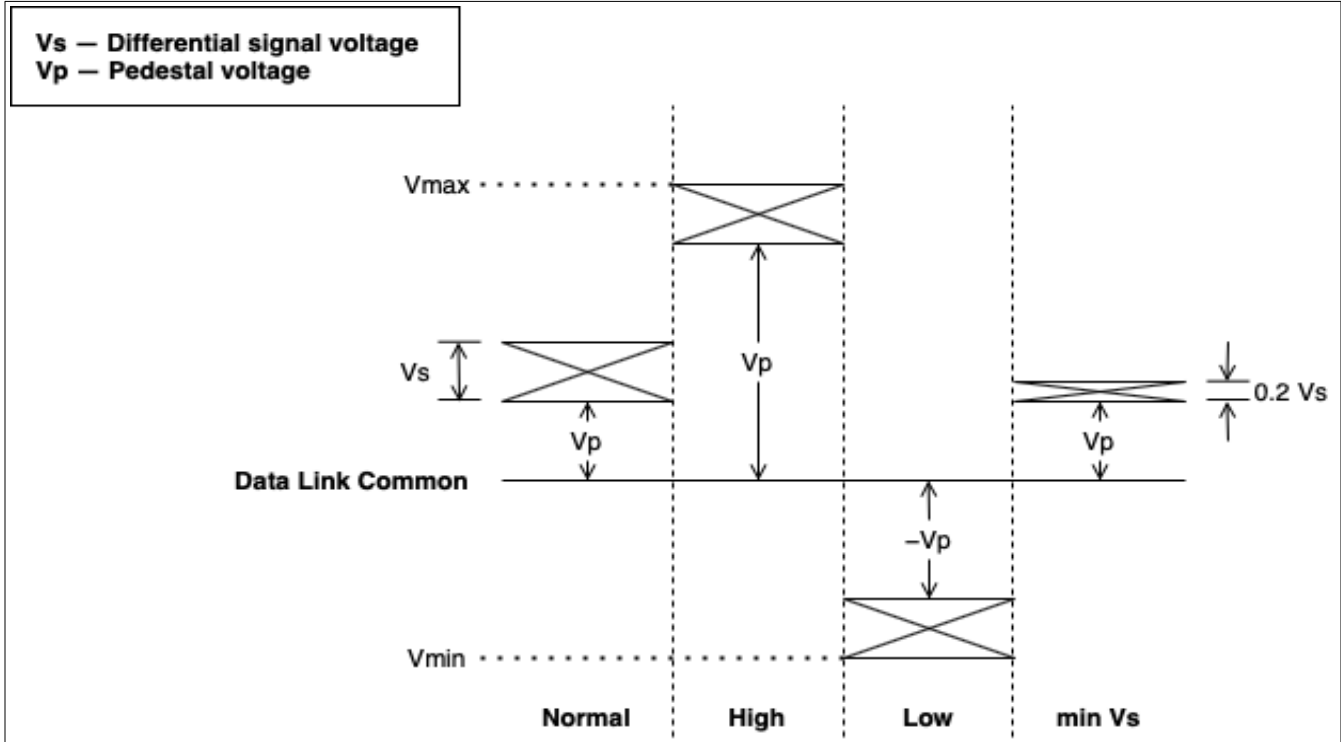
figure 1: Receiver Topology Tests

1	XLR Pin 1	5	Isolated Common	9	Non-Isolated Electronics
2	XLR Pin 2 or 4	6	Non-Isolated V+	10	Isolation Barrier
3	XLR Pin 3 or 5	7	Non-Isolated Signal	A	Optional Resistance A
4	Receiver V+	8	Isolated Electronics	B	Optional Resistance B

table 3: Receiver topology tests

Test	Point 1	Point 2	Measurement	Conditions	Pass	Fail
1	Pin 1	Data Link Common	Resistance		<0.2 ohms	>=0.2 ohms
2	Isolated Common	Data Link Common	Resistance	42 V Applied	<100 ohms	>=100 ohms
3	Data Link Common	Chassis	Resistance	42 V Applied	>22 Mohms	<=22 Mohms
4	Data 1-	Chassis	Resistance	42 V Applied	>22 Mohms	<=22 Mohms
5	Data 1+	Chassis	Resistance	42 V Applied	>22 Mohms	<=22 Mohms
6	Data 2-	Chassis	Resistance	42 V Applied	>22 Mohms	<=22 Mohms
7	Data 2+	Chassis	Resistance	42 V Applied	>22 Mohms	<=22 Mohms
8	Isolated Common	Non-Isolated Common	Resistance	42 V Applied	>22 Mohms	<=22 Mohms
9	Data Link 1-	Data Link 1+	Voltage	Normal Vs	Expected Output	Data Loss Behavior
10	Data Link 1-	Data Link 1+	Voltage	Minimum Vs	Expected Output	Data Loss Behavior
11	Data Link 2-	Data Link 2+	Voltage	Normal Vs	Expected Output	Data Loss Behavior
12	Data Link 1-	Data Link Common	Voltage	Normal Vs -7 V Vmin	Expected Output	Data Loss Behavior
13	Data Link 1+	Data Link Common	Voltage	Normal Vs +12 V Vmin	Expected Output	Data Loss Behavior
14	Data Link 2-	Data Link Common	Voltage	Normal Vs -7 V Vmin	Expected Output	Data Loss Behavior

Test	Point 1	Point 2	Measurement	Conditions	Pass	Fail
15	Data Link 2+	Data Link Common	Voltage	Normal Vs +12 V Vmin	Expected Output	Data Loss Behavior



**figure 2: Voltage differentials**

Normal Vs is commonly 1.5 V, but may range from +/-0.2 V to +/- 6 V

Vmax is 12 V

Vmin is -7 V

Vp is the difference between Data Link Common and Vs

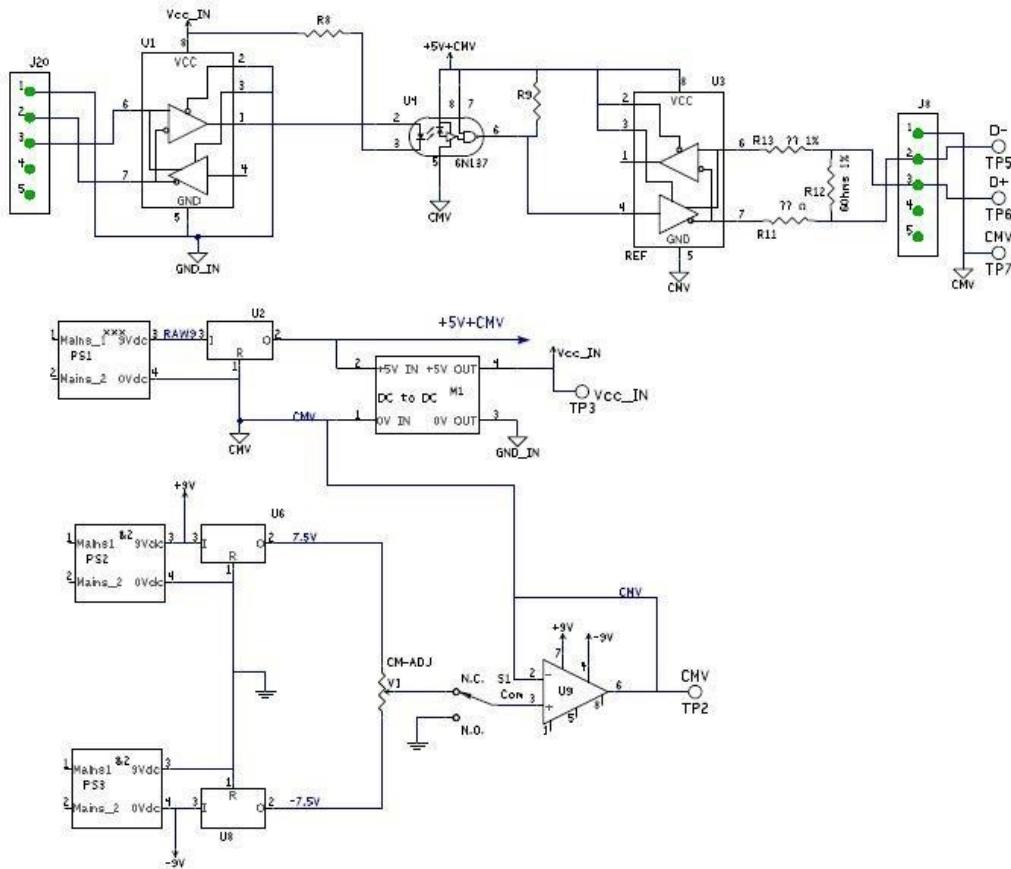


figure 3: Common Mode Test Set Schematic

### 6.2.3.2 Receiver Non-Preferred Topology Tests

Device receiver ports marked per 6.2.1.1 and declared in the user documentation per 6.2.1.2 with a non-preferred topology as Non-Isolated, Grounded, or Floating shall be tested according to the modified tests in this section. Devices that are not marked and fully declared as Non-Isolated, Grounded, or Floating shall not be tested according to this section.

#### 6.2.3.2.1 Non-Isolated Receivers

Non-Isolated receivers as described in Annex A2 of DMX512 shall pass all applicable tests of 6.2.3.1, with the Pass and Fail Values for Tests 2 and 3 of table 3, modified to a nominal 100 ohms. E1.11 specifies a tolerance for the 100 ohm resistor of +/- 20%. The wattage of the resistor is specified in DMX512 as being able to safely dissipate 2 W, which shall be confirmed by either visual inspection of the device or confirmation on the device bill of materials. In the case of multiple non-isolated receiver ports, the total parallel resistance shall be 100 ohms, and the resistor wattages shall sum to 2 W or greater.

#### 6.2.3.2.2 Grounded Receivers

Grounded receivers per Annex A3 of DMX512 shall pass all applicable tests of 6.2.3.1, with the Pass and Fail Values for Tests 2 and 3 modified to a nominal 0 ohms.

#### 6.2.3.2.3 Floating Repeaters

Floating repeaters per Annex A4 of DMX512 shall pass all applicable tests of 6.2.3.1. There is no modification to the Pass and Fail Values. An additional test shall confirm less than 0.2 ohms resistance between Data Link Common of the input connector and Data Link Common for the output connector.

## 6.2.4 Transmitter Physical Tests

Transmitter physical tests do not require access to device internal circuitry, and therefore do not require the same cautions as receivers.

### 6.2.4.1 Transmitter Preferred Topology Tests

DMX512 specifies a preferred topology for a grounded transmitter. Unless the device is marked with an alternate transmitter topology per 6.2.1.1.3, it shall pass all of the applicable tests in this section.

Where pin numbers are referenced, they refer to the pins of a 5-pin XLR. It is the responsibility of the tester to determine the appropriate connection points for other connectors.

Tests 2, 6, 7, 10, and 11 of table 4 apply only to devices where the second data link is implemented. For devices without a second data link, the test report shall show that these tests were not applicable.

A direct physical connection between the transmitter common and Earth Ground, as shown in figure 4 is disallowed. Earth Ground connection shall be as shown through Optional Resistance B. In practice Optional Resistances A and B may be only the resistance of internal wiring, regardless the physical connection point shall be as shown in figure 4.

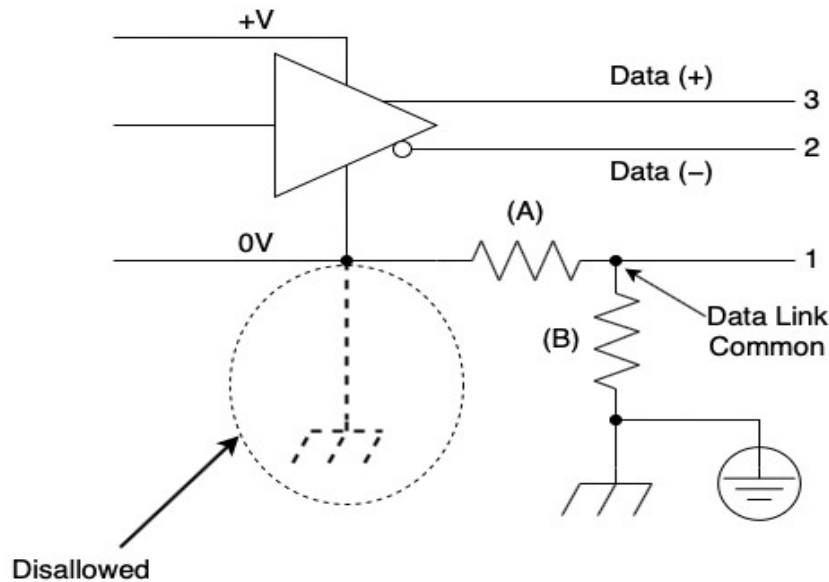


figure 4: Transmitter Preferred Topology Test

1	XLR Pin 1	3	XLR Pin 3 or 5	B	Optional Resistance
2	XLR Pin 2 or 4	A	Optional Resistance		

table 4: Transmitter topology tests

Test	Point 1	Point 2	Measurement	Pass	Fail
1	Data 1-	Data 1+	Voltage	$0 \leq V_s \leq 6 \text{ V}$	$V_s < 0, V_s > 6 \text{ V}$
2	Data 2-	Data 2+	Voltage	$0 \leq V_s \leq 6 \text{ V}$	$V_s < 0, V_s > 6 \text{ V}$
3	Data Link Common	Chassis	Voltage	0V	Any voltage
4	Data 1-	Data Link Common	Voltage	$0 \leq V_s \leq 6 \text{ V}$	$V_s < 0, V_s > 6 \text{ V}$
5	Data 1+	Data Link Common	Voltage	$0 \leq V_s \leq 6 \text{ V}$	$V_s < 0, V_s > 6 \text{ V}$
6	Data 2-	Data Link Common	Voltage	$0 \leq V_s \leq 6 \text{ V}$	$V_s < 0, V_s > 6 \text{ V}$
7	Data 2+	Data Link Common	Voltage	$0 \leq V_s \leq 6 \text{ V}$	$V_s < 0, V_s > 6 \text{ V}$

8	Data 1-	Chassis	Voltage	$0 \leq V_s \leq 6 \text{ V}$	$V_s < 0, V_s > 6 \text{ V}$
9	Data 1+	Chassis	Voltage	$0 \leq V_s \leq 6 \text{ V}$	$V_s < 0, V_s > 6 \text{ V}$
10	Data 2-	Chassis	Voltage	$0 \leq V_s \leq 6 \text{ V}$	$V_s < 0, V_s > 6 \text{ V}$
11	Data 2+	Chassis	Voltage	$0 \leq V_s \leq 6 \text{ V}$	$V_s < 0, V_s > 6 \text{ V}$

#### 6.2.4.2 Transmitter Non-Preferred Topology Tests

Device transmitter ports marked per 6.2.1.1, and declared in the user documentation per 6.2.1.2 with a non-preferred topology as Floating, shall be tested according to the modified tests in this section. Devices that are not marked and fully declared as Floating shall not be tested according to this section.

Floating repeaters as defined in DMX512 Annex A1 shall pass all applicable tests of 6.2.4.1, except for test 3. In addition, they shall pass tests 3, 4, 5, 6, and 7 of 6.2.3.1 for equivalent points of the transmitter.

### 6.3 Compliance Tests for Encode/Decode Issues

Encode/Decode issues relate to the way data is encoded in the DMX512 data packets, but not the timing of the data itself, which is described in 6.4. Examples include verifying correct START Code value for the packet, a valid number of slots in the packet, and proper framing of each byte.

#### 6.3.1 Receivers

General test equipment for testing receivers:

Transmitter capable of the requirements listed for each test. More than one transmitter may be needed to complete all tests

DUT Receiver port

Cabling compliant with E1.27 (-1 or -2 as appropriate to DUT) Measurement device

##### 6.3.1.1 START Code

Test equipment requirements:

Transmitter capable of sending different START Codes

Test conditions:

Break: 92 microseconds

MAB: 12 microseconds

MBB: 0 microseconds

Inter-slot Mark: 0 microseconds

START Code: 00h

NSC Slot data: Alternating 55h and AAh from data slot 1 to data slot 512

ASC Slot data: Tested ASC - Properly formatted alternate packet data

Procedure:

Test the receiver at the START Codes listed as required tests in table 5 and ensure the specified Pass Result occurs.

Full RDM compliance is beyond the scope of this standard, and the test in table 5 is to determine whether the DUT will properly filter RDM packets while receiving NSC packets. If the device is an RDM responder it may change output depending on the data in the RDM packets used for testing, but that output should be the expected output for that data.

**table 5: Required START code tests**

Start Code (hex)	Pass result
00	Expected output
CC	Expected output
F0-F7	No change

Alternate START Codes used by a device must be declared in the product documentation per E1.11, and applicable E1.11 ASCs as declared in the product documentation shall be tested per table 6 to ensure the specific Pass Result occurs. Any other START Code used by the device shall be tested for expected output and noted in the test report.

**table 6: Recommended START codes to test**

START Code (hex)	ESTA E1.11 Use	Pass Result
17	ASCII Text Packet	Expected output
55	55 hex test pattern	Expected output
90	UTF-8 Text Packet	Expected output
91	START Code Expansion <b>See Note</b>	Expected output
CF	System Information Packet	Expected output

Note:

91h followed by a 2 byte Manufacturer ID field is reserved for Manufacturer/Organization specific use, transmitted byte order is MSB, LSB. The next byte after the Manufacturers ID would normally be a manufacturer's sub-code.

### 6.3.1.2 Stop Bit Reception

Test equipment requirements:

Transmitter capable of sending frames with 1 or 2 stop bits

Test conditions:

Break: 92 microseconds

MAB: 12 microseconds

MBB: 0 microseconds

Inter-slot Mark: 0 microseconds

START Code: 00h

Slot data: NSC - Alternating 55h and AAh from data slot 1 to data slot 512

Procedure:

A) Set Transmitter to send 2 stop bits. Verify receiver has the expected output.

B) Change Transmitter to send 1 stop bit. Verify receiver enters data loss behavior

### 6.3.1.3 Slot Count

Test equipment requirements:

Transmitter capable of sending different numbers of data slots, including in excess of 512.

Test conditions:

Break: 92 microseconds

MAB: 12 microseconds

MBB: 0 microseconds

Inter-slot Mark: 0 microseconds

START Code: 00h

Slot data: NSC - Alternating 55h and AAh from data slot 1 to data slot 512

Slot data: Tested ASC - Properly formatted alternate packet data

Procedure:

A) Set Transmitter to 512 data slots. Verify receiver has the expected output.

B) Change Transmitter to send 513 data slots. Verify receiver follows behavior stated in published documentation. (Note: E1.11 allows a manufacturer to decide what a receiver does when there are too many slots, but whatever behavior is used it must be declared. Common behaviors include ignoring slots past 512 and rejecting the packet)

C) Set Transmitter to send 512 data slots and set all data slots to 00h. Change transmitter to send 0 data slots. Receiver shall not enter data loss behavior.



D) Set Transmitter to send 512 data slots, receiver to starting address 1, and set slot 257 to a non-zero level. Receiver shall not output as though it is receiving data on slot 1.

#### 6.3.1.5 Failure at valid address

Test equipment requirements:

Transmitter capable of sending data on all 512 slots.

Test conditions:

Break: 92 microseconds

MAB: 12 microseconds

MBB: 0 microseconds

Inter-slot Mark: 0 microseconds

START Code: 00h

Slot data: 55h on each address in table

Slot data: Properly formatted slot footprint data starting at each address in table

Procedure:

Test each of the addresses in table 7 and confirm expected output. Devices with very large slot footprints may not be possible to test at higher addresses, in which case the reported result should be not applicable. Devices that allow multiple non-contiguous address ranges, including devices that allow a separate address to be set for each output, shall be tested at a minimum with a contiguous address range, and should have non-contiguous ranges tested at each of the addresses in the table below.

**table 7: Address data validation**

Address	Pass result
1	Expected output
2	Expected output
4	Expected output
8	Expected output
16	Expected output
32	Expected output
64	Expected output
128	Expected output
256	Expected output

This tests each bit of the address, which is a minimum addressing test. It is preferred to test all addresses, however that is not practical for devices with manually set addresses, those that require a device reset to change the address, or other addressing changes that are time consuming to test. It is recommended to test additional random addresses in addition to the ones in the table.

During development it is recommended to test all addresses at least once. When testing is being done by a third party testing lab the device manufacturer should inform the lab of all addresses tested during development.

Devices with RDM may be able to automatically test all addresses.

Additional addresses tested should be included in the test report, and any addresses that fail shall be reported.

#### 6.3.1.6 Failure with different slot values

Test equipment requirements:

Transmitter capable of sending different values on different slots

Test conditions:

Break: 92 microseconds

MAB: 12 microseconds

MBB: 0 microseconds  
Inter-slot Mark: 0 microseconds  
START Code: 00h  
Slot data: 40h 7Fh C0h 3Fh repeated from data slot 1 to data slot 512

Procedure:

A) Verify receiver has the expected output for each of the levels sent at the following start addresses: 1, 10, 256, 257

B) Set Receiver to any of the addresses in 6.3.1.6.A. Proportionally fade all slots down and back up. Verify receiver has the expected output as the slots are faded down and back up.

Testers may evaluate additional addresses, and shall report results for any additional addresses tested.

Note: The test sequence is a modified staircase with alternating low and high bit counts.

#### 6.1.3.6.1

Testers may evaluate performance of receivers supporting Alternate START Codes. When evaluating ASCs a slot footprint and data pattern appropriate to the ASC shall be used. Results of ASC tests shall be reported in the test report.

#### 6.1.3.6.3 Auto-addressing Devices

Some devices use a receive-and-retransmit strategy to allow devices to be physically placed in any order and behave as though they are addressed sequentially. Typically each device will receive a packet from the previous device in line, process the first set of slots itself, and transmit the remaining slots to the next device in line as a new packet without the slots the device itself has processed. When testing strings of devices that use this technique the slot data should be adjusted for the slot footprint of the device, and the data pattern used shall be reported in the test report.

### 6.3.2 Transmitters

General transmitter test requirements may include several different receiver test devices, or all tests may be done by a single piece of test equipment.

#### 6.3.2.1 Stop Bit Transmission

Test equipment requirements:

Receiver capable of measuring Stop Bits

Test conditions:

START Code: 00h

Slot data: Alternating 55h and AAh from data slot 1 to data slot 512

If the following parameters can be set in the transmitter the following values should be used:

Break: 92 microseconds

MAB: 12 microseconds

MBB: 0 microseconds

Inter-slot Mark: 0 microseconds

Procedure:

A) Measure data for a minimum 1 minute, all packets shall have 2 stop bits. Any frames with one stop bit mean the test has failed.

#### 6.3.2.2 Slot Count

Test equipment requirements:

Receiver capable of measuring Slot Count

Test conditions

START Code: 00h

Slot data: Alternating 55h and AAh from data slot 1 to data slot 512

If the following parameters can be set in the transmitter the following values should be used:

Break: 92 microseconds

MAB: 12 microseconds

MBB: 0 microseconds

Inter-slot Mark: 0 microseconds

Procedure:

A) Set Transmitter to send only NSC packets, if it supports START code options. Measure data for a minimum of 1 minute, all packets shall have no more than 512 slots, not including the START code.

B) If Transmitter supports System Information Packets set it to send E1.11 SIP. Measure data for a minimum of 1 minute, all packets shall have no more than 512 slots, not including the START code. If Transmitter does not support SIPs report "Not Applicable".

#### 6.4 Compliance Tests for Timing

Timing issues may have the similar symptoms to encode/decode issues, but a different cause. Tests in this section generally require equipment capable of precise timing measurements, and may therefore be more suitable for lab testing than field testing.

##### 6.4.1 Receivers

DUT Receiver port

All ports must be tested individually on devices with multiple Receiver ports.

Where multiple steps are listed a DUT must pass all steps to pass the overall test.

##### 6.4.1.1 Receiver Break Length

Test equipment

Transmitter capable of variable Break length from 86 microseconds to 1.25S

Test conditions

Break: Evaluated parameter

MAB: 12 microseconds

MBB: 0 microseconds

Inter-slot Mark: 0 microseconds

START Code: 00h

Slot data: Alternating 55h and AAh from data slot 1 to data slot 512

Procedure

Test the receiver at each of Break time listed in table 8 and ensure the specified Pass Result occurs.

**table 8: Receiver port timing tests**

BREAK	Units	Pass result
86	microseconds	Expected output
88	microseconds	Expected output
92	microseconds	Expected output
176	microseconds	Expected output
352	microseconds	Expected output
1000	microseconds	Expected output
10	milliseconds	Expected output
100	milliseconds	Expected output
1000	milliseconds	Expected output

BREAK	Units	Pass result
1.25	seconds	Data loss

#### 6.4.1.2 Receiver Mark After Break Timing

##### Test equipment

Transmitter capable of variable MAB length from 8 microseconds to 1.0S

##### Test Conditions

Break: 92 microseconds

MAB: Evaluated parameter

MBB: 0 microseconds

Inter-slot Mark: 0 microseconds

START Code: 00h

Single Slot data: Alternating 55h and AAh from data slot 1 to data slot 512

DUT set to respond to multiple slot data starting at the first data slot. Send multiple slot data starting at the first data slot, selecting slot values that will provide the most apparent loss of data behavior as described in 6.1.

##### Procedure

Test the receiver at each of MAB time listed in table 9 and ensure the specified Pass Result occurs.

**table 9: Receiver MAB validation test**

MAB	Units	Pass result
8	microseconds	Expected output
12	microseconds	Expected output
900	milliseconds	Expected output
1	seconds	Data loss

#### 6.4.1.3 Receiver Mark Before Break Timing

##### Test equipment

Transmitter capable of variable MBB length from 0 microseconds to 1.0 second.

##### Test Conditions

Break: 92 microseconds

MAB: 12 microseconds

MBB: Evaluated parameter

Inter-slot Mark: 0 microseconds

START Code: 00h

Single Slot data: Alternating 55h and AAh from data slot 1 to data slot 512

DUT set to respond to multiple slot data starting at the first data slot. Send multiple slot data starting at the first data slot, selecting slot values that will provide the most apparent loss of data behavior as described in 6.1.

##### Procedure

Test the receiver at each of MBB time listed in table 10 and ensure the specified Pass Result occurs.

**table 10: Receiver MBB validation test**

MBB	Units	Pass result
0	microseconds	Expected output
100	microseconds	Expected output
900	milliseconds	Expected output
1	seconds	Data loss

#### 6.4.1.4 Receiver Slot Timing

##### Test equipment

Transmitter capable of variable inter-slot mark timing from 0 microseconds to 1.0 second.

##### Test Conditions

Break: 92 microseconds

MAB: 12 microseconds

MBB: 0 microseconds

Inter-slot Mark: Evaluated parameter

START Code: 00h

Single Slot data: Alternating 55h and AAh from data slot 1 to data slot 512

DUT set to respond to multiple slot data starting at the first data slot. Send multiple slot data starting at the first data slot, selecting slot values that will provide the most apparent loss of data behavior as described in 6.1.

##### Procedure

Test the receiver at each Inter-slot Mark time listed in table 11 and ensure the specified Pass Result occurs.

**table 11: Receiver slot timing validation test**

Inter-slot mark	Units	Pass result
0	microseconds	Expected output
100	microseconds	Expected output
2397	microseconds	Expected output
2398	microseconds	Data loss

Note: The first inter-slot comes after the START Code, and the mark after the last slot is the MBB, a separate test

##### Timing calculation:

$((2397 \text{ microseconds Mark} + 44 \text{ microseconds Frame}) * 512 \text{ Slots}) + 144 \text{ Reset Sequence} = 1,249,936 \text{ microseconds Pass}$

$((2398 \text{ microseconds Mark} + 44 \text{ microseconds Frame}) * 512 \text{ Slots}) + 144 \text{ Reset Sequence} = 1,250,448 \text{ microseconds Fail}$

#### 6.4.1.5 Receiver Break-to-Break Timing

##### Test equipment

Transmitter capable of variable Break, MAB and MBB timing from 0 microseconds to 1.0 second.

##### Test Conditions

Break: 500 microseconds

MAB: 152 microseconds

MBB: 500 microseconds

Inter-slot Mark: Not applicable

START Code: 00h

Single Slot data: None

Multiple Slot data: None

##### Procedure

Test the receiver with the Test Conditions and verify it does not go into Data Loss Behavior.

Tests in 6.4.1.1 through 6.4.1.4 test the longest a allowed packet, this test evaluates the worst case for a short packet, one with only a Reset sequence and no data slots. This type of packet is used as a "keep-awake" packet to prevent a fixture from going into data loss behavior when it is idle.

Testers may, at their option, test combinations of the timing parameters and slot count between the minimum packet length of 1196 microseconds and the maximum of 1.25S. Any receiver failures under optional test conditions shall be noted on the test report along with the timing conditions of the failure.

#### 6.4.2 Transmitters

It may not be possible to set all the transmitter parameters for the tests in 6.4.2.1-5, including the parameters being evaluated. If the parameters can not be set in the transmitter the minimum and maximum values shall still be measured.

##### 6.4.2.1 Transmitter Break Length

###### Test equipment

Receiver capable of measuring Breaks to within +/- 4 microseconds

###### Test Conditions

Break: Evaluated parameter

MAB: 12 microseconds

MBB: 0 microseconds

Inter-slot Mark: 0 microseconds

START Code: 00h

Single Slot data: Alternating 55h and AAh from data slot 1 to data slot 512

DUT set to respond to multiple slot data starting at the first data slot. Send multiple slot data starting at the first data slot, selecting slot values that will provide the most apparent loss of data behavior as described in 6.1.

###### Procedure

A) Measure Break length with all slots set to 00h for 1 minute.

Minimum measured Break length shall be longer than 92 microseconds

Maximum measured Break length shall not be longer than 1 second

B) Measure Break length with multiple slots changing rapidly for 1 minute.

Minimum resumed Break length shall be longer than 92 microseconds

Maximum measured Break length shall not be longer than 1 second

##### 6.4.2.2 Transmitter Mark After Break Timing

###### Test equipment

Receiver capable of measuring MABs to within +/- 1 microseconds

###### Test Conditions

Break: 92 microseconds

MAB: Evaluated parameter

MBB: 0 microseconds

Inter-slot Mark: 0 microseconds

START Code: 00h

Single Slot data: Alternating 55h and AAh from data slot 1 to data slot 512

DUT set to respond to multiple slot data starting at the first data slot. Send multiple slot data starting at the first data slot, selecting slot values that will provide the most apparent loss of data behavior as described in 6.1.

###### Procedure

A) Measure MAB length with all slots set to 00h for 1 minute.

Minimum measured MAB length shall be 12 microseconds or longer

Maximum measured MAB length shall not be longer than 1 second

B) Measure MAB length with multiple slots changing rapidly for 1 minute.

Minimum measured MAB length shall be 12 microseconds or longer

Maximum measured MAB length shall not be longer than 1 second

#### 6.4.2.3 Transmitter Mark Before Break Timing

##### Test equipment

Receiver capable of measuring MBBs to within +/- 1 microseconds

##### Test Conditions Break: 92 microseconds

MAB: 12 microseconds

MBB: Evaluated parameter

Inter-slot Mark: 0 microseconds

START Code: 00h

Single Slot data: Alternating 55h and AAh from data slot 1 to data slot 512

DUT set to respond to multiple slot data starting at the first data slot. Send multiple slot data starting at the first data slot, selecting slot values that will provide the most apparent loss of data behavior as described in 6.1.

##### Procedure

A) Measure MBB length with all slots set to 00h for 1 minute.

Maximum measured MBB length shall not be longer than 1 second

B) Measure MBB length with multiple slots changing rapidly for 1 minute.

Maximum measured MBB length shall not be longer than 1 second

#### 6.4.2.4 Transmitter Inter-Slot Timing

##### Test equipment

Receiver capable of measuring inter-slot mark to within +/- 1 microseconds

##### Test Conditions

Break: 92 microseconds

MAB: 12 microseconds

MBB: 0 microseconds

Inter-slot Mark: Evaluated parameter

START Code: 00h

Single Slot data: Alternating 55h and AAh from data slot 1 to data slot 512

DUT set to respond to multiple slot data starting at the first data slot. Send multiple slot data starting at the first data slot, selecting slot values that will provide the most apparent loss of data behavior as described in 6.1.

##### Procedure

A) Measure inter-slot mark with all slots set to 00h for 1 minute.

Maximum measured inter-slot length shall not be longer than 2397 microseconds

B) Measure inter-slot mark length with multiple slots changing rapidly for 1 minute. Maximum measured inter-slot length shall not be longer than 2397 microseconds

#### 6.4.2.5 Transmitter Break-to-Break Timing

##### Test equipment

Receiver capable of measuring packet length to within +/- 4 microseconds

##### Test Conditions

Break: 92 microseconds

MAB: 12 microseconds

MBB: 0 microseconds

Inter-slot Mark: 0 microseconds

START Code: 00h

Single Slot data: Alternating 55h and AAh from data slot 1 to data slot 512

DUT set to respond to multiple slot data starting at the first data slot. Send multiple slot data starting at the first data slot, selecting slot values that will provide the most apparent loss of data behavior as described in 6.1.

##### Procedure

- A) Measure packet length with all slots set to 00h for 1 minute.
  - Minimum measured packet length shall be longer than 1196 microseconds
  - Maximum measured packet length shall not be longer than 1250000 microseconds
- B) Measure inter-slot mark length with multiple slots changing rapidly for 1 minute.
  - Minimum resumed packet length shall be longer than 1196 microseconds
  - Maximum measured packet length shall not be longer than 1.25 S

### 6.5 Marketing Compliant Products

Users, designers, system integrators, and consultants will depend on accurate reporting of the tests in Section 6. It is recommended to request a copy of a third party test report before specifying or purchasing equipment, particularly if any device is in a show critical application. It is also recommended to perform tests on any equipment that has not already been tested to Section 6 of this Standard.

Manufacturers should conduct tests in Section 6 during development, prior to sending devices out for third party evaluation. Experience has shown a number of encode/decode and timing issues will not be found without testing. but may be found and easily corrected with testing.

Devices that pass all the tests in Section 6 as certified by an independent third party testing laboratory may be labeled as E1.68 compliant using the symbol below. Devices that do not pass all the tests, or are not tested by an independent third party laboratory, shall not be labeled as compliant with E1.68.

Manufacturers, dealers and distributors may perform tests in Section 6 on devices and report findings as a convenience to their customers, but shall not label devices as compliant without independent third party testing.

E1.68 symbol example:



## 7 DMX512-A Interoperability

This section is intended primarily for product developers, however others may find the information useful or interesting. Experience has shown that some parameters have the greatest interoperability within a range much narrower than allowed by the standard. This section provides information that is known through extensive field experience to provide the greatest interoperability between devices and the most stable DMX512 networks across a range of operating conditions.

### 7.1 Description of Interoperability

Interoperability is different than compliance. Compliance with a standard involves a set of tests that can be evaluated on a pass-fail basis. Devices that pass the tests are considered compliant with the standard. While any devices that are fully compliant with the standard would also be interoperable there are many existing devices that have not been tested for compliance, and some manufacturers may not choose to have new products tested for compliance. Designing new products with the parameters outlined in this section will not only provide a greater number of compliant products in the market, but also provide the greatest possible interoperability with legacy devices and new products not tested for compliance.

### 7.2 Interoperability Design for Physical Layer Issues

Two issues predominate with regard to physical device design, connectors and grounding.

Using 5-pin XLR connectors as the only DMX512 connector type on a portable device will eliminate the need for adaptors when used with any other compliant devices and E1.27-1 compliant cables.

Grounding should follow the preferred topology, and use a wire for data link common that is not the same wire used for safety grounding.

### 7.3 Interoperability Design for Encode/Decode Issues



### 7.3.1 Receiver Encode/Decode Issues

Good interoperability for receivers depends on properly interpreting the START Code, and fully testing the device during development to ensure reliability. While testing the START Code is very easy a surprising number of receivers that operate on Null START Code Data do not check to confirm the START Code is null. Correcting this simple problem would reduce field interoperability issues significantly. Designing a receiver to meet the following criteria will ensure maximum interoperability.

**table 12: Receiver recommended design criteria**

Start Code	Uniquely receives each declared Start Code
Stop bits	Only receives frames with two stop bits
Slot count	Receives packets of all lengths from 0 data slots through 512 data slots
Addresses	All addresses tested during development
Slot values	Tested during development with different slot values for each Start Code used

#### 7.3.1.1 Loss of Data Behavior

Receivers that hold the last data indefinitely as the sole data loss behavior may be difficult to troubleshoot, particularly for end users, as it is impossible to tell whether data has been lost. It is possible for considerable time to elapse between the loss of data and users observing a problem. A slow fade on data loss, or a series of reductions in output, will alert users that the device is no longer receiving data while maintaining some illumination.

### 7.3.2 Transmitter Encode/Decode Issues

Transmitter design for encode/decode interoperability is relatively simple.

**Stop Bits:** If a UART does not inherently support 2 stop bit frames there are several techniques to create a second stop bit. One is to always set the Parity bit in software, which will then appear as a stop bit on the line. Setting the Parity bit should be done in every transmitted frame. Another option is to Mark between frames for at least 4 microseconds after the first stop bit.

**Slot Count:** Transmitting a consistent number of frames is the best practice for interoperability. It is commonly done by padding the packet out to a full 512 slots using 00h for an approximately 44 Hz update rate. If a higher update rate is needed the number of padded slots can be reduced.

### 7.3.3 Transmitter Slot Footprints

Prior to the development of E1.20 Remote Device Management it was common practice to send configuration data to fixtures along with operational data. With RDM now in common use it is both possible and preferable to send configuration data via RDM and only use DMX512-A slots for live operational data.

## 7.4 Interoperability Design for Timing Issues

The following table provides timing information for RDM devices as outlined in the E1.11 standard. Recommended values have been developed to help ensure the maximum interoperability between transmitter and receiver.

Using these values will also provide good interoperability between NSC-only devices.

#### Timing – NSC-Only Applications

The following table provides timing information for NSC-only devices as outlined in the E1.11 standard. Recommended values have been developed to help ensure the maximum interoperability between transmitter and receiver.

**table 13: Timing for NSC-only applications**

Timing Parameter	Minimum	Recommended	Maximum
Break - Transmitter	92 microseconds	176 microseconds	1S
Break - Receiver	88 microseconds	See note	1S
MAB - Transmitter	12 microseconds	20 to 24 microseconds	1S
MAB - Receiver	8 microseconds		1S
Marking Time - Transmitter	0 microseconds	4 microseconds	1S

Marking Time - Receiver	0 microseconds	20 to 24 microseconds	1S
MBB - Transmitter	0 microseconds	20 to 24 microseconds	1S
MBB - Receiver	0 microseconds		1S

Maintaining timing within an instance or power cycle will help interoperability. For example, a transmitter that has consistent timing at each boot will be less likely to show flickering across a range of legacy and current receivers.

### 7.5 Marketing Interoperable Products

There are no separate compliance tests for interoperability. Devices designed to the guidelines in Section 7 may be marketed as E1.68 Interoperable only if they pass all the tests in Section 6.

**Annex 1 – Sample report**

<b>Port Result</b>		<b>Complies/Conforms/Fails</b>						
<b>Test</b>	<b>Description</b>	<b>E1.68 Clause</b>	<b>E1.11 Clause</b>	<b>Complies</b>	<b>Conforms</b>	<b>Fail</b>	<b>NA</b>	<b>Comment</b>
1	Port Marking	6.2.1.1.1	10					
2	Termination Marking	6.2.1.1.2	10.3					
3	Ground/Isolation Marking	6.2.1.1.3	10.4					
4	Port Disclosures	6.2.1.2.1	10.2, 10.5.1, 10.5.2					
5	Data Loss Handling Disclosure	6.2.1.2.2	10.5.3					
6	Packet Processing Latency Disclosure	6.2.1.2.3	10.5.4					
7	NULL Start Code Disclosure	6.2.1.2.4	10.5.5					
8	Slot Footprint Disclosure	6.2.1.2.5	10.5.6					