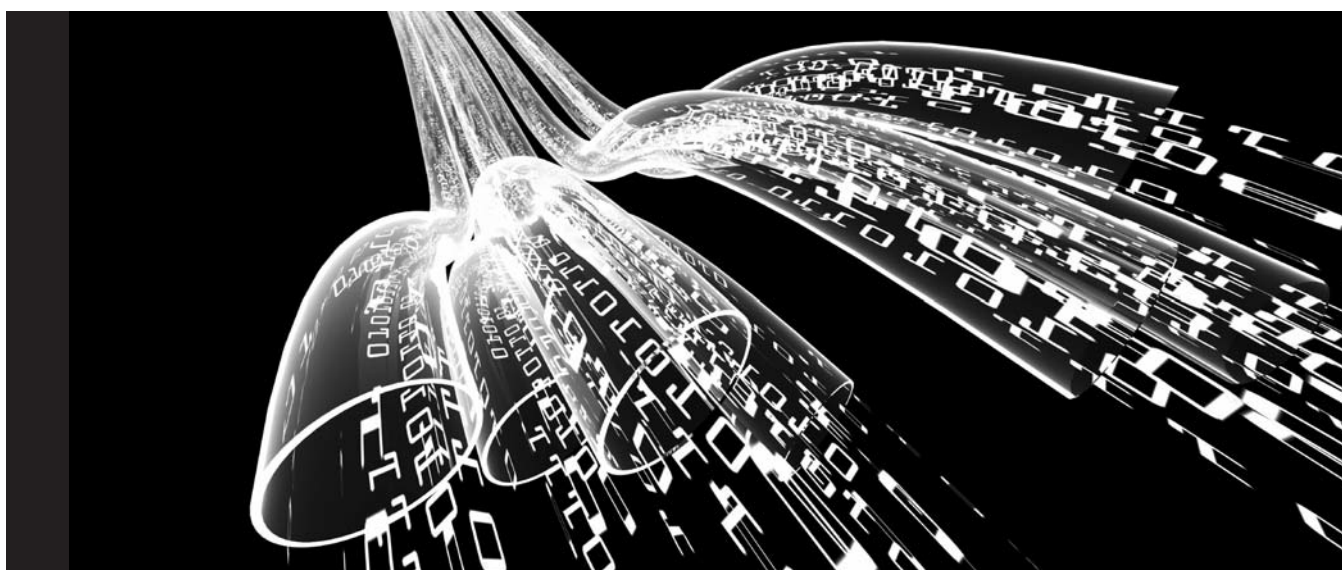


Recommended Practice for DMX512

A guide for users
and installers



2nd Edition

Incorporating USITT DMX512-A and
Remote Device Management - RDM

By Adam Bennette



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Recommended Practice for DMX512

**2nd Edition incorporating
USITT DMX512-A and
Remote Device Management - RDM**

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Adam has been involved in the design of DMX512 based products since their first introduction in 1986. Adam set-up his own business, A.B. Micro, making DMX512 testing equipment for engineers.

At present he is the Technical Director of Electronic Theatre Controls Ltd. in London.

Acknowledgements

Much of this new edition is based on the first edition 'Recommended Practice for DMX512' which was published in 1994 and was reviewed at that time by a team of industry colleagues. Their original comments and input are still pertinent in most cases and I am still grateful for their help with the original version, they are:

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This booklet is dedicated to the memory of Tony Gottelier who gave me so much support and encouragement with the first edition.

Adam Bennette, London, 2008

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How to use this document

The purpose of this document is to explain the DMX512-A specification and to offer examples and professional advice on how to set up a successful DMX512-A system. While it also offers advice on certain aspects of the design of actual DMX512-A equipment, it does not necessarily contain all the information required to design DMX512-A compliant equipment.

This document is a joint PLASA/USITT *Recommended Practice*, not an ANSI, USITT or PLASA *Standard*.

Readers wishing to design DMX512-A compliant equipment must also refer to the original ANSI E1.11-2008 (USITT DMX512-A), ANSI E1.20-2010 (RDM) Standards and the EIA-485 (RS-485) standard.

This document does not replace the USITT DMX512 (1990) nor the ANSI E1.11-2008 (USITT DMX512-A) and ANSI E1.20-2010 (RDM) Standards, and in all cases where there is any conflict, the ANSI Standards shall apply. The ANSI Standards are available from the address given on page 109.

If you wish to participate in the ongoing development and maintenance of the DMX512 standard by PLASA and USITT please contact those organisations directly. Contact details can be found on page 109.

Nearly all problems encountered by DMX512 users and installers are due to simple cable faults, poor cable layout or interference. There are also a few products on the market which do not conform exactly to the DMX512 specification. Following the advice given in the short summary on page 102 will ensure correct operation.

The need for a revised 2nd edition of this guide has arisen due to the revision of the DMX512 specification as well as the publication of a new Standard, Remote Device Management (RDM). The new specifications add features to the original DMX512 control protocol. Some of these features require systems to be set up differently from the previous simpler systems. In places in this booklet this means that advice is given that is either new or different from the previous edition.

Users who only require a simple DMX system, without any of the new features, may still use the original advice in the 1st edition of this booklet if they wish, however, systems set up in that way may not be upgradeable in the future. I therefore recommend that all new systems be set up in the way described in this 2nd edition.

Where new advice is given or where there is now advice that is in contradiction to the previous methods I have marked these with a line in the margin thus:

2nd Edition Revised Advice.

Warnings or emphasized texts are shown in italic, thus:

Warning or emphasis text.

DMX512-A protocol

Previous version of DMX512 specification

The DMX512 protocol was first developed in 1986 by a committee of the USITT (United States Institute for Theater Technology) as a means to control dimmers from lighting consoles via a standard interface. Before DMX, dimmers were either controlled via individual wires carrying a control voltage or by various proprietary digital or multiplexed analog links.

The analog, wire per dimmer, systems were bulky, expensive and non-standard. They necessitated adapter leads, amplifiers or voltage inverters in order to interface dimmers of one make with consoles of another make. In addition, a fault on the cable or connectors was difficult to repair.

The digital systems available before the widespread adoption of DMX512 were all different and incompatible. Furthermore, manufacturers were reluctant to reveal exactly how they worked for fear of commercial piracy. This left the end-user with very few options. If they wanted a certain console they often had no choice but to use dimmers from the same manufacturer.

DMX512 is not a perfect solution for entertainment control but it is by far the most widely used. Its original design was deliberately kept simple in order to persuade the largest number of manufacturers to adopt it. The simple design was attractive to manufacturers because it reduced the need for large investments or drastic re-design of their existing products.

The shortcomings of DMX512 have been widely discussed in various trade forums and some of these issues are dealt with later in this document. However, most problems found with DMX512 systems result from bad practices or a lack of understanding about what can and cannot be done with a DMX512 network.

Development of DMX512-A

During the 1990s as DMX became the dominant Standard for lighting control it became apparent to users and manufacturers that several improvements were desirable. At a meeting at the PLASA trade show in 1994 several proposals were made to allow the DMX cable to return information from devices or allow other functions, such as software downloads. Gradually a consensus was reached on the scope of work necessary and for several years a technical team under the auspices of ESTA (now PLASA) worked on the task of devising a way to add features to DMX512 without compromising its main function of level control in real-time. The result of this effort are the ANSI E1.11-2008 (USITT DMX512-A) and ANSI E1.20-2010 (RDM) specifications.

Now DMX systems may offer the user the simplest degree of level control through to a fully interactive control system able to report back from each device. In particular the new revised specification provides a means to remotely set the DMX address, thus saving users many trips up ladders to operate switches on devices.

The revised specification does not change the fundamental way that DMX may be used to operate dimmers and moving lights or other devices to set levels. Users with this simpler requirement need not be concerned at all with the workings of the advanced features.

Remote Device Management (RDM)

The main new feature is Remote Device Management (RDM). Throughout this booklet the term RDM is used to indicate use of a new feature that operates bi-directionally.

RDM offers a means to remotely configure and report the status of a device, for instance, set the DMX address, detect missing dimmer load, lamp failure, fog fluid low, operating temperature and so on.

RDM-capable DMX systems have much in common with simpler past DMX systems but may not function properly, or at all, when used with older DMX equipment.

RDM capable DMX equipment is backwards compatible with older simple DMX equipment providing that the older equipment properly implemented the original DMX512 or DMX512/1990 specifications.

Important note:

RDM capable DMX equipment will function normally, in the same way as previous DMX equipment, if the RDM features are not activated at the console or controller. RDM-capable devices cannot send any RDM information unless they are instructed to do so by the controller software.

Other enhancements in DMX512-A

The DMX512-A specification also defines several possible uses of the spare wire pair connected to pins 4 & 5. These features are for possible future implementation and have been defined so that if they are used, compatibility can be ensured. Currently none of these possible enhancements have been implemented in a standardised way. Equipment designers wishing to make use of these features should read the ANSI E1.11 specification.

These extra wires are now explicitly defined as signalling wires and are specifically not intended to carry power.

A successful DMX512-A system starts with a good quality cable of the right type. If system reliability is important there is no substitute for good cables and connectors, correctly built and installed. DMX512-A can be shown to work on inferior wire, even bell wire, but such systems will one day fail unexpectedly in the middle of an important show.

The cable should be suitable for EIA-485 (RS-485) use, with one or more low-capacitance twisted pairs, with overall braid and foil shielding. Conductors should be 24 AWG (7/0.2) or larger for mechanical strength and to minimise volt drop on long lines.

Ethernet cable, the type used for network connections in home and office networks, may also be used, subject to some care and limitations in the installation (see page 15).

A second pair of conductors may be present in the cable as spares or to carry other signals. Some dimmers send fault and status information back via these lines. Check if your DMX512-A equipment uses this second pair (most does not).

When cables are to be laid in permanent installations, or are for rental inventory, it is advisable to use a 2, or more, pair cable as the extra lines are required in order to ensure compatibility with future DMX512-A specifications. Some manufacturers have implemented talkback via these spare wires. The additional pair(s) could also prove very useful if the main pair develops a fault.

The shield is wired pin 1 to pin 1. The conductors are wired pin 2 to pin 2, pin 3 to pin 3. If the second pair is present the conductors are wired pin 4 to pin 4, pin 5 to pin 5. The shield *must* be connected at both ends even if the receiver does not use the ground connection, as otherwise extension cables would not be shielded.

The shield *must not* be connected to, or be in contact with, the shell or body of either the male or female connectors because chassis mounted connectors are



generally connected to mains ground and this could cause problems with ground loop currents. (see page 33).

Cable types

Belden cables:

Type:	Pairs:	ZΩ	Jacket:	AWG	Use:	Temp °C:
1162A	1	100	PVC	20	UL2498	80
1215A	2	150	PVC	26	IBM type 6 office cable	75
1269A	2	100	PTFE	22 (solid)	High temp, Plenum cable	200
8102	2	100	PVC	24	UL2919	80
8132	2	120	PVC	28	UL2919	80
8162	2	100	PVC	24	UL2493	60
8227	1	100	PVC	20	UL2498	80
82729	2	100	PTFE	24	High temp, Plenum cable	200
88102	2	100	PTFE	24	High temp, Plenum cable	200
89182	1	150	PTFE	22	High temp, Plenum cable	200
89207	1	100	PTFE	20	High temp, Plenum cable	200
89696	2	100	PTFE	22	High temp, Plenum cable	200
89729	2	100	PTFE	24	High temp, Plenum cable	200
89855	2	100	PTFE	22	High temp, Plenum cable	200
9182	1	150	PVC	22	UL2668	60
9207	1	100	PVC	20	Flame-proof	75
9271	1	124	PVC	25	UL2092	60
9729	2	100	PVC	24	UL2493	60
9804	2	100	PVC	28	UL2960	60
9829	2	100	PVC	24	UL2919	80
9841	1	120	PVC	24	UL2919	80
9842	2	120	PVC	24	UL2919	80

Proplex cables:

Type:	Pairs:	ZΩ	Jacket:	AWG	Use:	Temp °C:
PC222P	1	80*	Polyurethane	22	Heavy duty and portable	105
PC222T	1	110	PVC	22	UL2464	105
PC224P	2	110	Polyurethane	22	Heavy duty and portable	105
PC224T	2	110	PVC	22	UL2464	105
PC226T	3	110	PVC	22	UL2464	105

*Note about Proplex cable 222P: This cable is widely used with success even though its impedance measures as 80 ohms.

Alpha cables:

Type:	Pairs:	ZΩ	Jacket:	AWG	Use:	Temp °C:
9109	1	100	FEP	20	High temp	150
9816	1	95	PVC	18	Large diamter	80
9817	1	100	PVC	20	UL2498	80
9818	1	100	PVC	20	UL2498	80
9818D	1	100	Polyethylene	20	Direct burial	80
9821	1	124	PVC	25	UL2092	80
9823	1	150	PVC	22	UL2772	80

This table is not an exhaustive list of all the cables suitable for DMX512-A. Any *twisted pair, 120ohm, shielded EIA-485 cable* is suitable. The required cable gauge will depend on the length but it is recommended to be 22 AWG, 24 AWG minimum.

ZW is the characteristic impedance (see termination section on page 21). AWG stands for American Wire Gauge.

The above cables are available from electrical suppliers and specialised theatrical equipment suppliers (for addresses of cable manufacturers please see page 109).

Using Ethernet cables (Cat5, Cat5e, Cat6)

Standard cables for Ethernet 10base-T/100base-T, known as Cat5, Cat5e or Cat6, may be used for DMX in many circumstances with identical results to EIA-485 cable.

Ethernet cable categories, 5, 5e and 6 are suitable for DMX.

At DMX signalling rates ethernet cables have a characteristic impedance of 115 ohms, very close to the DMX/EIA-485 value of 120 ohms. The cables are twisted to provide immunity from interference in a similar way to EIA-485 cables.

Rules for using Ethernet cables:

- The cable must be suitably mechanically protected from abrasion and crushing. Cat5 cables are not very physically robust. Do not use them unless they are well protected.
- The cable must not be subjected to repeated bending. Cat5 cables have stiff cores that will break after a few flexings.
- There must be no sources of high-energy electromagnetic interference nearby. Cat5 cables (the unshielded type, which is the most common) do not provide the same degree of protection from interference as a proper EIA-485 shielded cable. Equipment that may interfere with DMX on Ethernet cable includes radio and television transmitters, welding equipment, induction heaters, radio sources such as radar, X-ray or MRI and CAT scanners, Heavy industrial machinery, and other equipment using high power electricity. If in doubt about the local electromagnetic environment do not use an Ethernet cable without shielding.
- In Europe, and other places that have adopted the same technical regulations as Europe for electromagnetic compatibility, Ethernet cables used for DMX must be either shielded or inside metallic conduits connected to earth. This is to prevent the cable from producing, or being susceptible to, interference with other equipment.
- Ethernet cable cores are small-gauge and fragile and are not suited to screw-down connectors and terminals. The action of screwing down on to a cable core will often break it or weaken it so it breaks later. Cat5 and similar wire should only be terminated in insulation-displacement connectors or in pressure terminals with protective leaves suitable for fine-gauge signal wires. The cable should be secured so that no mechanical strain is put on the cores.

Recommended minimum cable gauges

Length, feet	Length, metres	AWG	mm2	Note
295	90	26	0.128	Cat5/6 (1)
1000	300	24	0.2	
1640	500	22	0.325	(2)

Notes:

(1) The maximum length recommended for Cat5 cable used for DMX is shown as 90m. In practice the cable is capable of somewhat longer distances when carrying DMX signals. The 90m value is given for a different reason: it ensures that if a system is built based on Cat5 cable it is potentially possible to upgrade it later to carry Ethernet signals.

The ability of Cat5 to operate as an Ethernet carrier is not only related to cable length; other considerations apply that are outside the scope of this booklet.

Users wishing to build a system that may be later changed to Ethernet should consult a network installation specialist or study books on the subject.

However, in the meantime, limiting the cable length to 90m means that it may be possible to upgrade. If Cat5 cable are run longer than 90m then it will not be possible to re-utilise them to carry Ethernet later.

(2) 500 metres should be regarded as an absolute maximum. 500m cables should work with conventional DMX systems but experience with RDM-capable DMX systems has shown this to be not always true. RDM circuits present double the termination load to a transmitter. Some types of transmitters operating in certain conditions may not be able to reliably function on a 500m run.

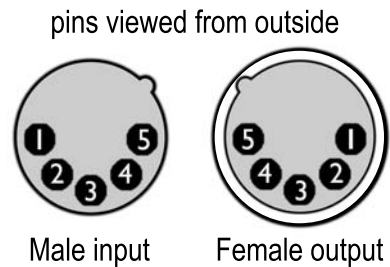
The recommendation is now to limit lines to 300m length, particularly if they feed multiple devices.

500m lines are still allowed provided the installer knows about the line loading characteristics of the equipment and is able to ensure that signalling voltages remain within the recommended limits (see page 69).

Connections

XLR Connectors

DMX512-A lines connect with equipment via XLR 5 pin type connectors. A female connector is fitted to a transmitter and a male connector to a receiver. DMX512-A specifies a 2 pair (4 conductor) cable with shield, although only one pair (2 conductor) and shield is required for standard DMX512-A signals. The second cable pair is reserved for unspecified optional uses. See page 13 for other considerations involving the second pair.



pin	Wire (EIA-485)	signal
1	shield	ground/return/0V
2	inner conductor (usually black)	data complement (-, inverted)
3	inner conductor (usually white)	data true (+, non inverted)
4	inner conductor (usually green)	spare data complement (-, inverted)
5	inner conductor (usually red)	spare data true (+, non inverted)

pin	Wire (Ethernet cable)	signal
1	White/Brown & Brown (connected together)	ground/return/0V
2	Orange	data complement (-, inverted)
3	White/Orange	data true (+, non inverted)
4	Green	spare data complement (-, inverted)
5	White/Green	spare data true (+, non inverted)

The above wiring chart for Ethernet wire in an XLR connector is shown in case it is occasionally necessary, however, it is not recommended to use Ethernet wire for portable wiring as it is not durable enough.

Ethernet wiring should normally only be used for permanently installed cables terminated to RJ45 connectors or terminal blocks.

The 5 pin connector is described in the original USITT DMX512 standard and should be the preferred connector type.

Some equipment may be fitted with 3 pin XLR connectors to allow the use of standard microphone cables, and in this case the pin-out is the same as the first three pins shown above.

The use of 3 pin connectors is not recommended and is not part of the DMX512-A standard.

Microphone and audio cables are not ideally suited for DMX512 transmission. It is strongly recommended that only cable suitable for high-speed data transmission, such as one of the types listed above, is used.

When 3 pin XLRs must be used care should be taken to ensure the user cannot accidentally plug them into microphone inputs with phantom power. Phantom microphone power may damage DMX equipment.

It should also be noted that DMX512-A signals may be routed down other cabling systems, for instance to colour changers, typically via 4 pin XLR style connectors. The same rules apply regarding cable characteristics and generally this will require the use of cable specially designed for this purpose.

| RJ45 (Ethernet) connectors

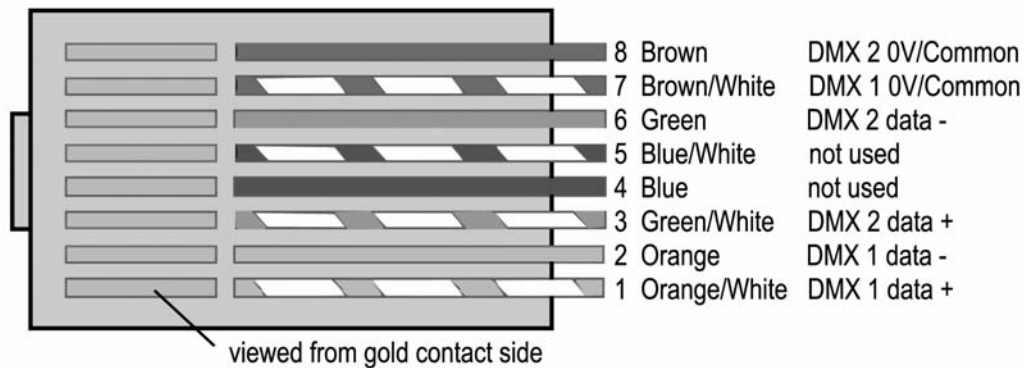
Where connections are to be made inside equipment racks or semi-permanently inside equipment or in patching bays, standard Ethernet-type RJ45 connectors may be used on Ethernet cable. These connectors are defined in the Standard IEC60603-7.

RJ45 connectors are not recommended in other locations as they are fragile and not intended for frequent mating.

| RJ45 wiring code

pin	Wire Colour	signal
1	White/Orange	data true (+, non inverted)
2	Orange	data complement (-, inverted)
3	White/Green	spare data true (+, non inverted)
4	Blue	Not used
5	White/Blue	Not used
6	Green	spare data complement (-, inverted)
7	White/Brown	Signal common / 0V for data line 1
8	Brown	Signal common / 0V for data line 2
	Metal shell (if present)	Drain - (shield on STP or FTP cables)





Ethernet cable used for DMX512 and wired on RJ45 connectors must not be plugged into either Ethernet equipment, such as hubs, switches, computers, modems or data terminals nor into telephone equipment. Such connections may cause severe damage or malfunction.

Ensure that Ethernet cables wired for DMX512 are clearly marked to advise users against mis-plugging with incompatible equipment. Particular attention should be given to patch bay systems in proximity to similar Ethernet patch bays.

| Compatibility of RJ45 connectors

Several manufacturers started using RJ45 connectors to carry DMX signals long before the ANSI E1.11 Standard was finalised. Several wiring plans have therefore been in use for some years that are not the same as each other and not the same as the system finally published.

When connecting RJ45 DMX wiring to existing system ensure the pin-out is the same.

If equipment fails to function when using RJ45 / Ethernet wiring, and the wiring is known to be properly made, then it is likely the connector pin-outs differ. One end will need to be changed or an adaptor introduced.

Incorrect or missing termination is probably the single most common reason for faulty DMX512-A systems.

The terminator is a resistor fitted between the two data lines (pins 2 & 3 of an XLR 5 pin connector) at the end of the cable furthest from the transmitter.

If a terminating resistor is not fitted, when the signal arrives at the far end of the line it is 'reflected' back down the line to the transmitter. At certain line lengths and conditions the reflected signal can cancel out the real signal, resulting in errors. A terminator resistor 'soaks away' the signal at the far end of the line, preventing reflections.

The resistor value is typically between 110-130 ohms $\frac{1}{2}$ watt. Previous simple DMX systems, with no RDM features, could be terminated at the far end only, as the transmitter was always at the near end. RDM systems allow any device to be a transmitter therefore both ends of the line could be distant from the transmitter.

It is recommended that all DMX512-A systems are built with a terminator at each end of the line.

The far-end terminator is a simple resistor, as before. The near-end (console end) terminator is a resistor network (see Line Biasing on page 23 for details).

The termination resistance should ideally match the 'characteristic impedance' of the cable (see column $Z\Omega$ in the cable lists on page 14). The characteristic impedance is the impedance of a line of infinite length, which, by definition, would not suffer from reflections. Placing a resistor equal to the characteristic impedance at each end of a line of finite length causes the cable to behave as if it were infinitely long, from the transmission circuit's point of view.

Cables for DMX512-A have a characteristic impedance of approx. 100-150 ohms. RS-422 (a predecessor of EIA-485) is optimised for 100 ohm lines, EIA-485 for 120 ohm lines.



DMX512-A systems may appear to work fine without the terminator resistors (indeed they may be forgotten or lost without anyone noticing at first) until they unexpectedly fail.

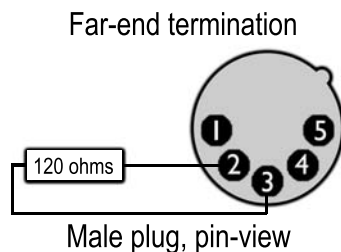
Always check for the presence of the terminator resistors. A simple resistance check across one end of the cable (turn off all devices on the line and measure resistance between pins 2 and 3) can reveal the presence of the terminator resistor, or faulty (too much or too little) termination. This resistance should be around 60-75 ohms on short or heavy-gauge cables and may be higher with very long cables due to the additional resistance of the cable conductors themselves.

The two 120 ohm resistors together in parallel results in a measured resistance of 60 ohms.

If the resistance measures as approximately 120 ohms then the network is probably a correctly terminated simple DMX network. This should function properly for conventional DMX but will not function with RDM.

Some devices are fitted with a switch to select an internal terminator. This switch may be labelled 'end-of-line' or 'last-rack'. It should only be switched in on the last device on the line.

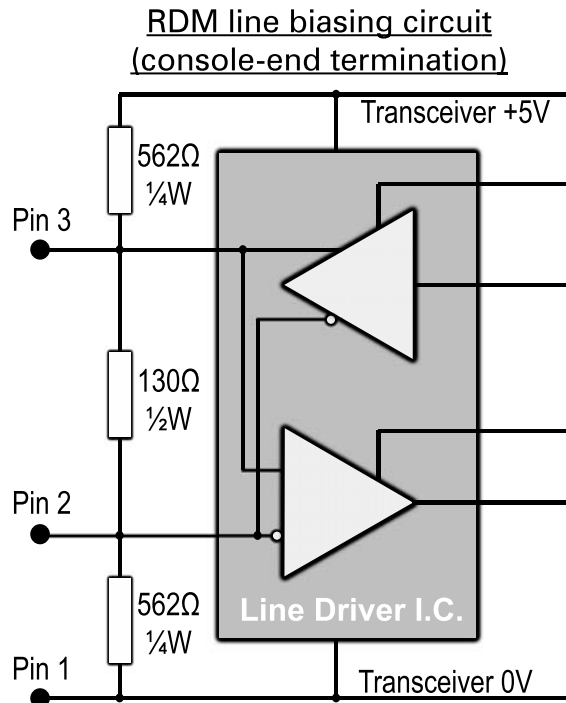
Another common type of terminator is an XLR male plug fitted with a resistor which can be plugged in to the output of the last device. This is simply a male 5 pin plug with a 120Ω resistor soldered across pins 2 & 3. Every lighting electrician's toolbox should include at least one of these 'dummy plug' terminators.



| Line biasing

RDM systems also feature another type of line termination known as a biasing network. This circuit is a set of resistors arranged to hold the data lines in a known state if no transmitter is driving the DMX line.

During RDM transactions there are short times when the console has requested data from an RDM device and has changed into receive-mode waiting for a reply. Until the device takes control of the line to send a reply the line is in an unconnected state with no transmitter to hold the two wires in the idle condition. Unless the line is externally forced to the idle condition it could be prone to noise that could be misinterpreted by receivers as the start bit of a data byte (see page 71).



The defined resistances are 562 and 130 ohms $\pm 2\%$. In practice the common values of 560 and 130 ohms ($\pm 1\%$) may be used.

One, and one only, of the connected devices should feature an RDM-line-biasing-network. Normally this will be in the console. Check with the manufacturer of the console and the devices if they have an RDM-line-biasing switch that must be selected, and only engage ONE of them on each RDM-capable DMX line.

In a system employing RDM splitter / repeater amplifiers each new RDM capable branch must be biased. Normally this would be achieved by the RDM splitter

Connection of more than one biasing network to an RDM line, and also to a non-RDM line, may cause errors or malfunction. If an RDM system is prone to errors check that one and one only line biasing network is activated.

Line biasing is not necessary on conventional DMX lines that are not RDM capable.

On lines that *are* RDM capable, and enabled for RDM transactions, the line *must* be biased even if there are no RDM responder devices on that line. The console or splitter may place the line into the floating, disconnected state even though no reply will take place back to that particular output.

Biasing may be applied to normal DMX lines with no ill effect. Because of this it is recommended for reasons of simplicity to bias all DMX lines whenever a switch or option for biasing is present.

All DMX lines with RDM enabled must be terminated at both ends even if no actual RDM responder devices are connected and only conventional DMX (receive-only) devices are connected.

One, and one only, of the connected devices on each separate DMX or DMX-RDM line should feature an RDM-line-biasing-network.

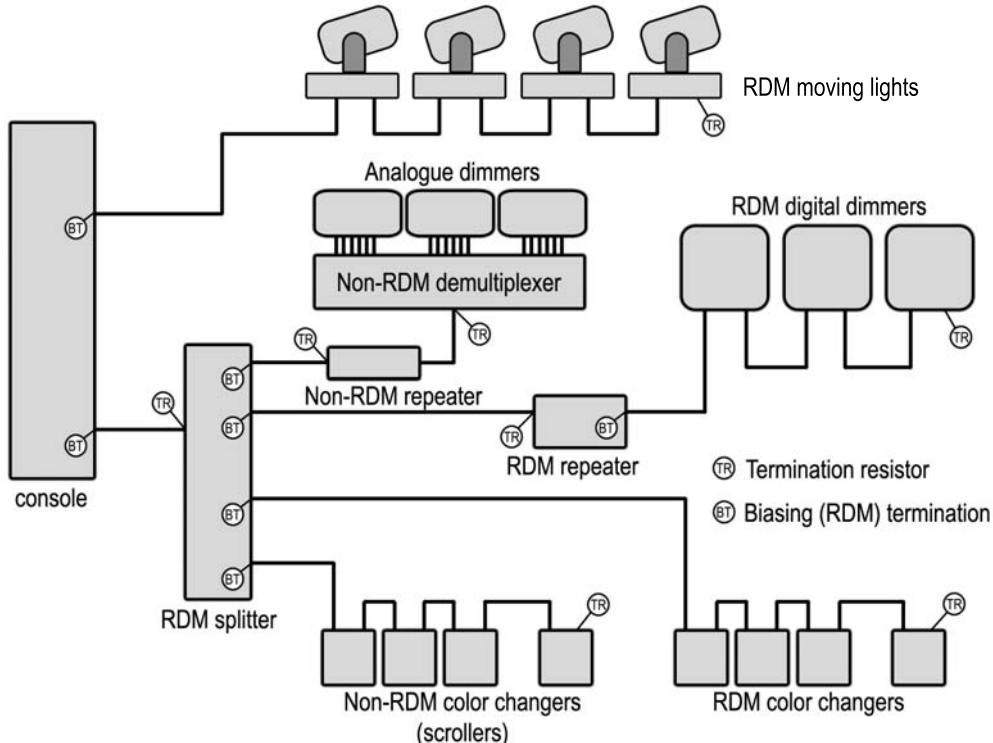
Mixed RDM and non-RDM systems

If a system contains a mix of RDM and non-RDM capable devices then only those DMX lines supporting RDM need be terminated at both ends and fitted with bi-directional, RDM capable, in-line equipment (such as repeaters). Lines carrying only conventional DMX receivers can still be treated in the same way as before, with a single terminator at the far end and simple opto-isolators or repeaters - *providing no RDM traffic is allowed on that line*.

When upgrading installed systems to include RDM it may not be necessary to upgrade all the branches. For instance, a DMX line that exclusively feeds an analog convertor to drive older dimmers need not be made RDM capable.

If the lines are general purpose they should be be upgraded to ensure future compatibility.

Example DMX512-A network:



Note that only the line from the output of the non-RDM repeater is not fitted with the 2nd, console-end, biasing termination.

Using RDM with devices that do not check the Start code

Some old DMX devices exist that do not check the Start code. They cannot distinguish RDM traffic from normal DMX levels. If they are used on an RDM-enabled system they will respond to RDM messages as if they were dimmer levels and produce the appearance of errors or flicker.

If an existing system includes devices that are so simple and basic (and non-compliant with any DMX specification, past or present) that they do not check the Start code then they must be isolated from RDM traffic. Certain types of RDM splitters offer features to disable RDM traffic on each output port independently. Alternatively there are several makes of DMX 'translators' that can filter out undesired Start codes and ensure that only normal dimmer level information is passed on.

Mixing RDM and non-RDM devices downstream of splitters

It is not advised to place RDM capable devices downstream of a non-RDM capable splitter that is fed with RDM data from the main controller. If possible the input of the non-RDM-capable splitter should be isolated from RDM traffic.

There is a theoretical, but rather improbable, situation where the RDM device would respond to a message and corrupt the output of the splitter. The corruption could possibly be mis-read by other non-RDM devices on that DMX branch causing errors or flicker.

This is a real risk only if an RDM device, which has been discovered and addressed elsewhere on the system, is then moved downstream of the non-RDM splitter.

It is advisable, but not compulsory, to connect RDM-capable devices to RDM-capable splitters and not to ordinary non-RDM-capable splitters wherever practical.

DMX512-A will only function correctly, especially with long cables, when a single line is employed from the first device to the last device.

A transmitter, i.e. a console or controller, is now considered to be simply another device and could in principle be located anywhere along the DMX line. However, because of the need to bias the line in combination with termination, and because this is normally present in the console or transmitter, the normal practice will be to place the console at one end of the line.

A line can have up to 32 unit loads (less if the receivers do not comply with the EIA-485 spec. - see page 35) hung off it anywhere down its length. A typical EIA-485 receiver represents approximately one unit load. These devices should connect to the line with very short (less than 30cm - 12") cables in order to prevent the creation of 'Y' splits (see below), but in practice this length can be extended to several metres. This is normally accomplished inside the devices which, if fitted with input and pass-through connectors, can be daisy-chained together.

The EIA-485 link as used by DMX512-A is capable of operation on lines of up to 1km (3281') in length. This is the absolute maximum. It is recommended to keep the line length below about 300m (1000'), beyond which signal amplifiers (repeaters) should be considered.

When very long lines are employed, care should be taken to select a cable with sufficient conductor cross-sectional area. The resistance of the cable must allow at least 0.2V to be developed across each of the 120 ohm terminator resistors at each end of the cable when driven with as little as 2V at the transmitter. Do not use a cable with conductors less than 22 AWG. in size on long lines. The D.C. resistance should not be confused with the characteristic impedance. D.C. resistance can be measured with a standard ohmmeter and should not exceed approx. 200 ohms per conductor.

DMX512-A lines should be kept away from power cabling, particularly load cables from dimmers, and should not be run in conduit or trunking with power cables or cables carrying large currents as this could cause interference and errors.

Simple splitter cables ('Y' leads)

Do not use simple splitter cables / 'Y' leads / 'DMX Twofers'

A 'Y' lead is a hard-wired connection between a male (console-side) connector and two female (dimmer-side) connectors; all pins 1 are joined, all pins 2 etc.

If 'Y' leads are used, particularly at a distance from the transmitter, then a complex set of reflections will ensue, causing severe signal degradation and increased error rate.

Splitter amplifiers are the only reliable method for splitting the DMX512-A network into different branches. See next section.

Repeater and Splitter / Distribution amplifiers

Simple Repeater amplifiers as described in the 1st edition will NOT WORK with DMX512-A systems that employ RDM or any of the advanced features that use the DMX line as a bi-directional link.

Simple Repeaters (non RDM capable)

When very long lines are employed, or more than 32 devices are required, it is necessary to boost the signal through a repeater amplifier, also known as a buffer amplifier. The input of the repeater amplifier is like the input of any other DMX512-A device; the output is like that of any other DMX512-A transmitter. The line from the console should be terminated in the normal way - the repeater need not be at the end of the line. The second, repeated, line is also terminated at each end.

Lines can be repeated in this way many times before re-generation errors occur, providing that the repeater amplifiers, and particularly opto-isolated circuits, are sufficiently fast. If these circuits cannot reproduce the rising and falling edges of the signal without some distortion or delay, the chaining together of such devices will eventually corrupt the signal.

Repeater amplifiers that only restore the electrical levels of the DMX512-A signal can only be used with simple DMX systems not using any RDM bi-directional features. Such simple amplifiers do not re-create the timings between the individual bits. Re-generation of the timing can only be achieved with special equipment that decodes the DMX512-A input and then re-transmits it through a separate encoder (UART) and output driver circuit. Such devices can also be used to modify the DMX512-A timings in order to allow the use of non-compliant DMX512-A receivers with modern fast consoles (see page 78).

RDM bi-directional Repeater amplifiers

Repeater amplifiers capable of handling DMX-RDM signals contain processors that read in the data stream and decode the packet Start codes to see if an RDM



message has been sent that requires reversing the line connection in order to receive a reply from a device.

Only amplifiers specifically designed to handle RDM can perform this task.

Built-in repeaters

Many devices, particularly colour changers and large dimmer racks, have built-in repeater amplifiers to re-generate the DMX512-A signals. These designs are usually fitted with a relay to switch the input directly to the output in the event of power failure or malfunction so that subsequent units are still fed with data. Note that this switch-over is purely mechanical and is not synchronised to the DMX512-A data. As the contacts change-over there will be a brief loss of signal. Devices down-line from the changeover may receive bad DMX512-A data. This will not be corrected until the next new packet of levels arrives. Thus, with a slow console the wrong dimmer levels may persist long enough to be very noticeable.

When the repeater is active, each output is driving a 'new' DMX512-A line, which should be terminated in the normal way. However, if these lines are very short, e.g. to the next module in a rack, termination would not normally be necessary. Still, it is desirable for the following reason. When the outputs are routed directly from the inputs, if the module is off or has failed, the termination is also removed, thus the next module will provide the termination. The last module would have a terminating plug in its output socket. If all the modules in the rack are off, or have failed, the line will be terminated into the plug. With such a system any other devices will always see a correctly terminated line.

Built-in repeaters should not be expected to be fully DMX-RDM compliant and will not pass RDM traffic back to a console.

If in doubt about presence of built-in repeaters, and how this can affect the network, try measuring the termination resistance while cycling power on each

of the devices on the line. The resistance should remain substantially the same (60-75 ohms) and other devices down-stream should continue to respond to DMX512-A levels, although there may be glitches in their operation, as described above.

Splitters

Splitter amplifiers are like repeaters but they have more than one output. Each output drives the same signal but down separate lines. These are also known as distribution amplifiers since they allow the DMX512-A line to be replicated and sent in different directions to devices distributed throughout a building or concert site.

There are important differences between isolating and non isolating repeaters and splitters which are discussed below (see page 33).

DMX512-A networks using RDM bi-directional features will only work if Splitters are used that are specially designed to handle RDM signals. Ordinary splitters will prevent RDM information from being sent back from devices. Only simple DMX control of levels, in one direction only from the console to the devices, will continue to function.

RDM messages should, if possible, be disabled in a console or controller if RDM devices are connected downstream of non-RDM capable in-line equipment. Failure to prevent RDM transmission in this case may result in system malfunction.

Connection of pins 4 & 5

The second pair in the DMX512-A line is described in the DMX512-A specification but its use is not defined. There are many devices and systems in the field that use the second pair, on pins 4 and 5, for various purposes. Some systems implement talkback using the pair as a return EIA-485 line to the console or a separate fault and status display unit. Other systems may employ the two wires of the 2nd pair as direct control signals, for temperature indication for instance.



Most DMX512-A devices, with input and pass-through connectors for daisy-chaining, simply connect the first three pins; 1 to 1, 2 to 2 and 3 to 3. Not all devices also connect pins 4 to 4 and 5 to 5.

Talkback systems which utilise the second pair as a return line require special distribution amplifiers and custom bi-directional repeaters and isolators.

The ANSI E1.11-2008 (USITT DMX512-A) Standard now specifies how signals should behave on the 2nd line connected to pins 4 & 5. A number of separate methods are allowed as defined in Annexe B of the Standard. Readers desiring to use pins 4 & 5 for some supplementary purpose should read the requirements for electrical levels, registration of Alternate Start codes (if required) and suitable markings in this annexe.

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| Grounding

In the manufacture of DMX512-A equipment there are several approved methods for connection of the signal common, or line ground, to the mains/chassis ground. The EIA-485 standard requires that the line ground be tied to the mains ground in both the transmitters and receivers, unless the common-mode voltage exceeds the specified values (see page 70). In practice this means that manufacturers sometimes connect to mains ground and sometimes leave the line ground floating.

The ANSI E1.11-2008 (USITT DMX512-A) version of the DMX Standard now includes Annexe A which defines the various different grounding connection methods that may be used and how they interact with each other. For full details read that section of the Standard. Here follows general advice on the basic requirements for grounding to ensure correct operation, this is, however, not the only way it may be done.

The ground wire of the line should be connected to mains ground at the transmitting end in most DMX512-A installations (except battery powered transmitters, testers etc.) for reasons of interference rejection. In a standard EIA-485 set-up the line ground may also be connected to the receiver mains ground. This can cause special problems with large lighting systems, ranging from signal errors to catastrophic failures.

It is important when installing a DMX512-A network to determine which units have their DMX512-A cable shield connected to mains ground and which do not. This can be ascertained with a simple continuity check between pin 1 of the device's connector and mains or chassis ground.

If all the devices (except the transmitter / console) are isolated from ground it will not normally be necessary to take any special precautions. If one or more devices are grounded it may prove necessary to install isolation circuitry to part or all of the DMX512-A network.