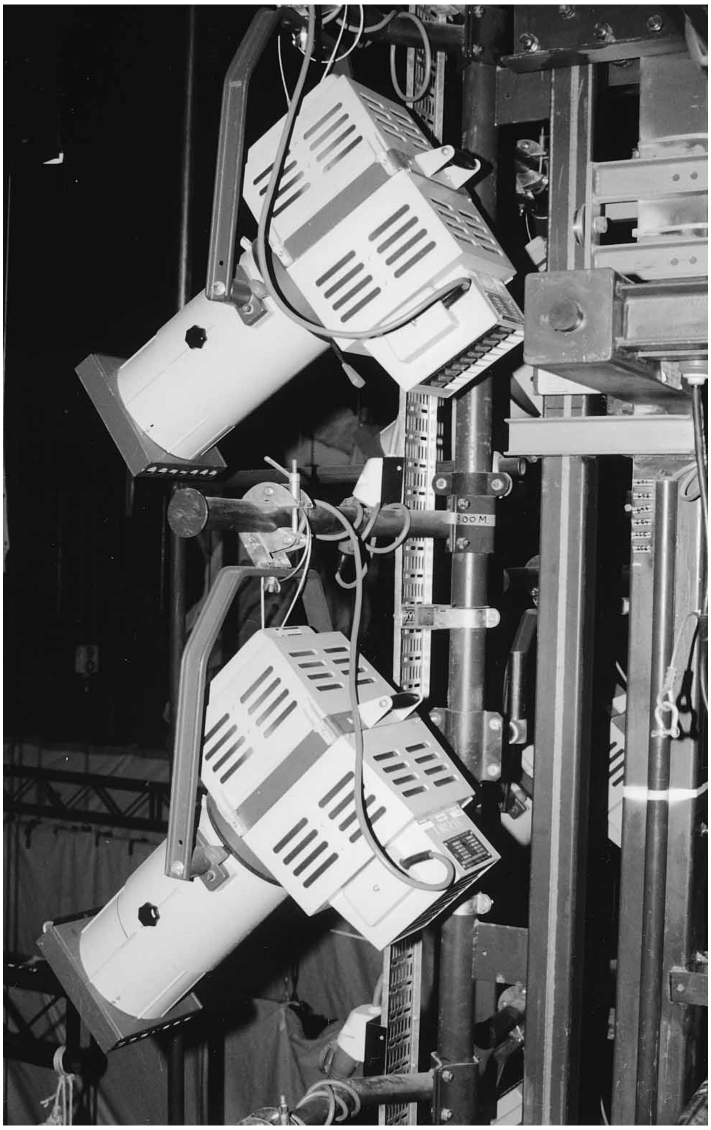
stage-lighting control

with DMX512 protocol

Before the computer age, it required quite a number of assistants to control the stage lighting in a theatre. Today, however, even here the computer has proved its usefulness as a tool. With the DMX512 (***D***igital ***M***ultiple***X*** for 512 units) standard, a computer can control the entire lighting system, including ancillary functions such as the colour filters and dimmers. In this setup, a simple interface cable enables the computer to control up to 512 separate lighting units.



By our Editorial Staff

Some of us theatregoers may remember the large theatre lights that were manually operated. Each light required at least a pair of hands – a labour-intensive and therefore costly affair. When electronic control units, and later the computer, became available, many theatres adopted analogue lighting control systems that were much simpler to operate, and therefore more cost-effective.

However, over the past ten years or so, digital control systems controlled by computer have become the norm. In most smaller theatres, the set of instructions developed for the United States Institute for Theatre Technology (USITT), code-named DMX-512, has been adopted. This is an efficient, yet simple, digital protocol, accepted in many parts of the world, which enables all aspects of the stage lighting to be controlled by a computer.

IN TIMES GONE BY...

In the early years of (analogue) electronic control units, an analogue signal was required for each control channel, that is, each lighting function that had to be controlled. What's more, a separate cable or pair of wires in such a cable was needed for each of these functions. This cable had to distribute linear control voltages of 0–10 V according to an internationally accepted set of rules. Evidently, although this is a practical setup when there are not that many lights involved, it becomes cumbersome and costly when many lights are to be controlled, because it results in many or very thick cables. However, for the technicians involved, the use of low voltages means that it is a safe system that can be checked with a simple multimeter.

With the increase of technical facilities whereby modern projectors fulfil more and more functions, the analogue system becomes more and more impracticable. Each piece of equipment needs several channels, which makes the cabling ever more complicated. Today, some lighting units provide 25–30 functions.

In larger theatres, these difficulties with analogue systems led in the early 1980s to the introduction of digital control systems, which in the mid-1980s resulted in the USITT adopting the digital DMX-512 standard. In this system, each pair of wires can control up to 512 functions. In practice, of course, the number is restricted to 32. However, each unit being controlled may use several channels at a time, so that a fair amount of the total available capacity is used.

Although the DMX-512 protocol is not new, it may not be known to many readers. Moreover, a successor is already being developed: the DMX-B. Fortunately, the new set of standards is backwards compatible with the DMX-512, so that older equipment remains usable.

EFFICIENT AND EFFECTIVE

The DMX-512 Standard was last modified and officially laid down as a norm by the USITT in 1990. It is based on the much more widely used RS485 Standard. A basic layout of a DMX-512 link between transmitter and receiver, both of which use the same driver, is shown in **Figure 1**. Interconnection is via a symmetrically controlled pair of wires.

The data are transmitted asynchronously serially over the wires. The settings are sent sequentially, that is, first the level for dimmer 1, then that for dimmer 2, and so on, until the levels for all connected dimmers (up to 512)

1

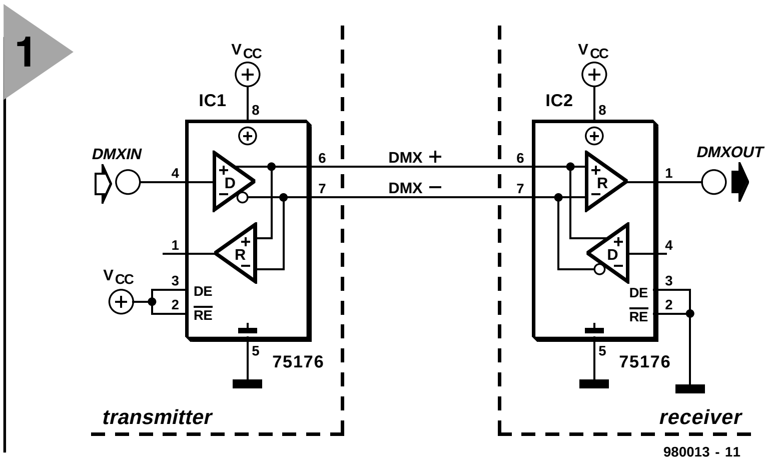
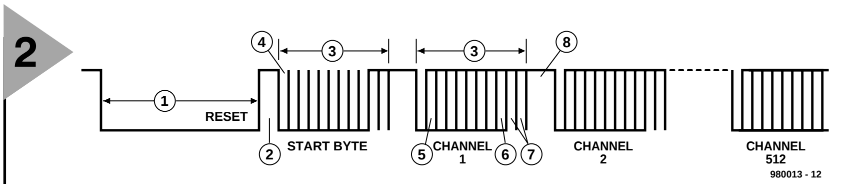


Figure 1. Basic layout of a simple transmitter and receiver used in the DMX-512 system. The driver is a standard driver for the RS485 system and is readily available.

2



no.	name	min.	typ.	max.	unit
1	reset		88	88	µs
2	mark	8	-	1	µs
3	frame	43.12	44.0	44.48	µs
4	start bit	3.92	4.0	4.08	µs
5	LSB	3.92	4.0	4.08	µs
6	MSB	3.92	4.0	4.08	µs
7	stop bit	3.92	4.0	4.08	µs
8	mark (between frames)	0	0	1.00	s
9	mark (between trains)	0	0	1.00	s

Figure 2. The timing diagram shows the maximum width of a data block with which up to 512 lighting units can be controlled. In this setup the repetition rate is 44.1 Hz.

How to make a terminator

Terminators are of great importance to ensure good and reliable communication, but, owing to their small size, are easily mislaid. It is, therefore, useful, to be able to make one at low cost.

Remove the hood from an XLR plug and solder a 120 Ω, 0.25 W resistor between pins 2 and 3, and replace the hood. That's all! The photograph shows a completed terminator.

3

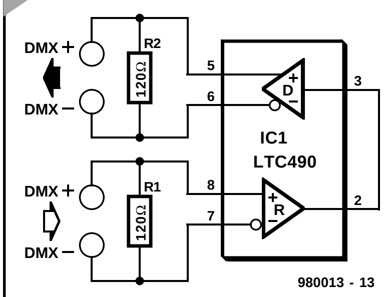


Figure 3. When lines longer than about 1 metre are needed, a bus repeater as shown will be essential.

4

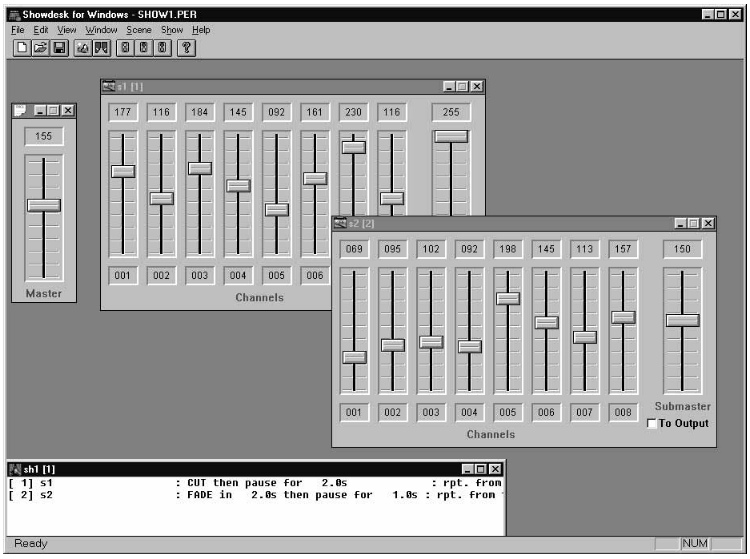


Figure 4. To get a better idea of the facilities provided by the DMX-512 standard, download a demo version of ShowDesk from web site http://www/fpfltd.com

have been sent.

The reset pulse is followed by a mark signal that indicates the onset of communication. Normally, the mark signal must be at least 8 µs long, but there are systems which are able to recognize a mark-to-break width of 4 µs; these are coded DMX-512/1990 (4 µs).

The onset of a cluster of bytes is marked by a reset signal that is followed by a start byte. This is followed by the brightness data for the first dimmer in the shape of an 8-bit value 0–255, that is, 00_H–FF_H. The relationship of this value with respect to the present brightness setting is a matter for the dimmer itself. For instance, the manufacturer of the dimmer may give it a control curve according to which its brightness increases or decreases. In the case of lamps whose brightness must change rapidly, use may be made of a shutter; the DMX-code then arranges the opening and closing of the shutter.

Each DMX-512 instruction consists of a start bit, eight data bits, and two stop bits (one frame). In the quiescent state, the level on the communication line is high (mark), whereas the active level is low (break or space). The break signal itself is not less than 88 µs wide, a time that corresponds to two frames. The system recognizes the break as a reset signal, whereupon all current operations are discontinued.

The next step is the transmitting of a number of n + 1 frames, each of which contains the setting of one of the connected dimmers. The first transmitted frame, that is, the start byte, marks the onset of the series of commands and has a fixed value 00_H. This indicates that the settings refer to the dimmers. Because of this start code, standards that use a different start code for controlling other types of unit may be added at a later date. For this reason, the connected dimmers must not react when the communication is

Figure 5. A modern control room from where the lighting manager controls the stage lighting resembles a computer centre.

5

6

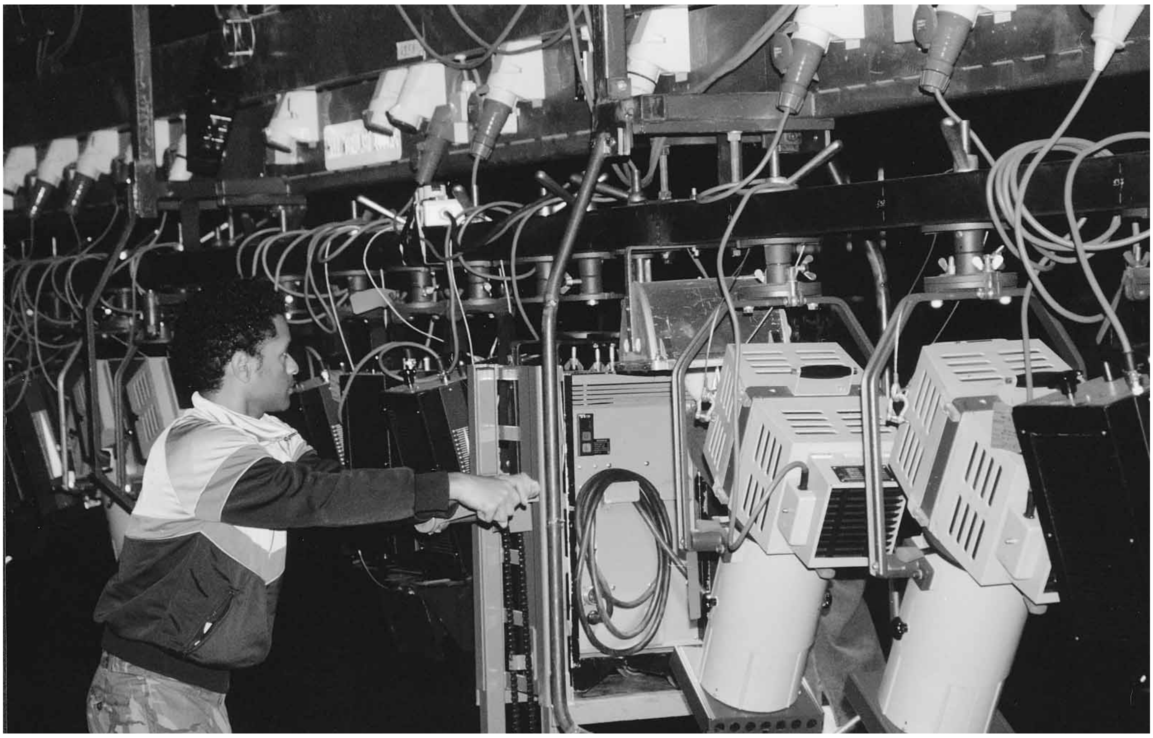


Figure 6. Modern theatre lights may have more than 25 functions. For each of these functions, the light uses a DMX address.

begun with a start code other than 00_H.

TIMING

As mentioned earlier, the DMX-512 standard supports up to 512 dimmers; a minimum is not stipulated. After the data has been transferred to the final dimmer in the chain, the data line returns to the quiescent state (mark). The next reset signal indicates that a new transfer of data is imminent. It is imperative that two sequential setting instructions are separated by an interval (pause) of not less than 1196 μs.

The data rate in the DMX-512 standard is 250 kbit/s. Since one bit lasts for 4 μs, a complete instruction, including the stop and start bits, takes 44 μs. The timing diagram in **Figure 2** shows a complete sequence of 512 bytes, the data stream required for the theoretical maximum of 512 dimmers. When all times are added, the maximum time duration is 22,668 μs, which corresponds to a repetition rate of 44.1 Hz. From this, it is clear that the use of the maximum number of dimmers restricts the speed of operation.

The DMX-connection allows 32 lighting units to be linked to the bus. There is no limitation as to the number of addresses that each of these units can handle.

CABLES AND ALL THAT

The cables carry rectangular-wave signals at a frequency of 250 kHz maximum. Each signal may contain components at frequencies up to 2.5 MHz. This means that in the DMX system cables must be used that are quite different from the ones used in analogue systems. No longer can standard cable with simple connectors be used: specific types of cable with corresponding connectors are imperative.

As mentioned earlier, the system is based on the RS485 interface, which is an improvement of the earlier RS422 system. The improvements make possible more connections to the bus and additional space for more masters. The latter facility is not used in the DMX512 system, but the former enables applications within a network. Although the RS485 standard limits the length of the cable, exceeding the specified length within reason will not create difficulties: distances of up to 1 metre (3.3 ft) are perfectly usable, provided that the final unit in the chain is terminated correctly into an impedance of 120 Ω.

If larger distances need to be spanned, a bus repeater should be used. The circuit of such a repeater is shown in **Figure 3**. Note that both the input and output are terminated into 120 Ω. The DMX-512 standard does not specify the electrical isolation.

SOME LIMITING VALUES

It is important that the driver can handle signal levels between 1.5 V and 5 V at a common-mode potential between –7 V and +12 V.

The leakage current at the output should not exceed 100 μA during an output signal.

The input impedance of the receiver must be not lower than 12 kΩ, while the output load must not exceed 60 Ω.

Short-circuit currents of 150 mA to earth and 250 mA to the positive supply line are permissible.

This article is based on information available in the relevant Internet information from Soundlight (http://www.soundlight.de/techtips/dmx512/dmx512.htm).

[980013]

Pinout of connectors used

5-way AXR (XLR) plug

pin	function
1	earth (screen)
2	DMX-
3	DMX+
4	n.c. (may be linked to DMX–)
5	n.c. (may be linked to DMX+)

3-way AXR (XLR) plug

pin	function
1	earth (screen)
2	DMX-
3	DMX+