

## Application Note DK9222-0311-0029

### Light

#### Keywords

EL6851  
DMX  
DMX512A  
RS485  
Show technology  
Lighting  
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Lighting control  
Lighting technology  
Master  
Slave  
XLR  
Light  
Stage  
Show

## Fast communication with the DMX protocol

**This application example describes DMX – a standard transmission protocol for lighting technology – and the Beckhoff DMX EtherCAT terminals EL6581 (- 0000: master, -0010: slave), with which the PC- and EtherCAT-based control technology can be used for show, stage, special effects and drama applications.**

### DMX

DMX is the standard protocol for controlling professional stage and lighting effects equipment, which is used, for example, in the dynamic lighting of showrooms and salesrooms as well as for exclusive displays of light and color in high-profile buildings, such as hotels and event centers. As the bus system used in professional lighting technology, DMX works with RS485 physics. DMX stands for 'Digital Multiplexing' and enables serial data transmission with a data rate of 250 kbit/s. Color mix and brightness values are transmitted to DMX slaves in the form of static light sources (e.g. spotlights). In the case of moving light sources (e.g. moving heads and scanners), angles for pan/tilt and motion profiles stored in the device are additionally communicated. The topology configuration corresponds to daisy chain cabling (all slaves in a 'universe' in series); therefore, the slaves have an input and an output port. Three-pole XLR plugs are used for cabling.

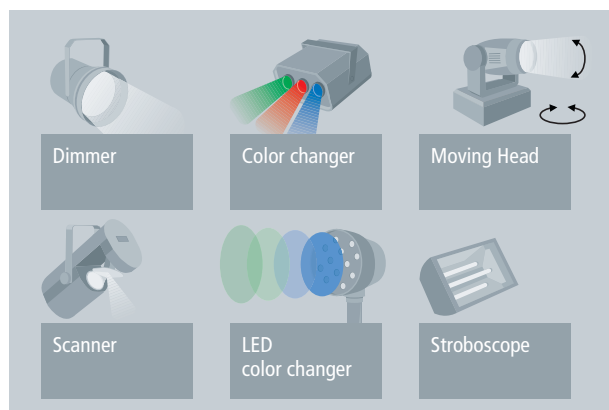


Fig. 1 Typical DMX slave devices

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Fig. 2 Accent lighting with DMX

## Characteristics of the bus system

### Transmission according to RS485

DMX uses serial RS485 physics for data transmission, in which the information (DMX frame) is transmitted as a difference signal on two lines. RS485 is relatively immune to EMC interference. A DMX frame encompasses a maximum of 512 bytes, wherein a byte is designated as a channel, slot or value. In order to maintain high performance of the system despite serial transmission, the controller sends a frame with 250 kbaud to all devices (Broadcast). Each device is assigned a certain address range during configuration of the DMX strand, therefore, a device only accepts that part of the data from the frame that is placed in the address range assigned to it. Due to the RS485 physics, a maximum of 32 slaves are allowed in one strand without repeaters.

### Utilization of the frame

The frame of the DMX protocol, which is up to 512 bytes long, is termed a 'universe' and one byte within the universe is termed a 'channel.' This channel represents a certain device setting in 256 increments (8-bit), e.g. dimming, color, focus etc.

A universe thus encompasses up to 512 channels, which would theoretically correspond to 512 DMX slaves. However, RS485 is physically limited to 32 slaves and moving light sources take up additional channels for further parameters such as tilt, pan and speed (in 8 or 16-bit resolution). If many moving DMX slave devices (high number of channels due to many features) are connected to a DMX master or a universe, then 512 channels may not be sufficient for the maximum number of 32 slaves

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under certain circumstances. In such applications, several DMX universes must be connected in parallel.

#### Data transfer rate

DMX requires approx. 22 ms for the transmission of the data if the full frame length is transmitted, which is equivalent to a refresh rate of 44 Hz. The human eye would perceive changes of light at this low frequency as 'non-harmonic' and 'discontinuous.' Fade up/down transitions only appear to be even at frequencies above 200 Hz. The data transfer rate needed for harmonious fades/changes of light can only be achieved by reducing the amount of user data per universe and as a result, the transmission duration of the frame is reduced.

Ratio of data transfer rate to user data quantity	
No. of channels	Refresh rate
512	~44 Hz
64	~300 Hz
16	~1000 Hz

Note:  
not all DMX Slave devices can work with a variable high refresh rate, since the internal data processing is sometimes too slow.

Fig. 3 Increasing the DMX refresh rates

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#### DMX and EtherCAT | The EL6851 DMX EtherCAT terminal from Beckhoff

The Beckhoff I/O system offers the EtherCAT-based EL6851 DMX terminal for professional lighting equipment and impressive light displays. The EtherCAT technology represents the ideal backbone for the connection of DMX universes due to its low cycle times of up to 100  $\mu$ s and high data transfer rates. Lighting for professional shows, theater and drama productions in particular requires the use of many DMX slaves, which have to be distributed across several universes because of physical or performance-related restrictions.

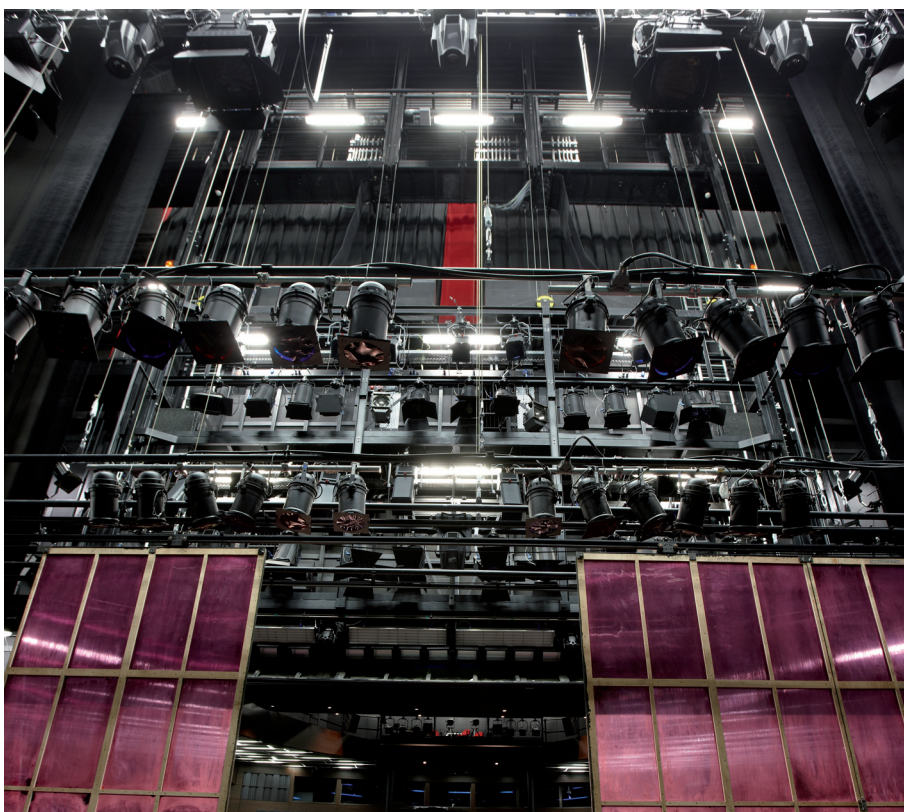


Fig. 4 Spotlight bank for stage lighting in the 'Schauspielhaus' in Nuremberg, Germany: view of the many DMX slaves

All essential stage and show systems can be controlled with EtherCAT as the universal bus system backbone with its many signal options. Since EtherCAT was developed for real-time communication, it enables the parallel operation of a virtually unlimited number of DMX universes in combination with the EL6851-0000 DMX master terminal. For example, at least 100 DMX universes can transmit the full protocol width of 512 channels with only one PLC task and with a cycle time of 10 ms. To aid in programming, IEC 61131-3 compliant function blocks are available for Beckhoff's TwinCAT automation software. A Beckhoff controller in the form of an Embedded PC or Industrial PC can be used at the command level. Alternatively, any DMX master can be used in connection with the EL6851-0010 DMX slave terminal.

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#### EL6851-0000 DMX master

The EL6851-0000 DMX master terminal permits the direct connection of up to 32 DMX devices and supports transmission of the full DMX protocol width of 512 bytes in just one control cycle using EtherCAT. The EL6851-0000 can send DMX frames of any length and, as a result, the refresh rate can be varied in accordance with the application requirements. Thanks to its support for the DMX512A standard and the RDM function (internal DMX diagnostics), the EL6851-0000 supports all common DMX devices.

#### EL6851-0010 DMX Slave

The EL6851-0010 DMX slave terminal is the link to the DMX world and enables the integration of Beckhoff EtherCAT I/Os in professional stage and effect lighting. The DMX slave terminal can be used under any DMX master in order to make the data in the DMX telegram usable as process data for the controller. This allows the data to be used arbitrarily, for example for outputting on digital outputs, stepper motors or dimmer terminals. As a result, theater and show stages can be constructed with standard hardware at reduced cost, but with full flexibility.

#### Special features of the Beckhoff EL6851 DMX terminal

- Galvanic isolation of the RS485 interface eliminates the coupling of remote devices via earth loops.
- The required RS485 terminal resistor can be switched on in the terminal.
- RDM is already implemented

The internal DMX diagnostics and parameterization via RDM are possible with function blocks of the TwinCAT PLC library DMX. However, the RDM protocol must be programmed in the controller, since the EL6851 exclusively offers Layer-2 functionality.

#### RDM (Remote Device Management)

Extension of the DMX protocol for central configuration/monitoring of DMX devices:

- device addressing
- selection of different device profiles
- device parameterization
- error diagnostics
- monitoring of temperature, voltage, current and frequency

Fig. 5 RDM services

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#### Practical example: DMX master

The integration of several universes is uncomplicated with the EL6851-0000 EtherCAT DMX master terminal, since the ideal control platform for stage and show equipment includes data transmission in the superordinate command level with EtherCAT as the fast fieldbus and Beckhoff PC-based control technology. All essential stage and show systems can be controlled with EtherCAT as the universal bus system backbone with its many options to cover most signal types.

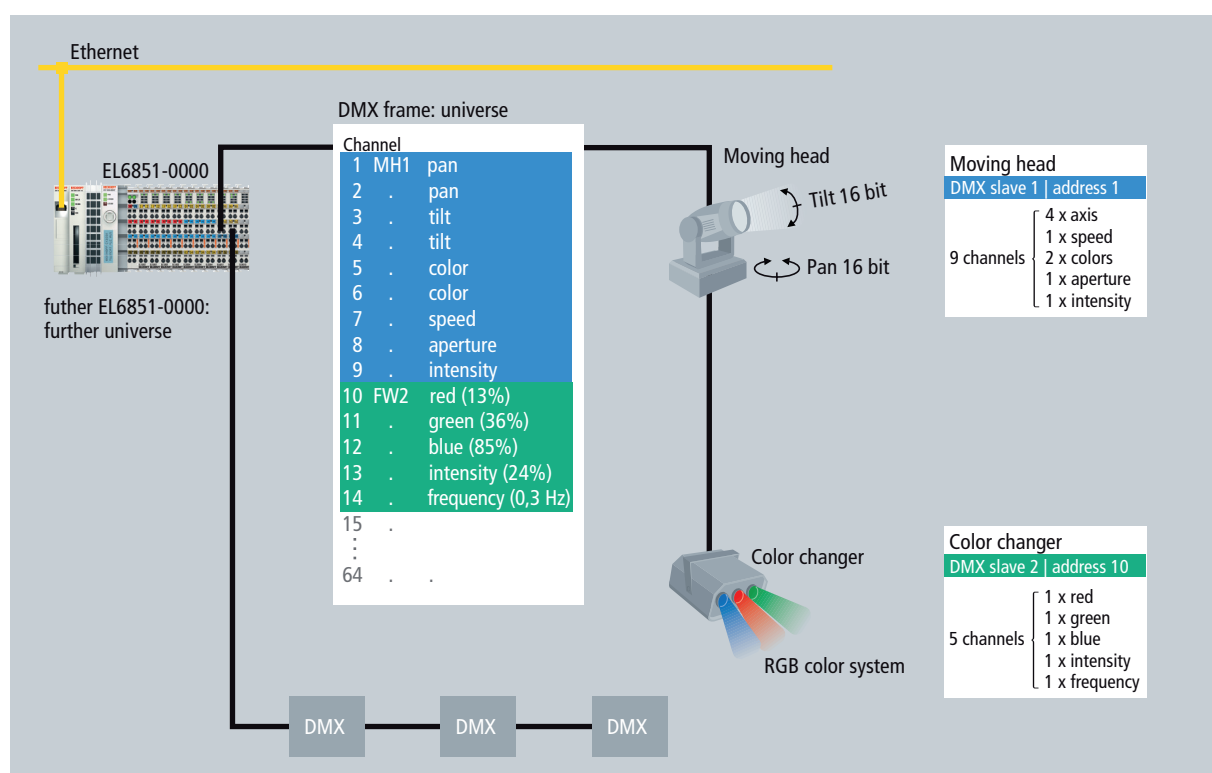


Fig. 6 Individual universes are each implemented by an EL6851-0000 within a lighting application.

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#### Practical example: DMX slave

The EL6851-0010 DMX slave terminal enables the integration of DMX applications into PC-based control technology and unites the advantages of both systems: lighting control via DMX whilst at the same time using standard components.

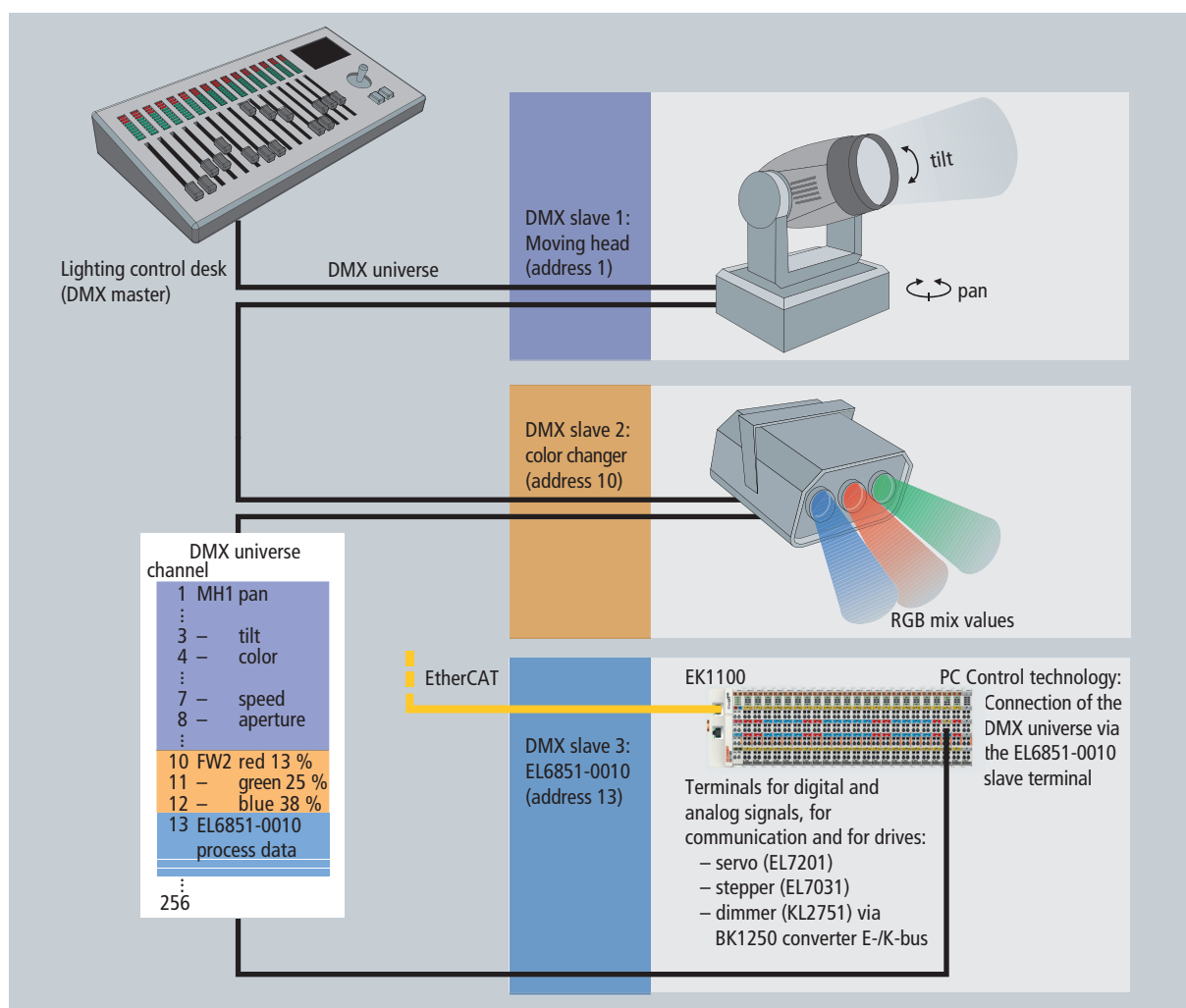


Fig. 7 Integration of PC-based control technology by means of the EL6851-0010 DMX slave terminal

The modularity of the Beckhoff I/O system offers a suitable terminal for every signal, so that the type of signal and the number of channels are matched to the application. Non-DMX-capable devices such as DALI lamps or universal dimmers can also be addressed via the Beckhoff I/O system. When using drive technology (moving stage elements etc.), low-priced standard drives such as stepper, servo or DC motors can be integrated simply via the appropriate EtherCAT terminals. The control technology is scalable: the required performance class can be selected from the extensive product range, from Industrial PCs to the local Ethernet controller. The long-term operation of the application is ensured by the simple extendibility and changeability of the system: additions and conversions can easily be integrated.

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- DMX master/slave [www.beckhoff.com/EL6851](http://www.beckhoff.com/EL6851)
- TwinCAT PLC library DMX [www.beckhoff.com/english/twincat/twincat\\_plc\\_dmx.htm](http://www.beckhoff.com/english/twincat/twincat_plc_dmx.htm)
- Servomotor-EtherCAT Terminal 50 V DC, 4 A [www.beckhoff.com/EL7201](http://www.beckhoff.com/EL7201)
- Stepper motor terminal 24 V DC, 1,5 A [www.beckhoff.com/EL7031](http://www.beckhoff.com/EL7031)
- Stepper motor terminal 50 V DC, 5 A, with incremental encoder [www.beckhoff.com/EL7041](http://www.beckhoff.com/EL7041)
- 1-channel universal dimmer terminal 230 V AC, 300 VA (W) [www.beckhoff.com/KL2751](http://www.beckhoff.com/KL2751)
- 1-channel universal dimmer terminal 230 V AC, 600 VA (W) [www.beckhoff.com/KL2761](http://www.beckhoff.com/KL2761)
- „Compact“ coupler between E-bus and K-bus Terminals [www.beckhoff.com/BK1250](http://www.beckhoff.com/BK1250)
- Beckhoff Building Automation [www.beckhoff.com/building](http://www.beckhoff.com/building)
- Beckhoff Building Automation lighting [www.beckhoff.com/english/applicat/building\\_beleuchtung.htm](http://www.beckhoff.com/english/applicat/building_beleuchtung.htm)

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