

STM32 based Art-Net DMX controller with USB Interface

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This is a DIY construction manual for a set of simple and compact **Art-Net capable DMX512 controllers** based on the **STM32F042F6 (or STM32F070F6)** microcontroller (20 pin TSSOP) and the **STM32 Nucleo-L476**.

Both models consist of three essential peripherals:

- **Commands and setup** are handled with the USB interface included in the microcontroller.
- **Art-Net** is communicated via a **WIZ850io** compact wired Ethernet module
- less dramatic: DMX is transmitted by a MAX487 IC or compatible.

DMX control is not restricted to Art-Net, alternative command sets are implemented, which are operated via USB:

- a set of MIDI channel messages based commands
- a set of ASCII text based commands
- the MiniDMX protocol, which is supported by a number of DMX control software

A number of lighting scenes can be stored permanently in the Microcontroller flash and be reloaded by command. Soft fade transitions up to 12.7 seconds are possible.

In accordance with the active mode of operation, the USB interface works as virtual COM port (USB CDC Class) or is seen as a standard MIDI interface at the host PC (USB MIDI Streaming Class). **The mode is set** by DIP switch (Nucleo) respectively by a jumper (STM32F042, which may be replaced by a front panel switch).

The USB interface is "full speed USB2.0" grade.

Both hardware versions are "USB Bus Powered". For Art-Net controlled operation USB communication is not necessary, then power can be supplied by an USB power bank, for example, or another 5Volt source (max ca. 200mA).

It is **NOT allowed to use this device together with any safety critical applications**, where malfunction could result in personal injury oder noticeable material damage !

All information about this project is provided 'as is' – without any warranty or responsibility

Hardware of the STM32 Nucleo-L476 based version:

The **STM32 Nucleo-L476** was chosen for this project because it does not need a hardware modification when the ST-LINK part is cut off.

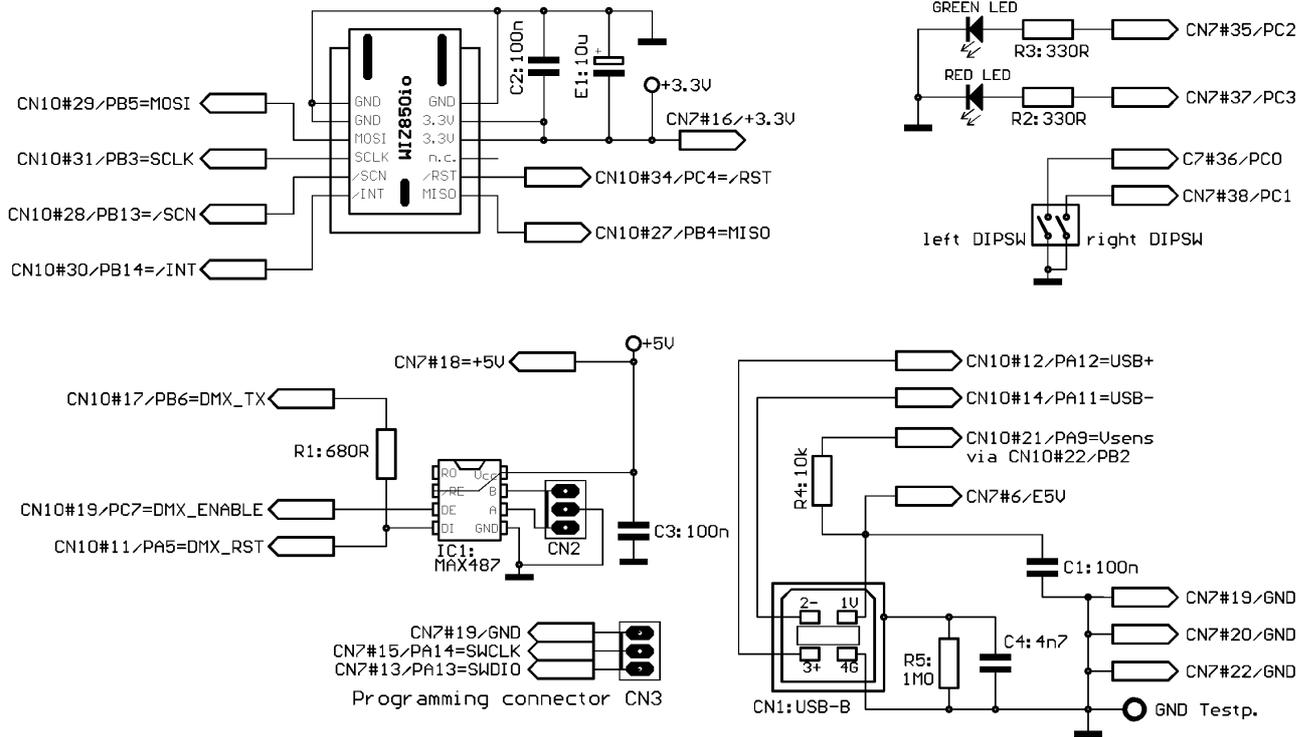
The microcontroller is clocked by an internal oscillator (HSI48), whose frequency is synchronized with and stabilized by the low frequency crystal oscillator provided on the Nucleo board. This technique provides a very stable USB interface and DMX output, too.

Because it is not possible to re-start the STM32 microcontroller USART immediately after the DMX reset pulse, the USART Tx is kept running in idle state during DMX reset. It is fed via a resistor to the DMX driver MAX487, which is pulled low by another Open Drain output of the microcontroller during DMX reset.

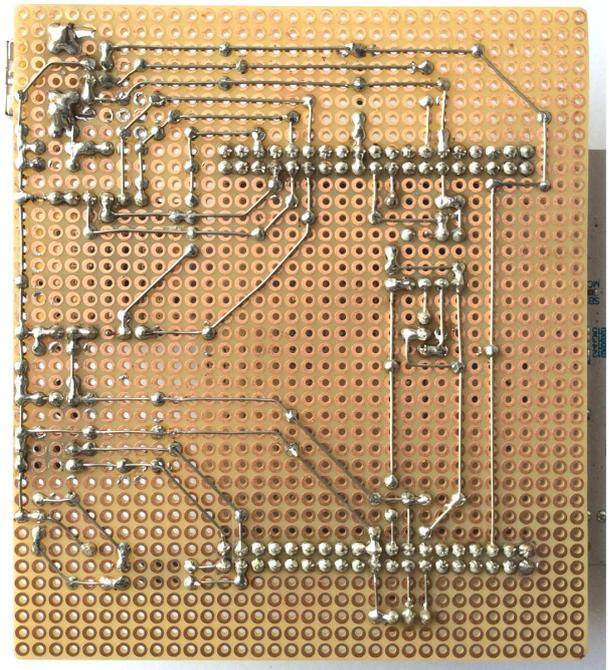
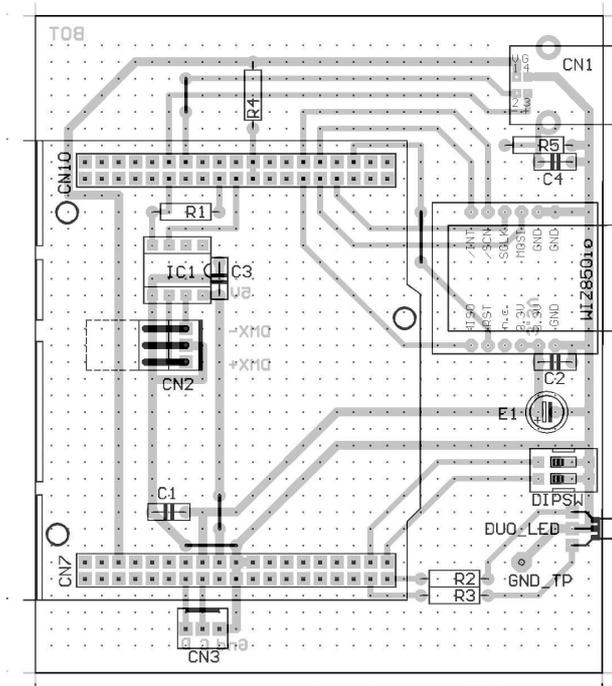
The additional circuitry for the WIZ850io, USB connector, DIP switch and LED is located on a Veroboard with round copper dots. For reasons of better soldering of the sockets for the Nucleo and component placement as well as better "stand alone" usefulness, it is not designed as a "shield", but as a "base board" instead. It can be used with or without the ST-LINK part of the Nucleo module.

Schematic diagram:

The connector CN7,CN10#pin numbers refer to the Nucleo board. For details see the Nucleo User Manual:



Assembly:



Special parts:

STM32 Nucleo-L476RG: sources www.funduinoshop.com, Mouser, RS-Components, Farnell

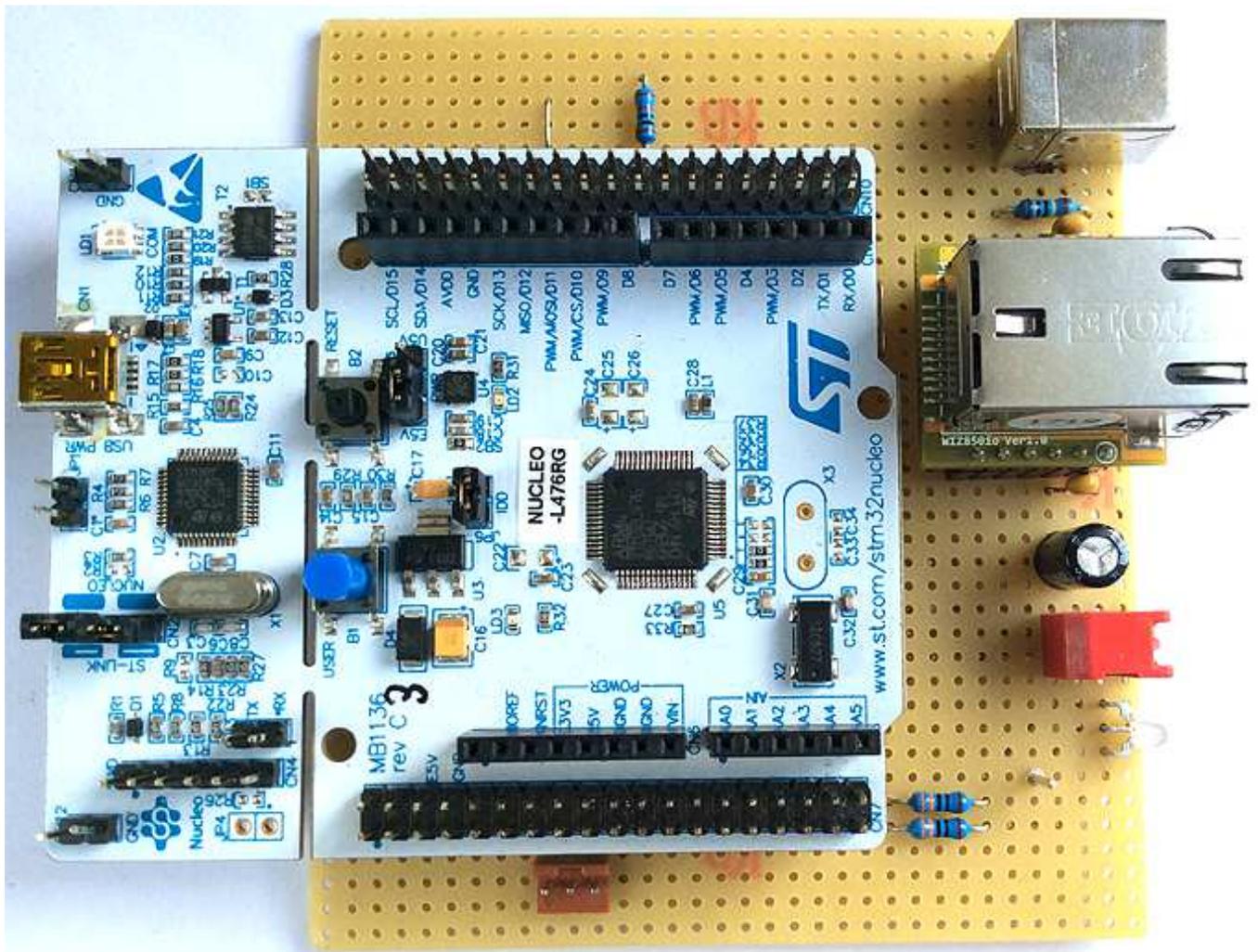
IC1: MAX487 CPA, source Reichelt, RS Components, Farnell

Connector CN2: source Reichelt PS 25/3W BR

LED: V-L-115-WEGW: source Conrad 187496. Flattened side directed to PCB for correct colours.

Other dual red/green LED types may be used, but then values of R2 and R3 have to be adjusted

WIZ850io: sources www.tme.eu/de, <https://shop.wiznet.eu>



Modes of operation selection:

is done with the two pole DIP switch:

- **both switches OFF:** setup mode. See description of Setup Commands below
- **left switch down:** Art-Net controlled DMX. Simultaneously, the ASCII command set and the Mini-DMX protocol is active. Detailed description and how to separate the ASCII commands from Art-Net see under ASCII commands below
- **right switch down:** only Art-Net controlled DMX is active. No communication via USB
- **both switches down:** Art-Net controlled DMX. Simultaneously, the MIDI command set is active. Detailed description and how to separate the MIDI commands from Art-Net see under MIDI commands below

The different command sets are described below commonly for both hardware versions.

Programming:

If the ST-LINK module is still at the Nucleo board, see instructions in the Nucleo manual.

If the ST-LINK module is cut off: A 3 pin programming adaptor is provided on the Veroboard. See programming instructions for the STM32F042 version below.

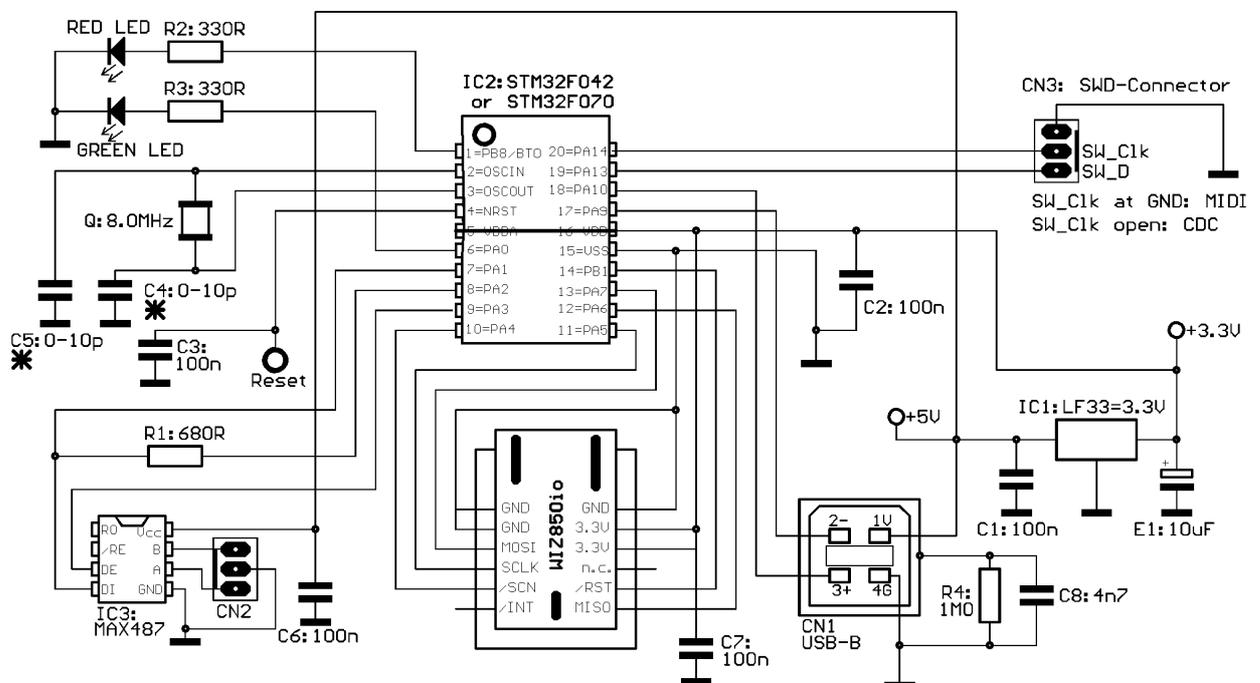
Hardware of the STM32F042 / STM32F070 based version:

The microcontroller is clocked by an external 8Mhz quartz crystal (HC49U case). Optionally, firmware is available for 6Mhz, 12 MHz or 16MHz crystals. Use of the internal MSI48 oscillator and stabilisation by USB is not useful for this project, because Art-Net can be operated without USB data connection. Then DMX would become instable.

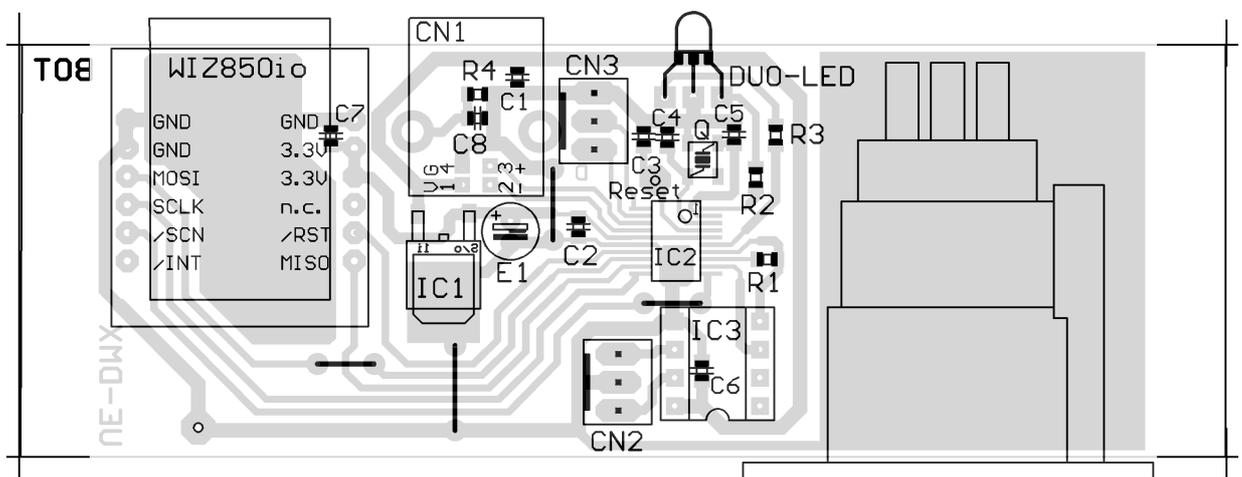
Because it is not possible to re-start the STM32 microcontroller USART immediately after the DMX reset pulse, the USART Tx is kept running in idle state during DMX reset. It is fed via a resistor to the DMX driver MAX487, which is pulled low by another Open Drain output of the microcontroller during DMX reset.

For easy reproduction with simple tools, the hardware is built on a single layer PCB with a small number of jumper wires. Thickness and spacing of the printed wires is designed for hobbyist technologies. The PCB is designed with a mixture of through hole and SMD parts.

Schematic diagram:



Assembly: It is highly recommended, not to solder C4 and C5 for a first functional test, see "Special parts".



The total board size is 108x37mm, the partial area filled with electronically relevant circuitry is 65x37mm. The additional PCB area is only necessary to be mounted into a special case later on.

This assembly drawing is shown from the **component side**! IC1, IC2 and all SMD parts are viewed through the PCB! All SMD resistors and capacitors are size 0805.

Special parts:

IC1: 3.3 V regulator: LF33 CDT, source Reichelt, Conrad 1185435

IC2: STM32F042F6P6, STM32F070F6P6 source: www.tme.eu, RS Components, Mouser

IC3: MAX487 CPA, source Reichelt, RS Components, Farnell (www.hbe-shop.de)

Quartz Q and C4,C5: Though most quartz crystals are specified for ca. 10 to 20pF, it seems that the STM32F042 processors need a much lower value for C4 and C5.

So it is highly recommended, not to solder C4 and C5 for a first functional test.

If everything works well (usually, my experience), then leave it as it is (see packshoot).

If not, tip the wires to the quartz with a high impedance 1:10 oscilloscope probe.

If the oscillator is on then, solder 10pF there or each 4.7 pF.

...Test works only when R2 and LED are installed. Else the processor goes into serial boot mode !!

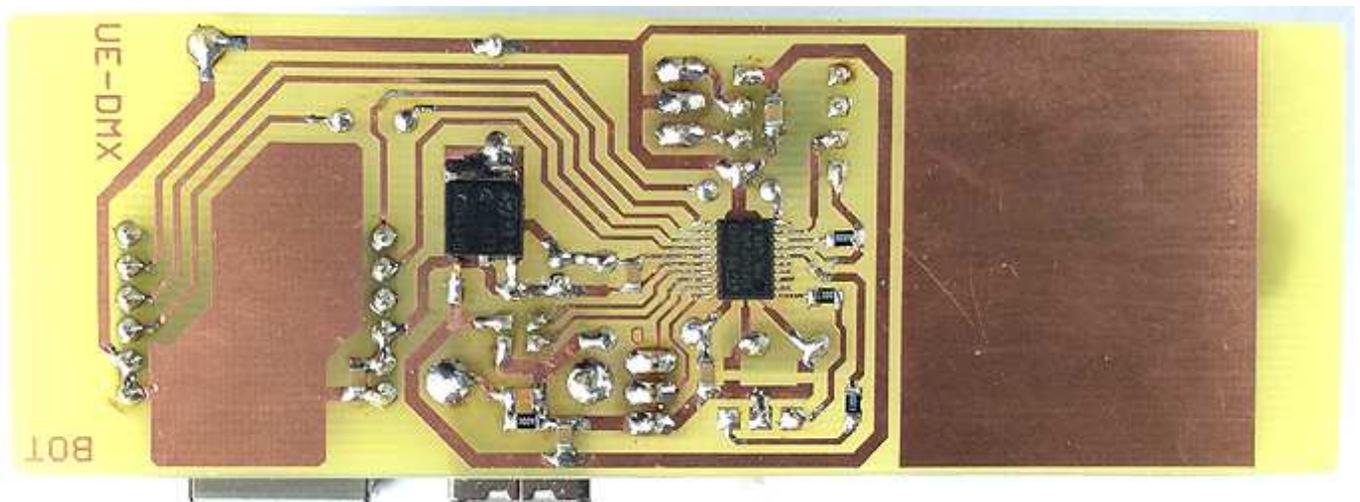
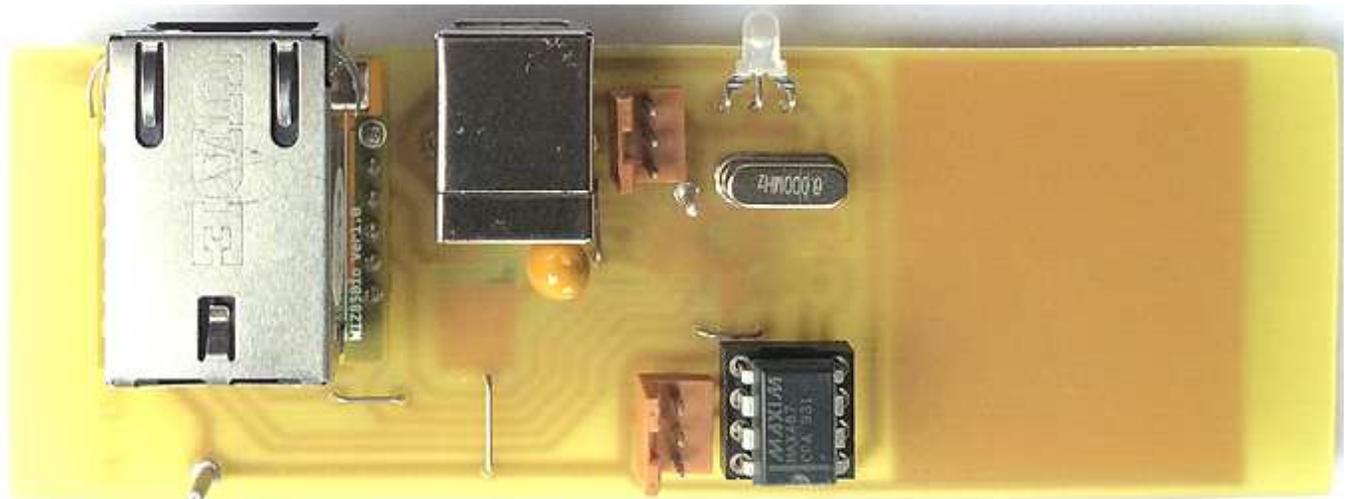
WIZ850io: sources www.tme.eu/de, <https://shop.wiznet.eu>

Connectors CN2, CN32: source Reichelt PS 25/3G BR or Conrad 741221

LED: V-L-115-WEGW: source Conrad 187496. Flattened side directed to PCB for correct colours.

Other dual red/green LED types may be used, but then values of R20 and R21 have to be adjusted

E1: Tantal 10uF, min 10V. A standard Electrolytic Capacitor may be used, too



Select Modes of operation:

In addition to the Art-Net protocol, which is active permanently, **a selection can be made between an ASCII text based command set and a MIDI message based command set:**

- In default state (**no jumper** at the programming connector), USB is configured according to USB CDC Class. i.e. it is connected to a **virtual COM port** at the PC and the **ASCII command set is active**.
With the special command '\ ' you are in the **Setup Mode**, details see below.
- When **a connection is made between pin PA14 (SWD-Clk pin) and Ground** (e.g. place a jumper on CN3 or connect it with a front panel switch), USB is configured according to USB MIDI Streaming Class and the board is seen at the PC as a **standard MIDI interface and the MIDI command set is active**.

The different command sets are described below commonly for both hardware versions.

Programming:

Because no RS-232 port is available on this board, programming is possible only with an SWD programmer. Instead of buying a dedicated ST-LINK module it is recommended to get a STM32 Nucleo-64 module, which is less expensive, can be configured as programmer and additionally be used for other experiments with STM32 microcontrollers. How to program external parts with the Nucleo, read its manual. When the programmer is cut off (i.e. used standalone) and the programming software sends a problem like "no target voltage", connect the 3.3V output (pin next to text U1) of the regulator (5 pins) on the ST-Link part with R23 (4.7 kOhm, pad directed towards the SWD connector) to pretend a supply voltage of the programmed device.

Build a short programming adaptor (wire length max 25 cm):

- connect the 2nd pin of the Nucleo SWD connector (counted from the side towards the Mini USB connector) with pin PA14 of our board (red in the photo above).
 - connect the 3rd pin with Ground of our board (brown in the photo above).
 - connect the 4th pin with pin PA13 of our board (black in the photo above).
- These pins are broken out at connector CN3.

Operation instructions for both versions:

Installation:

--- **start the ST-LINK software.** Click item "Connect" of the "Target" menu. After some seconds, a screen with the connection report and a listing should appear. Sometimes, but usually not, it is necessary to reset our board for a moment while you connect it with ST-LINK. When you are connected, select "Program&Verify" from the "Target" menu and upload the hex code. After programming, click item "Disconnect" of the "Target" menu and remove the ST-Link adaptor.

By default the USB interface works with the STM Vid/Pid as well as with a unique Ethernet MAC ID and ESTA and Art-Net ID provided by courtesy of Cinetix,
but this is only allowed for test and evaluation inside your shack! For any public use, your individual Vid/Pid and MAC ID must be activated ! (how to do see below "Setup" p.11)

In default state, the board is connected to a virtual COM port at the PC. This can be observed with the Windows Device Manager. When USB is connected the first time, the driver gets installed. If you already have installed the "STM32 Virtual Com Port Driver" for the ST-Link programmer, by default our board uses the same driver and will be listed under "COM and LPT

ports" as "STMicroelectronics Virtual COM Port". Else download the "STM32 Virtual Com Port Driver" from the STM website and install it. You can change the COM port number under "advanced settings" in the Device Manager. Else keep the default settings. The baud rate is not relevant in this case, any works. Handshake is not supported.

When the MIDI command set is active (how to do, see hardware specific above), **the board is seen by the PC as a standard USB / MIDI interface.** When the USB cable is connected first, a driver gets installed automatically (Windows XP or later). In the Windows Device Manager it appears under "Audio-,Video & Game Controller" as "STM32-UsbDmx" or simply as "USB-Audio Device".

By default, the device is sensitive for MIDI Channel 1 (Status Byte low nibble = 0 !)

For a functional test and other manual MIDI to DMX operation, the simple console software "MidiTerm" is available from my website <www.midi-and-more.de>.

In ASCII as well as in MIDI mode, the DMX transmitter starts automatically with all 512 DMX channels at zero level (or with a user designed lighting scene, see ASCII command ~ page 8).

Attention: when the DIP switch / jumper is changed during operation, the board performs a new USB enumeration within 1-2 seconds. Unfortunately (at least under Windows) a MIDI software or Virtual COM port on the PC has to be closed then and restarted after. So the software or COM port should be **closed before mode change**, else restart of this software may be blocked. In this case, another reset/enumeration of the USB device is necessary to re-enable the software.

Modes of Operation:

ASCII command set

activation is hardware specific, see above.

Short reference of all ASCII commands

S n	address DMX channel for subsequent action (n=1 - 512)	p.8
V n	set DMX level at addressed DMX channel (n=0 - 255)	p.8
,n (comma)	increment DMX channel address first, then set level (n=0 - 255)	p.8
+	increase addressed transmit buffer level DMX channel by one	p.8
-	decrease addressed transmit buffer level DMX channel by one	p.8
= n	set n DMX channels starting from (addressed ch.+1) to level of addressed ch.	p.8
T n	soft Fade Time n in 1/10 seconds	p.9
R n	read n bytes from transmit buffer starting from the addressed DMX channel	p.9
C n	limit DMX cycle length to n DMX channels (n=24 to 512)	p.9
D	set output of all DMX channels immediately to 0 (Panic function)	p.9
*0,1	block or allow Art-Net simultaneously with ASCII commands	p.9
~ n	save transmit buffer a as preset no. n	p.9
@ n	load preset Nr. n into buffers	p.10
\	start SETUP mode (STM32F042 only , Nucleo version uses DIP switch)	p.10

MiniDMX protocol

p.10

SETUP mode

p.11

Detailed description of all ASCII commands:

Every control command and every state message is assigned with a single characteristic letter. If a command expects a parameter, it is listed after the command letter in acute angular brackets <...>. **Number values are always in decimal format and are sent via USB as ASCII text.**

This compact format is suitable to enter commands manually as well as for automatic generation and parsing in an application software.

Address the DMX channel to be manipulated with following commands:

S <DMX channel number>

The **parameter addresses a DMX channel**, on which subsequently described commands have an effect.

In DMX slang sometimes the word 'slot' is used as synonym for 'DMXchannel' because during DMX transmission every DMX channel is represented by a specific time slot in the transmission cycle.

Parameter: DMX address (range 1 to 512) is the number of the DMX channel to be manipulated with subsequent commands

Comment: No action is started immediately. But the address content will be applied to subsequently given commands.

Example: **S123** addresses DMX channel number 123

Transmit buffer manipulation:

V <level>

Write parameter into the transmit buffer of the actually addressed DMX channel.

Parameter: level (range 0 to 255) is the value (lamp intensity, e.g.) which will be immediately transmitted at the actually addressed DMX channel.

Example: **V34** sets the DMX level to 34 at the DMX channel which is actually addressed

, (comma) <level>

First this command increases the actually addressed DMX channel automatically, then it writes the parameter into the transmit buffer for the new DMX channel'.

Parameter: level (range 0 to 255) is the value or intensity which will be immediately transmitted at the incremented and now actual DMX channel

Comment: except the fact that the DMX channel is pre-incremented, the ',' (comma) command does the same as the **V** command.

+ (no parameter)

Increase (add 1 to the) level of the actually addressed DMX channel

Comment: The byte cannot be made greater than decimal 255. If it is already equal to 255, the + command is ignored. If a fade process is active at this DMX channel, only the final value is increased.

- (minus, no parameter)

Decrease (subtract 1 from the) level of the actually addressed DMX channel

Comment: The byte cannot be made less than 0. If it is already zero, the - command is ignored. If a fade process is active at this DMX channel, only the final value is decreased.

= <block length>

This command writes the final level of the addressed DMX channel into the number of <block length> DMX channels starting from (addressed channel+1). A new fade to this

final level is started from the actual level of each of these channels. The fade time is given by the actual content of the FADETIME register.

Parameter: <block length> (1 to 512) is the number of DMX channels into which the same level is copied. Independent of <block length>, channel 512 is never exceeded

Additional features:

T < tenths of seconds>

Enter parameter into FADETIME. No action is started directly.

Parameter: FADETIME is always entered in tenths of seconds. Maximum fadetime is 12.7 seconds. This is valid for all subsequent level changes until a new T command is given. The Fade Time is stored together with preset no.0 and reloaded together with it, explicitly after power up.

Example: T113 sets the Fade Time to 11.3 seconds

R <number of bytes>

Poll <number of bytes> of the DMX transmit buffer starting from the actually addressed DMX channel and send them via USB.

Parameter: number of polled bytes (1 to max. 512) . After possibly the level of DMX channel no.512 is sent, the output stops.

Syntax of the resulting state message:

R<number of bytes> from S <1st channel no.>: V <DMX level> [,<DMX level>...] <CR >

*** <0, 1>**

***0 blocks Art-Net.** Art-Net is received furthermore in the background, but its data are not copied into the DMX buffer.

***1 allows Art-Net to change the lighting pattern**

The *0 command is useful to intervene manually into a computer controlled lighting show.

Control is given back to Art-Net with command *1. Art-Net is received in the background furthermore, but not copied to the DMX transmit buffer. The LED blinks, when an ArtPoll message is received.

C <number of DMX channels>

limits the DMX cycle to a specific number of DMX channels.

Minimum is 24, maximum is 512

D (no parameter)

Sets all DMX channels immediately to level 0. Panic function, no soft fade.

~ <preset number>

save the current content of the transmit buffer permanently in the microcontroller flash memory.

Nucleo version: presets 0 ... 127, F042 version: presets 0 ... 13 (increased with firmware 1.4)

@ <preset number>

Loads the permanently stored lighting scene into the DMX transmit buffer.

Preset number 0 is automatically loaded after power on. Together the Fade Time and the max number of transmitted DMX channels is loaded and activated. This way the first lighting scene may be faded softly out of dark.

\ (Backslash) (no parameter)

opens the Setup/Configuration command interpreter.

Exists only for the STM32F042 version. The nucleo version opens Setup with a DIP switch

The next command codes and numeric values are interpreted as setup commands.

The Setup/Configuration command interpreter can only be quit by command 'E'

Operation with MiniDMX protocol

The MiniDMX protocol is formally implemented as ASCII command 'Z' here.

The practical reason is that each MiniDMX data packet starts with the character hex5A='Z'. This way, **no switch or other configuration is necessary to start or terminate operation of the MiniDMX protocol.** After the data packet is completely received and processed successfully (i.e. put into the DMX transmission cycle), the firmware returns back to the ASCII command main loop and waits for the next ASCII command (or MiniDMX data packet).

While MiniDMX is active, the LED is blinking.

If no MiniDMX compatible data byte is received within max. 100 milliseconds, processing of this data packet is cancelled, the firmware jumps back to the main ASCII command interpreter and waits for the next 'Z' (or which command ever). So the 'Z' command and MiniDMX constitutes a distinct mode of operation, though it is embedded in the ASCII protocol.

When MiniDMX data packets are received, each active fade process is terminated immediately. MiniDMX packets for 256 DMX channels (type A1), for 512 DMX channels (type A2) and for 96 DMX channels (legacy type A0) are accepted. When A1 (or A0) packets are received, the levels on DMX channels 257 (or 97) to 512 remain unchanged.

Unfortunately the original website with the specification of the MiniDMX protocol is not online anymore.

The MiniDMX protocol is supported by a number of good PC based DMX software products like preferably 'DMXControl 3'. It is supported by 'DMXControl 2' and 'Freestyler' too, but the operation is less smooth then. While such a software is active, it occupies the USB port. Parallel data input by terminal software etc. is impossible then.

Any software else using the virtual COM port at the PC must be closed before the lighting software is started, else the port is blocked !

SETUP mode:

is activated during ASCII mode with command code [

After '?' is typed into the terminal, a list of the briefly explained configuration commands is returned:

```
List of Setup Commands:
!          list actual setup entries
V          set Vid/Pid of this device (hex)
M          set Ethernet MAC ID (hex)m5.m4.m3.m2.m1.m0.
G hh.hl.lh.ll set gateway IP (ip3.ip2.ip1.ip0)
I hh.hl.lh.ll set IP of this device (ip3.ip2.ip1.ip0)
S hh.hl.lh.ll set subnet mask of this device (m3.m2.m1.m0)
A 0 ,2, 10 set Art-Net 'IP addr A' (0, 2, 10, (default=0))
N 0-15     set Art-Net Subnet (0-15)
U 0-15     set Art-Net Universe DMX OUT (0-15))
C 1-16     set MIDI base channel
|          Save new setup permanently and activate it
E          exit SETUP (F042 only)
```

Commands and their subsequent parameters may be entered in arbitrary order or as a single item. Every input is finished with a "Carriage Return" (= dec13=hexD). All changes of Ethernet parameters and of MIDI channel are activated immediately, but only **stored permanently by command '|'**. Else changes will be lost after power off. Not to disrupt the active USB connection **Vid/Pid is exclusively set after power on** according to the permanently stored values. So a change is lost when not stored permanently with command '|'.

Detailed descriptions:

Command code "V": enter your individual USB Vid as a **4 digit hex number** (leading zeroes must be typed). Then a letter "P" appears and you enter your own USB Pid the same way as a 4 digit hex number. It is stored permanently with command '|' and can be reset to the default by entry of Vid = 0000 and Pid= 0000. **In MIDI mode the Pid is automatically set 1 higher** than set up, else the host PC may get confused.

By default the STM Vid/Pid is used, but this is only allowed for test and evaluation inside your shack! For any public use, your individual Vid/Pid must be activated!

To install the device with your own Vid/Pid, for example you could copy and rename the file "stmcdc.inf" and change the respective entries to your Vid/Pid with an ASCII text editor. Install it "manually" when asked by Windows.

Command M changes the Ethernet MAC address of this Ethernet interface

After programming the microcontroller firmware, always the following **provisional** MAC ID (hex) 00.50.C2.92.8F.FD (Nucleo version) respectively 00.50.C2.92.8F.FC (STM32F042 version) is active (registered for and provided by courtesy of Cinetix).

This is intended to allow a simple first test, configuration and startup. It is not allowed to distribute products with this MAC address! You have to register and configure your individual MAC address for every product you bring out of your lab!

To set your individual MAC address, proceed as follows:

Enter **"M" followed by six hexadecimal bytes**, which represent your MAC ID, each item written in ASCII text as two hex digits (0..9,A,B,C,D,E,F case independent) separated by a dot ("."). The last byte is terminated by a <carriage return>.

Commands **G, I, S** define the **network address** of this Ethernet / USB interface.

Ethernet IP addresses are entered as 4 decimal numbers 0 to 255 separated by periods.

To make the first operation as easy as possible, **at delivery following default parameters are configured**, which are compatible with many small networks:

IP address 192.168.0.240, subnet mask 255.255.255.0

Art-Net specific configuration commands :

A sets the Art-Net IP address byte 'A' <0, 2, 10> default = 0

With A0 a user defined Art-Net IP address is active.

This is the IP address of the device (see command I), but all bits are set, whose corresponding bits in the Subnet Mask are zero. I.e. the resulting Art-Net IP is the maximum broadcast address, which is possible in the actual network.

With default settings, this way the effective Art-Net IP will be 192.168.0.255.

Differing from the recommendation given in the Art-Net manual, this configuration fits most easily with small local networks and known lighting software like DMX-Control. It is recommended for most network cases.

"Broadcast" setting in the lighting control software, if available, works too.

With A2 the Art-Net IP (2. plus bytes B.C.D as defined in the Art-Net manual) is active and the SubnetMask is 255.0.0.0.

With A10 the Art-Net IP (10. plus bytes B.C.D defined in the Art-Net manual) is active and the SubnetMask is 255.0.0.0

Art-Net always uses its reserved port 0x1936, needs not to be configured

N sets the Art-Net "Subnet" (0---15) (not to be confused with the network Subnet Mask!!)

U sets the Art-Net "Universe" for DMX OUT (0---15)

Command code "C": configures the MIDI base channel 1...16 (in decimal format) for which MIDI messages are accepted. The MIDI channel (inserted as low nibble into the MIDI **status byte**) - **is always one less (0...F) !** Some MIDI commands are accepted with a MIDI channel higher than the base channel (especially set DMX address 1-512).

If the MIDI base channel is 14 or higher, not all 512 DMX channels can be addressed with a simple NOTE ON message, because the maximum MIDI channel is 16. Alternatively CONTROL CHANGE messages number 80-83 (hex 50-53) are available to address any DMX channel.

Command code "E": quits the setup mode back to standard ASCII mode (STM32F042 version only, the Nucleo version uses a DIP switch). If changes shall be saved permanently, this must be performed with command '|' (you will be asked by the firmware).

MIDI Channel Message protocol of the DMX512 transmitter activation is hardware specific, see above.

By default MIDI channel no. 1 is the base channel for command input. This may be changed in the SETUP mode. Details see above.

Quick start and basic commands:

The most frequently used application is **lighting control with NOTE ON messages from a sequencer.**

To address any of the DMX channels 1 to 127, control data have to be sent on the selected MIDI base channel. How to access DMX channels 128 to 512 see below.

The 1st data byte of the MIDI command defines the DMX channel to be addressed. The 2nd data byte of the command describes the DMX level (light intensity) to be set.
 the 2nd MIDI data byte is multiplied by 2 inside the USB/DMX Interface.

Exception: 2nd data byte 127 sets the DMX level to 255

Or described in the opposite way of thinking: **to set a certain DMX level (0 to 255) with a simple MIDI command, HALF OF the intended DMX level has to be entered in the 2nd MIDI data byte..**

To write data into DMX channels 128 to 256 with these commands, the MIDI commands are sent on the **next higher MIDI channels** as described in the table:

coded MIDI channel	1 st data byte	addresses DMX channel #-	calculation of 1 st data byte
as selected base channel	1 to 127	1 to 127	= DMX channel
as base channel + 1	0 to 127	128 to 255	= DMX channel minus 128
as base channel + 2	0 to 127	256 to 383	= DMX channel minus 256
as base channel + 3	0 to 127	384 to 511	= DMX channel minus 384
as base channel	0 special case !	512	= 0

This means: on a sequencer program you have to **reserve a block of 4 MIDI channels** for full control of the USB / DMX Interface and the corresponding edit tracks have to be initialized.

Attention: data which are meant for other MIDI equipment which works on these channels may be misinterpreted.

This limitation can be worked around with somewhat **more complex CONTROL CHANGE commands, which allow to adjust any DMX channel 1 to 512 with full 8 bit accuracy using only the MIDI base channel.** See description of the appropriate commands below.

The response of the USB/DMX Interface to NOTE ON messages with **velocity=0** or to any **NOTE OFF** messages is prevented with PROGRAM CHANGE command 121 and allowed again (default state) with PROGRAM CHANGE command 120. This way you can "play in" DMX level timing with NOTE ON on a keyboard or sequencer without care about note ends.

Survey of all MIDI Channel Commands (MIDI Implementation Chart)

Abbreviations:

DB means "data byte", DB1 means "1st data byte" (note value, controller number), DB2 means "2nd data byte" (velocity, controller value)

When using PROGRAM CHANGE commands you should take into account, that most MIDI devices and software physically send the data byte value "0" when "program no.1" is selected and so on ! **In the table "DB" denotes the physically transferred data byte.**

MIDI message configured MIDI channel plus up to 3 additional MIDI channels	special data values	function /effect	p.
NOTE OFF	DB1 = DMX channel ++ DB2 = ignored	DMX level --> 0.	14 17
NOTE ON MIDI channel = base ch. + up to next 3 channels	DB1 = DMX channel ++ DB2 = DMX level ./ 2	set DMX channel and level (only 1 MIDI message / 7bit resolution) DMX level = DB2 * 2	14 17
CONTROL CHANGE MIDI channel = base ch.	DB1 = 1 DB2 = 0..127	set Fade Time 0 ...12.7 sec (DB2 / 10) in steps of 1/10 sec	16
	DB1 =36 (hex24) DB2 = 1 to 10	poll (entry of DB2) levels of DMX OUT starting from the actually addressed DMX channel	16
	DB1 = 64 (hex40) DB2 = 0..127	limit number of transmitted DMX channels to (DB2+1) * 4 DB2 min= 5 →24DMX channels	16
	DB1 = 72 (hex480) DB2 = 0..127	fill DB2 DMX channels starting from (addressed ch.+1) to the level of actually addressed channel	16
	DB1 = 80–83 (hex50-53) DB2 = 0..127	address DMX channel using only one single MIDI channel. "	15
	DB1 = 84 (hex 54) DB2 = 0..127	set DMX level at addressed DMX ch. to DB2 *2 adjust DMX level with 8 bit resolution to even value	15
	DB1 = 85 (hex 55) DB2 = 0..127	set DMX level at addressed DMX ch to DB2 *2 + 1 adjust DMX level with 8 bit resolution to odd value	15
	DB1 = 86 (hex 56) DB2 = 0..127	First increase addressed DMX channel there set DMX level to DB2 *2 . adjust DMX level with 8 bit resolution to even value	15
	DB1 = 87 (hex 57) DB2 = 0..127	First increase addressed DMX channel there set DMX level to DB2 *2 + 1 adjust DMX level with 8 bit resolution to odd value	15
	DB1 = 96 (hex 60) DB2 = preset number	load preset from Flash memory	17
	DB1 = 112 (hex70) DB2 = preset number	save preset nonvolatile in flash memory	17
	DB1 = 119 (hex 77)	DB2 has the same meaning as the data byte of the corresponding PROGRAM CHANGE command.	
PROGRAM CHANGE MIDI channel = base ch.	DB = 8	decrease DMX level (minus 1) at addressd channel	15
	DB = 9	increase DMX level (plus 1) at addressed channel	16
	DB = 64 (hex 40)	block transmission of Art-Net to DMX OUT	17
	DB = 65 (hex 41)	enable transmission of Art-Net to DMX OUT	17
	DB = 120 (hex 78)	Note velocity 0 is transferred to DMX level (default)	17
	DB = 121 (hex 79)	Note velocity 0 and Note Off is ignored	17
	DB = 127 (hex7F)	Panic: set DMX level of all channels to zero	16

Simple setting of DMX channel and DMX transmit level

NOTE ON (NOTE OFF is internally converted into a NOTE ON with velocity = 0)

The first MIDI data byte (note value/pitch) sets the DMX channel.

The 2nd data byte (note velocity) describes the light intensity to be set.

The DMX level is **twice of** the second MIDI databyte.

Or vice versa: the **2nd MIDI data byte is HALF OF** the intended DMX level (0 to 255).

Following exceptions do apply:

Velocity 127 sets the DMX level to 255

after PROGRAM CHANGE 121 is sent, Note OFF and NOTE ON with velocity = 0 are ignored

BUT: NOTE ON with velocity = 1 sets DMX level to 0

This simple method works only for DMX channels 1 to 127.

To address DMX channels 128 to 512, the USB / DMX Interface expects control commands on a higher MIDI channel corresponding with following table:

coded MIDI channel	1 st data byte	addresses DMX channel-	calculation of 1 st data byte
as selected base channel	1 to 127	1 to 127	= DMX channel
as base channel + 1	0 to 127	128 to 255	= DMX channel minus 128
as base channel + 2	0 to 127	256 to 383	= DMX channel minus 256
as base channel + 3	0 to 127	384 to 511	= DMX channel minus 384
as base channel	0 special case !	512	= 0

Address the active DMX channel with:

CONTROL CHANGE

This alternative command version is used, **when all MIDI messages shall be sent on the MIDI channel = selected base channel.**

The coarse range is selected by the first data byte, which has to be chosen according to this table:

1st data byte	addresses DMX channel no.	2nd data byte	calculation of 2nd data byte
80 (hex50)	1 to 127	1 to 127	= DMX channel
81 (hex51)	128 to 255	0 to 127	= DMX channel minus 128
82 (hex53)	256 to 383	0 to 127	= DMX channel minus 256
83 (hex53)	384 to 511	0 to 127	= DMX channel minus 384
80 (hex50)	512	0 (special case!)	= 0

This command does not directly trigger any action. But the updated active DMX address register will be executed together with subsequent commands.

Set DMX level with 8 bit resolution at the addressed DMX channel with:

CONTROL CHANGE

MIDI channel as selected base channel

1st data byte = 84 (hex54) adjusts to an **even** DMX level

2nd data byte: desired DMX level divided by 2

i.e vice versa: DMX level= 2nd data byte * 2

1st data byte = 85 (hex55) adjusts to **next odd** DMX level

2nd data byte: desired DMX level divided by 2

i.e vice versa: DMX level= 2nd data byte * 2 **plus 1**

1st data byte = 86 (hex56) **first increases the addressed DMX channel**

and adjusts this one to an **even** DMX level

2nd data byte: desired DMX level divided by 2

i.e vice versa: DMX level= 2nd data byte * 2

1st data byte = 87 (hex57) **first increases the addressed DMX channel**

and adjusts this one to **next odd** DMX level

2nd data byte: desired DMX level divided by 2

i.e vice versa: DMX level= 2nd data byte * 2 **plus 1**

Simple modifications of the DMX level with:

PROGRAM CHANGE

MIDI channel as selected base channel

data byte = 8 decrease (subtract 1 from) the level of the addressed DMX channel

data byte = 9 increase (add 1 to) the level of the addressed DMX channel

With these commands the disadvantage of lower accuracy of 7 bit MIDI data can be compensated. Furthermore it is useful to perform extremely slow fade transitions.

data byte = 127 (hex 7F) sets all DMX channels to level 0

Set Fade Time with:

CONTROL CHANGE

MIDI channel as position of rotary switch

1st data byte = 1, then

2nd data byte = 0 – 127: fade time in 1/10second units
(setting range 0 –12.7 seconds).

The actual value of Fade Time is copied into the respective resource when the fade process is started. Immediately after then the Fade Time can be modified without retroactivity on running fade processes. Any number of fade processes can be active simultaneously.

Fill a block of DMX channels starting from (addressed channel+1) with the final level of the actually addressed DMX channel with:

CONTROL CHANGE

MIDI channel as position of rotary switch

1st data byte = 72 (hex48)

2nd data byte: block length (1 to 127)

Comment: The fade duration is given by the actual setting of the Fade Time.

Poll DMX transmit buffer at the actually addressed DMX channel:

CONTROL CHANGE

MIDI channel as selected base channel

1st data byte = 72 (hex 48)

2nd data byte 1 to 10

The response comes as a sequence of CONTROL CHANGE messages:

first CC: actually addressed DMX channel, format as described for CC 80-83

second CC: 1st data byte = 1, 2nd data byte = actual Fade Time/4

following CCs: DMX level at this and subsequent channels,
format as described for CC 84,85

Limit the number of transmitted DMX channels with:

CONTROL CHANGE

MIDI channel as selected base channel

1st data byte = 64 (hex40)

2nd data byte = 5 ... 127 (hex 7F)

The number of transmitted DMX channels (DMX cycle length) is calculated as follows:

cycle = (2nd data byte+1) * 4. The minimum 2nd data byte is =5 -> 24 DMX channels

Save, store preset (= actual lighting scene) with:

CONTROL CHANGE

MIDI channel as selected base channel

1st data byte = 112 (hex70)

2nd data byte = preset number 0 ... 127 (Nucleo) or 0 ... 13 (STM32F042)

The actual lighting scene is stored nonvolatile in the microcontroller flash memory.

Load preset (= lighting scene) with:

CONTROL CHANGE

MIDI channel as selected base channel

1st data byte = 112 (hex70)

2nd data byte = 0 ... 5 preset number (STM32F042) or 0 ... 127 (Nucleo)

Preset number 0 is automatically loaded after power on. Together the Fade Time and the max number of transmitted DMX channels is loaded and activated. This way the first lighting scene may be faded softly out of dark.

Change mode of operation with :

PROGRAM CHANGE

MIDI channel as selected base channel

data byte = 64 (hex 40) block Art-Net

Art-Net is received in the background furthermore, but not copied to the DMX transmit buffer.
The LED blinks, when an ArtPoll message is received and responded.

data byte = 65 (hex 41) allow Art-Net (will overwrite DMX levels set by MIDI Commands)

data byte = 120 (hex 78) NOTE ON messages with 2nd data byte (velocity) = 0
are accepted and set the DMX level to 0 (**=default**)

Any NOTE OFF message (with arbitrary velocity) sets the DMX level to 0

data byte = 121 (hex 79) **NOTE ON messages with 2nd data byte (velocity) = 0
are ignored** and all NOTE OFF messages are ignored

but: NOTE ON messages with velocity = 1 set the DMX level to 0.

This mode is active, until it is revised with PROGRAM CHANGE 120 or device new start

General comment on PROGRAM CHANGE messages:

When formatting a PROGRAM CHANGE message, many MIDI sequencers and other MIDI control equipment demand that the data value (program number) has to be entered one higher than the physically transmitted data byte. (Example: user entered program #1 is transmitted as hex C0 00), **The USB / DMX Interface evaluates PROGRAM CHANGE messages with the physical parameter as described in the manual. Check your equipment if the parameter has to be entered by 1 higher**

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