Introduction to DMX

A Martin Acade·Media Seminar

ACADE•MEDIA

MARTIN PROFESSIONAL EDUCATION WORLDWIDE

Introduction to DMX

A Martin Acade·media Seminar

PREPARED BY CHRIS WEST AND MARC ANDERSON

Draft 13, for internal review only
September 2, 2004
Published in Denmark by Martin Professional

CONTENTS

INTRODUCTION

ABOUT THE COURSE

DMX512 is a standard that specifies a way to control lighting equipment. It has become an internationally recognized method for controlling entertainment lighting, and it is seeing increasing use in architectural lighting.

Basic knowledge of DMX is necessary to anyone working with Martin's intelligent lighting systems, whether as a designer, installer, technician, or operator. This course covers the basics of designing, setting up, and troubleshooting DMX systems for intelligent lighting. It is non-technical and is suitable for people with little or no previous experience with DMX.

The DMX standard was developed in 1986 by the United States Institute of Theatre Technology (USITT) and revised in 1990. It is the USITT DMX512 (1990) standard that is in use today. An updated version, DMX 512-A, is nearing release but has not been approved as of this writing. DMX 512-A will build on the 1990 standard, so this material will still be very relevant when 512-A is implemented.

A SYSTEM FOR DELIVERING MESSAGES

"DMX" stands for "Digital Multiplex". "Digital" refers to binary data in the forms of 0's and 1's. The data consists of commands to which lighting equipment respond. "Multiplex" means simultaneous communication of two or more messages on the same wire. Put it all together and DMX-512 is a way to rapidly transmit 512 commands on one wire.

One way to understand DMX-512 is to compare it to a postal system. The control desk is the post office. The signal that carries the commands is the mailman and the cable connecting the DMX system is the delivery route. The 512 commands, called a DMX packet, is the mail bag. The individual commands are postcards to the lighting devices. On the postcards are numbers from 0 to 255 written with 1's and 0's.

The DMX system has some important limits to be aware of.

- A DMX "mailman" can carry no more than 512 messages.
- The DMX route can be 1000 meters long, but to be sure the messages are delivered reliably in bad conditions, we keep it down to 500 meters.
- There may be no more than 32 receivers on a route.
- The route must not have any branches or splits.

There are ways to get around these limits that we'll discuss as we go.

BUILDING A DMX SYSTEM

DMX SYSTEM COMPONENTS

CONTROLLER

The Martin XCiter DMX Controller

CONTROLLER BASICS

The first thing we need in a DMX system is a controller. This is the post office, the place from which DMX messages are sent.

Controllers come in all shapes and sizes. They can be consoles with faders and buttons or software programs that run on personal computers. Any controller from any manufacturer will work with any lighting equipment as long as both the controller and the equipment comply with the DMX standard.

The first thing you can do with a controller is live, real-time, control of your intelligent lights, dimmers, and other DMX equipment. But in addition to that – and this is where the fun begins - most DMX controllers allow you to program and save intricate routines for automatic playback.

Programmable controllers are always required for controlling intelligent lights during live performances, but in other situations a simpler controller may be sufficient. In applications where the same routines are used over and over again – typical in architectural, retail, and some club applications - a "playback" controller can be used. A playback controller provides an easy, user-friendly way to control lights.

The LightCorder DMX Playback Controller

It is a little off-track, but some lights provide synchronized stand-alone operation, also known as master-slave operation, where no controller is required. In this application, one of the lights, the master, functions as a controller and sends DMX messages to the other lights, the slaves. This only works when all of the lights are identical or specifically designed to work together.

ONE CONTROLLER ONLY

There can only be one controller in a DMX system. Sophisticated DMX systems *do* exist that use a special combiner to merge the outputs from two controllers into a single data stream, but that's getting pretty advanced and the principle is the same. We'll stick to the basics for now: just one controller.

DMX CHANNELS, PACKETS, AND REFRESH RATE

DMX commands (our postcards) are sent in a group of 512 commands called a DMX packet, which is like a mail bag. Each command in the packet has its own slot, called a DMX channel. DMX channels are numbered from 1 to 512 and are very important when it comes to getting the commands to the right device. You will hear much more about DMX channels, so it's important to understand what they are.

The speed at which a controller sends packets is called its "refresh rate." It's not too important at this point, but full, 512-channel packets can be sent at a rate of up to 44 per second. Most controllers are a little slower.

512 CHANNELS PER UNIVERSE

If you've looked at DMX controllers, you probably noticed that they range in channel capacity. The LightJockey, for example, is available with 512, 1024, or 2048 channels. Except for some smaller controllers, all DMX controllers provide some multiple of 512 channels.

Each multiple of 512 channels is called a "DMX universe." In our postal system, a DMX universe is one mail delivery route. A controller that provides 1024 channels has separate 2 DMX universes or delivery routes. When you design a DMX system with more than 512 channels, you have to take the 512 channel limit into account and divide the DMX devices into separate universes.

DATA CABLE

A DMX Cable

RS-485 CABLE IS BEST FOR PORTABLE APPLICATIONS

If you work with DMX enough, you will run into problems caused by the cable. Yes, you can run DMX data through just about anything, even plain lamp cord. Microphone cable is used a lot in DMX systems and it *often* works okay. But we always recommend using RS-485 cable, which is also called EIA-485 cable.

Why? If you compare a data signal before and after it has travelled through a long cable, you'll see that the signal is smaller after travelling through the wire. This is called "loss" because the signal gradually becomes weaker. The signal will also be slightly distorted, that is, it gets a different shape, as it goes through the wire. Distortion makes the signal harder to read.

Distortion and loss are less in RS-485 cable than in other types. It gives you the cleanest, strongest signal possible. It gives you the best chance to stand up to cable damage, electrical interference, loose connections, poor solder joints, and all the other things that can bring down your lights when you least expect it.

That's why.

RS-485 CABLE OPTIONS

You'll have a number of choices to make when you buy your RS-485 cable. You have to select the wire thickness, jacket type, number of twisted pairs, and connectors.

Thickness: Generally speaking, the thicker the wire, the better. But thickness adds weight and cost so you don't want to use thicker wire than you really need. Wire thickness is usually specified in a unit called AWG, which stands for "American Wire Gauge". AWG is confusing because the smaller the number, the thicker the wire. For cable runs up to 300 m (1000 ft.) you can use 24 AWG cable. For longer runs, you'll want at least 22 AWG cable and/or signal amplifiers, which we'll discuss later.

Jacket: Data cables are insulated and jacketed with a variety of materials for different purposes and to meet different safety standards. Plenum cable, for example, has a flame-retardant jacket and gives off less toxic gas and smoke in case of fire. Other cables are specifically designed for outdoor use or underground burial.

Number of twisted pairs: The DMX512 (1990) standard specifies that DMX cable have two pairs of data wires that are twisted together. DMX data is transmitted over the first twisted pair but no use is defined for the second pair. Though some DMX equipment uses the second twisted pair to implement non-standard, proprietary features, most does not. When using Martin products and most other DMX equipment, cable with just one twisted pair of wires works just as well. However, the coming DMX 512A standard does define uses for the second data pair, so more products are likely to use it in the future.

RS-485 Cable Characteristics

- RS- 458 cable is shielded, usually with copper braid and aluminum foil, to keep external signals and the electromagnetic garbage that floats around from getting into the data wires.
- RS-485 cable is "balanced" by twisting the data wires around each other. Balancing the cable is a neat trick that effectively cancels out interference that does manage to get through the shield.
- RS-485 cable has a characteristic impedance of 100 – 120 ohms. The most important thing with impedance is not so much the actual value, but that all cables have the same characteristic impedance. Part of the data signal gets reflected back down the wire when cables of different impedance are used.
- RS-485 cable has a low capacitance to minimize signal distortion. The lower the capacitance, the cleaner the signal.

XLR Connections

3 and 5-pin XLR Plugs

Though the DMX standard specifies 5-pin XLR connectors, both 3-pin and 5-pin XLR connectors are common. The reasons are discussed a little later.

The connectors are wired as shown below.

Connection	Pin
ground, Screen or shield	1
data complement (cold / -)	2
data true (hot / +)	3
spare data –	4
spare data +	5

CATEGORY 5 UTP CABLE IS SUITABLE FOR PERMANENT INSTALLATIONS

Category 5 UTP (unshield twisted-pair) cable makes an excellent substitute for RS-485 cable in permanent installations. A study conducted by the Entertainment Services and Technology Association in 2000 concluded that, "Results of these tests indicated that Category 5 UTP cable performed as well as conventional DMX512 cable." Category 5 UTP cable is widely used for connecting local area networks and is readily available with RJ-45 connectors.

While not appropriate for most entertainment lighting applications, Category 5 UTP cable is recommended for permanent architectural lighting applications.

DMX EQUIPMENT

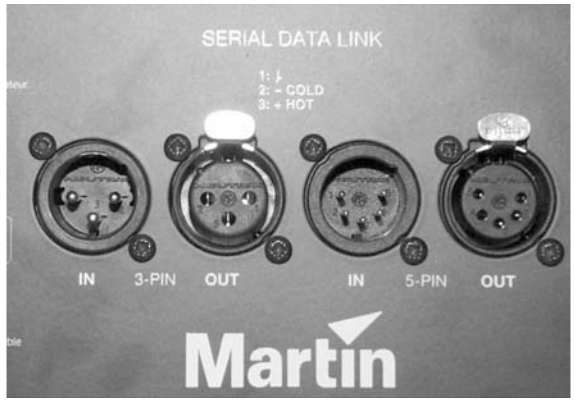
The Martin MAC 550

DATA CONNECTIONS

DMX equipment, whether moving lights, scrollers, dimmers, smoke machines, or something else, has an input socket to receive data from the controller and an output socket to send the data on to the next device. The sockets on truly DMX (1990) compliant equipment are 5-pin XLR. But much DMX equipment, including most Martin products, has 3-pin XLR sockets.

Having 3-pin and 5-pin sockets is a pain when mixing products from different manufacturers. It's not meant to make life difficult, it just happened that way. Martin used 3-pin connectors before DMX was an accepted standard because there was no need for 5 pins. If your DMX equipment has 3-pin connectors, look at the bright side: they are stronger and less expensive than 5-pin connectors.

In 2000, Martin began to put both 3-pin and 5-pin XLR sockets on its touring fixtures to make life easier. You can use any combination of input and output, but you cannot have 2 inputs or 2 outputs.



3-pin and 5-pin XLR Sockets

RJ-45 connectors are beginning to show up in place of XLR connectors on architectural lighting products such as Martin's Cyclo DMX series, which are intended for permanent installation and are suitable for connection with Category 5 UTP cable. The trend towards RJ-45 connectors has been recognized and their use is expected to be allowed in the coming DMX512-A standard.

CONTROL PROTOCOL

So far we've only talked about how to communicate using DMX. But what do we say? What is in the 512 DMX messages?

The answer is numbers from 0 to 255 that come from a list of commands known as a control protocol. The protocol lists the following:

- each lighting effect (dimmer, color, gobos, focus, pan, tilt, etcetera)
- what the effect does at every level from 0 to 255.
- the channel that controls the lighting effect

To control a DMX device, you send it the DMX values, or levels, that correspond to the action listed in its protocol. Lets say that we want to blackout a MAC 250 Entour. Referring to its protocol, we can see that DMX values from 0 to 19 on channel 1 command the Entour to close its shutter.

MAC 250 Entour DMX Protocol (18 Channel Extended Mode)

Channel	Value	Percent	Function
1			**Shutter, Strobe, Reset, Lamp On/Off**
	0 - 19	0 - 7	Shutter closed
	20 - 49	8 - 19	Shutter open
	50 - 72	20 - 28	Strobe, fast → slow
	73 - 79	29 - 31	Shutter open
	80 - 99	31 - 39	Opening pulse, fast → slow
	100 - 119	39 - 47	Closing pulse, fast → slow
	120 - 127	47 - 50	Shutter open
	128 - 147	50 - 58	Random strobe, fast
	148 - 167	58 - 65	Random strobe, medium
	168 - 187	66 - 73	Random strobe, slow
	188 - 190	74 - 75	Shutter open
	191 - 193	75 - 76	Random opening pulse, fast
	194 - 196	76 - 77	Random opening pulse, slow
	197 - 199	77 - 78	Random closing pulse, fast
	200 - 202	78 - 79	Random closing pulse, slow
	203 - 207	80 - 81	Shutter open
	208 - 217	82 - 85	Reset fixture
	218 - 227	85 - 89	Shutter open
	228 - 237	89 - 93	Lamp on
	238 - 247	93 - 97	Shutter open
	248 - 255	97 – 100	Lamp off
2			**Dimmer Coarse**
	0 - 255	0 – 100	Closed → open
3			**Dimmer Fine (LSB)**
	0-255	0-100	Closed → open
			Color
			Continuous Scroll: full color positions:
	0	0	White
	11	4	CTC
	22	9	Yellow 603
	33	13	Blue 104
	44	17	Pink 312
	55	22	Green 206
	66	26	Blue 108
	77	30	Red 301
	88	35	Magenta 507
	99	39	Blue 101
	110	43	Orange 306
	121	47	Dark green
	132	52	Purple 502
	143	56	White

Extract from the MAC 250 Entour DMX Protocol

Channel Requirements

Most DMX devices require more than one DMX channel. The MAC 2000 Performance is a channel hog, taking 31 DMX channels. The MAC 250 Entour is more typical of a moving light: taking 18 DMX channels. Roughly speaking, each controllable effect within a device requires its own channel. Some effects use 2 channels for very precise “16-bit” control, which we will explain later.

Address Setting

Every DMX device needs an address, also known as a “start channel”. The address is a number from 1 to 512 that tells the controller where to send messages. The address is usually set on the device through a control panel or DIP-switch.

DIP-switches

The start channel also tells the device which messages to read. It works like this: each device within a DMX universe receives the whole DMX packet, all 512 messages, even though it only needs a few of them. When a fixture set to address 100 receives a DMX packet, it counts to channel 100 and starts reading commands.

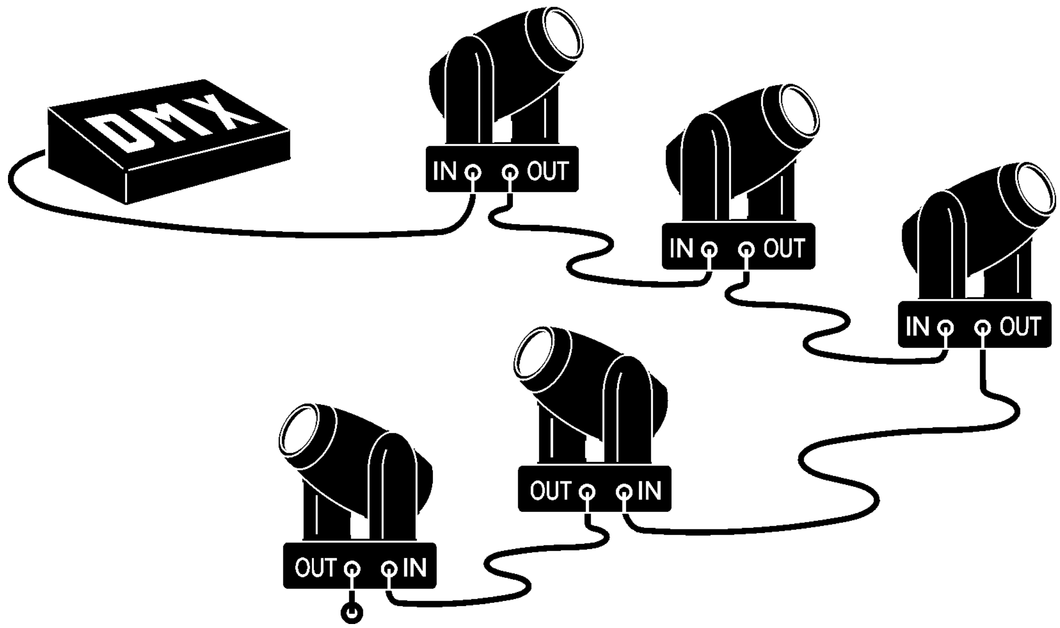
We’ll go into the details of how to set channels a little later.

Channel Space

The device’s start channel is the first channel with a command for that device. Its “channel space” is the entire group of channels that contain its commands. If the device uses 10 channels and the start channel is 100, then its channel space is channels 100 – 109.

The channel space for each fixture must be unique and non-overlapping. Two or more identical fixtures *can* be set to the same address and share the same address space. If so, they will respond to the same commands and behave identically; individual control will not be possible.

CONNECTING THE PIECES



A DMX Daisy Chain

WIRE IN A DAISY CHAIN

A DMX network is wired in what is known as a "daisy chain", where the controller is connected to fixture 1, fixture 1 is connected to fixture 2, fixture 2 is connected to fixture 3, and so on until the last fixture.

KEEP CABLE RUNS UNDER 500 METERS

DMX is designed to work with cable runs of up to 1000 meters. DMX can be transmitted over longer distances, but this requires amplification or another means of transmission such as Ethernet or radio. To be on the safe side, keep cable runs to 500 meters or less.

CONNECT UP TO 32 RECEIVERS

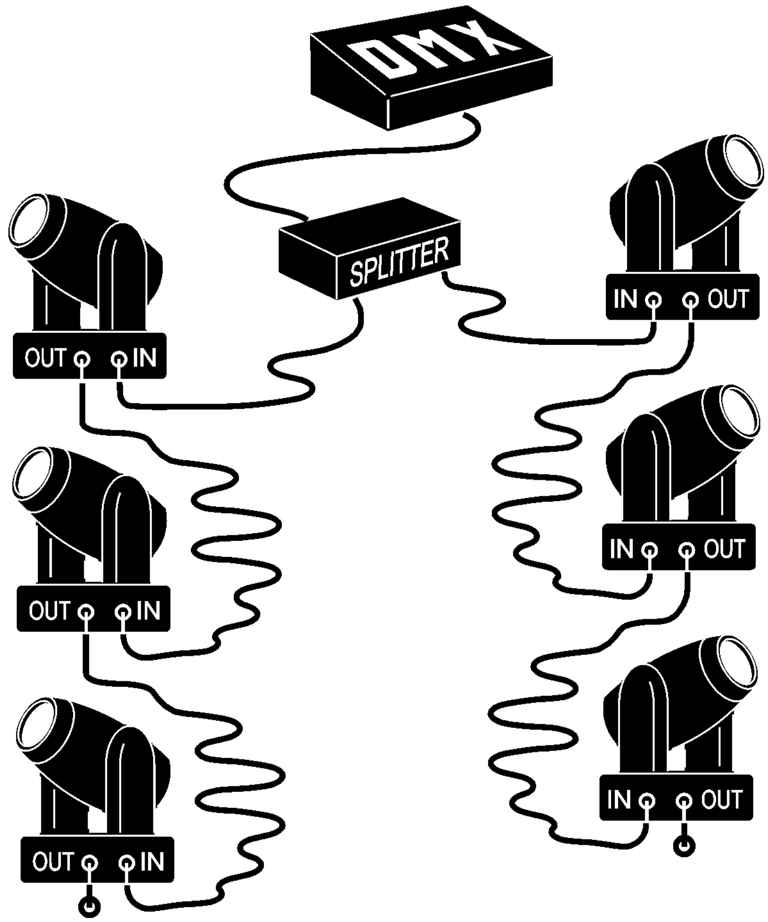
When the DMX signal goes through a DMX device it loses a small amount of power. To make sure the signal remains strong enough to be read, the DMX standard specifies that there may be no more than 32 DMX devices connected in a single chain. If you put a few more fixtures on the chain, they will most likely work, but you are inviting trouble.

If you get deep into DMX, you will hear about "unit loads". This is a way of describing how much power is taken out of the signal by a DMX device. Most devices take 1 "unit load" of power, so the number of unit loads and the number of devices is the same: 32. But some DMX devices take less, perhaps a half unit load. You could safely put 64 of these on a line because the number of unit loads still totals 32. Until you're an expert, stick to the 32 device maximum.

USE A SPLITTER-AMPLIFIER

A Splitter-Amplifier

Splitter-amplifiers are extremely useful DMX wiring accessories. They provide a way to get around the 32 fixture / 500 meter limits, branch a cable run into several directions, isolate problems, and protect expensive equipment. You won't be able to do without them in large installations.



Splitting the Daisy Chain

One thing a splitter-amplifier does is boost the signal so it can travel another 500 meters, to an additional 32 lights, or both. Several splitter-amplifiers can be chained together to extend the cable run as far as you'll need for everything but the most exotic applications.

The other thing a splitter-amplifier does is copy the incoming signal to 2 or more outputs, each of which is amplified. Using a splitter-amplifier is like making copies of the mail for 2 or more mailmen, each with his own 32 house, 500 meter route. It is important to realize, however, that they each carry the same messages: there is no way to get around the 512 channel packet size.

A splitter-amplifier is also the only safe way to branch a cable run in different directions. A "Y" split results in unwanted signal reflections because you can't effectively terminate each branch. We'll get to termination in a moment.

Most splitter-amplifiers have another nice feature: they break the electrical connection between the input and the output through a trick known as "opto-isolation". Electronics convert the input signal to light, transmit the light a tiny distance, and then convert it back to an electric signal. This prevents electrical problems that occur on one branch, a short circuit for example, from disturbing the root or the other branches. And if mains power should ever find its way onto the DMX cable, which can be quite destructive to connected equipment, the splitter-amplifier will blow, saving your expensive controller.

TERMINATE THE END OF THE LINE

Lets take a look at the end of the mailman's route. He gets to the last house and delivers the mail. Now what? The route ends. There are no more houses to deliver to and the back door is locked. So what does our mailman do? He still has some energy left so he turns around and starts heading back to the post office, annoying and confusing everyone as he goes. So we put something at the end of the route to stop the mailman from going back. We call this something a "terminator".

A terminator is a trap. It opens the back door for the mailman and tricks him into going through it. When he does, the terminator soaks up his energy so he can't go back the other way. This results in a cleaner, less distorted DMX signal.

Electrically, a terminator is a resistor that converts the energy in the DMX signal to a little bit of heat so that the signal will not reflect or bounce back down the line. Ideally, the resistor value should match the characteristic impedance of the data cable, but in practice a 120 ohm, quarter-watt resistor works fine.

Inside an XLR Termination Plug

The most common way to terminate a DMX line is to plug a terminator plug into the output socket of the last fixture in the chain. The terminator plug consists of a male XLR plug with a resistor soldered to pins 2 and 3. Though some devices provide a "last device" option that terminates the DMX line when enabled, Martin products do not.

There are two special termination conditions worth mentioning. First, if you create branches in the cable run using a splitter-amplifier as described above, each branch must be terminated. Second, both ends of the data chain must be terminated if the controller is somewhere in the middle of the DMX line, instead of at the beginning. This can occur in a master/slave setup where the master fixture is somewhere in the middle of the chain.

Addressing and Setup

One of the most frequent problems with DMX systems is the address setting, so we will spend some time going through the procedure. Skip this section if you know how to set DMX addresses.

Set Address on Controller and Device

Each DMX device must be assigned an address, or a start channel, so that it knows which commands to respond to. Remember, a DMX device receives all channels in the DMX packet but only responds to the commands in its channel space.

In most cases, the address settings must be assigned on the controller as well. The exceptions are simple controllers like the Martin 2518 DMX Controller, and playback controllers. But on sophisticated programming controllers, you need to configure the fixture addresses.

Determine Channels and Mode

The first thing you need to do is find out how many channels your DMX devices require. You need to be familiar with the features and operating modes of the devices because the number of channels can vary depending on the mode. This is so important that it bears repeating: the number of channels can vary depending on the mode. Got it?

For example, the MAC 500 provides a 12-channel mode, two 14-channel modes, and a 16-channel mode. The differences between these modes is described later. Generally, if your controller has plenty of channel capacity, select the mode that uses the most channels. If you are short on channel capacity, study the options and select the mode that best meets your needs.

You also need to verify that the controller supports the selected mode. You will run into problems, for example, if you try to operate a MAC 500 in the 12-channel DMX mode when the controller only supports the 16-channel mode.

ASSIGN CHANNEL SPACE

Once you know how many channels each device needs, the next step is to list the devices in a table. One-by-one, assign each device a unique, non-overlapping channel space. The easiest way to do this is to start at channel 1 and count up the required number of channels for the first device. Then use the next available channel as the start channel for the next device. An example is shown below.

Device	Channels	Channel Space
CX-10 no. 1	10	1 – 10
CX-10 no. 2	10	11 – 20
CX-10 no. 3	10	21 – 30
CX-10 no. 4	10	31 – 40
MX-4 no. 1	7	41 – 47
MX-4 no. 2	7	48 – 54
Wizard no. 1	8	55 – 62
Atomic no. 1	4	63 – 66
Atomic no. 2	4	67 – 70
Entour no. 1	18	71 – 88
Entour no. 2	18	89 – 96

SET ADDRESSES AND MODES

Once you've laid out the channel spaces in a table, you're ready to configure the devices and the controller. The procedure is different on every controller, so we won't go into that here.

FIXTURES WITH CONTROL PANELS

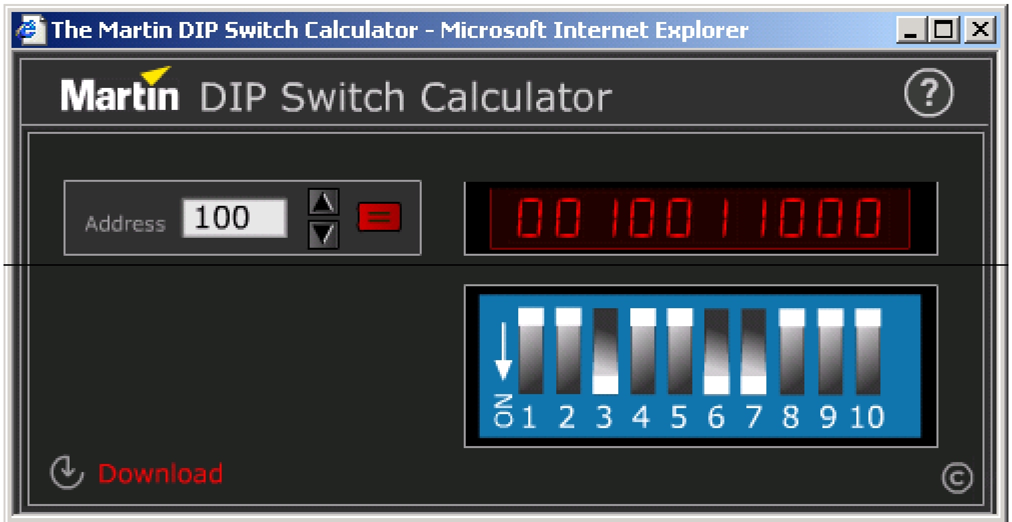
Setting the mode and address on fixtures with control panels is straightforward and described in the user manual. For example, for the MAC 250 Entour, the procedure is as follows:

1. Apply power.
2. Press [menu] to enter the main menu.
3. Select AddR using the [up] and [down] keys. Press [enter].
4. Select an address using the [up] and [down] keys. Press [enter].
5. Press [menu] to return to the main menu.
6. Select PSET using the [up] and [down] keys. Press [enter].
7. Select 16BT for standard 16-bit mode, or 16EX for 16-bit extended mode. Press [enter] .
8. Press [menu] to return to the main menu.

FIXTURES WITH DIP-SWITCHES

Setting the address on fixtures with DIP-switches can seem difficult but it is fairly simple once you learn how. We'll describe three ways to find the pin setting for the desired DMX address.

DIP-SWITCH CALCULATOR



One way to find DIP-switch settings is to use a DIP-switch calculator. You enter the address in the calculator and it displays the proper DIP setting. Just set the switch as shown in the display.

There's a calculator you can download at **http://www.martin.com/service/dipswitchpopup.htm**.

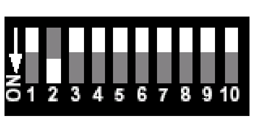
DIP-SWITCH TABLE

DIP switch Setting					#9	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
					#8	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1
0 = OFF					#7	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1
1 = ON					#6	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
#1	#2	#3	#4	#5																	
0	0	0	0	0			32	64	96	128	160	192	224	256	288	320	352	384	416	448	480
1	0	0	0	0		1	33	65	97	129	161	193	225	257	289	321	353	385	417	449	481
0	1	0	0	0		2	34	66	98	130	162	194	226	258	290	322	354	386	418	450	482
1	1	0	0	0		3	35	67	99	131	163	195	227	259	291	323	355	387	419	451	483
0	0	1	0	0		4	36	68	100	132	164	196	228	260	292	324	356	388	420	452	484
1	0	1	0	0		5	37	69	101	133	165	197	229	261	293	325	357	389	421	453	485
0	1	1	0	0		6	38	70	102	134	166	198	230	262	294	326	358	390	422	454	486
1	1	1	0	0		7	39	71	103	135	167	199	231	263	295	327	359	391	423	455	487
0	0	0	1	0		8	40	72	104	136	168	200	232	264	296	328	360	392	424	456	488
1	0	0	1	0		9	41	73	105	137	169	201	233	265	297	329	361	393	425	457	489
0	1	0	1	0		10	42	74	106	138	170	202	234	266	298	330	362	394	426	458	490
1	1	0	1	0		11	43	75	107	139	171	203	235	267	299	331	363	395	427	459	491
0	0	1	1	0		12	44	76	108	140	172	204	236	268	300	332	364	396	428	460	492
1	0	1	1	0		13	45	77	109	141	173	205	237	269	301	333	365	397	429	461	493
0	1	1	1	0		14	46	78	110	142	174	206	238	270	302	334	366	398	430	462	494
1	1	1	1	0		15	47	79	111	143	175	207	239	271	303	335	367	399	431	463	495
0	0	0	0	1		16	48	80	112	144	176	208	240	272	304	336	368	400	432	464	496
1	0	0	0	1		17	49	81	113	145	177	209	241	273	305	337	369	401	433	465	497
0	1	0	0	1		18	50	82	114	146	178	210	242	274	306	338	370	402	434	466	498
1	1	0	0	1		19	51	83	115	147	179	211	243	275	307	339	371	403	435	467	499
0	0	1	0	1		20	52	84	116	148	180	212	244	276	308	340	372	404	436	468	500
1	0	1	0	1		21	53	85	117	149	181	213	245	277	309	341	373	405	437	469	501
0	1	1	0	1		22	54	86	118	150	182	214	246	278	310	342	374	406	438	470	502
1	1	1	0	1		23	55	87	119	151	183	215	247	279	311	343	375	407	439	471	503
0	0	0	1	1		24	56	88	120	152	184	216	248	280	312	344	376	408	440	472	504
1	0	0	1	1		25	57	89	121	153	185	217	249	281	313	345	377	409	441	473	505
0	1	0	1	1		26	58	90	122	154	186	218	250	282	314	346	378	410	442	474	506
1	1	0	1	1		27	59	91	123	155	187	219	251	283	315	347	379	411	443	475	507
0	0	1	1	1		28	60	92	124	156	188	220	252	284	316	348	380	412	444	476	508
1	0	1	1	1		29	61	93	125	157	189	221	253	285	317	349	381	413	445	477	509
0	1	1	1	1		30	62	94	126	158	190	222	254	286	318	350	382	414	446	478	510
1	1	1	1	1		31	63	95	127	159	191	223	255	287	319	351	383	415	447	479	511

DIP-Switch Settings

You can also use this table to find the pin setting. Locate the desired address in the lower-right part of the table. Follow the row over to the left to read the setting for pins 1 to 5. Then follow the column up to the top to read the settings for pins 6 to 9. Set the "1" pins to ON and the "0" pins to OFF.

Here are some examples.



Channel 2

Channel 14

Channel 46

Channel 100

Example DIP settings

THE SUBTRACTION METHOD

The third way to find the pin setting is to work it out yourself.

Each pin has the value shown below. The idea with this method is to find the combination of pin values that add up to the DMX address.

pin	1	2	3	4	5	6	7	8	9	10
value	1	2	4	8	16	32	64	128	256	OFF

DIP Values

1. Write down the address.
2. Starting from the right (pin 9), find the highest pin value that is less than or equal to the address. Write down the pin number.
3. Subtract the pin value from the address and write down the remainder.
4. Find the highest pin value that is less than or equal to the remainder. Write down the pin value.
5. Subtract the pin value from the remainder and write down the new remainder.
6. Repeat steps 4 and 5 until there is no remainder.
7. Set pins that you wrote down to the ON position. Set the other pins to off.
8. Refer to the device user manual for information on mode setting.

This method is illustrated below for channel 100.

step 1	100	
step 2	- 64	7
step 3	36	
step 4	-32	6
step 5	4	
step 4	-4	3
step 5	0	

OTHER FIXTURES

Several Martin Architectural products for outdoor use have neither control panel nor DIP-switch. Setting the address on these devices is achieved with a PC or one of Martin's remote control devices.

TROUBLESHOOTING DMX

There are many things that can go wrong with a DMX system, but the most common fault is always the same, human error! When you run into problems, it is often a good idea to get someone else to check your system, especially with more complex rigs. This section describes how to find and correct the most common problems.

COMMON DMX PROBLEMS

Problem	**Possible Causes**
No fixtures respond to controller	Open or short circuit on data line
	Reversed signal
	Defective controller
	Multiple transmitters
Some fixtures fail to respond to controller	Incorrect setup
	Open or short circuit on data line
	Reversed signal
	Defective transceiver
Random movement or flicker	Poor signal quality

INCORRECT SETUP

If a device responds to the controller but does not perform as expected, the problem is either a programming error or an incorrect address or mode setting.

If the address setting on the device does not match the address setting on the controller, then the device will read the wrong commands. If the device is set correctly but its channel space overlaps with another fixture, then each of the devices will respond in some unpredictable way to commands for the other device.

Check the setup by comparing the mode and address assigned on the controller to the mode and address set on the fixture.

Open or Short Circuit

The data signal may not reach the fixtures if there are short circuits, broken wires, poor solder joints, broken connector pins, loose connectors, etc. anywhere in the line. A short or open circuit can also occur at the PCB jumper connections on fixtures with configurable XLR connectors.

A short circuit causes a failure on the whole DMX line.

An broken wire (open circuit) may affect all, some, or none of the fixtures. DMX receivers can, under good conditions, read the signal even when one of the data wires is broken.

Testing the line can be done with a Martin Wife, Martin Link Tester, or an ohm meter.

To test the data link with an ohm meter, disconnect the link from the controller and turn off all fixtures. Measure the resistance across pins 2 and 3 of the XLR male plug: the reading should equal the termination resistance (120 ohms) plus the cable resistance.

Higher readings, from approximately 400 - 20,000 ohms, indicate that the data link is not terminated. A reading below 80 ohms indicates either a short circuit or, possibly, too many terminators.

Test	Normal Value	Abnormal Value	Possible Fault
Pin 1 to Pin 2	greater than 2000 ohms	Open circuit	Broken wire or connector
		Less than 200 ohms	Short circuit or faulty receiver
Pin 1 to Pin 3	greater than 2000 ohms	Open Circuit	Broken wire or connector
		Less than 200 ohms	Short circuit or faulty receiver
Pin 2 to Pin 3	90 to 120 ohms approx.	400 to 20k ohms	Incorrect termination
		open circuit	Broken wire or connector
		Less than 75 ohms	Short circuit or multiple terminators
Connector shell to any pin	open circuit	Less than several Mega-ohms	Short circuit to connector body

Ohm meter tests

Poor Signal Quality

A poor quality signal often causes intermittent problems such as a random flicker or twitch in some of the lights. The problem might be caused by too long a run for the cable type, low quality cable, too many connected devices, or missing or improper termination. If you do not follow the wiring recommendations described earlier, the signal will not be as good as it could be.

Check the wiring and termination. Upgrade the cable if necessary or add splitter-amplifiers to the system to strengthen the signal.

Multiple Data Signals

There can only be one DMX signal at a time. If there are multiple signals, perhaps from fixtures operating as masters, errors and possibly damage will occur.

To detect additional signals, disconnect the data link from the controller output and test with the Martin WIFE, Martin Link Tester or another DMX tester. If you don't have these tools, a fixture set to channel 1 will probably react if there is a signal on the line when the controller is disconnected.

Reversed Signal

The data sockets on Martin products introduced before 1997, the RoboScan 812 and the PAL 1200 to name just two, were wired differently than later products. The early products have 3-pin XLR connectors wired with pin 2 to data + (hot) and pin 3 to data - (cold), which is the opposite of the DMX standard. When using older Martin products in a DMX system, it is necessary to reverse the signal polarity with a swap cable that connects pin 3 to pin 2 and pin 2 to pin 3. The connector wiring is always indicated near the XLR socket.

DMX-compliant devices connected downstream from an earlier Martin device will not be able to read the DMX data unless the signal is re-reversed with a second swap cable.

Defective Transceiver

If the fixture resets but does not respond to the controller, and everything else is okay, then the fixture's transceiver may be defective. The problem can also be in a different fixture, though, because a faulty transceiver sometimes puts 'noise' onto a DMX line that causes problems with other fixtures.

One way to locate a defective fixture is to disconnect the DMX cables from the input and output sockets and plug the cables into each other while the controller is running. If the problem goes away when you do this, there is a problem with the fixture.

Another useful troubleshooting technique is to set a nearby fixture of the same type to the same address as the problem fixture. If the nearby fixture performs properly, then you can assume there is a problem with the fixture and not the DMX signal.

Defective Controller

If a whole link is down and the cable checks out okay, the problem is probably with the controller. You can confirm this by substituting the controller with another controller or a transmitting device such as the MP-2 or Lightcorder. Test the controller output with a DMX tester such as the Martin Wife.

If you are using a Martin fixture with a digital display, you can read the DMX values received on each channel, usually under `DMXL`. Some of the most recent fixtures also display the DMX refresh rate (packets per second) and the percentage of DMX packets received.

Martin DMX Modes

Many Martin lighting fixtures provide several DMX operating modes that allow the user to reduce the number of channels required. The mode that uses the most channels provides all available features and is recommended whenever channel capacity is not an issue. This section describes the differences between these modes to help you select the mode that best meets your needs.

Note: your controller may not support all operating modes: always confirm that the selected operating mode is supported.

8 and 16 bit Control

“16-bit control” is an option that allows the user to control effects much more precisely than “8-bit control”.

“8-bit control” is a way of saying 1-channel control because a single DMX channel contains 8 bits (1’s and 0’s) that communicate DMX levels from 0 to 255.

“16-bit control” means 2-channel control. If you add 8 more bits from a second DMX channel, you can write any number from 0 to 65,536. So with two channels and 16 bits, you have over 65,000 levels to work with instead of 256!

What does this mean in practical terms? Lets take a typical moving head with a 540° pan range. With 8-bit control and 256 levels to move the head from full left to full right, each level has to move the head approximately 2 degrees. If the light is 10 meters from the stage, each level moves the beam about 34 centimeters or 1 foot.

With 2-channel, 16-bit control, the 540° pan range can be divided into 65,536 increments as small as 0.008 degrees. At 10 meters, the beam moves a mere millimeter per level! The actual numbers depend on the mechanical gearing, but you get the idea of the difference between 8 and 16-bit control.

16-bit control is most useful with pan and tilt, but it is used increasingly with other effects where a high degree of precision is desirable such as color mixing, dimming, and gobo rotation.

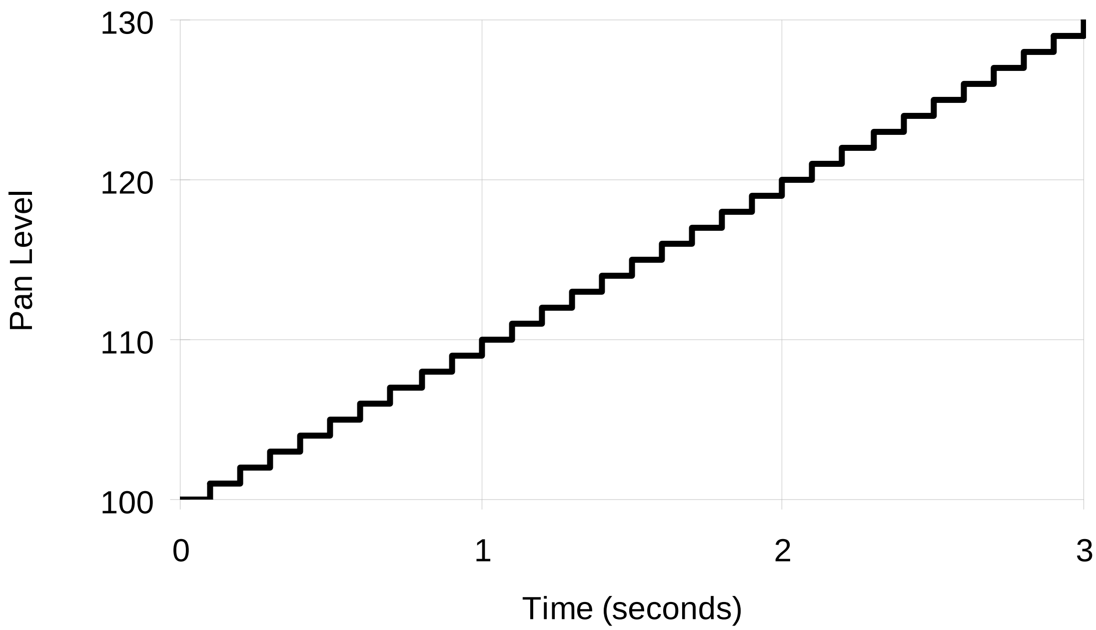
Tracking and Vector Control

Most Martin lighting fixtures provide two ways to control the speed at which lighting effects move: “tracking control” and “vector control.”

To illustrate the difference, lets take a 30° pan movement from left to right. To do this, we focus the beam on the left and save this position. Lets say it works out to DMX level 100 on the pan channel. Then we move the beam to the right 30° and save this second position, which we’ll say is at DMX level 130. Lets say we want a 3 fade time; there are two ways to do this.

With tracking control, you set a 3-second fade time on the controller. To execute the movement, the controller increases the fixture’s pan level from 100 to 130 over 3 seconds as shown below.

We call this tracking control because the light follows, or tracks, small, timed changes in position sent from the controller. The controller tells the fixture where and when to move every step of the way.



Example of a tracking mode fade

With vector control, you set a level on the lighting fixture's pan and tilt speed channel. Lets say that a level of 20 on the speed channel works out to 10° per second. To execute the movement, the controller sends level 130 on the pan channel and level 20 on the pan and tilt speed channel, telling our fixture to go 30° to the right at 10° per second.

Each method has its advantages and disadvantages. With some fixture / controller combinations, tracking control results in jerky, stop and go movement because the fixture has to repeatedly move and stop. Vector control can be harder to program, but may result in smoother movement, particularly at very slow speeds. If you choose not to use vector control, some Martin products allow you to disable it and save 2 DMX channels.

MODE CONFIGURATIONS

Martin's moving heads introduced before 2000 typically offer 4 DMX modes with the features shown in the following table. Later products, starting with the MAC 2000 Profile, generally do not provide the tracking-only option but do provide 8-bit and 16-bit control options. For specific mode options, consult the device's user manual or DMX protocols.

DMX Mode	Bits	Tracking / Vector	Channels saved
1	8	Tracking only	4
2	16	Tracking only	2
3	8	Tracking and Vector	2
4	16	Tracking and Vector	0

MAC 250 Entour DMX protocol

16 Bt (16 Bit Mode)	16 Ex (16 Bit Extended)	Value	Percent	Function
1 [1]If DMX Reset is disabled in the menu, a reset command can only be executed if the CTC filter is selected, the prism is on (not rotating) and the open gobo is selected. A 5 second delay can be given to the reset command from the fixture menu under, dRES. [2]If DMX Lamp Off is disabled in the menu, a lamp off command can only be executed if the CTC filter is selected, the prism is on (not rotating) and the open gobo is selected.				**Shutter, Strobe, Reset, Lamp On/Off**
		0 - 19	0 - 7	Shutter closed
		20 - 49	8 - 19	Shutter open
		50 - 72	20 - 28	Strobe, fast → slow
		73 - 79	29 - 31	Shutter open
		80 - 99	31 - 39	Opening pulse, fast → slow
		100 - 119	39 - 47	Closing pulse, fast → slow
		120 - 127	47 - 50	Shutter open
		128 - 147	50 - 58	Random strobe, fast
		148 - 167	58 - 65	Random strobe, medium
		168 - 187	66 - 73	Random strobe, slow
		188 - 190	74 - 75	Shutter open
		191 - 193	75 - 76	Random opening pulse, fast
		194 - 196	76 - 77	Random opening pulse, slow
		197 - 199	77 - 78	Random closing pulse, fast
		200 - 202	78 - 79	Random closing pulse, slow
		203 - 207	80 - 81	Shutter open
		208 - 217	82 - 85	Reset fixture
		218 - 227	85 - 89	Shutter open
		228 - 237	89 - 93	Lamp on
		238 - 247	93 - 97	Shutter open
		248 - 255	97 – 100	Lamp off
2	2			**Dimmer**
		0 - 255	0 – 100	Closed → open
	3			**Dimmer Fine (Lowest Significant Byte)**
		0-255	0-100	Closed → open
3	4			**Color**
				Continuous Scroll: full color positions:
		0	0	White
		11	4	CTC
		22	9	Yellow 603
		33	13	Blue 104
		44	17	Pink 312
		55	22	Green 206
		66	26	Blue 108
		77	30	Red 301
		88	35	Magenta 507
		99	39	Blue 101
		110	43	Orange 306
		121	47	Dark green
		132	52	Purple 502
		143	56	White
				Stepped Scroll
		156 – 159	61 – 63	White
		160 – 163	63 – 64	CTC
		164 – 167	64 – 65	Yellow 603
		168 – 171	66 – 67	Blue 104
		172 – 175	67 – 68	Pink 312
		176 – 179	69 – 70	Green 206
		180 – 183	70 – 72	Blue 108
		184 – 187	72 – 73	Red 301
		188 – 191	74 – 75	Magenta 507
		192 – 195	75 – 76	Blue 101
		196 – 199	77 – 78	Orange 306
		200 – 203	78 – 79	Dark green
		204 – 207	80 – 81	Purple 502
				Continuous Rotation
		208 – 226	82 – 88	CW, fast → slow
		227 – 245	89 – 96	CCW, slow → fast
				Random color
		246 – 248	96 – 97	Fast
		249 – 251	98 – 98	Medium
		252 – 255	99 – 100	Slow
	5	0 - 255	0 - 100	**Color (Lowest Significant Byte)**

4	6			**Rotating Gobo selection and shake**
				Indexing: set position on channel 5 in 16 bt mode or channel 6 in 16 Ex mode
		0 - 4	0 - 2	Open gobo
		5 - 10	2 - 4	Gobo 1
		11 - 15	4 - 6	Gobo 2
		16 - 20	6 - 8	Gobo 3
		21 - 25	8 - 10	Gobo 4
		26 - 30	10 - 12	Gobo 5
		31 - 35	12 - 14	Gobo 6
		36 - 42	14 - 16	Gobo 7
				Rotation: set rotation speed on channel 5 in 16 bt mode or channel 6 in 16 Ex mode
		43 - 50	17 - 20	Open gobo
		51 - 58	20 - 23	Gobo 1
		59 - 65	23 - 26	Gobo 2
		66 - 73	26 - 29	Gobo 3
		74 - 81	29 - 32	Gobo 4
		82 - 89	32 - 35	Gobo 5
		90 - 96	35 - 38	Gobo 6
		97 - 104	38 - 41	Gobo 7
				Rotation with shake, slow → fast: set rotation speed on channel 5 in 16 bt mode or channel 6 in 16 Ex mode
		105 - 119	41 - 46	Gobo 7, Shake slow → fast
		120 - 134	47 - 52	Gobo 6, Shake slow → fast
		135 - 149	53 - 58	Gobo 5, Shake slow → fast
		150 - 164	59 - 64	Gobo 4, Shake slow → fast
		165 - 179	65 - 70	Gobo 3, Shake slow → fast
		180 - 194	70 - 76	Gobo 2, Shake slow → fast
		195 - 209	76 - 82	Gobo 1, Shake slow → fast
				Continuous scroll
		210 - 232	82 - 91	CW slow → fast
		233 - 255	91 - 100	CCW fast → slow
5	7			**Gobo rotation** (active when you select gobo on channel 4 in 16 bt mode or channel 5 in 16 Ex mode)
		0 - 255	0 - 100	Index position 0 - 395
				Continuous rotation (direction and speed)
		0 - 2	0 - 1	No rotation
		3 - 127	1 - 50	CW, slow → fast
		128 - 252	50 - 98	CCW, fast → slow
		253 - 255	99 - 100	No rotation
6	8	0 – 255	0 - 100	**Gobo Rotation ((Lowest Significant Byte)**
7	9			**Gobo Wheel 2 (static). Selection and Shake**
		0 - 7	0 - 3	Open gobo
		8 - 15	3 - 6	Gobo 1
		16 - 23	6 - 9	Gobo 2
		24 - 31	9 - 12	Gobo 3
		32 - 39	13 - 15	Gobo 4
		40 - 47	16 - 18	Gobo 5
		48 - 55	19 - 22	Gobo 6
		56 - 63	22 - 25	Gobo 7
		64 - 71	25 - 28	Gobo 8
		72 - 79	28 - 31	Gobo 9
		80 - 87	31 - 34	Gobo 10
		88 - 95	35 - 37	Open
				Gobo Shake
		96 - 105	38 - 41	Gobo 10 - Shake, slow → fast
		106 - 115	42 - 45	Gobo 9 - Shake, slow → fast
		116 - 125	45 - 49	Gobo 8 - Shake, slow → fast
		126 - 135	49 - 53	Gobo 7 - Shake, slow → fast
		136 - 145	53 - 56	Gobo 6 - Shake, slow → fast
		146 - 155	57 - 60	Gobo 5 - Shake, slow → fast
		156 - 165	61 - 65	Gobo 4 - Shake, slow → fast
		166 - 175	65 - 69	Gobo 3 - Shake, slow → fast
		176 - 185	69 - 73	Gobo 2 - Shake, slow → fast
		186 - 195	73 - 76	Gobo 1 - Shake, slow → fast
		196 - 205	77 - 80	Open Gobo - Shake, slow → fast
				Continuous Rotation
		206 - 230	81 - 90	CW slow → fast
		231 - 255	91 - 100	CCW fast → slow

8	10			**Focus**
		0 - 255	0 - 100	Infinity → 2 meters
	11	0 - 255	0 - 100	**Focus (Lowest Significant Byte)**
9	12			**Prism**
		0 - 19	0 - 7	Prism off
		20 - 79	8 - 31	Rotating prism, CCW fast à slow
		80 - 89	31 - 35	No rotation
		90 - 149	35 - 58	Rotating prism, CW slow à fast
		150 - 215	59 - 84	Prism off
				Prism/Gobo Macros
		216 - 220	84 - 86	Macro 1
		221 - 225	87 - 88	Macro 2
		226 - 230	89 - 90	Macro 3
		231 - 235	91 - 92	Macro 4
		236 - 240	93 - 94	Macro 5
		241 - 245	95 - 96	Macro 6
		246 - 250	96 - 98	Macro 7
		251 - 255	98 - 100	Macro 8
10	13			**Pan**
		0 - 255	0 - 100	Left → right (128 = neutral)
11	14			**Pan Fine (Lowest Significant Byte)**
		0 - 255	0 - 100	Left → right
12	15			**Tilt**
		0 - 255	0 – 100	Left → right (128 = neutral)
13	16			**Tilt Fine (Lowest Significant Byte)**
		0 - 255	0 – 100	Left → right
14	17			**Pan/Tilt Speed**
		0 - 2	0 - 1	Tracking
		3 - 245	1 - 96	Fast → slow
		246 - 248	96 - 97	Tracking, PTSP NORM (menu override)
		249 - 251	98 - 98	Tracking, PTSP FAST (menu override)
		252 - 255	99 - 100	Blackout while moving
15	18			**Effects Speed**
				Dimmer, focus
		0 - 2	0 - 1	Tracking mode
		3 - 245	1 - 96	Fast → slow
		246 - 251	96 - 98	Tracking
		252 - 255	99 - 100	Maximum speed
				Color
		0 - 2	0 - 1	Tracking mode
		3 - 245	1 - 96	Speed, fast → slow
		246 - 248	96 - 97	Tracking, SCUT OFF (control menu override)
		249 - 251	98 - 98	Tracking, SCUT ON (control menu override)
		252 - 255	99 - 100	Blackout while moving
				Gobo selection
		0 - 245	0 - 96	Normal (no blackout)
		246 - 248	96 - 97	Normal, SCUT OFF (control menu override)
		249 - 251	98 - 98	Normal, SCUT ON (control menu override)
		252 - 255	99 - 100	Blackout while moving
				Indexed gobo rotation (only if gobo type = indexed)
		0 - 2	0 - 1	Tracking mode
		3 - 245	1 - 96	Fast à slow
		246 - 251	96 - 98	Tracking
		252 – 255	99 - 100	Blackout while moving
				Prism
		0 - 251	0 - 98	Normal (no blackout)
		252 - 255	99 - 100	Blackout while moving

DMX Summary

Basic Rules

- There are 512 channels per DMX line
- You can put a maximum of 32 DMX receiving devices on one line.
- The maximum recommended cable run is 500 meters.
- The DMX line cannot be split into branches.
- To add more fixtures, create a branch, or extend the cable run, you can use a splitter-amplifier.
- The end of every line must be terminated.
- Use RS-485 cable for best results.

Important Facts

There are some common misconceptions about DMX and Martin fixtures. Some people may tell you otherwise, but these are the facts:

- Martin fixtures are not buffered between the input and output sockets.
- Martin fixtures do not self terminate.
- You do not plug the last fixture back into the controller.
- DMX travels through Martin fixtures when the fixtures are powered down. (This does not apply to the amplified outputs of the Martin RS-485 Opto-Splitter.)
- ‘Y’ splits cause reflections that corrupt the DMX signal. Using two 60 ohm terminators, one on each output, doesn’t help.

FURTHER READING

- Bennette, Adam; *Recommended Practice for DMX 512 - A guide for users and installers*
- Cadena, Richard; *Focus on Lighting Technology*
- Simpson, Robert; *Lighting Control: Technology and Applications*