



# **ART2000 T4**

## **4 module Digital Dimming System**

### **Operator's Manual**

software version OS3R1



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**\*8200-0152\***

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## INTRODUCTION

# 1. The ART2000 digital dimming system

This manual is designed to help you get the most out of your Avolites ART2000 digital dimming system. Even if you hate reading manuals, read this section because the next couple of pages contain some **important safety information** which you should be aware of.

At the end of the manual there is a quick summary of how the DMX control system works, a Glossary explaining some of the technical terms used in the manual, and an Index which can be used to find what you need in the manual.

## 1.1 What it does

The ART2000 system provides a complete solution to Dimming and Moving Light Power distribution. You no longer need to have separate mains distribution making set up times faster and reducing the number of individual components needed to put a show together.

The ART2000 controls up to 48 individual channels. Four modules of a maximum of 12 channels can be plugged in. The following module types are currently available:

- 12 channel 16Amp dimming module
- 6 channel 32Amp dimming module
- 3 channel 63Amp dimming module
- 12 channel 16amp distribution module for powering moving lights
- 12 channel 16A Relay module, to switch on/off mains under DMX control.

Modules of the same channel count can be freely interchanged, and the rack can be easily configured 'per job' as required.

When loaded with 16A modules the system can be fitted with a patch bay and up to 20 Multipin outlet connectors which ensure that cabling will be as simple and reliable as possible.. Each channel of each multipin outlet connector can be patched to any dimmer output using the hot-patch. The hot-patch has a lamp test indicator making faults easy to find when a single dimmer channel powers more than one light fixture. Alternatively direct outputs are available if a patch is not needed

The 'Load Check' indicators for each dimmer module or relay module channel give a sure indication that a load is present and the test faders on each dimmer channel or relay channel allow you to quickly check what's connected without having the use of a console.

The design incorporates full monitoring and status feedback via the backlit LCD display. For simple events you can operate without a console by setting up a dimmer state on the test faders, or you can record 12 internal memories for replaying a simple show.

Other features include full DMX patch and merge (2 DMX lines), dimmer curve and output limit selection per channel, power OK indicators, optional volt and amp metering and optional RCB or ELDC protection.

## 1.2 Important safety information

***This system uses 3-phase power and can be a serious hazard to health.*** This manual is however not a safety manual.

The system should be installed and operated only by a competent person. When installing you should check local regulations regarding the separation of lighting fixtures on different phases (see also section 6 One Phase per multipin Outlet). If you are in any doubt as to the safe installation of the system you should employ the services of a qualified electrical contractor.

Do not operate the system with any dimmer modules missing because this makes live parts accessible.

Blanking plates are available from avolites to allow modules to be removed and the rack used. If you do want to use the system with a module removed fit the blanking plate (Avolites part number 17-80-0129)

If Cam-lok<sup>™</sup> loop-out terminals are fitted, ensure that cables or covers are fitted to the loop-out terminals before turning on the power, as live parts are otherwise exposed.

Before turning on the ART2000 rack, ensure that the neon power connection lights on the control panel are correctly illuminated. These lights will indicate most connection errors. The system may be damaged if it is turned on with the power feed connected incorrectly.

## 1.3 Quick start instructions

When connecting the power feed to the system, ensure EARTH is connected first, then NEUTRAL, then the PHASE conductors. The system requires a 3 phase (TN-S) mains supply.

Ensure that the Bay and utility breakers are turned off and the optional RCD breakers are turned on before you turn on the power feed.

Turn on the dimmer feed and check that the "Connection" neons are correctly illuminated (top 5 on, bottom 2 off). Check that the voltage is what you expect using the voltmeter. If not OK, correct the fault before going any further.

Power up the control module by turning the rotary switch below the Connection neons to R, Y or B to select the phase you want to feed the electronics from (normally phase R).

You can now turn on the Bay and Utility breakers and use the ART2000 system.

To turn the system off, reverse the above procedure.

It is preferable not to use the RCB as an ON/OFF switch, as arcing may reduce the RCB's protecting ability.

## 2. Features of the ART2000

This chapter gives a quick rundown on what each part of the ART2000 rack does. If you are new to the system, read this!

Some Parts described in this manual may not be on the system before you, this is because the ART2000 system can be supplied from the factory with various different options.

At the rear of the unit, near the bottom of the rack, are the power input connections. These can be either Cam-lok™, Powerlok™, BAC™, Cee 63 or Cee 125A type connectors. Loop output connectors may also be fitted.

**Note:** When connecting power to the ART2000, always connect the EARTH first, then the NEUTRAL, then the PHASE conductors.

If Cam-lok™ loop-out connectors are fitted, ensure that either covers or connectors are fitted before turning on the power, as these connectors otherwise have exposed live terminals.

output connectors



Utility panel

Power input

### 2.1 Utility power panel

Above the power input is the utility power panel. This may be fitted with variety of single phase connectors and optional 32A 3-phase connectors. The utility power is for feeding motors and other devices needing static power. The circuit breakers for the utility power panel are on the front of the rack. The 32A 3-phase connector shares the 32A breaker with the normal 3x 16A utility outputs.

### 2.2 Output connectors

The rear panel mainly houses the output connectors. Depending on the option selected these can be either multipin connectors like the Socapex™ and the Harting™ connector or single phase direct outlets like the Cee 16A or Cee 32A. These connectors link the ART2000 rack to the load which you want to control.

In both cases it is best to connect these without the channel being energized as this reduces arcing and prolongs the life of connectors

## 2.3 The hot-patch panel

On top of the rack is the optional hot-patch panel. This allows you to decide how the 48 dimmer channels are connected to the 120 output circuits which are available on the multipin connectors. The front half of the panel has the outputs of the modules. Module A has 4 outlets per channel, and modules B, C and D have 2 outlets per channel.

The hotpatch is normally wired in parallel, thus each socket will have live and neutral connected (220V). The optional series patch is labelled clearly to be series (110V)

For the occasional 110V lamp Avolites has a custom Wieland<sup>®</sup> series lead, part number 03-13-0040

The rear half of the panel has 20 sets of six connectors, one set for each of the multipin outlets on the rear of the rack.

At the very front of the hot-patch panel is a lamp test socket. This allows you to test the continuity of any circuit. There is also a desk lamp socket to allow a gooseneck lamp to be fitted so you can see what you are patching.

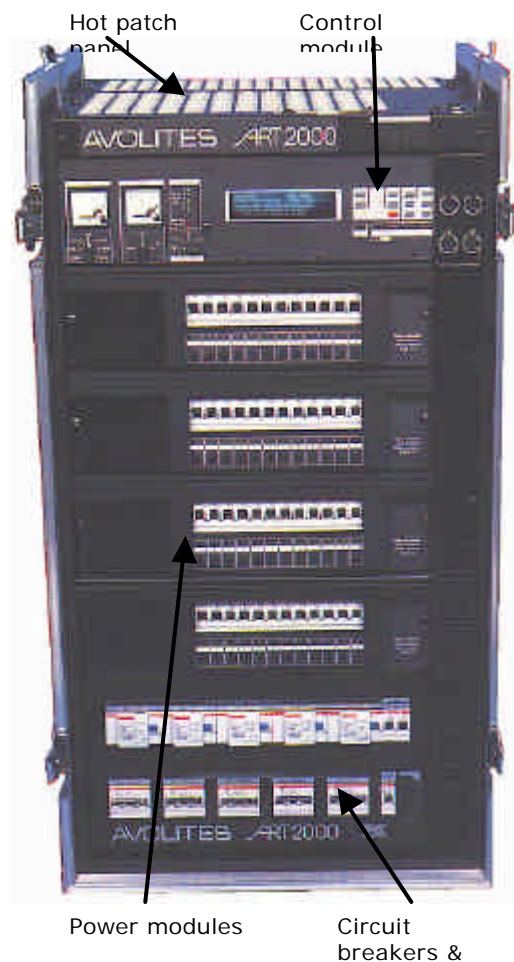
## 2.4 Main circuit breakers

On the front of the rack, down at the bottom, there is a 3-phase circuit breaker for each module, and one for the utility power. Above the circuit breakers may be fitted an RCB for each module. There are also three individual circuit breakers for the utility power sockets.

## 2.5 Power modules

The main part of the rack is taken up with the 4 power modules. These are interchangeable modules, and the available types are:

- **12x16A Dimmer module:** Each channel has a 16A C-type circuit breaker, a control knob and a "load present" indicator light per channel. The indicator lights when a load is connected to the channel, and the channel is turned off. The control knob allows manual control of the channel, if the local control option is turned on.
- **6x32A Dimmer module:** Each channel has a 32A C-type circuit breaker, and the same control and indicator features as the above 12 channel dimmer module.
- **3x63A Dimmer module** Each channel has a 63A C-type circuit breaker, and the same control and indicator features as the above 12 channel



dimmer module.

- **12x16A Breaker module:** Mains distribution modules provide static power, which can be routed through the hot-patch bay and down the multicore cables, usually used to power intelligent lighting. The module has 12 channels of mains power, which can be manually switched using the front circuit breakers.

Note: If the mains distribution module is fitted as module B, C or D then 24 static power outputs are available on the hot-patch panel. If it is fitted as module A then 48 static power outputs are available.

- **12x16A Contactor module:** Relay modules are like mains distribution modules but each channel can be switched on/off by DMX control. These modules are useful if large numbers of ballasts or other special lighting effects need to be controlled. The relay module has "load present" indicators and control knob allowing manual control of the channel.
- **Blank panel:** If a bay is to be left empty fit a blanking panel to balance the air flow inside the dimmer and prevent live parts to be exposed

### Dimmer Channel Mapping

The ART2000 system allocates dimmer channels depending on the module type fitted to the rack up to a maximum of 48 dimmer channels.

Therefore a two bay frame fitted with two 6 channel modules will use dimmer channel 1-6 and 7-12, and the same frame fitted with 12 channel modules will allocated channels 1-12 for the first module and 13-24 for the next module. In the case of a breaker module preceding a dimmer module in the rack the dimmer channel 1 will start at the first available dimmer channel.

Module Type	Allocated channels
12 channel 16A dimmer	12
6 channel 32A dimmer	6
3 channel 63A dimmer	3
12 channel 16A contactor	12
12 channel 16A breaker	0
No Bay fitted (blanking plate)	0

## 2.6 Control module

At the top of the rack front is the control module. This allows you to set up how the dimmers will work. There are also voltage and optional current meters, with phase selector switches, and neon indicators to show if the power is connected correctly.

The voltmeter switch allows you to measure the phase-neutral and phase-phase voltages. A rotary switch below the test neons allows you to select which phase the electronics is powered from.

The "Display contrast" control allows you to adjust the darkness of the display.

The "Reset" button allows you to reset the system using a small pointed implement.

## 3. Installing the ART2000

This chapter contains details of how to install the ART2000 rack, either for



temporary or permanent operation.

### 3.1 Positioning the ART2000 rack

Choose a location for the rack which is as near to the power feed as possible and allows access to the front and back of the rack. Consider how the cables will run in from the power feed and out to the lights, and try to avoid crossing walkways.

If you are unsure about the safety you should contact a competent body to advise you.

The ART2000 system is designed to operate in a maximum ambient temperature of 40°C and can run continuously when fully loaded at 16A per channel. The rack is fan-cooled, you must ensure there is adequate ventilation available - if the system is running in a closed room, consider providing external ventilation to the room (see Specifications on page 29 for cooling information). The system may shut dimmer modules down if it cannot release the heat generated.

If you are using the system on an outdoor stage, ensure that the rack is situated somewhere dry and clear of the ground. If you shelter the rack with tarpaulins make sure that you do not obstruct the air vents. Black tarpaulin is generally unsuitable.

### 3.2 Power modules

The ART2000 system has four "bays", in which you can fit either dimmer modules, power distribution modules or relay switch modules. The modules need to be of the same channel capacity (all 12 channel or all 6 channel modules). If you have a selection of ART2000 modules and need to change the configuration of the rack by swapping modules, this is the time to do it.

Power distribution modules are used to feed static power down the multipin outlet, usually to run intelligent lighting. If you do not require this facility you can replace power distribution modules with dimmer modules and have more dimmers in the rack (if you have spare dimmer modules available).

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#### 3.2.1 Changing power modules

- ➔ *Disconnect the mains to the rack*
  - ➔ *Unscrew the 2 M6 screws at the front of the module*
  - ➔ *Use the handles in the front to pull it out (take care, it is quite heavy)*
  - ➔ *Fit the new module by guiding it into the slides*
  - ➔ *Push it home and refit the screws.*
- 

Only operate the system when all the modules are screwed in place, otherwise the connectors may be damaged.

**Note:** Avoid changing modules when powered because this may cause arcing, which will damage the connectors.

### 3.3 Power supply

You need to provide a three phase and neutral power supply to the ART2000 (TN-S) which is capable of delivering the amount of power required to run all the lights which are connected to it. If the power supply

is under-rated it may trip during your show if you turn too many lights on at once. This is obviously not a good thing to happen. Also, an overloaded mains supply can suffer from a distorted waveform which can make it difficult for the ART system to control your lights smoothly.

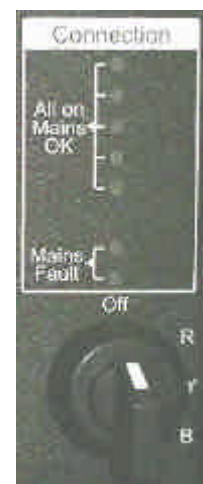
**Warning:** Never use mains supplied with "reduced neutral" cable sizes, as dimmers inherently dump large currents in the neutral connection. These kind of mains supplies are sometimes called "industrial " and are not suitable for dimmer applications.

When ordering or specifying a mains supply state that it is for "phase angle controlled light dimming"

The frequency of the mains is automatically tracked by the system, which makes the ART system suitable for use on local generator sets.

### 3.3.1 Connecting the power supply

- ➔ **Ensure the bay and utility circuit breakers are turned off**
- ➔ *Before handling the power cables ensure yourself that they are "dead"*
- ➔ *Connect the power supply to the Power Input terminals on the rear of the rack (earth first, then neutral, then phases)*
- ➔ *If loop out terminals are fitted you can use these to connect a second rack, provided you do not overload the supply. (Both Powerlok™ and Camlok™ have a 400A limit). Cover unused Camlok™ loop out connectors*
- ➔ *Turn on the power feed - do not turn on the racks yet.*
- ➔ *Check the connection neons on the front panel. The top 5 neons should all be lit. The bottom 2 should not be lit. Also check any other racks you have linked in.*
- ➔ *Check that the voltage of the supply is what you expected, using the voltmeter (the voltmeter and neons are fed through the control fuses)*
- ➔ *If all is OK, power up the control module by turning the rotary switch below the neons to the red phase.*



**If the connection neons or voltmeter indicate a problem, DO NOT TURN THE RACK ON until you have corrected the problem, or you may cause serious damage to the rack and connected equipment.**

When you turn on the power, the control module will start up and display the following screen:

```

Li ne A 001 Dmx ok      Li ne B 001 No Dmx
Status Runni ng OK      Mode   Test Off
-----
OS 3.0R1      UCode 1.0      PDE 1.0/1.2

The ART team wi shes you happy di mmi ng
  
```

Now you can then power up the system by turning on the bay and utility circuit breakers.

If the display shows other messages, this may indicate that a problem has been found. See the Troubleshooting section on page 24 for details of what

to do.

If you cannot read the display you may need to adjust the display contrast control at the bottom right hand corner of the display.

Note: The phase selector intended usage is that it allows you to power the electronics of a different phase in case of a phase failure. There is normally no need to go to the yellow or blue phase.

### 3.4 Connections to lights

You connect the lighting rig to the ART2000 either through the multipin connectors (Socapex or Harting) or through direct outlets on the rear panel. There are up to 20 multipin connectors, each of which carry 6 channels (Harting-type connectors may carry 8 channels). The optional hot-patch panel allows you to determine which dimmer channel controls which output circuit (direct out versions do not have a hot patch).

Do not connect or disconnect the multipin connectors whilst channels are turned on, as this may cause arcing which will damage the connectors.

Note: Only connect loads through the multipin outlets, direct outlets or the utility outlets. DO NOT try to power any equipment directly from the dimmer output patch on the hot-patch panel as the patch cables do not carry an earth connection.

### 3.5 Control connection

Two DMX inputs (and linked outputs) are provided, these allow you to use two consoles (such as a normal "static light" console and a moving light console), or to have a back-up control link. Normally the system will combine the two inputs with a highest-takes-precedence rule. It is also possible to configure the system so that some dimmers are controlled by one DMX input only (see section 4.5).

If you need to change the DMX start address of the system this is described in section 4.1.

If you are linking the DMX cable on to other devices, ensure the termination switches are set to Off. If this is the end of the DMX line, set the termination switch to **On** for that DMX line. An indicator light comes on when the termination is **On**.

### 3.6 Patching module channels to lights

If a patch is fitted you need to patch each light to a dimmer by connecting cables on the hot-patch panel. There are two patch options series (110V) and parallel (240V). Most patches are parallel and the following text assumes a parallel patch

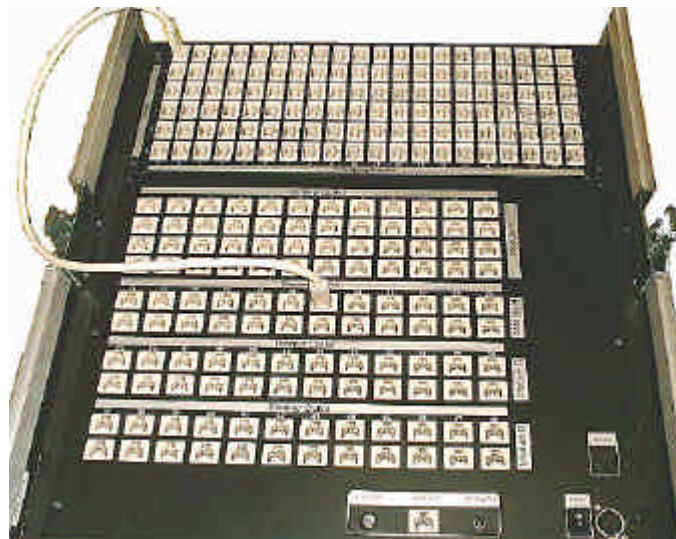
At the front of the hot patch panel are the outlets from the modules. Module A has four outlets per channel, and modules B, C and D have two outlets per channel.

At the back of the hot patch panel are the plugs which link to the multipin connectors. There is a plug for each circuit on each connector. The picture shows module channel 19 (channel 7 on module B) connected to circuit 1 on multipin connector 1.

You can check if a circuit is working by plugging the patch cable into the lamp test socket rather than a module outlet. If the circuit is OK the lamp test light will come on.

You should also see the indicator lights on the channels come on when you connect a load to them.

The lamp test is powered by a PP3/MN1604/6F22 9V battery which is in the plastic compartment on the front of the rack. Press the Battery Test button to check the battery state. There is also a second compartment which holds a spare battery, though if you need it someone will probably have already stolen it.



A Series patch requires two loads to be connected to work, this as the 2 loads will be wired in series with each other to allow the use of 110V lamps. The first bay allows two sets of loads to be connected (thus four loads are needed)

### 3.7 Testing channels using the local control faders

When you are setting up the rig, it is useful to be able to fade up a channel from the dimmer rack. Each dimmer module or relay module channel on the ART2000 has a fader to allow you to do this. However, the faders can be disabled to prevent people playing with them. The display shows "Faders on" or "Faders off" to tell you what the current setting is.

---

#### 3.7.1 Using the local faders

- ➔ *Press TEST ON to enable the faders*
  - ➔ *Turn the fader on the channel you want to change*
  - ➔ *The fader and the DMX input are combined, whichever is highest has control*
  - ➔ *Press TEST OFF when you have finished.*
- 

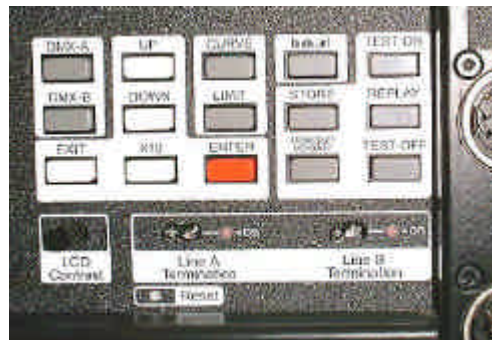
The local faders combine with the DMX input using highest-takes-precedence (HTP) rules, in other words if the DMX input is turning the channel on full, you will not be able to take control using the local fader.

You can also program 12 memories into the ART2000 rack, which is useful in case of emergency, or for very simple setups where you do not need a control console. This is described on page 19.

## 4. Setting user options

The ART2000 has a simple user interface. Each function has its own button, shown on the right, so you don't get lost in multiple menus.

This section describes how to configure the ART2000 rack to your requirements.



### 4.1 Setting the DMX start address

In normal use, you will just set one start address for all 48 dimmers. Module channel 1 will operate from the DMX start address you set, and the other 47 channels will follow in a continuous block of channels. This is called "Rack Patch" mode, because the whole rack is patched in one go.

You can set the DMX start address differently for the two DMX inputs, so for example channel 1 can be controlled by DMX channel 100 on one console and DMX channel 300 on the other console. This can be useful if two consoles are controlling the rig, as sometimes happens if you are using moving lights with external dimmers to control the lamp, and normal static lights in the same show.

You can also allocate each channel to an individual DMX control channel. This is called Channel Patch mode and is described later.

#### 4.1.1 Setting the DMX start address

- ➔ Press the DMX A button to change the start address for DMX line A
- ➔ Press the UP or DOWN buttons to change the start address shown on the screen
- ➔ To change in decades, hold down the X10 button and press Up or Down
- ➔ Press ENTER to store the new start address.

The display shows

```

Li ne A 001   Dmx ok       Li ne B 001   No Dmx
Status Runni ng ok       Mode   Test Off
-----
Change Li ne A Modul e start address
Current start address is 001
      New start address is 002

Dmx address 000 is not supported
  
```

You can set the start address for DMX line B by using the DMX B button in the same way.



The display looks like this:

```

Line A 001 Dmx ok      Line B 001 No Dmx
Status Runni ng OK      Mode   Test Off
-----
Change di mmer channel curve
di mmer channel  48  curve: Li near Curve
di mmer channel  01  curve: Li near Curve
di mmer channel  02  curve: Li near Curve

```

The available dimmer curves are:

- **Linear Curve** - linear response with standard tungsten halogen lamps
- **Relay On >50%** - channel turns on full wave, if input above 50%
- **Relay Off >50%** - channel turns off full wave, if input above 50%
- **OS3R0 linear** – previous software version linear curve
- **Alt.linear** – generic linear curve
- **Square law** - square law dimming curve
- **5% Pre heat** - channel stays on at 5%, input scaled over remaining 95% using a linear curve
- **10% Pre heat** - channel stays on at 10%, input scaled over remaining 90% using a linear curve
- **15% Pre heat** - channel stays on at 15%, input scaled over remaining 85% using a linear curve
- **User curve**- direct DMX 255 steps to firing angle, use this curve when using a curve in the console

You can modify all 48 channels in one go by holding X10 and pressing CURVE. The following screen display is shown:

```

Line A 001   Dmx ok      Line B 001   No Dmx
Status Runni ng ok      Mode   Test Off
-----
channel Curve setup for all channel s
selected Curve is: Li near Curve
press ENTER to change ALL channel s
press EXI T to abandon

```

Use the UP and DOWN buttons to select the desired curve, then press Enter.

## 4.4 Limiting the output of a dimmer

Each dimmer channel can have its own "Limit" setting. This allows you to restrict the maximum output of the dimmer. You might want to do this to match the intensity of different lamps. The dimmer will scale its output over the remaining DMX data range.

Tip: The limit function can also be used to "slow down" the fading response of theatrical lights, which are often not used at full power. You can use this to match a 500W lamp fade speed to a 650W lamp.

### 4.4.1 Setting the dimmer limit

- ➔ Press the **LIMIT** button
- ➔ Select the channel you want to set using the **UP / DOWN** buttons, then press **ENTER**.
- ➔ Select the Limit you want for that channel using the **UP/DOWN** buttons, then press **ENTER**.

To modify the limit for all 48 channels in one go, hold **X10** and press **LIMIT**. The following screen display is shown:

```

Li ne A 001   Dmx ok   Li ne B 001   No Dmx
Status Runni ng ok       Mode   Test Off
-----
Channel Li mi t setup for all channel s
selected Li mi t i s: no li mi t set
press ENTER to change ALL channel s
press EXI T to abandon

```

Use the **UP** and **DOWN** buttons to select the desired limit, then press **Enter**.

## 4.5 Soft Patch

The ART2000 system allows you to allocate any DMX address to any dimmer channel on an individual basis. You can also set different allocations on DMX line A and line B.

It is important to know that the Art2000 will truncate the dimmer channels depending on the bay requirements. Consider the following set-ups:

Example 1

Bay 1	12x 16A dimmer	Dimmer channel 1-12
Bay 2	12x 16A dimmer	Dimmer channel 13-24
Bay 3	12x breaker	No dimmer channels allocated
Bay 4	12x 16 A dimmer	Dimmer channel 25-36

Example 2

Bay 1	12x 16A dimmer	Dimmer channel 1-12
Bay 2	12x 16A dimmer	Dimmer channel 13-24
Bay 3	12x 16A contactor	Dimmer channel 25-36
Bay 4	12x 16A breaker	No dimmer channels allocated

Example 3:

Bay 1	6x 32A dimmer	Dimmer channel 1-6
Bay 2	6x 32A dimmer	Dimmer channel 7-12
Bay 3	6x 32A dimmer	Dimmer channel 13-18
Bay 4	6x 32A dimmer	Dimmer channel 19-24

The main application of the softpatch is to patch around faults or problems. You should preferably use the patching facility in your control console to allocate dimmers to DMX channels, because there is no way of transferring the patching information from the dimmer rack if you need to change to a



different rack.

When the ART system leaves the factory the soft Patch is pre-loaded with a patch starting at DMX 001 dimmer channel 1 till DMX 048 dimmer channel 48. This is called a "one-to-one" (1:1) patch. (see also 4.9 Wipe-all function ) In most cases you may want to start from a different start address like 200 or 127. You can select a start point for the 1:1 patch after the patch mode is set to softpatch.

### Changing the patch mode

To use the soft Patch, you need to change the mode for DMX line A or B. The mode can be different for each line.

#### 4.5.1 Turning on the softpatch

- ➔ Hold X10 and press DMX-A or DMX-B. The display will show the Soft-Patch screen.
- ➔ Press UP / DOWN to change the **NO** into **Yes**, and press ENTER. The 1:1 Patch screen will now appear
- ➔ If you do **not** want a 1:1 patch to be loaded press EXIT,
- ➔ if you want to load a 1:1 Patch change the **NO** into **Yes** using the UP / DOWN button.
- ➔ Select the start address where the 1:1 patch needs to start from and press Enter.

Screen shot after X10 and DMX A:

```

Li ne A 001   Dmx ok      Li ne B 001   No Dmx
Status Runni ng ok      Mode   Test Off
-----
Do you want to use a softpatch for Li ne A
                        Yes
  
```

Screen shot after ENTER:

```

Li ne A 001   Dmx ok      Li ne B 001 No Dmx
Status Runni ng ok      Mode   Test Off
-----
Do you want to start wi th a 1:1 softpatch?
                        No
  
```

To switch of the soft-patch, repeat the above procedure selecting NO when asked if a soft-patch is to be used. The soft Patch information is not lost when you switch off the softpatch.

When a DMX line is in softPatch mode, the top line of the display shows "Patch" rather than the base DMX address.

If you need to allocate an individual dimmer channel to a different DMX address you do the following:

---

#### 4.5.2 Patching individual dimmer channels

- ➔ Press DMX-A or DMX-B (the Dmx input must be set to softpatch mode)
  - ➔ The middle line of the display shows the active dimmer. Press UP / DOWN to select the dimmer channel you want to change, then press ENTER
  - ➔ Press UP / DOWN to set the DMX address for this dimmer channel, then press ENTER
  - ➔ Repeat for other dimmers, or press EXIT to finish
- 

The display shows

Li ne A Patch Dmx ok	Dmx B 001	No Dmx
Status Runni ng ok	Mode Test off	
-----		
Dmx A softpatch		
Di mmer Channel 48	Dmx address 048	
Di mmer Channel 01	Dmx address 001	
Di mmer Channel 02	Dmx address 002	

---

#### 4.5.3 "Parking" DMX channels

You can set the DMX address of a channel to 000, this "parks" the dimmer channel so it is not controlled by that DMX line. This is useful if you want a dimmer to be controllable from only one of the two DMX lines, or if you want to disable a dimmer.

---

#### 4.5.4 Behaviour of "X10 and UP /DOWN "

When scrolling through dimmer channels the X10 and UP or DOWN combination will jump to the first dimmer channel of the following or preceding bay. Thus in a frame with four 12 channel modules pressing X10 and UP when selecting dimmer channels will result in the channel jumping from 01 to 13, 25 and 37.

When changing DMX addresses the X10 and UP or DOWN combination will jump in decades. Thus start addresses 015 changes into 25, 35 etcetera.

#### 4.5.5 *When Dmx data has been interrupted*

The ART2000 system can detect the availability and usability of Dmx Data and will show this in the screen

Line A Patch Dmx ok	Dmx B 001	No Dmx
Status Running ok	Mode Test	off
-----		

- "Dmx ok " indicates Dmx data which can be used (Line A in above screen shot)
- "No Dmx" indicated either no dmx connected or bad Dmx (Line B in above screen shot)

The ART2000 will retain the last received DMX data if a single Dmx Data stream is interrupted (this in accordance with DMX 512 1990).

You can clear this data by pressing X10 and TEST OFF and all the channels held at a level by the interrupted Dmx data will fade to off.

When two data streams are present and one is interrupted the ART2000 will fade out the "locked" data from the interrupted Dmx stream after 5 seconds and in 5 seconds. This will allow you to regain control over channels held at a level by the interrupted Dmx Stream.

## 4.6 Storing dimmer level memories

The ART2000 system can store 12 memories internally. A memory contains the state of all the 48 channels. This can be useful to keep the show going if the control console stops working, or if you have a very simple static set-up which does not require a control console.

If you have multiple racks of Avolites ART dimmers (2000, 4000 or 6000), you can instruct all connected ART systems to store a "Global" memory. Once you have stored memories, you can play back these memories from one control module, allowing you access to all the channels on all the racks using the controls on the first rack. If you are planning on doing this, the first rack in the DMX line will be the Master rack, and all the others will be Slaves. The Master rack will use the DMX-A line to command the downstream racks to save or play back the memory, and so it is best if only ART systems are connected to the DMX line downstream from the Master, since other systems may interfere with memory replay or recording.

## 4.7 Storing a memory

When you store a memory, it records the current state of all the dimmers channels. Memories can either be stored as "local" (just the current rack) or "global" (the current rack will store the memory and instruct all downstream systems to store as well). This is particularly handy when storing memories on a multiple dimmer system setup, as you will only have to store 12 global memories, and not 12 memories for every system.

Use the following procedure to store a memory

### 4.7.1 *Storing a memory*

- ➔ Press the **STORE** button
- ➔ Select the Fader location you want to store in using the **UP / DOWN** buttons, then press **ENTER**
- ➔ Select "**Local**" or "**Global**" using the **UP/DOWN** buttons, then press **ENTER**.

---

Screen shot after memory 6 has been entered:

Li ne A 001    Dmx ok    Li ne B 001    No Dmx  
 Status Runni ng ok    Mode Test off  
 -----  
 Store a memory to a channel fader  
  
 Store memory 06 as a **Local** memory

## 4.8 Replaying a memory

You can replay a memory either locally (just the current rack) or globally (the current rack and all downstream racks). When you replay a memory locally, the output is HTP mixed to any DMX levels which may be present.

Use the following procedure to replay a local memory.

---

### 4.8.1 Replaying a local memory

- ➔ Press the **REPLAY** button
  - ➔ Turn the fader for the memory you want to replay (faders 1-12 on the top dimmer module)
  - ➔ Press **TEST OFF** to stop the memory replay.
- 

**Note:** The faders used to replay a memory are the first 12 faders on Bay 1  
 If a power distribution module is fitted in Bay A, no memories can be replayed locally.

If you want to replay a memory globally (i.e. turn on Memory 1 on all the racks), you need to carry out the following procedure at the Master rack (the one which is first in the DMX line).

**Note:** that the DMX line will be interrupted; if you have other equipment connected after the master dimmer rack they will lose DMX.

---

### 4.8.2 Replaying a global memory

- ➔ Press the **TRANSMIT MEMORY** button on the Master rack
  - ➔ Press **ENTER** to confirm
  - ➔ Turn the fader for the memory you want to replay (faders 1-12 on the top dimmer module). The memory will replay on all racks.
  - ➔ To stop transmitting memories, Press the **TRANSMIT MEMORY** button on the Master rack
  - ➔ Press **ENTER** to confirm
- 

You can pre-view what channels are stored at what level in a memory without replaying it

---

### 4.8.3 Pre-viewing a memory

- ➔ Press **X10** and **STORE**

➔ Use UP and DOWN to cycle through the 12 memories

---

Memory pre-view screen shot

Line A 001	Dmx ok	Line B 001	No Dmx
Status Running ok		Mode Test off	
-----MEMORY 01 STORED LEVEL-----			
Chan.	1	2	3 4 5 6 7 8 9 10 11 12
Bay 1	00	00	00 00 00 00 00 00 00 00 00 00 00 00
Bay 1	00	00	00 00 45 00 00 00 00 00 00 00 00 00
Bay 1	00	00	00 00 00 00 00 00 09 00 00 00 00 00
Bay 1	00	00	00 00 00 00 00 00 00 00 00 00 00 00

Pressing the EXIT button will restore the normal screen.

## 4.9 Wipe-all function

When a rack returns from a job, it is likely that all kinds of user settings are not set the way you want it. The ART2000 system has a Wipe-all function, which allows you to reset the system to factory default setting:

---

### 4.9.1 Wipe all function

- ➔ Power down the control unit (rotary switch)
  - ➔ Press and hold the UP and DOWN button
  - ➔ Power up the control unit
  - ➔ Wait for the start-up screen to state "happy dimming"
- 

The ART2000 factory settings are:

- Line A and B are set to "rack patch" mode.
- Line A and B are set to start address 000.
- All channels have the linear curve, and no limit applied.
- All the memories are cleared.

## 5. ELDC Option

The ART2000 can be fitted with the ELDC Option, This option allows you to disable the RCB from tripping the bay breaker during live shoots.

The ELDC system will power up in the "RCB enabled" mode indicated by the Green switch being lit. After that each bay can be individually disabled using the ELDC Master control key-switch and the Red disable switch.

The decision to disable the ELDC must be made by a competent body capable of understanding the safety implications.

The switches will indicate the status of the ELDC system

Green switch lit	ELDC detector active and enabled (Bay is Protected)
Red switch lit	ELDC detector active and disabled (Bay is unprotected)
Green or red switch <b>not</b> lit whilst bay breaker is on	<p>ELDC detector <b>not</b> active, possibly because of a blown ELDC control fuse .</p> <p><b>The ELDC system is <u>not</u> to be used in this mode the bay is unprotected and unsafe to use</b></p>

### 5.1.1 Disabling an ELDC RCB

- ➔ Turn and hold the ELDC master control key-switch to "Allow RCB Disable"
- ➔ Select the bay(s) to be disabled by pressing the Red "RCB disable" switch, the red switch is now lit
- ➔ Return the ELDC master control key-switch to the centre position

When the Key-switch is in the centre position the key can be removed and **no** changes can be made to the Disable selection.

The RCB's will return to the "enabled mode" after a power down and up cycle

### 5.1.2 Resetting the RCB Disable Selection.

- ➔ Turn the Master RCB control key-switch to "Reset RCB disable", all green switches are now lit
- ➔ Return the Master RCB control key-switch to the centre position

Note: The ELDC Sensor tripping current is rated at 30mA/30mSec. Power for the ELDC system is derived from the RED L1 Phase of the relevant bay breaker and should be 240V  $\pm$  10%. An internal fuse protects the ELCD contact avolites for more details

**Warning:** Do not use the system without either the Green or Red indicator lit on used bays

## 6. One Phase per multipin Outlet

Some locations dictate that only one phase is patched per multipin outlet.

Follow the following procedure to hot patch and soft patch the dimmer;

Use Patch leads to connect all Red channels to the first multipin outlet, then the yellow channels and last the blue channels (i.e. dim Ch. 1 to multipin 1.1, dim ch 4 to multipin 1.2)

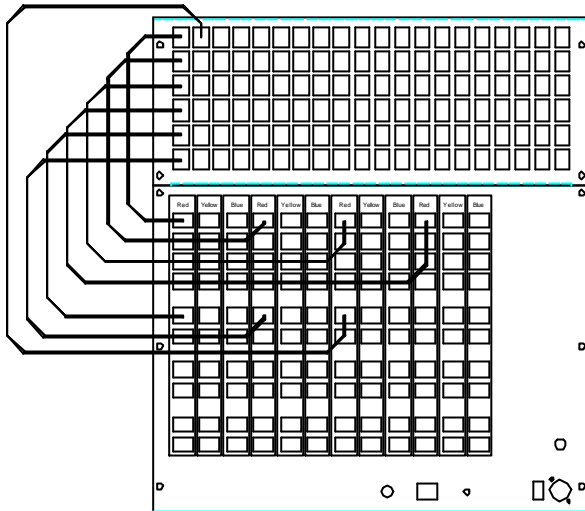
	Multipin	1	2	3	4	5	6
Red Phase	Multipin 1	1	4	7	10	13	16
	Multipin 2	19	22	25	28	31	34
	Multipin 3	37	40	43	46		
Yellow Phase	Multipin 4	2	5	8	11	14	17
	Multipin 5	20	23	26	29	32	35
	Multipin 6	38	41	44	47		
Blue Phase	Multipin 7	3	6	9	12	15	18
	Multipin 8	21	24	27	30	33	36
	Multipin 9	39	42	45	48		

Check that the controller is in patch mode (see 4.5 Soft Patch )

Enter the following patch, on the DMX line to be used:

Dim 1	Dim 2	Dim 3	Dim 4	Dim 5	Dim 6	Dim 7	Dim 8	Dim 9	Dim 10	Dim 11	Dim 12
Dmx 1	Dmx 17	Dmx 33	Dmx 2	Dmx 18	Dmx 34	dmx 3	Dmx 19	Dmx 35	dmx 4	Dmx 20	Dmx 36
Dim 13	Dim 14	Dim 15	Dim 16	Dim 17	Dim 18	Dim 19	Dim 20	Dim 21	Dim 22	Dim 23	Dim 24
Dmx 5	Dmx 21	Dmx 37	dmx 6	Dmx 22	Dmx 38	dmx 7	Dmx 23	Dmx 39	Dmx 8	Dmx 24	Dmx 40
Dim 25	Dim 26	Dim 27	Dim 28	Dim 29	Dim 30	Dim 31	Dim 32	Dim 33	Dim 34	Dim 35	Dim 36
Dmx 9	Dmx25	Dmx 41	Dmx 10	Dmx 26	Dmx 42	Dmx 11	Dmx 27	Dmx 43	Dmx 12	Dmx28	Dmx 44
Dim 37	Dim 38	Dim 39	Dim 40	Dim 41	Dim 42	Dim 43	Dim 44	Dim 45	Dim 46	Dim 47	Dim 48
dmx 13	Dmx 29	Dmx 45	dmx 14	Dmx 30	Dmx46	dmx15	Dmx 31	Dmx47	Dmx 16	Dmx 32	Dmx48

Below is a schematic drawing of the first 7 channels (red phase multipin outlet 1 and 2



## 7. Troubleshooting

The ART2000 system includes many self-testing features. If there is an internal problem in the system, the control module will usually detect the problem and tell you about it.

The Status line on the display tells you if the system is happy and healthy, or if there is something you need to worry about. "Running OK" means that everything is good. "warning" means that there is a problem, but the dimmer will carry on working.

### 7.1 System setup

You can display more information about the system by holding down the X10 button and pressing the LEVEL button. (Above STORE)

Li ne A 001	Dmx ok	Li ne B 001	No Dmx
Status	Runni ng ok	Mode	Test off
-----BAY STATUS-----			
	Found	Chan	Control Temp OverTemp Run
Bay 1	Yes	12	123 20 No 81
Bay 2	Yes	12	456 21 No 71
Bay 3	No	00	789 -127 No 00
Bay 4	Yes	12	101 21 No 61

This screen shows the status of the bays, where:

Found	Yes	indicates module detected
	No	indicates module not present or undetected
Chan	00	No channels detected
	12	12 channel dimmer or relay module detected
	6	6 channel dimmer module detected
	3	3 channel dimmer module detected



Control		A run counter inside the dimmer controller (should not be stationary)
Temp		Temperature of the module ( $\pm 3$ degrees C)
OverTemp		Indicates the state of the over temperature switch on the module
Run		A run counter on the Module controller (should not be stationary)

To see the software details press UP or DOWN when the above screen is active

X10 and LEVEL SCREEN the press UP

```

Li ne A 001   Dmx ok   Li ne B 001   No Dmx
Status Runni ng ok   Mode   Test off
-----SOFTWARE VERSION-----

ART OS3.0R0 Ucode 1.0 PDE1.0/1.2

```

Pressing the EXIT button will restore the normal screen.

The internal software can be updated using PC software and special cable, (Avolites part number 1808-0016) available from Avolites. Full instructions are given by the PC software.

## 7.2 Overheating

If the system detects that it is overheating (heatsink temperature over 80°C), it will display the following warning

```

Li ne A 001   Dmx ok   Li ne B 001   No Dmx
Status Runni ng ok   Mode Test off
-----WARNING-----
Bay 1 temperature is over 80 C! "
Is the fan working for this bay?"
Bay will shut down at 90 C! "

```

Ensure that all fan vents are clear and that sufficient air flow is available to naturally cool the module.

If the temperature continues to rise the following message will appear

```

Li ne A 001   Dmx ok   Li ne B 001   No Dmx
Status warni ng   Mode Test off
-----WARNING-----
Bay 1 has shut down at 90 C!
Check for cause of over-heating!
Bay may resume operation if cooled.

```

The affected dimmer module is be shut down.

### 7.3 Module sensing

If the system detects that it cannot communicate with a module which was OK at power-up, it displays the following message

```

Li ne A 001   Dmx ok       Li ne B 001   No Dmx
Status warni ng           Mode  Test off
-----WARNI NG-----
Bay 1 not found

```

A module not being correctly fitted in a bay or being removed whilst powered up usually causes this.

### 7.4 Problems with setup changes

If the system cannot write setup changes into its permanent memory it displays the message below. The system will continue to operate but setup changes will be lost when it is powered down.

```

Li ne A 001   Dmx ok       Li ne B 001   No Dmx
Status  Warni ng           Mode  Test off
-----WARNI NG-----
There was a probl em savi ng data!
Pl ease try agai n.

```

Please Contact Avolites for service if this problem occurs.

### 7.5 Dimmer Engine Control Problems

If the system cannot start-up one or more of the four dimmer engines the following message will appear

```

Li ne A 001   Dmx ok       Li ne B 001   No Dmx
Status Warni ng           Mode Test off
-----WARNI NG-----
Bay 1 dimmi ng control stopped!
...control now restarted

```

The system will restart the dimmer engine within about 10 seconds. Stopping dimmer engines is generally a sign of bad mains, or bad connections on the control board

The remaining bays will work as normal and the dimmer can be used

### 7.6 Software upgrade

Any ART system running OS 2.0R0 or higher software can be upgraded using a serial cable and a PC.

The Software will be made available free of charge, on the Avolites web site under "Downloads", you will also find data on how to make the cable

Alternatively you can buy the cable from Avolites, part number: 1808-0016

## 7.7 Resolving circuit problems

If a dimmer circuit does not operate as you expect, don't panic! There are several possible causes.

Check the lamp: on the hot-patch panel on top of the rack, connect a cable from the multicore outlet to the lamp test socket and check that the lamp test light comes on. If not, the lamp or multicore cable is faulty. Try another lamp or a different cable.

Check the dimmer channel: With all control channels at zero, plug the hot patch cable from the multicore outlet to the dimmer channel. The neon on the dimmer channel should come on to indicate a load is present. Press Test On and fade up the manual fader on the channel. If this does not work there is a problem with the dimmer channel (check the channel circuit breaker is turned on!). If you have a spare dimmer module try changing the module.

Check the control setup: If all the above is OK, then you may have a DMX control problem. Make sure that the rack is set to the same DMX channel as the control console. If the display shows that the DMX line you are using is in Channel Patch mode, make sure the dimmer channel has not been patched somewhere else or has been "parked".

If you are experiencing common faults or patterns (such as every 3rd channel not working) this can indicate a phase supply problem.

You may be able to solve problems by restarting the dimmer rack or pressing the reset button using a small pointed implement.

---

## CHAPTER SEVEN

---

# 8. Introduction to DMX

This section is for those who are put off by dip switches, lights that move unexpectedly and strange digital control systems that fly down microphone cables.

## 8.1 Ordinary lighting

Standard lighting consists of a variety of light bulbs connected to dimmers. The lights may be anything from par cans to theatrical lanterns, and the dimmer controls the intensity of the light. A typical controller for standard lighting has a set of sliders, and each slider controls the intensity of one dimmer using a low-voltage control signal of 0 to 10 volts. The standard way to link the sliders to the dimmers is by using a multicore cable with one core for each dimmer channel.

## 8.2 The problem with big lighting rigs

Because each dimmer channel needs its own control signal, if you have a large lighting rig, the control cable can end up being huge, with big expensive connectors. If you are using intelligent lighting, like scans, this gets even worse, because some of the more complicated fixtures use 20 channels or more per fixture. You soon need a better way of getting the control signals from the control console to the equipment.

## 8.3 The DMX control system

Fortunately, there is an easy to use system for controlling intelligent

lighting and dimmers with large numbers of channels. It is called DMX-512, which stands for Digital MultipleX, and it sends up to 512 control signals down a 2 core or 4 core screened cable. The cable can be simply daisy-chained from each lighting device to the next - all DMX devices have a loop-through connector which allows you to link to the next device. Normally a 5-pin XLR connectors is used and in the case of the ART system, all 5 pins should be connected.

Control consoles using the DMX system send out the level for channel 1, followed by the level for channel 2, then 3, then 4 and so on, all the way up to a maximum of 512 (though not all DMX systems send out all the channels). It then goes back to channel 1 and goes round again.

All the units connected to the DMX receive all the channels, and you tell them which channels to respond to by setting the "start address" on each unit. The computer inside the dimmer or fixture waits for the correct channels to come up, then reads in the levels for those channels and uses them to set the dimmer levels or the fixture positions.

## **8.4 A few cautions about using DMX**

DMX is a robust system which normally works very well, provided you keep to a few simple rules. Here are a few tips for making DMX work well.

- DMX cabling should be twisted-pair shielded data cable. Microphone cable is not recommended because it degrades the signal, especially on long runs.
- Always "terminate" the last dimmer or fixture on the DMX line, either with a special termination plug, or the ART2000 rack has terminator switches which do this for you. The termination is a 120 ohm resistor across the DMX data lines which prevents data interference on the line. It might work without but...
- Don't split the DMX cable. Loop it from one unit to the next. If you have to split it, use a proper active splitter unit like the Avolites Rack splitter or Avolites truss splitter, part numbers 33-65-1000 (19" mounting, 8 outputs) or 33-65-2000 (truss mounting splitter using a self-fixing strap, 6 outputs).
- The DMX specification says you should not have more than 32 unit loads on one DMX line. Either use several DMX lines (Avolites consoles usually have more than one) or use a DMX splitter unit. Again, you will probably get away with using more if you have to, but the DMX signal will be weaker than it should be.
- Don't run your DMX lines near high voltage cables or neon supplies. They may pick up interference which will stop the system working.

## CHAPTER EIGHT

## 9. System specification

The figures below give the specification of the standard ART2000 system.

<b>Power Ratings</b>	Minimum	Maximum
Mains input voltage (phase - neutral)*	110V/220V	120V/240V
Mains input frequency	42Hz	72Hz
Current drawn per phase		274A
Current per channel		16A/32A/63A

\*System is manufactured for either 110V or 240V

<b>Environmental ratings</b>	Minimum	Maximum
Ambient temperature	0°C	40°C
Internal heatsink temperature		70°C
Relative humidity	-	90% non-condensing

<b>Fan cooling airflow</b> (cubic ft/min)	Minimum	Maximum
Normal operation	80 CFM	100 CFM
Maximum load		850 CFM

<b>Physical information</b>	
Dimensions (all rack lids fitted)	580 x 1005 x 1180 mm LxDxH
Weight	198Kg (48x16A)

<b>Channel/Phase information</b>	12 channel module	6 channel module	3 channel module
Red phase	1,4,7,10	1,3	1
Yellow phase	2,5,8,11	2,4	2
Blue phase	3,6,9,12	3,5	3

## 10. Connector pinouts

The tables below give the wiring of the connectors used on the standard ART2000 system.

DMX connectors (5 pin XLR)

DMX LINE A

<i>Pin</i>	<i>Function</i>
1	Earth
2	Data -
3	Data +
4	Line B Data -
5	Line B Data +

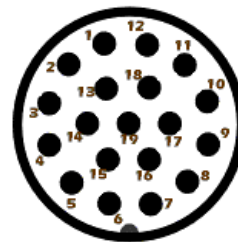
DMX LINE B

<i>Pin</i>	<i>Function</i>
1	Earth
2	Data -
3	Data +
4	(loop through)
5	(loop through)

Multipin outlet connectors: Various types of connector may be fitted by Avolites. See previous page for phasing of outputs.

**Socapex™ 19 pin**

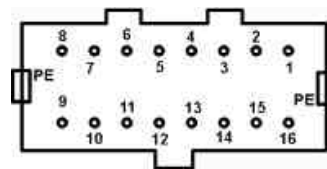
<i>Pin</i>	<i>Function</i>
1	Live 1
2	Neutral 1
3	Live 2
4	Neutral 2
5	Live 3
6	Neutral 3
7	Live 4
8	Neutral 4
9	Live 5
10	Neutral 5
11	Live 6
12	Neutral 6
13	Earth
14	Earth
15	Earth
16	Earth
17	Earth
18	Earth
19	Earth



Harting<sup>™</sup> / Electroflex<sup>™</sup>: There are 4 different ways that these connectors can be wired, please consult Avolites if you are unsure as to which standard is in use on your system.

**Harting<sup>™</sup> / Electroflex<sup>™</sup> (Harting 1-2)**

<i>Pin</i>	<i>Function</i>
1	Live 1
2	Neutral 1
3	Live 2
4	Neutral 2
5	Live 3
6	Neutral 3
7	Live 4
8	Neutral 4
9	Live 5
10	Neutral 5
11	Live 6
12	Neutral 6
13	
14	
15	
16	
Earth	Earth

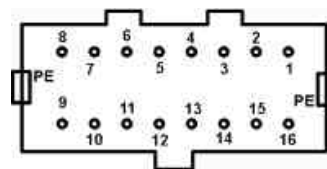


**Harting<sup>™</sup> / Lectroflex<sup>™</sup> (Harting 1-2 & extra Earth)**

As above, but pins 13-16 connected to earth.

**Harting<sup>™</sup> / Lectroflex<sup>™</sup> (Harting 1-9)**

<i>Pin</i>	<i>Function</i>
1	Live 1
2	Live 2
3	Live 3
4	Live 4
5	Live 5
6	Live 6
7	
8	
9	Neutral 1
10	Neutral 2
11	Neutral 3
12	Neutral 4
13	Neutral 5
14	Neutral 6
15	
16	
Earth	Earth



**Harting<sup>™</sup> / Lectroflex<sup>™</sup> variant (Harting 1-9 & extra Earth)**

as above, but pins 7, 8, 15, 16 are also connected to earth.

## 11. Glossary of technical terms

ADDRESS	see START ADDRESS
BAY	The ART2000 rack has 2 or 4 bays depending on the model , each of which can hold either a dimmer module, relay module or power distribution module.
CHANNEL	One circuit of a dimmer/distribution system, which may be connected to one or more lamps in parallel. Also used to refer to the slider controlling the dimmer on the control console and the control value in the DMX system which links the two.
SOFT PATCH	Patching mode where each dimmer channel can be assigned to any DMX Address (they do not need to be in a sequence)
CURVE	How the output of the dimmer corresponds to the input. Used to correct for non-linear response of some types of lamp.
DIMMER	Device which allows control over the intensity of a lighting fixture.
DMX	DMX512(1990) a specification for communication between control desks and dimmers or fixtures, Originally for Dimmers it has been adopted as a control protocol for most lighting systems. It can carry 512 different slots of 8-bit data.
HOT-PATCH	A plugging system which allows you to connect any dimmer channel output to any Multicore channel. The "hot" refers to the patch carrying mains voltage.
HTP	Highest Takes Precedence, a mechanism for determining the output level of a Channel held in more than one Playback Channel. The Channel outputting the Highest value at any given time will always determine the level of the Channel. Also see LTP.
INTELLIGENT LIGHTING	Generally refers to some type of motorised light or colour changer. Also called Intelligent Fixture, Device, Instrument, Moving Light.
MODULE	An electronics pack containing either 12 dimmer channels or 12 power distribution channels.
MULTICORE	A cable/connector system which can carry multiple connections. Often used to connect 6 lights to a Dimmer rack instead of using 6 separate cables. Sometimes the brand name of the connector is used, e.g. Socapex or Harting.
PHASES	Mains power is supplied in three different live conductors, each called a phase. Consult an electrician for more details.
PREHEAT	If a small voltage is left applied to a lamp when the channel is turned off, it turns on faster. This technique is called Preheat.



RACK PATCH	Patching mode where dimmers are allocated to sequential DMX control channels
RCB	Residual Current Breaker. Helps to protect the user against electrocution by detecting an imbalance between the current leaving the unit down the live conductor and the current returning down the neutral, and isolating the supply the current differs by more than 30mA.
RISE TIME	The time taken for the mains output to rise to full voltage when the dimmer channel turns on. This happens 100 times per second and has a large effect on the amount of interference generated by the dimmer (longer rise time = less interference). It also affects the acoustic noise made by a lamp filament.
START ADDRESS	The first DMX channel used by the dimmer or fixture. Usually a block of channels is used, starting from the Start Address.
TERMINATION	The end of a DMX run should always be fitted with a terminating resistor to prevent data problems. The ART2000 rack has switches to do this.
TN-S	Type of three phase power system with neutral bonded to earth at the substation, and a separate earth conductor throughout the system.

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