Entertainment Services and
Technology Association

Application Guide for
ANSI E1.3 - 2001
Entertainment Technology
Lighting Control Systems
0 to 10V Analog Control Specification

CP/1999-1008r4

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Contents

1 Scope

This document explains some of the design implications that may not be obvious in the E1.3 standard. It also offers some troubleshooting guidance for users of analog control equipment. This document does not add any requirements to the E1.3 standard, nor does it remove any requirements. All the recommendations in this document are advisory only.

2 Signal amplitude

The control signal for this standard is nominally 0 to 10V DC. Section 6.1.1 of E1.3 sets a maximum output range for transmitters of -0.2V to 12.0V. Section 6.2.1 sets the minimum voltage range a receiver must accept without damage as -0.5V to 30.0V. The two different voltage ranges are set so that E1.3 compliant receivers and transmitters will work with each other and also with the vast majority of legacy equipment that is nominally “0 to 10V analog” but that was designed and built before the adoption of E1.3.

The E1.3 transmitter range is set to cover the 0V to 10V scale of meaningful output levels while allowing for manufacturing tolerances and some minor anomalies in output voltage that may result with simple transmitter circuit designs. The 12V maximum is low enough that it is believed not to be likely to damage pre-E1.3 equipment. However, the equipment designer and equipment user should be aware that there is no guarantee that this is the case. Therefore, it is advisable, but not required, to limit the output voltage on E1.3 transmitters to 10.0V.

The E1.3 receiver input voltage acceptance range is set to cover the range of voltages that are likely to be encountered with legacy equipment or if a power supply line is inadvertently connected to a signal line. No guarantee can be made that legacy equipment called “0 to 10V analog” will never impose voltages outside this range.

3 Diode protection

Blocking diodes are required to allow multiple controllers or output devices to be paralleled to control the same dimmers or receiving devices. However, the requirement that blocking diodes be present on the outputs of all E1.3 controllers may cause a dead zone at the low end of control. The dead zone will be caused by forward voltage drop of the blocking diode, which is about 0.6V with silicon diodes. This voltage drop across the diode will cause the output voltage to stay at zero in a dead zone until the fader arm voltage is above 0.6V, a value known as “one diode-drop.” At that point the blocking diode will start to conduct, and the output voltage from the controller will start to rise. This diode-drop must be compensated if smooth low-end fading is desired. For manufacturers of inexpensive controllers, some hints are offered below to compensate for the dead zone:

3.1 Limit the slide pot travel

Since the output will stay at zero until the slide pot reaches a voltage above the diode-drop it is possible to limit the slide pot’s travel such that at the slider’s minimum stop the output has just reached zero.

3.2 Raise the potentiometer’s bottom terminal voltage

Instead of tying the bottom slide pot terminal to common, tie it to some voltage other than common such that the outputs are just at zero when the slide pot is at minimum. A fixed resistor or a diode can be placed between the bottom of the pot and common to raise the bottom of the pot one diode-drop above common.

3.3 Scale the slide pot travel

Print the scale next to the slide pot with “0” where the slide pot just begins to overcome the diode drop, with “5” where the output is five volts (into a specified load), and with “10” where the output is ten volts.

3.4 Include the blocking diode within a feedback loop

For consoles using op-amps, the blocking diode can be placed in the feedback loop of the output driver stage. This has the disadvantage of placing some of the console's circuitry after the blocking diode. A high voltage on the output can therefore damage the console unless additional protection circuitry is added.

3.5 Include a compensating diode within a feedback loop

For consoles using op-amps, a diode of the same type as the blocking diode can be placed in the feedback loop of the output driver stage, while leaving the blocking diode outside the loop. This will introduce an offset into the driver's output that should closely match the forward voltage drop of the blocking diode. It is recommended that a large-value resistor be placed in parallel with the diode to avoid instability.

4 Cabling

Unlike digital and analog multiplex control cables, 0 to 10V cables can be almost any type of conductor or cable. However, the voltage drop in the cable is a major concern. Sections 7.1.1 and 7.1.2 of E1.3 limit the voltage drop in the individual channel conductors and in the common conductor to no more than 0.1V. This limit can be easily exceeded if the current flow in a conductor and the conductor's resistance are not carefully considered.

The common conductor is particularly a concern. If the transmitter is powered from the mains or batteries and supplies all the signal current, the common conductor carries the return current for all the channels. Inattention to the total return current in the conductor and the resistance of that conductor can result in a voltage drop great enough to lower the effective signal voltage and noticeably change the output of the receivers. What is worse, the voltage drop will vary with the signal voltages, which can result in unwanted interaction between channels. For example, a situation can result in which fading up a group of dimmers causes the other dimmers parked at a set level to fade down.

It has often been common practice for an analog lighting controller to be powered from the dimmers it controls, with the power being distributed to the controller in the same cable that carries the individual channel conductors. In this case, the common conductor carries the return current from the controller power supply. Excessive voltage drop in this case will tend to raise the "0V level" at the controller above the "0V level" at the receivers, which can cause "off" control signals to be read at the receivers as something other than off. Dimmers may ghost, or scrollers may fail to go all the way to the first frame.

A simple application of Ohm's Law and some work with a multi-meter can ferret out excessive voltage drop problems in the common conductor and in the individual channel conductors. If necessary, several conductors in parallel or a larger conductor (numerically smaller gauge or larger cross-section) may be used to reduce the voltage drop.

5 Connectors and pin assignments

E1.3 requires labeling to show signal connector pin assignments. It recommends, but does not require, that the pinout should follow a pin number equals channel number configuration with the highest pin number used as signal common.

While no particular connector and no particular pinout is required by E1.3, equipment designers may want to consider using one of the connectors and pin arrangements found on legacy equipment. A selection of these is noted below.

Connector	Typical number of channels	Pinouts	Channels
CHAMP (Centronics)	32	1 - 32	Channels 1-32
		33 & 34	Not used
		35 & 36	Signal common
Cinch Jones 8-pin	6	1 - 6	Channels 1-6
		7	Power supply (or fan relay)
		8	Signal common
Cinch Jones 10-pin	6	1 - 6	Channels 1-6
		7	Power supply
		8	Signal common
		9	Power supply (+15V)
		10	Power supply (-15V)
Cinch Jones 10-pin[1]	6	1 - 6	Channels 1-6
		7	Not used (or signal common)[2]
		8	Signal common
		9	Not used
		10	Not used
Cinch Jones 15-pin	12	1 - 12	Channels 1-12
		13	24V to dimmer for fan relay
		14	Power supply
		15	Signal common
CPC-28 (Amp)	8	1 - 8	Channels 1-8
		9-24, 27	Not used
		25	Power supply (+15V)
		26	Power supply (-15V)
		28	Signal common
DA-15 Strand (DB-15)	12	1 - 12	Channels 1-12
		13 & 14	Signal common
		15	No connection

Note 1: There is an extremely large installed base of 10-pin Cinch-Jones cables made with 8 conductor cable connected to pins 1-8 only.

Note 2: There is a large installed base of 10-pin Cinch-Jones cables made with pins 7 and 8 tied together.

For many years it was the standard practice in the New York metropolitan area to use 10-pin Cinch-Jones plugs to provide six analog control channels. Pins 1-6 were used for channels 1-6. Pins 7 and 8 were used as the common while pins 9 and 10, originally used for a contactor enable, were left unconnected. This led to the use of an 8-conductor cable; however the original installed base of 10-pin plugs on both dimmers and controllers perpetuated this arrangement.

Connector	Typical number of channels	Pinouts	Channels
DB-25 (Artistic Licence, EDI, et alia)	24	1 - 24 25	Channels 1-24 Signal common
DD-50 (DB-50)	48	1 - 48 49 - 50	Channels 1-48 Signal common
DIN 5-pin 180° (N.J.D. Electronics et alia)	4	1 2 3 4 5	Channel 1 Signal common Channel 4 Channel 2 Channel 3
DIN 7-pin (N.J.D. Electronics et alia)	4	1 2 3 4 5 6 7	Channel 1 Signal common Channel 4 Channel 2 Channel 3 +15V power -15Vpower
DIN 8-pin (Zero 88 et alia)	6	1 - 6 7 8	Channels 1-6 Power supply Signal common
DIN 8-pin (Pulsar et alia)	6	1 2 3 - 8	Power supply Signal common Channels 1-6
D-Subminiature 9-pin (Rosco/ET)	6	1 - 6 7 - 9	Channels 1-6 Signal common
Socapex 337P	30	1 - 30 31 - 34 35 - 37	Channels 1-30 Not used Signal common
SRC-16 (Cannon)	12	1 - 11 12 13 14 15 16	Channels 1-11 Power supply (+15V) Power supply (-15V) Not used Signal common Channel 12
XLR 5-pin	4	1 - 4 5 Shell	Channels 1-4 Power supply (+15V) Signal common
XLR 7-pin	6	1 - 6 7 Shell	Channels 1-6 Power supply Signal common

Note: The shell of many XLR-style connectors does not make a good electrical contact. The XLR pinouts listed above are for reference since they have been used in the past. It is not advisable to use these XLR pinouts since they use the shell for the signal common.

6 Troubleshooting hints

6.1 Testing controllers

One advantage of 0 to 10V control over digital or analog multiplex is its simplicity and ease of troubleshooting. Testing a controller or other sending device's output can usually be done with an inexpensive voltmeter.

Place the negative probe on the signal common output pin and the positive probe on the output channel to test. With the output at zero the voltmeter should read zero volts. With the output at full, the voltmeter should read ten volts. With the output at 50%, the voltmeter should read five volts. If the output looks good on the meter but fails to drive the dimmer or other intended controlled device, repeat the measurements with the output loaded with a 20,000 ohm resistor.

6.2 Testing receivers

One simple test of a receiver can be made with a 9V and a 1.5V battery. Connect the negative terminal of the 9V battery to the common input of the receiver. Tie the positive terminal to the channel input you wish to test. The receiver should go to its appropriate response for 90%. If it responds but you can't tell if it's the 90% response, perform the same test with the 1.5 volt battery. The receiver should go to the appropriate 15% response. Unless the receiver has a toggled, two-state response with the trip point above or below these points, the difference between the 90% and 15% responses should be obvious.

A difficult-to-track-down fault may appear to be in the receiver but actually be a problem with the controller/cable/receiver combination. Improperly designed controllers with op-amp outputs may become unstable with reactive loads. The controller output then oscillates at high frequency at some point in the output range, which then can make the receiving device behave bizarrely. A hint that this is the problem is that the symptoms disappear as soon as the control cable is unplugged to start troubleshooting.

6.3 Testing cables

A simple continuity and short circuit test will almost always find a bad analog cable. Unless a cable has been damaged internally by being pulled or by being smashed with a sharp-edged object, intermittent connections are almost always found where the cable enters the connector. Intermittent connections usually can be found by wiggling the connector strain-relief. Maintaining the integrity of the connector strain-relief is important for maintaining reliable analog cables. The electrical connections of the wires should not be relied upon for making the mechanical connection of the analog control cable to the connector.

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