80th birthday release

A Theater Lighting Adventure

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ABSTRACT

In 2013, the incandescent-lamp based house lighting system of the Rohovec Theater at New Mexico State University–Alamogordo, in Alamogordo, New Mexico, was completely replaced by an LED based system. As with the earlier system, one of the two sets of lights in the new system—intended for use in connection with theatrical productions—was controlled by the theater's theatrical light control system, and was intended to be dimmable, using a modern dimming interface system intended for such fixtures. But from the completion of the upgrade, that set of lights could not be dimmed, and in fact on some occasions one half of those lamps flickered. This article tells the story of how this malfunction was diagnosed and corrected. Extensive technical background is provided.

1. INTRODUCTION

1.1 About the author

I am a retired engineer, having spent a great portion of my professional career in the telecommunication field. I had only twice, before the adventure described here, been seriously associated with a stage theater, in both cases through a volunteer community theater company. In about 1956-1957, while in college, I was a lighting operator with The Shaker Players, a community theater company in the Cleveland Ohio area. It primarily performed in a well-equipped (for the time) high school auditorium. The lighting system there was "traditional", with large, lever-controlled rheostats.

In 1969-1971, I was Director of Sound Production at Albuquerque Little Theater in Albuquerque, New Mexico, which had its own well-equipped theater. I had almost no contact with the lighting control system there, which was in any case not of the modern, electronically-controlled form (again, it used large, lever-controlled rheostats).

Although, as my followers well recognize, I often will study intensely some topic with which I had not previously been involved and write of what I have learned, but theatrical lighting control systems (of whatever vintage) had not earlier been one of them.

1.2 University of New Mexico–Alamogordo

New Mexico State University–Alamogordo[1] (NMSU-A), a satellite of NMSU itself (the state's second largest state university, with its main campus in Las Cruces), is the community college of Alamogordo, New Mexico and the surrounding region of Southern New Mexico.

1.3 The Rohovec Theater

The Rohovec Theater at NMSU-A is a well-equipped and comfortable 250-seat theater. It occupies the entirety of its own building on the NMSU-A campus[2].

1.4 The Theatre on the Hill

The Theatre on the Hill is a community theatre company operated by NMSU-A, with participation by the community at large. It normally performs in the Rohovec Theater. It typically offers three major productions each year.

1.5 The Theatre on the Hill Guild

The Theatre on the Hill Guild is a volunteer civic organization which provides support of many kinds to the theater company's operations.

2. The Rohovec theater's lighting control system

2.1 Introduction

The Rohovec theater is equipped with a comparatively-modern electronic theatrical lighting control system (initially installed in 1996). It is operated from the technical booth at the rear of the theater auditorium.

The system was manufactured by Electronic Theater Controls, Inc, (ETC).

2.2 The dimmer rack

The actual electronic dimmers in the lighting control system are housed, as plug-in modules, in an ETC *Sensor* SR48 dimmer rack located in the technical booth. The rack has a capacity of 48 such modules, each typically carrying two dimmer circuits.

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[1] The official presentation of its name is "New Mexico State University Alamogordo" but for clarity I prefer the form with the *en dash* in it.

[2] Known as "The Rohovec Fine Arts Center" in honor of Marvin D. Rohovec, who established NMSU-A. The name is curious for a building containing only a theater.

In addition to the modules, there is in the rack the Control Electronics Module (CEM), essentially the “brains” of the rack.

In figure 1 we see the dimmer rack.

Figure 1. The TEC *Sensor* SR48 dimmer rack

In the left panel of the figure, we see the rack in place, with the door closed. In the right panel we see the rack with the door open to the left.

The rack as we see it is populated with 30 ETC D20 dimmer modules, each of which carries two independent dimmer circuits, each of which can operate a load of up to 20 A (2.4 kW).

The remaining 18 “slots” carry ETC AFM (Air Flow Module) modules. These are “dummies” which maintain the overall aesthetic appearance of the rack face, prevent there being any opening into the (dangerous) power voltage wiring area behind the modules, and, perhaps most importantly, keep intact the pattern of the airflow system, driven by a fan at the top of the rack, which cools the modules and the common control unit.

Inside the door we see the full-length air filter, through which the incoming air passes before being distributed to the modules.

Halfway up, we see the CEM.

In figure 2 we see (in the lower portion of the figure) a closeup view of several D20 dimmer modules. Above are several AFM Air Flow Modules.

Figure 2. D20 dimmer modules (bottom) and AFM modules (top)

In figure 3 we see a close up of the center portion of the rack face.

Figure 3. D20 dimmer modules and CEM

There we see, in addition to several D20 dimmer modules, the Control Electronics Module (CEM), with its management control panel.[3]

On the left are the dimmer numbers associated with the two dimmer circuits of each of the dimmer modules. You will notice that they are not in consecutive numerical order as we go through the slots from top to bottom. Here is the reason.

The lighting system is powered by a three-phase 120/208 V service feed. The first 16 module slots are fed from "phase A". the second 16 from "phase B", and the third 16 from "phase C".

In a three-phase system, it is desirable, to the extent possible, to evenly distribute the load over the three phases.

The dimmer numbering scheme used in this rack is intended to distribute the load of consecutively-numbered dimmers generally evenly over the three phases. If, for example, a rack were equipped with only 9 modules (18 dimmers), and they were mounted so as to have dimmer numbers 1-18, then 3 modules (6 dimmers) would be fed from each of the three phases, leading (as much as possible) toward equal loads on each phase.

You will also note that the modules have paper tags with handwritten numbers. These are the numbers of the slots (1-24) in which the modules currently reside.

It is my conjecture that these tags are artifacts of the house lighting upgrade project. Probably many of the dimmers had to be removed to gain access to the power wiring on the "backplane" of the dimmer rack (which must be done from the front of the rack). Likely all the modules were removed, after labeling them so that they could be replaced in exactly the slots from which they were removed.

Figure 4. D20 dimmer module

ETC photo

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[3] The message "no data port A" seen on the display panel reflects the fact that when this picture was taken, the control console was turned off and thus there was no DMX signal to the rack.

2.3 The dimmer modules

In figure 4 we see a TEC D20 dimmer module.

The TEC D20 dimmer modules control the "effective voltage"[4] fed to the load by delaying the onset of the voltage on each half-cycle of the AC wave by a controllable amount. This is done with silicon controlled rectifiers (SCRs), semiconductor devices that until they are "triggered" afford essentially an open circuit in the path to the load, and once triggered provide almost a zero resistance in the path to the load (which persists until the current through the device drops to almost zero near the end of the half-cycle).

In each dimmer circuit, there are two SCRs, one used during each of the two half-cycles of the SC wave (they only work for current in one direction).

When the control command to the dimmer is "0", the SCRs are never triggered, and thus there is no AC output. When the control command is "100" (on a scale of 0-100), the SCR is triggered a little before the onset of each half-cycle, and thus the output is essentially the complete AC waveform (the effective voltage then being the same as for the supply voltage).

With the dimmer level at an intermediate level between 0 and 100, the SCRs are triggered partway through the half cycle. When this happens, the output waveform rises suddenly from zero to wherever the source waveform is at that instant. Because of these "sharp leading edges", the output waveform contains substantial high-frequency components. These can cause noise into audio circuits traveling near the circuits to the lighting instruments and can cause other sorts of mischief.

To mitigate this, the dimmers contain a low-pass filter consisting of a series inductor.[5] The inductor is of the toroidal design (overall has a "donut" shape) and is physically quite large (they actually occupy most of the volume of the dimmer module). (In a D20 dimmer, it must carry a current of 20 A RMS.)

The behavior of the low-pass filter is specified in terms of the rise time of the "sharp edge" of the delivered waveform (measured between the points at which the voltage is 10% and 90% of its final value, with a

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[4] This term means the "RMS" (root-mean-square) value of the AC wave, which determines the average power delivered into a resistive load, such as an incandescent lamp.

[5] Because it makes the wiring simpler, the inductors are actually **before** the SCR circuit. Since both are series elements, the sequence doesn't matter.

resistive load corresponding to the unit current rating). For a standard D20 dimmer that is specified as 350 μs.[6]

On the left are two circuit breakers, one for each dimmer circuit. They are seen here in their off positions.

2.4 The control console

The lighting system is controlled from a TEC *Insight 2* control console. We see it in figure 5.

Figure 5. TEC *Insight 2* lighting control console

It includes, among its other controls, a field of 108 small control sliders. In a basic configuration (as is, for the most part, in place at the Rohovec theater), each of these sliders will control a single dimmer and thus a certain light circuit (perhaps controlling one or more stage lighting instruments).

When needed, a slider can be assigned to control more than one dimmer. In addition, the console can work with predefined "cues", each of which puts into effect a certain stage lighting "look" composed, in general, of dimmer settings of multiple lighting instruments.

The significance of the "decoration" of some of the sliders will be discussed later.

A conventional (if somewhat ancient) computer monitor (not seen here) allows the operator to see the status of the system at any time, and is used for such tasks as programming predefined light "cues".

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[6] For situations in which greater suppression in the high frequency components is needed, there is a special version of the dimmer module with a rated rise time of 500 μs.

2.5 The DMX-512 control circuit

The commands from the console are conveyed to the dimmers over a single DMX-512 (hereinafter, just "DMX") control circuit that runs from the console to the dimmer rack (and today, beyond). The DMX system uses a digital multiplex protocol that allows the control of up to 512 separate dimmers (or other controlled devices) over one DMX circuit. Each dimmer has a distinct "DMX address", running from 1 to 512, by which the dimmer recognizes the commands intended for it.[7]

The actual commands can range in value from 0 to 255 (being conveyed by an 8-bit word). However, in the usage in the Rohovec system, the commands are on a more coarse basis, being considered to have a range of 0-100. I believe that 0 on the console is encoded as 0 on the DMX circuit, and 100 on the console as 255.

The DMX circuit emerges from the rear of the console over a 5-pin XLR-type connector, We can see this in figure 6:

Figure 6. DMX ports

There are in fact two DMX output ports on the console (only one used here). The default arrangement is that one is for the DMX signal controlling dimmers 1-512 and the other for the DMX signal controlling dimmers 513-1024, and the port connectors are labeled accordingly.

There is also a DMX input port. This is used when, for example, two consoles are "daisy-chained". (For example, an auxiliary console might be fitted to increase the overall number of control sliders.)

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[7] In the SR-48 rack, this address recognition is done on behalf of the individual dimmers by the CEM.

2.6 Overall

Although these two equipment units provide for a great deal of flexibility in how the entire system is set up, in the Rohovec installation at present the relationships are very straightforward (typically following the "factory defaults"). For example, for the most part, console slider 9 sends its commands with DMX address 9, which controls dimmer number 9.

3. THE UPDATED HOUSE LIGHTING SYSTEM

3.1 The update

In 2013, the house lighting system of the Rohovec Theater was completely updated. The existing incandescent based lighting fixtures[8] were replaced with LED-based fixtures, in the interest of improved energy efficiency and reduced ongoing maintenance expense. The project also involved the replacement of the suspended ceiling within which the fixtures were mounted. It was a substantial project.

The new house lighting system (like the prior one) centers about two major wholly separate "subsystems". These utilize separate sets of ceiling-mounted LED-based downlight fixtures, the two sets interleaved across the house ceiling:

- The "general" lighting system. These fixtures are controlled, in five zones, by conventional wall switches located about the house, and are not dimmable. This system is used to provide illumination in the house not in the context of an actual theatrical production, such as when the theater is used for lectures, meetings, classes, and even preparations for a theatrical production.
- The "theatrical" lighting system. These fixtures are controlled, in two zones[9] (house left and house right), by the theatrical lighting control system (controlled from the technical booth), and are (intended to be) dimmable. This system is used to provide illumination in the house in the context of a theatrical production.

In addition, the new installation includes a third subsystem, a set of LED-based wall sconces located on the two side walls of the house, also controllable by the theatrical lighting control system (but not dimmable).

Our concern here is primarily with the "theatrical" houselight system.

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[8] I use here the familiar term "lighting fixture" rather than the more technically correct "luminaire".

[9] Why no longer four zones I have no idea. The additional cost to retain the four-zone arrangement, for one thing, would have been trivial.

3.2 Dimming of the theatrical house light system

The new theatrical houselight system utilizes a wholly different basis of controlling and dimming the lights than that used for the earlier incandescent fixture system. This new approach was nevertheless integrated into the theater's existing light control system (although, as we will see, somewhat imperfectly). This will be described in more detail shortly.

4. ENTER THE AUTHOR

4.1 Joining the theater company

In 2014, my wife, Carla, joined The Theatre on The Hill, taking a role in a special "monologues" production in connection with "V-Day", an event that celebrates women's rights to enjoy their bodies and be free from abuse and violence. Later that year, I joined the company, taking a role (as did Carla) in a more conventional dramatic production.

I purposely did not intrude into the theater's technical operations (I hardly ever even went into the technical booth). I was afraid that once I started, I would get "sucked in", and at the (then) tender age of 78, I did not need anything new and "complicated" on my plate.

4.2 An anomaly in the house lights

But we both soon noticed that, many times, when what I later learned were called the "theatrical" houselights were on, one zone of them (the "house left" side) flickered. I mentioned this to the head of the NMSU-A Theater Arts department, essentially the theater's general director, wondering what was going to be done about that. She said, "Well that's only the half of it. That whole set of houselights can't be dimmed, either".

I asked when this arose, thinking that perhaps there had been some recent modification of the system that hadn't gone well. I was startled to learn that in fact the new "theatrical" houselights had never been able to be dimmed.

I thought, naïvely, that surely this would have been called to the attention of the contractor who made the upgrade, as the system apparently never performed as presumably specified. But, as I learned, for any number of reasons, it wasn't.

4.3 A minor issue

Two sliders on the console control the two zones of the theatrical house lights (not well as was mentioned just above). The leftmost slider controlled the right-hand zone of the house lights and vice versa.

And the arrangement was inconsistent with that for the sliders for the wall sconces, where the leftmost slider controlled the left-hand zone. While this was not debilitating, it was at the least *nikulturniy*[10].

4.4 Jumping in

Finally, at a meeting of the Theater on the Hill Guild in early 2016, I said that this persistent situation was untenable, and suggested that I would undertake a study of the system to see if I could find the cause of the misbehavior. The general director said, in effect, "Well, that sounds like a good idea." And so I was off on a new adventure.

Of course I knew nothing about the details of the new lighting system nor (as I intimated earlier) did I have any knowledge of modern theatrical lighting control systems in general, much less about the specific one at the theater. But of course such situations have never slowed me down.

At the request of the general director, the head of the Physical Plant department at NMSU-A provided me with an excerpt from the job drawings for the lighting update she thought would be important to me, And indeed it was!

It was a note that referred to the need to install a "Panel to convert DMX to 0-10V signal to dim the [theatrical houselights]".

Aha! Of course I had no idea what DMX was nor about "0-10 V dimming control".

4.5 Taking a peek

So I located the infamous "panel", actually a very nice little black cabinet mounted adjacent to the dimmer rack (seen to the left of the dimmer rack in figure 1), evidently (from the markings on it) supplied by TEC. Inside was a Pathway eDIN 1004 DMX-analog interface unit. I had no idea what that was, but soon found out (thanks to the Internet). And I got a lot of information about the DMX-512 control system, and about our dimmer rack, and about the modules in it, and about our control console, and was soon awash in information.

5. PRINCIPLE OF CONTROL OF THE NEW THEATRICAL HOUSE LIGHTS

In the prior incandescent theatrical house lighting system, the fixtures, then in four zones (front/rear and left/right), were controlled by dimmers in the theatrical lighting control system, just as would be done for stage lighting instruments. These dimmers operated (as

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[10] A Russian term that can be approximately translated as "unstylish".

described earlier) by varying the effective voltage of the AC power fed to the fixtures, turning it off altogether when the lights were to be "off", and varying it to control the dimming state of the lights when they were on.

This dimming approach is not workable for LED fixtures of the type used for the new installation. Rather, a wholly different dimming concept is used.

When the lights are "on" (at whatever dimming level), the fixtures are fed 120 V AC power at full voltage.

The dimming level of the fixtures (when they are "on" at all) is controlled by a separate low-voltage DC circuit, connected to all fixtures in a zone. The voltage on this control circuit, ranging from 0-10 V DC, instructs dimming circuitry in each fixture itself as to the dimming level that is desired (0 V representing the lowest light output that is attainable, and 10 V the highest).[11]

6. IMPLEMENTATION OF THE CONTROL SCHEME

6.1 Control of the AC power feed to the theatrical house light fixtures

Each zone of the fixtures receives its AC power from a dimmer in the dimmer rack. These dimmers, however, are configured in what is called the "switched mode: they can only turn the AC power on and off, not ever put it to an intermediate value (as would have been done when the dimmer would be used to dim incandescent house light fixtures or a stage lighting instrument).[12]

These dimmers are controlled by the two "house light control sliders" on the lighting control console. The intent was that whenever one of the sliders is moved up from "zero", the corresponding dimmer turns on the AC power to the fixtures.[13]

But it didn't seem to happen that way. In fact, only after the sliders were moved up to 86 or above (on their 0-100 scale) were the fixtures energized.

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[11] There are two subtly-different forms of this control protocol. The one here is known as the "current sinking", or just "sinking", version.

[12] The "switched mode" of any dimmer can be established from the CEM.

[13] We note that the sliders have a substantial "zero" zone such that an inadvertent small movement cannot put them "off zero".

6.2 Control of the low-voltage dimming control circuits

The low voltage control circuits that control the dimming level of the fixtures are controlled by two channels of the *interface unit*. We see the interface unit cabinet in figure 7.

The interface unit itself, on a "DIN" mounting rail, is at the bottom of the cabinet. Above, mounted on a separate DIN rail, is its power supply unit, which runs from 120 V AC and provides 24 V DC to operate the interface unit. As we can see, the AC feed from this comes, through the upper conduit, from the dimmer rack.

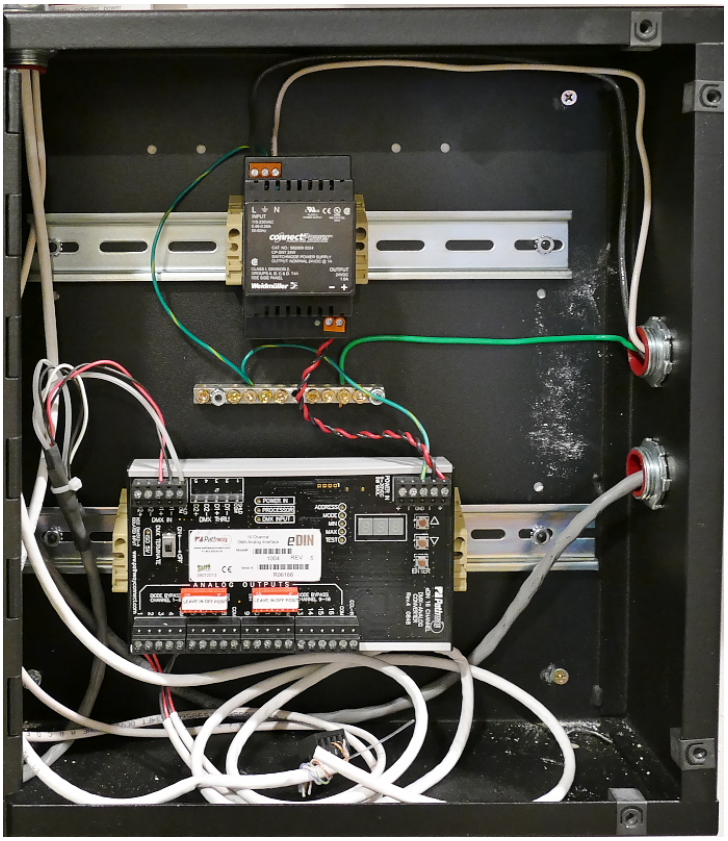

Figure 7. Interface unit (bottom) and its power supply unit (top)

The DMX control circuit is now extended beyond the dimmer rack to the interface unit.

The DMX addresses for the ports in the interface unit are set so that the ports that feed the two low-voltage control circuits are controlled by the same two DMX addresses that control the dimmers switching the AC feed to the corresponding ceiling fixtures. Thus, as the slider for a zone is advanced in the range beyond "zero", the voltage on the control circuit would be proportionately increased, in turn causing the dimming circuitry in the fixtures to proportionately increase the output level of the LED lamps.

But it didn't seem to happen. Over the entire range of the slider in which the fixtures were energized (only 86-100), the light output of the fixtures was constant.

Except of course that those on the house left side sometimes "pulsated".

7. THE CAUSES OF THE PROBLEM

7.1 Introduction

My investigation eventually determined that the misbehavior was caused by two situations.

7.2 AC power feed to the fixtures

Recall that the AC power to the fixtures is provided via two dimmers, configured in their "switched" mode so that they can only be "off" or "full on". They change from off to full on when the setting of the controlling slider rises above a certain point (the "switching threshold"). The threshold for any dimmer operating in this mode can be set on the dimmer rack's CEM control panel.

It would in fact be desirable for the switching threshold to be "1" (recall that the sliders work on a 0-100 scale), so that as soon as the slider is moved off zero, the dimmer would turn on and provide (full) AC power to the fixtures,

We found that, however, that for both dimmers involved, this "threshold" level was set to 86 (which appears to be some sort of default for the rack version we have). Thus, if we were to start with the slider set to 100 and move it down, to gradually dim the house lights, when the slider went below 86, the AC power to the fixtures would be shut off and the lights would abruptly go completely dark, and remain so for the rest of the downward travel of the slider to 0.

But of course during the change from 100 down to 86, the lights didn't dim any. So there was more to the story.

7.3 Power feed to the interface unit

The interface unit requires 120 V AC power to its power supply to energize it. Early investigation revealed that, as we found the system, the interface unit was not ever receiving any AC power, and thus it was always wholly inoperative.

In that situation, the interface unit always left the control circuits to the fixtures at "almost full"[14]. Thus, as the slider was moved over the range 86-100, within which the fixtures were energized, no change in light level occurred.

Further investigation revealed that this unit received its AC power from a third dimmer in the dimmer rack, which (like the ones mentioned above) is configured in the "switched mode" so that it could be only "off" or "full on". This dimmer is controlled by a separate control slider on the console (not one associated with any house light zone). When this slider is moved above a certain point (yes, 86), the dimmer turns "full on", providing power to operate the interface unit. The slider becomes, in effect, an "on-off switch" for the interface unit.

Was the intent of this to allow this unit to be "powered down" when the houselights are not in use (or whenever the console is shut off)? Perhaps, or perhaps it is just an accident of incomplete system planning or execution.

Anecdotal evidence suggests that no one in the theater staff was ever advised of this arrangement during or after the renovation. (Current staff, including the general director, who has been at the theater from long before the renovation, and the current volunteer lighting technician and operator, were not aware of it.)

So the slider that "turned on" the AC power to the interface unit was never "turned on". In fact, it was among a large group of sliders that were believed to not control anything, and they were all taped together in the "off" position.

It would of course be desirable that this interface unit always receive AC power, not requiring the lighting operator to move a slider (or do anything else, even energize the console) to turn that power on. This outlook was confirmed by the manufacturer of the interface unit.

It seemed likely that the "electrically ambiguous" state of the low voltage control ports with the interface unit unpowered was the cause of the "flickering" of one of the two zones of the theatrical houselights. The mechanism of this was not determined.

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[14] In that situation, the electrical status of the control ports was "ambiguous".

8. CORRECTION OF THE PROBLEM

8.1 Introduction

In February and March of 2016, the corrective steps described below were taken.

8.2 AC power feed to the fixtures

On the two dimmers used to feed the AC to the house light fixtures, both already set to the "switched" mode (in which they can only be off or full on), the switching threshold was set to 1 (easily done on the CEM of the dimmer rack).

Now, whenever the control slider for a house light zone is moved off "zero", the dimmer turns on the AC power to the fixtures.

8.3 AC power to the interface unit

The first thought was to configure the dimmer that supplies the AC power to the interface unit (already configured as "switched"–that is, it can only be off or full on) to be on all the time, regardless of the state of the command to it from the console–a submode of the "switched" mode that is generally available in TEC dimmers. Thus, the AC power to the interface unit would not be dependent on the lighting operator turning a slider up (which in any case would not activate the dimmer when the console was turned off).

The manual for this model of dimmer rack clearly describes how to do that: by setting the switching threshold of the dimmer to "0".[15] But we found that the rack CEM would not permit any setting less than "1".

Subsequent contact with ETC as to why we cannot set the switching threshold to "0", as described in the manual, yielded the observation, "You should be able to set it to 0. There must be some bug in the software (in the CEM) that prevents that."

There is no prospect of software updating for the CEM.

So, instead (and this is in fact more intellectually satisfying), I replaced that dimmer with an ETC "continuous" module (type CC15). This has no circuitry, just a direct path from the circuit breakers to the outputs. It is intended to feed accessory items from the dimmer rack. It is perforce "always full on".

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[15] In a newer version of the CEM, for a dimmer that was configured in the switched mode, the threshold menu includes a special setting, "always on".

Figure 8. CC20 constant current module

ETC photo

Figure 8 shows a module of this type (actually a CC20[16]):

8.4 Inconsistency in the relative positions of the house light sliders

Ideally, this inconsistency would be cured by reversing the connection of the two house light AC feed circuits to the two dimmers that control the AC feed to the lights, and a corresponding reversal of the connection of the two low-voltage dimming control circuits to the two ports of the interface unit.

The latter step would be trivial, but the former step would require work with power circuits. Protocol suggested that this work would have to be done by a licensed electrician, presumably from the University staff (of course under technical direction of the author).

To avert the administrative complications of this, an alternate solution was implemented.

The association of the two sliders with the two AC power control dimmers, and the two dimming control circuits of the interface unit, was reversed by programming of the "patch mapping" in the console. Now the leftmost slider controls the left-hand zone of the theatrical house lights and the rightmost slider controls the right-hand zone.

9. AN ALTERNATIVE FOR THE AC POWER FEED TO THE FIXTURES

In fact, the arrangement recommended by ETC to feed "switched" AC power to LED fixtures is not to use a conventional dimmer (configured to the "switched" mode) but rather to use another type of module. It is physically interchangeable with a dimmer module, but instead of dimming circuitry has a power switching relay for each of its two circuits.[17]

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[16] The difference from the CC15 is in the rating of the circuit breakers, 20 A.

[17] This would be an ETC "relay" module, such as type R15 or R20, the difference being in the rating of its circuit breaker, 15 or 20 amperes.

This clearly would have been the best arrangement to put in place at the time of the upgrade.

But it does not seem that, at this point, there would be any actual advantage to changing to this configuration. I have not recommended that such a change be made.

10. BENEDICTION

Fiat lux, sed non nimium (let there be light, but not too much).

11. ACKNOWLEDGEMENTS

I would like to acknowledge the special assistance of the following in this challenging project:

- Connie Breding, Associate Professor of Theater Arts at NMSU-A and "general director" of the theater, for her overall support of the project.
- Nancy Montgomery, of the NMSU-A Physical Plant organization, for making available to me pivotal portions of the job drawings for the house lighting upgrade.
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- Robert Armstrong, Manager–Technical Sales and Product Support with Pathway Connectivity, the manufacturer of the DMX-512 interface device used in the system, for his great assistance as I learned about this matter.
- Steve Steele, Technical Support Specialist, Electronic Theater Controls, Inc., (ETC), for his assistance in this matter.
- Carla Kerr, my wife, and president of The Theatre on the Hill Guild, for her great technical assistance during the field work on this matter, and for her support of my several weeks' round-the-clock obsession with bringing this difficult matter to a successful conclusion. She was also the very capable copy editor of this article.

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