Risetime and Noise

December 5, 1996

## Risetime and Lamp Noise — what's the connection?

Everyone agrees that while a certain amount of dimmer noise at the rack is OK, noise at the lighting fixture is unacceptable. The popular wisdom is that the only way to prevent this dimmer–induced lamp noise is to specify high risetime dimmers, or to use sophisticated (and relatively fragile) IGBT switching.

While dimmer risetime is a factor, it's certainly not the whole story. To eliminate noise from dimmed lighting fixtures, filament design and fixture construction are far more significant factors than risetime.

**What is risetime anyway?**

Most dimmers in use today use a solid state device that switches current on at a precisely calculated point during each main's half-cycle – that's 120 times a second on 60 cycle supplies. Switching during the mid-section of the half wave results in a current surge that hits the dimmer output cables and the lamp filament like a wave hitting a breakwater – physically shocking the filament, and potentially giving rise to an audible 120Hz buzz.

Just as disturbing, load cabling will transmit the same pattern as low-frequency interference, which can, in certain circumstances, be picked up by audio and video equipment. This can normally be avoided by careful studio wiring layout, avoiding parallel runs of dimmer load and susceptible signal cables, but sometimes it's unavoidable, such as when all cable on a remote shoot have to pass through the same hole in a wall!

*Fig. 1*

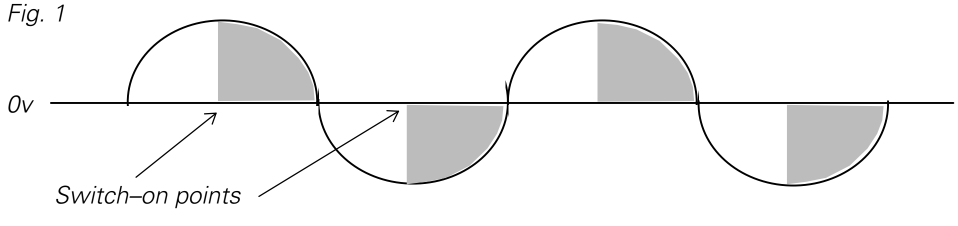
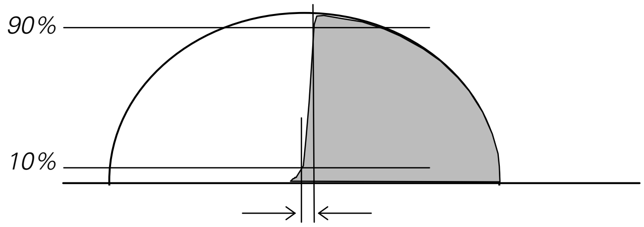



Figure 1 shows a typical case where a dimmer is firing halfway through each AC half cycle, producing a lamp level of around 50 percent. The current rises instantaneously at the switch–on point, and then switches off when the AC curve crosses zero volts (zero crossing).

In order to smooth the current rise, an inductor (choke) is normally connected in series with the switching device (SCR). The inductor retards the current rise sufficiently to reduce its impact on devices connected downstream. The degree of this retardation is called risetime, and is expressed in microseconds (µS). This should not be confused with Response Time, measured in milliseconds (mS), which is the time taken to ramp the dimmer output to a newly received control level. Sensor's response time is very fast, at about 26mS. Remember, a fast response time is generally considered to be a Good Thing, a fast risetime usually a Bad Thing.

To understand risetime better, look closely at one AC half–cycle:

Fig.2




Risetime (in μS)

Risetime is measured as the time taken for the output current to rise from 10 percent to 90 percent of its switch–on level. Generally speaking, the slower the risetime, the greater the reduction in noise.

It has been generally (and correctly) accepted in North America that a risetime of 350μS will provide adequate noise reduction for theatrical applications, and that 500μS is required for television studios, to avoid interference with audio and video systems. Much higher risetimes are sometimes called for in sensitive areas like concert halls, where very low ambient noise levels are required.

**Slew Rate**

It should be noted that risetime in itself is not very meaningful. What really matters is the *rate of rise*, or slew rate. A good slew rate is smooth and constant, with the same rate of rise across the whole risetime. Two dimmers with the same risetime might have radically different slew rates, and produce quite different results in terms of filament noise attenuation. Fortunately, most of the iron powder core chokes being used in today's dimmers provide a very even slew rate, so this is not generally a real-life issue.

**Load Factor**

Another point to bear in mind is that risetime values are always quoted based on nominal dimmer loading – 2.4kW on a 2.4kW dimmer. In reality, dimmer loads may be much less. One 575W fixture on a 2.4kW dimmer is common. There may be concerns that actual risetimes will be much reduced when dimmer loadings are low.

A feature of the iron powder core chokes used in ETC Sensor dimmers is that they perform very well on reduced loads. We specify that half-load risetime shall be 80 percent of that for full load. In fact, a single Source Four connected to a Sensor D20 350μS dimmer will result in a risetime of around 300μS – not a significant reduction and much better than our own specification.

## Acoustic Noise – the real issue

Since any well-designed dimmer should provide low-frequency interference suppression adequate for most purposes, the real issue remaining is acoustic noise, which comes in two forms: filament buzz, and thermal cycling.

## Filament Buzz

We *know* it's a problem (isn't it?), so we try to limit it by increasing dimmer risetime

This is logical, but it overlooks one very important question – how susceptible to noise is the filament in the first place? Stage and studio lamps comprise a number of coiled filaments, arrayed on a grid of wire supports. It is generally true that a big, straggly filament, such as those found in scoops, fresnels and cyclorama floods, are going to make a lot more noise than the kind of compact filament used in an ellipsoidal spotlight.

To bear this out, ETC conducted a range of acoustic tests at an independent research facility, which came up with some very interesting findings.

We wanted to know whether the audible noise from the filament of the HPL lamp used in ETC Source Four, Source Four jr and Source Four PAR fixtures, would be significantly affected by dimmer risetime. We also wanted to know whether there would be any significant difference between its use with conventional and reverse phase-angle IGBT dimmers. As a point of interest, we also ran a parallel test, using a 1kW scoop (a possible worst case lamp). Tests were run with the dimmer level set to produce the maximum noise at the filament. Here are the results of the testing.

| Dimmer Type | Risetime | Source Four, HPL lamp, dBA @ 1m | 1kW Scoop, 1kW PS/52 lamp, dBA @ 1m |
|---|---|---|---|
| ETC Sensor D20 | 350µS | 2 | 37 |
| ETC Sensor D20 | 500µS | 6 | 35 |
| ETC Sensor D20 | 800µS | 4 | 32 |
| Rosco IPS | na* | 0 | 34 |

** The IPS dimmer uses both forward and reverse phase angle firing mode. Rise and fall times are controlled electronically and are claimed to be 800µS.*

In all cases, the HPL filament is inaudible. None of these levels can be heard by the human ear.

By contrast, the scoop certainly *is* audible, but demonstrates that there is not a great deal of difference in sound pressure level between any of the dimmers tested. Of those, the 800µS Sensor was the best, but the differences between the IPS and Sensor 500µS and 800µS would be imperceptible. You would just barely notice the difference between any of these and the standard Sensor 350µS dimmer.

*So, by far the most significant factor here is the filament, not the dimmer.*

## Guidelines

Increasing dimmer risetime adds cost and reduces dimmer efficiency, resulting in:

| | 350µS | 500µS | 800µS |
|---|---|---|---|
| Lamp Socket Voltage (assumes 1.5V cable losses) | 115 volts | 113 volts | 109 volts |
| Lamp Color Temperature | 3,200 | 3,180 | 3,140 |
| Light Output (at full) | 100% | 94% | 83% |
| Dimmer room heat (per kW) | 29 watts | 46 watts | 79 watts |

So, you don't want to increase risetime unless you *really* have to. Here are some common-sense guidelines which will help in planning new, noise-critical installations.

**TV Studios**

Use a 500µS risetime dimmer as standard. The typical TV studio contains a lot of planar filament lamps in fresnel fixtures, as well as linear lamps in cyc lights. The optimum level of noise prevention would seem to be 500µS. This should also provide adequate protection against inductive interference with audio and video systems, even if cables are run close to each other for short distances. The additional expense of going to 800µS will result in noise reductions which will be imperceptible.

**Theaters**

Look at the fixtures to be used first, and then choose the dimmers. Since most theaters contain 80-90percent ellipsoidal spotlights, it seems logical to choose Source Four, which is demonstrably the best ellipsoidal currently available. This of course has the added benefit that you'd be using the HPL lamp, which is inherently quiet, irrespective of the dimmer used.

There's no point in spending more on the dimmers than is necessary, and 350µS risetime is therefore the obvious choice. Bear in mind that, even if the theater will be using other sources, such as PAR64s and Fresnels, they will not typically be close to the audience, so their acoustic properties are much less critical.

**Concert Halls**

The same argument applies as for theaters. It is now possible to design concert hall lighting using a mix of energy efficient, cool beam fixtures, with inherently quiet filaments. We recommend MCM (cool beam) Source Four PARs for concert platform downlights. The MCM PARs project much less heat on performers and instruments, and are acoustically silent. Source Four fixtures for front and side fill share both of these qualities.

For musicians, keeping instruments cool is critically important – when they get hot, they can go out of tune.

A side benefit is the use of 575W fixtures in place of conventional 1kW types, resulting in the generation of much less heat. This presents a lower load to the air handling systems, which can therefore function at a lower, quieter, level.

Having chosen light sources which are inherently silent, the choice of dimmer risetime becomes non-critical, and 350µS should be perfectly adequate. If conventional low-wattage light bulbs are to be used in houselight circuits, their straggly filaments may be prone to dimmer-induced noise. Installing a number of 500µS dimmer modules for houselights may therefore be justifiable.

## Thermal Cycling

This may actually be more significant than filament buzz in terms of its capacity to annoy an audience. What we're referring to are the loud cracks and pops made by some lighting fixtures as they heat up and cool down. This has nothing whatsoever to do with the dimmer, or the lamp. It's a fixture design issue.

In conventional ellipsoidal fixtures with aluminum mirrors, and constructed from a combination of sheet metal and cast or extruded aluminum components, much of the heat emitted from the filament is projected through the optical train. This means that the gate, usually made from steel or stainless steel components, heats up much faster than the other components. Add to that the differing coefficients of expansion of the various materials used, and the cracking and popping you hear as they all expand at different rates is not surprising. And it's not over when the fixture stabilizes at its maximum temperature. Switch the fixture off, or fade it to a lower level, and the whole process happens again, in reverse.

ETC Source Four fixtures have an enormous advantage in this regard. Firstly, Source Four's dichroic mirror removes most of the heat from the beam, so the mechanical components in front of the reflector heat up more slowly, and stay much cooler. Second, the components that do expand as they get warm - the reflector housing and the lampholder casting - all have the same coefficient of expansion, and go through their thermal cycles at the same rate, minimizing the noises resulting from differential rates of expansion/contraction. The glass mirror does expand faster than the castings around it, but this is absorbed by the unique isolation characteristics of the Source Four mirror mountings.

For Source Four PAR, the mirror is made of the same cast aluminum as the entire fixture, eliminating *all* thermal expansion differences.

The factors which make a difference are (a) use of a dichroic reflector (cold mirror), and (b) use of a small number of components with a like coefficient of expansion.

There's a simple test, which anyone can do. Just switch on a fixture - and wait. When it reaches thermal equilibrium (probably about ten minutes for a typical ellipsoidal), switch it off. Compare the noise during warm-up and cool-down.

## Further Developments

We are planning further tests to determine and quantify acoustic differences between a wider range of lamp types, and to verify the differences in thermal cycling noise levels in various fixtures. When this work has been done, we shall publish the results in greater detail.

## Summary

- Filament design is much more significant than dimmer risetime in determining audible noise.
- There is no audible noise from an HPL filament, irrespective of dimmer type.
- With inherently noisy filaments, there is no audible difference in noise between Sensor 500µS, Sensor 800µS and Rosco IPS dimming. There *is* a perceptible difference between these and the Sensor 350µS dimmer.
- Theater and Concert Halls: Use Source Four and 350µS dimmers.
- TV Studios: Use 500µS risetime dimmers, to cope with Fresnels, cyc lights etc.
- Thermal cycling is just as big an issue as filament buzz. Source Four performs much better than casting and sheet metal construction fixtures. The dichroic mirror is also significant.

TB/11/6/96