Dimming Fluorescent Lamps

Dimming fluorescent lamps is not all that easy to do. If you reduce power to the lamp, the filaments will n as hot, and will not be able to thermionically emit electrons as easily. If the filaments get too cool by dimm the lamp greatly, usually the lamp will just go out. If you force current to continue flowing while the electr are at an improper temperature, then severe rapid degradation of the thermionic material on the filaments i likely.

For more details, look in this document describing discharge mechanics and a few other technical aspects discharge lamps.

Reducing the voltage to most ordinary fluorescent fixtures seems to be largely successful for a small amou dimming, up to 30 to 50 percent dimming. This seems to usually work for preheat fixtures and rapid start fixtures of 40 watts or less. This may work even slightly better with 40 watt rapid start fixtures fitted with watt 4 foot T12 bulbs.

I do not recommend this for the dual-20 watt "trigger start" fixture, which sometimes barely works at full voltage.

If the bulbs intermittently or occaisionally go out and restart or try with difficulty to restart, you have defin dimmed them too much. They need more power. Failure to give the bulbs enough power to run nice and smoothly is probably bad for them. Frequent starting attempts are hard on the starters if this happens in a preheat fixture.

The effect of slight dimming on life expectancy of the bulbs is uncertain.

To Get Major Dimming of Fluorescent Lamps

To effectively, reliably and safely dim fluorescent lamps below around half brightness or so, you need spe equipment that may only work properly with a specific lamp. Such equipment typically gives some power the filaments to keep them at a workable temperature while the current flowing through the bulb is greatly reduced.

If you want to try this yourself, I recommend against trying to just reduce voltage to the ballast to greatly reduce current flowing through the lamp. Here's why: (Example using a simple choke or inductor or "react ballast)

Suppose you have the tube and the choke in series, powered by a variable current source, as opposed to a variable voltage source. Suppose you had optimum filament heating regardless of current through the lamp Due to the "negative resistance" characteristic most gas discharges have, the voltage across the tube will increase as current is decreased. In fact, there will be a point at which the combined tube-ballast voltage is minimized, and the current will typically be high enough to run the bulb at 20 to 40 percent of its normal brightness. This minimum voltage across the lamp-ballast combination is indeed the minimum voltage tha work at all, and the discharge will probably not be too stable if you are not much above this voltage. This means that it is typically impossible to very greatly dim a fluorescent tube just by reducing voltage.

Because of this, major dimming requires impedance-varying means, current-varying means, or something similarly fancy such as pulse-width-modulation. And, you still need to properly heat the filaments (require amount can even vary with degree of dimming) to run greatly dimmed lamps without filament coating dam or at all.

designed by an expert. Such a system may only work properly with very specific bulbs, not just anything o same size or even same size and rated wattage. Avoid substituting preheat for rapid start or vice versa. You may also need to use tubes only of a specific diameter, even if they are normally interchangeable with tube a different diameter.

UPDATE 6/17/2001 - There has been a thread on this in mid-June 2001 in the newsgroup sci.engr.lighting Additional rules to follow if more than one lamp is controlled by the same dimmer control:

1. All lamps (bulbs) controlled by any given dimmer control should be of the same brand, same wattage, a replaced all at once ("group relamping") when they start wearing out.

2. All ballasts controlled by any given control should be of the same brand and model.

Violating this can have the lamps dim unequally. In addition, the lamps may dim unequally or work irregu while dimmed until they have been "seasoned" or broken in. This is widely regarded as requiring 10 hours operation at full power.

One of the experts is Lutron. This way to their fluorescent dimming ballast info.

Other major fluorescent lamp ballast manufacturers also have dimming ones.

If you want to build your own dimming ballast, one way may be to use the International Rectifier 21591 IC First read up on it and the associated application notes in the International Rectifier website.

Other IC makers also offer parts and have online datasheets and application notes useful for fluorescent lar dimming, electronic ballasts and the like. But if you are not a seasoned electronic project builder, do not ex to get a dimming fluorescent lamp ballast working next weekend!

Here are some exceptions!

1. There is such a thing as a cold-cathode fluorescent lamp. They resemble "neon" signs, but are generally slightly greater diameter. They are not too standard nor widely available. They are also typically a bit less efficient than hot-cathode lamps. However, they can be dimmed to any degree without any chance of dama them or causing any excessive wear. It should also be noted that starting these frequently does not cause ar excessive wear. (If excessive current flows during the first half-cycle of operation, a generally insignifican amount of extra wear occurs.)

Although dimming these is safe, there is usually a limit to degree of dimming just by reducing voltage. Bel certain point, these usually just go out. Fortunately, these usually dim more than hot-cathode lamps and sta

There are also miniature cold cathode fluorescent lamps, often used for backlighting LCD screens and in ir scanners. (LCD screens sometimes use other means of lighting such as a white electroluminescent panel.) I the large ones, miniature cold cathode fluorescent lamps are dimmable.

2. Many "neon" signs are actually a variation of cold-cathode fluorescent lamps!

3. There are dimmable, electrodeless compact fluorescent lamps generally known as induction lamps. Thes now available from electrical/lighting supply shops. These use an even different way to get electricity from metal to gas. These lamps work at a very high frequency, which lets current flow capacitively through the g or use induction to get power from a coil to the mercury vapor discharge. No metal electrodes touch the mercury vapor discharge. These lamps should work at least reasonably well with ordinary light dimmers.

at Home Depot. They have conventional electrodes and can run into problems from severe dimming, but a
tested to work reasonably on all common dimmers and without significant risk of fire or catastrophic failu
even if the dimmer malfunctions.

One more thing to watch out for!

Light of typical "cool-white" fluorescent color, or any similar color, often has a dreary gray effect when it
dim. If you are using a dimmable fluorescent fixture in the home, you may want to use it with "warm white
bulbs, or something similar with a color temperature no more than about 3,500 Kelvin.

Above written by Don Klipstein.

Now, for some stories and suggestions from others on dimming of fluorescent lamps.

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Sam's dimming experiments:  (sam@repairfaq.org)
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OK, I did some experiments using both a dual-lamp Circline fixture and a
typical dual-40 W bulb shop light - both with magnetic (rapid start
probably) ballasts.

The common wisdom is not entirely correct. You can dim fluorescents.
I do not know about the long term reliability or stress on the ballasts
but I could achieve dimming down to around 30 to 50 percent brightness
(using my standard-issue eye-balls, calibrated annually) with a relatively
stable light output - no excessive flicker and no tendency to go out (though
to get down to the low end requires starting high and backing off).

I tried both a Variac and a cheap light dimmer with similar results.

(If you want to go below the 30-50 percent threshold reliably, however,
some means must be provided to keep the filaments hot.)

How about long term reliability?

This was a 'quick' experiment. All I did was observe the light output.
A cheap light dimmer just means the kind you get at a home center for $4
or so. Long term reliability is certainly not known. The purpose was
simply to show that just because something is stated to be impossible
does not always mean that it is - not a suggestion that it is.


Dimming fluorescents 2:
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(From: John Shotton (J.A.Shotton@bnr.co.uk)).

I have been running four 5ft (1.5inch dia) tubes like this for 15 years.

The circuits (4 off) are resonant start, i.e. there is a second winding on
the ballast which connects across the tube in series with a 8uF capacitor
(remember in the UK the supply is 230volts). Thus the heaters are
energised at all times.

I originally experimented with a moving iron wattmeter (measures true rms
power) a photodetector and a variac. Allowing for ballast loss (computed
from current and resistance) the light output was directly proportional to
power consumption. The lamps would dim to around 10% but they wouldn't
start at this level.
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transformer with several taps so that I can get around 6 light levels, though they will not start on the two lowest settings and is slow at starting on the next two settings. I cant remember offhand what light output they will self start on, but it must be around 30-40%. If you are interested e-mail me and I'll try and dig up my origonal results.

As for tube life. The lights are on most of the time it is dark from around 5pm till 1am. I fitted my third set of tubes about two years ago, and this was not because the second set had failed but because we wanted a change from daylight color-matching to tri-phosphor 2700degK - I've still got the second set should we decide to revert to the daylight effect.

When I did my original experiments I also tried it with normal ballast circuits, i.e. with a starter across the tubes. I cant remember the results, but I didn't persue it so they can't have been good. I believe it would work if the heaters were energised at all times from a seperate winding.

Dimming fluorescents 3:

(From: David Gibson (dgibson@microconsultants.com)).

My company designed a fluorescent dimmer some years ago. It dims 40 x 40W tubes fitted with high power factor inductor/capacitor control gear as used in Australia and other 220-240V countries. Its main claim to fame is that it can cope with the highly capacitive nature of power factor corrected luminaires, and is hence easily retrofitted. A number of large office buildings in Australia are fitted with our/my dimmer.

Unfortunately, the standard ballast used in the US (and I presume other 120V countries) uses, I believe, a resonant circuit which cannot be dimmed with our design.

The luminaires it does work with contain basically a tube/choke series combination across the line, plus a power factor correction cap also across the line. The lamp filaments are heated only during turn-on by a starter switch that completes an additional circuit at startup.

The purpose of these dimmers is energy saving. A photocell measures the ambient light, and maintains a reasonable constant light level in the office. Energy saving is possible because lighting systems must be overdesigned to allow for lumen depreciation due to lamp ageing, plus the fact that daylight allows lower levels of electric light.

Performance is as follows:

Dimming range: We budget for 40% of light output (60% reduction). In the lab we have achieved down to 26%.

Power saving: At 40% light power is about 35% (yup, you win twice)

Lamp savings: In a 26 storey building in Sydney, for which good figures are available, lamp replacement rate was reduced to about 40%, i.e. we more than doubled lamp life.

Overall power savings: Same building, independently audited figures, lighting bill was reduced by 45%. This included secondary savings from reduced airconditioning and a time switching system integral to our design which ensures lights are off at night etc.

Power factor improvement. Undimmed tubes have a power factor of

Line harmonics: During dimming the percentage of harmonics increases as current drops, but the absolute level (total amps) decreases.

(The power companies love it!).

Our design uses a hard-won, patented proprietary dimming method which has nothing to do with triacs. It uses high frequency switching and some very fast and smart firmware.

The same lamps can be dimmed using triacs, but the power factor correction caps must be removed from every fitting. The required triac circuit is slightly modified; the patents belong to a competitor. Its power factor is lousy.

Dimming fluorescents 4:

(From: Andrew Gabriel (andrew@cucumber.demon.co.uk)).

I have made a dimming fluorescent fitting out of a standard fitting (which started out as a switch-start series ballast), and an ordinary phase control (triac) dimmer.

My only reservation is that this is all for standard 200-250V switchstart flourescents - when I've seen American books describing flourescent lamp control gear, it is quite different, presumably because of the lower mains voltage being unsuitable without more complex control gear.

There are three significant things you have to do:

1 The lamp extinguishes at around half power because the filaments at each end are no longer heated sufficiently during one half cycle's bombardment with electrons to emit electrons in the following half-cycle. I overcame this by supplying the filaments with a few volts from a miniture mains transformer with a pair of isolated low voltage secondaries, around 4 volts IIRC for a 5 foot 80W fitting (it doesn't need to be anywhere near enough voltage for a visible glow from them). Also, with this transformer fitted (and the switch-starter removed), the tube actually fires up all by itself without flashing, since it is now really rapid start fitting.

  I also have a switch to disable the dimmer, and when disabled, it also switches the filament transformer's primary to be across the tube rather than the mains. Thus initially when the tube is non-conducting and the tube voltage is 240V, the filaments are heated, but as the tube starts up and its voltage drops to its running value of around 100V, the additional filament heating provided by the transformer, which is unnecessary when the lamp is running normally, is all but disabled.

2 The second problem is that all cheap triac dimmers fire the triac with a pulse and expect the triac to continue conducting until the zero crossing point (or more strictly, zero current). However, an inductive load takes time to start conducting, and at the end of the triac firing pulse, the current through the triac will not have reached the minimum holding current when the dimmer is set low, which also results in sudden extinguishing of the tube when dimming down. To overcome this, I added a small incandescent lamp to the output load on the dimmer, in my case it's a 40W spotlight pointing at a painting, so it's a useful additional feature.

problem with a cheap dimmer, but it wasn't.

3 Ensure the power factor correction capacitor is before the dimmer, or you'll destroy the triac. In a commercial environment, I think I would also include some protection against typical triac failure modes of a one-way open or short, which would result in high levels of DC through the inductor which will overheat it and/or destroy the lamp.

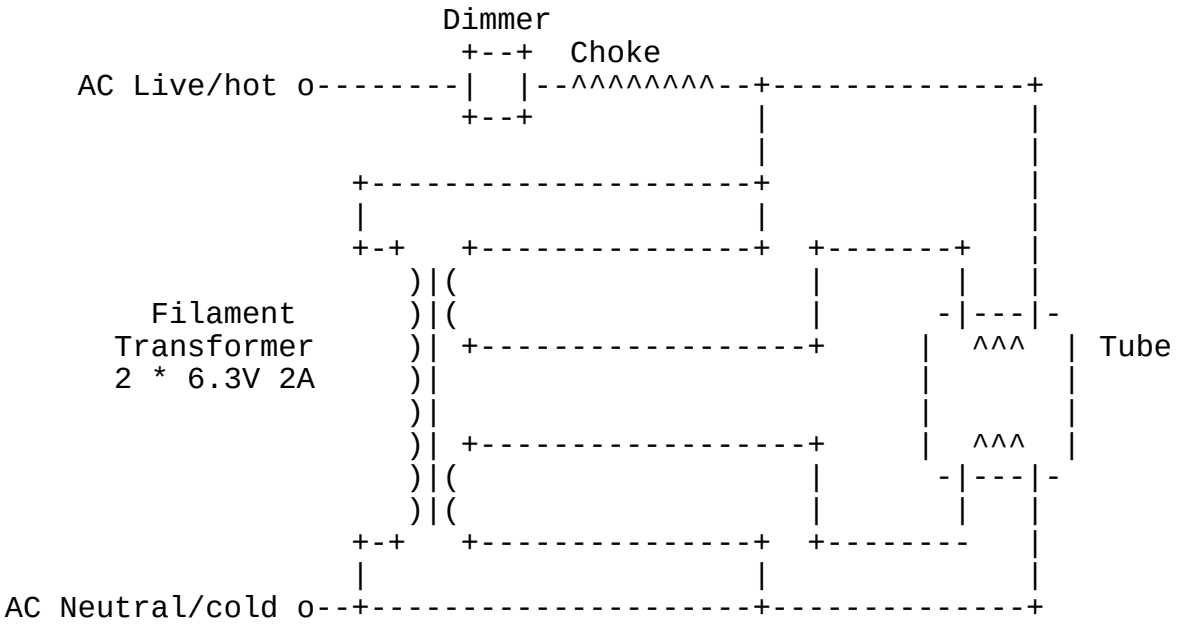
BTW, I did all this 20 years ago as a teenager. However, the fitting in question is still running, and has never required a lamp change in that time, nor is there any blackening at the ends of the tube. It is normally run at full brightness with the dimmer disabled.

Dimming fluorescents 5:

(From: Peter Miller (p.miller@elec.gla.ac.uk)).

I've tinkered a bit... the trick is to keep the filaments at the ends of the tubes warm. You will NOT be able to dim down to zero - probably about 25% at best.

Here is a possible circuit:



The lamp must be in a earthed / grounded reflector fitting. The metal end caps of the tube must be connected to the reflector. The dimmer MUST be a 'hard fired' dimmer capable of operating an inductive load. The choke is a standard type for the tube in use. Play with an inexpensive everyday tube before using expensive aquaria ones. With a 240V supply a 4 ft 40W tube operates ok. The main difficulty with this circuit is in getting the tube to start - starting is greatly helped by a grounded reflector fitting and connecting the metal end caps of the tube to the reflector (Dont ask - it works!). The transformer can be a standard valve filament transformer - use a separate transformer for each end of the tube if you are unsure of the insulation between the secondaries of any transformer that you buy. As the tube draws less current the voltage across it rises, turning up the heat in the filaments. At start up, maximum voltage is across the lamp and so the filaments are fully on. All dimming ballasts/chokes use some scheme to add extra heat to the filaments at dim running. An undimmed tube draws enough current to keep the filaments warm by itself. There is no glow starter or other

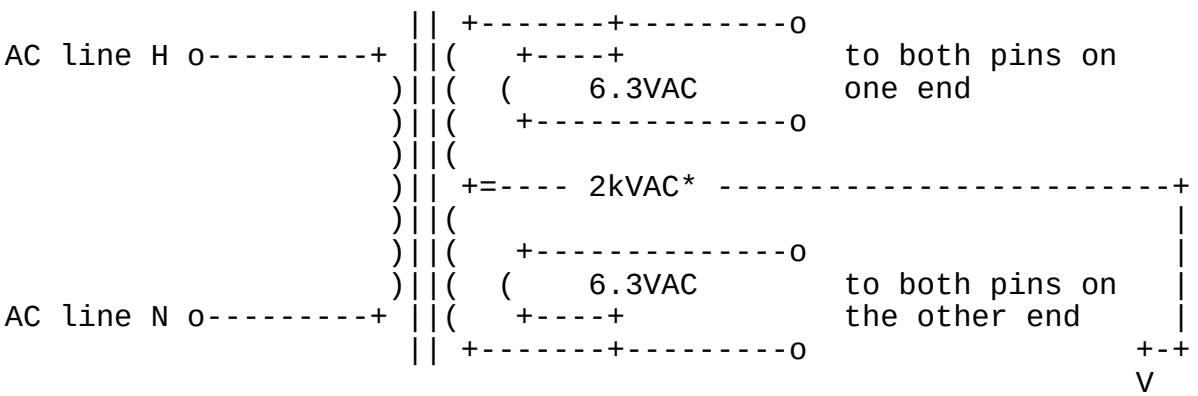
tubes are a real pain to start.

Dimming fluorescents 6:

(From: Bruce G Bostwick (llbgb@utxdp.dp.utexas.edu)).

This applies to rapid start fixtures.

If the fixture says "RAPID START" somewhere on it or on the package it came in, the internal schematic will be roughly as follows:



Most of the 48" 40-watt "shop light" type of bulbs use this. *The high voltage winding of the secondary is on a branch magnetic circuit that limits the output current to the mercury discharge. Open circuit voltage will be in the kilovolt range, while the voltage across a lighted tube will be somewhat less than that and _exceedingly_ non-sinusoidal.

If you're using the big bulbs (F96T12's for example) the ballast will only have the high voltage winding and the cathodes are heated by ionic bombardment from the mercury arc. These take a bit longer to light up when the power is turned on.

If you want instantaneous on/off control, I'd suggest using 4-footers and linking up two ballasts in such a way that the cathode heaters are driven from one which is always on, and the arc is driven from the other which is turned on and off as you desire. They won't last too long that way, but it will work better for show effects. The cathodes could be driven from a pair of low-voltage filament transformers, but be sure to isolate them well -- or you could use a ballast with a blown HV secondary ...

Another suggestion: Use solid-state relays to drive the ballast primaries. These are fairly cheap and provide clean current-zero-crossing switching even with very reactive loads (I've used them for such! ;-) and provide a neat and rugged way to connect the lights to logic controls such as your computer -- great for light sequencing.

Dimming fluorescents 7:

(From: Andrew Gabriel (andrew@cucumber.demon.co.uk)).
Hugh T. Hoskins writes:
>The meeting room of a group to which I belong is illuminated by dimmable
>fluorescent lighting. The technology is vintage 1965. Each fixture has
>one GE # 6G5001 Dimming Ballast for each of the 40w tubes, and there is
>one GE # 6G5005 Auxiliary Ballast for every 6 to 8 Dimming Ballasts.
>The total count is 84 tubes, 84 ballasts, and 12 auxiliaries. All of
>the Auxiliary Ballasts are fed from a single GE # 6G5006 Intensity

>The problem at this point is that one of the Auxiliary Ballasts has failed.

I'm trying to imagine what this Auxiliary Ballast does, and the only thing I can think of is providing a filament supply independant of the dimming supply? It would help to know how it's connected.

If this is the case, it would be possible to make one from lots of small mains transformers, one per filament (or fewer if multiple secondaries are well isolated from each other). It might be more intellegent than this, i.e. only powering the filaments while the tube is non-conducting initially at switch-on and when power output is dimmed below about halfway, but replicating this additional functionality would not be essential.

There was (and maybe still is) a UK firm producing dimming (and rapid start) ballasts, called TranStar. However, their design did not use an "Auxiliary Ballast", just one rapid start dimming ballast per one or two tubes.

End of various anectdotes and suggestions from others on dimming of fluorescent lamps.

Written by Don Klipstein.

With help and encouragement by Sam Goldwasser (sam@repairfaq.org).

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