The R390A Ballast tube (RT510/3TF7)
Larry Haney, 07-29-2023, version 2

The R390A Ballast tube (RT510/3TF7) in the IF deck has been a very popular discussion item on the list forum, off and on for ever. And rightly so, it is expensive, not very reliable and somewhat fragile. This discussion is so popular that it has its own section in the 'Pearls' labeled ‘Ballast tube’, and what a section it is - 239 pages.

The reason I'm writing this is that the discussions are quite repetative and the important information can be condensed into a few pages. And, it would take a person a very long time to go through all the entries in the Pearls, so hopefully, this will save someone a lot of time.

There is a 2nd tube number besides the 3TF7 that also works correctly in our 390s – a **TJ311M01**, and there is even a 3rd option – a **2HTF11B** (courtesy of Jacques Fortin).

My summary of all the information in the Pearls Ballast tube section is at the end of this document.

Here's some entries in the 'Ballast tube' section I thought were interesting:

Date: Wed, 27 Jan 1999 15:46:03 -0600
From: Nolan Lee <nlee 'at' gs.verio.net>
Subject: [R-390] Tidbits from Amperite on Ballast Tubes

OK, after listening to all of the hype and BS about the ballast tubes in the R390A, I figured I'd research it a bit and post my findings. Put your boots on bubba, it's gonna get deep... <grin> If one of you guys is saving stuff for an R390A FAQ, the info below would go well in it. Diggin' thru a 1982 Amperite AM-82 application quide, I found a few interesting things that I'll pass on to you guys. If you deal with a distributor that handles Amperite, get them to get you a copy, it's an interesting book. The resistance wire is usually iron, and the glass envelope is filled with either hydrogen or helium gas for heat conductivity. The glass envelope runs about 160 degrees F. Current regulation is usually within plus or minus 1%.. They work with either AC, DC, or pulsating current. When the current in the circuit is increased to a high enough level for the regulating function to start working, only a small portion of the filament will glow. As the voltage across the ballast increases, more and more of the filament will glow. When the entire filament is glowing, you're at "max" and any additional increase will overheat the tube and shorten it's life.

The rated life expectancy when operated as recommended within it's ratings is 2000 hours. Run it at "max" all of the time and it's only 1000 hours. Run it at 80% of max and it's 5000 hours. Here's a direct quote from Amperite AM-82 that you'll really find interesting:

---snip---
DUTY CYCLE DEPENDENT
If a steady voltage of a value in the middle of the operating range is applied to the tube continuously, it's life will be tens of thousands of hours. Opening and closing the circuit with the resulting expanding and contracting of the filament greatly reduces the life of the tube. Also, as in incandescent lamps, turning the unit on and off many times will reduce it's life especially if the unit if operated near it's maximum voltage. If full voltage is applied to the tube, the circuit may be opened and closed only a few hundred

times before the current is outside of the limits or the
filament is burned out. Thus the life of the tube will be determined entirely by it's duty cycle.
---snip---

I figure that over the last 23+ years that I've had the old Collins, it's been on for "24 and 7" for at least 15 of those years. 15 years is 131,400 hours. That original 3TF7 is still going just fine. I'm not saying that it won't puke when I finish the overhaul of the receiver and power it up, but even if it did, it gave pretty damn good service.
The folks at Amperite that I've dealt with have been a hell of a nice bunch. I needed some information on some odd "non standard" numbered ballast tubes. They transferred me to an engineer and I received all of the answers that I needed. Very sharp and friendly bunch of people.

For what it's worth, there's another part number for the 3TF7 that was used for tubes that had different testing requirements than the standard mil-spec and was for a Govt contract in 1978, and not for civilian or commercial sales. After I corner the market on them I'll post the number. <grin> Just joking.... a friend of mine found a stash of them and sent me three of them last week or so to research and experiment with. After talking to the engineer at Amperite a few hours ago, there's no need to experiment. I now know exactly what they are. The end flap of the boxes is labeled as follows:

Amperite
TJ311M01
The side panel is labeled as follows:
5905-00-681-4707 Resistor Current Regulating 1 ea.
DLA900 78-M-T921 A 5/78
The tubes themselves are labeled as follows:
(circled Amperite "A" with lightening bolt)
Amperite TJ311M01 Ballast 820
So, if you spot any of these TJ311M01 marked ballast tubes, grab a few, they'll work just fine in your R390A. I'd be curious to hear from any of you that bought an R390A that contained one of these or any of you that have information on the contract number or the FSN for them, listed above.

From: wa6ube 'at' aol.com
Date: 10 Jan 1998 18:25:46 GMT
Subject: Re: R390A mods/fixes anywhere?

I have a couple of R390 receivers. One of the more common problems is having a failure of the 3TF7 Ballast tube that is used in series with the filaments of the PTO and VFO tube.
Note that ALL of the filaments in the R390 are in various forms of series connected circuits in order that all the various tubes can have their correct filament voltages obtained from a 25 volt power source.

* Note that V508 and V701's filaments are in series.
* V508 is a type 5749 tube and is used in the BFO oscillator circuit.
* V701 is also a 5749 tube in the PTO oscillator.

Because both of these circuits effect the frequency stability of the receiver, i.e. if the PTO or BFO freq were to shift, then the received signal would also appear to shift, it is important that the stability of both

of these two circuits are held to reasonable tolerances. The purpose of the 3TF7 ballast tube is to allow the two 5749's to be powered off of the 25 volt filament supply, AND also allow an amount of filament current regulation. This is so that line voltage jumps won't pull the frequency of these two oscillator circuits. New 3TF7's can be expensive I've seen them advertized NEW for around $80.00 ea several years ago. Since one of the functions of the 3TF7 is to act as a series dropping resistor to allow 12 volts @ 300 ma for the two 5749 filaments. that are in series, I came up with a simple replacement for this ballast tube:

* move the wire on pin #2 of the 3TF7 socket to Pin #4...
* move the wire on pin#7 of the 3TF7 socket to Pin #5.
* Plug in a 12BY7A or 12BH7 tube into the socket in place of the 3TF7.

Kind of weird to have a tube with a cathode, grids, and a plate in it only being used for it's filament, but, hey it works and eliminates the need for a rare and expensive ballast tube. :-)

Patricia Gibbons <wa6ube 'at' aol.com>
City of San Jose - ITD-Communications Mobile radio repair shop supervisor
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Larry Haney - Instead of moving the wiring on the RT510 socket, I'd suggest adding 2 jumpers so that either tube can be used.

Date: Thu, 29 Jan 1998 10:06:57 -0600
From: clarence thompson <clarence 'at' kilgore.net>
Subject: [R-390] Solid State

Good Morning all, I have a 390 that has a solid state device in the place of the ballast tube,and has been in there since I received the 390; it seems to work just fine?? what is this replacement for the ballast tube? .... and will
it effect the proper operation of this fine receiver?

Date: Thu, 29 Jan 1998 23:28:48 -0600
From: "Dr. Gerald N. Johnson, P.E." <geraldj 'at' ames.net>
Subject: Re: [R-390] Solid State

Well yes, but... The circuit is AC and the regulator prefers DC. There was a mod for that problem in the NC-300 published about a third century ago that added a half wave rectifier then a solid state voltage regulator. That's a little easier to set up, at least in concept. The solution of using a 12 volt tube and shorting the ballast will keep the radio working, but tosses out the cathode temperature stabilization that helps keep the radio from slow drifts.

Right now, my 390 is sitting in the barn waiting for me to build a house nearby, then maybe I'll dig it out and see about making it work. If I was to work on the ballast circuit, I think what I would do would be to build a current regulator out of a LM317K, and put it in the middle of a bridge rectifier. E.g. I'd run the AC terminals of the rectifier to the supply and to the tube, the two ballast terminals, and then I'd run the of the bridge to the input of the current regulator, and - of the bridge to the output of the current regulator.

Setting the current would be more of a problem,
probably shoot for 600 ma on peaks, and then turn it up until the tube drew adequate current to match its operation on 600 ma AC (providing it was 600 ma instead of 300ma. that was needed). Whatever the current, I'd set for that current peak and see if it worked, look at the voltage on the tube with a scope and see how much higher I needed to make it to get the desired heat into the tube. The stability of such an arrangement would probably be 50 times or so better than the ballast tube. That's what I'd do. I KNOW the diode bridge scheme will work because I used it 15 or 20
years ago to use a single transistor to regulate the AC current to an alternator's field coil when I couldn't get access to the alternator's rectifier but wanted to add a voltage regulator.

Date: Sat, 21 Feb 1998 21:58:48 +0000
From: "Roger D. Johnson" <n1rj 'at' ime.net>
Subject: Re: [R-390] Ballast tube in 390A

The ballast tube is there for the same reasons as the crystal ovens. This is a military receiver designed to operate under extremes of temperature and voltage. Many of these were used in mobile radio sets powered by generators (AN/GRC-26D for instance). In normal home useage, I'd turn the ovens off and power the oscillator filaments from the 6.3 volt line.
GL, Roger

Larry Haney - For those of you considering replacing the Ballast with a resistor - it should be 5 W, and about 42 ohms (this value is not critical).

Date: Sun, 22 Feb 1998 10:07:12 -0600
From: "Dr. Gerald N. Johnson, P.E." <geraldj 'at' ames.net>
Subject: Re: [R-390] Ballast tube in 390A

I compute the value should be 42 ohms...73, Jerry, K0CQ

Date: Sat, 27 Jun 1998 12:27:33 -0500
From: "Dr. Gerald N. Johnson, P.E." <geraldj 'at' ames.net>
Subject: Re: [R-390] RT510/3TF7

>The former Army tech who sold me my R-390As said to use a 50 Ohm 5W power resistor in place of the >ballast tube. I do and it works fine. Just bend the leads and stick in the appropriate holes in the socket. >The "ballast" limits filament inrush current to the BFO and the PTO oscillator tubes (that bright orange >light when you first turn on a tube). You can also use any tube with a 12.6 V filament connected to the >appropriate pins. The "purists" insist on the 3TF7; I think they're a waste of money.

Are you sure that tube life hasn't been cut from 102,000 hours to 59,000 hours? Are you sure that stability specs are met with line voltages varying from 98 to 142? and ambient temperature varying from

2 to 40¯C? Do any of these side effects affect your operation? If not the resistor works well. Doesn't limit the in-rush current as well as the 3TF7 or my solid state circuit, but does cut it down.
73, Jerry, K0CQ

Date: Sat, 27 Jun 1998 16:08:20 -0500
From: Nolan Lee
Subject: Re: [R-390] RT510/3FT7

It's funny, but in over twenty three years with probably a half a dozen different R390A's I never had a 3TF7 fail. I've had to replace missing ones but I've never had one fail in service. I don't see why so many people are worried about the thing. Granted, I keep spares, but they're mainly in the event that I pickup a radio that's missing the 3TF7. If the radio is operated with 115 Volt input as designed, are these really prone to failure? I supose that with ~125 volt or so input voltage, the filament voltages would be about 10% higher than they should be. I'd imagine that this would shorten the life of the tubes and the 3TF7. How many of you guys run your radios at the input voltage that they were designed for?

Date: Sat, 27 Jun 1998 15:44:44 -0500
From: "Dr. Gerald N. Johnson, P.E."
Subject: Re: [R-390] RT510/3FT7

I suspect more 3TF7 fail in shipping than in operation. The filament isn't supported well. Because supports would upset its self heating thermal operation. High line voltage would run the 3TF7 at higher temperature.

Date: Wed, 11 Nov 1998 08:32:41 -0800
From: "Phil Atchley"
Subject: [R-390] Another Ballast Tube Mod...

When I opened up this R-391 I found a 12BH7 in the Ballast socket. Upon examination somebody has soldered two fine leads to the tube pins, one from pin 2 to pin 4, one from 5 to pin 7. When I plugged this into my R390A the set works just fine. (those pins are "grid" pins on the 12BH7 and with no cathode connection the tube doesn't even see it) This keeps the R-390A 100% intact wiring wise, looks original and you don't have to do a PTO/BFO re-alignment like you would if you changed the PTO/BFO tubes out. And it is cheap, flat 12BH7's are a dime a dozen as they are used in old tv's, etc. I'm sure other 12 volt .300 amp filament tubes would work as well. I just discovered that I probably have a whole slew of "ballast" tubes. (we all probably do)

Date: Tue, 12 Jan 1999 22:26:20 EST
From: SBJohnston ‘at’ aol.com
Subject: [R-390] R-390A Ballast replacement ideas

>Hi, just got into this reflector a short time ago. I am very much interested in how you hooked up the I/C
>regulator to replace the ballast tube. I think I'm using a resistor or something. Haven't looked for a

>while. Could u pass the pin numbers and what goes where along to me.

Well, I'm in the same boat - but in my case I haven't thought much about it for ten years! Hold on and I'll go see if I documented the change in the manual... No, I don't see any of my notes on it... but let's figure it out... The ballast resistor tube RT-510 provides some measure of current regulation (and limits the initial inrush current as a byproduct) for the filaments of two tubes: V505 (BFO) on the IF subchassis and V701 (VFO). These tubes each expect 6.3 V on their filaments. Since they are wired in series, they need 12.6 v. The RT-510 is fed from the 25.2 vac line, so there must be a 12.6 v drop across RT-510. I've read here on the list that ballast tubes are not so rare as they once seemed to be, so it may make sense to replace the bad ballast. If not... I see two main ways to operate with no ballast tube:

Plan 1. Remove ballast tube and feed both oscillators with 6.3 vac directly.
No special filament regulation. In my experience, houses and businesses with modern electrical service have very stable primary AC voltage. If you are going to use the R-390A in such an environment, then special regulation is not required. In this case, I would change the tubes from series wiring to parallel, and feed them from the 6.3 VAC line used for the other tubes. To do this, you could remove RT-510, disconnect the wire from pin 7 of the socket for RT 510 and move it to chassis ground. This puts the BFO tube V505 and VFO tube V701 in parallel. Then connect a new wire from pin 3 of the BFO tube V505 to the 6.3 VAC line which is available on any of the other IF tubes' pin 4 or J512-pin20. I'd get it from pin 4 of a nearby tube.

Plan 2. Replace ballast tube with a regulator.
Solid-state filament regulation using 7812 IC regulator. If you feel you need extra-stable R-390A performance, or will be using it on an unstable primary AC power source, you can build a three terminal regulator into the IF chassis in place of the ballast tube RT-510. The first step is to rectify the 25.vac to DC... connect the anode of a diode such as a 1N4007 to pin 2 of the RT-510 socket. Connect the cathode of the diode to an unused pin of the socket. Connect an electrolytic capacitor with a value something like 100 uF at 50v between the cathode of the diode and chassis ground to smooth the pulsing DC. Mount the 7812 three-terminal regulator on a nearby chassis surface (no need to insulate it - the tab can go to ground) and connect the left pin (1) to the junction of the new diode and cap. Connect right lead (pin 3 of the 7812 - the output lead) to pin 7 of the RT-510 socket. Connect the middle lead of the regulator to chassis ground (or just use the tba mount to make the connection for you). For added reliability, connect a 1 uf electrolytic or tantalum cap between pin 7 and ground to surpress any tendency for the regulator to oscillate. For a less intrusive mod, I suppose if you added a ground to an unused pin of the RT-510 socket you could build the regulator on an old tube base and make it a removable module. Be sure to heat sink the regulator appropriately. pin 2 of RT-510 pin 7 of RT-510 socket. In both cases, I would bend the shield ring around the RT-510 socket inward on the upper side of the chassis so that you can't accidentally plug a tube into the socket later on. And, perhaps note the change using an extra-fine "sharpie" marker on the chassis surface nearby. Again, it may be wiser to replace the ballast tube, but this gives you some options...I'd probably do Plan 1.

Date: Wed, 13 Jan 1999 10:27:12 -0500
From: Will Schendel
Subject: Re: [R-390] R-390A Ballast replacement ideas

The neatest way to eliminate RT-510 was recommended by David Medley. He has an article on his web

site. I have used this method and it works fine, if you have reasonably stable line voltage. Most of us do. Replace V505(BFO) and V701(VFO) with 12BA6 tubes. Place a jumper between pins 2 and 7 in the RT-510 socket. Dave recommends a paper clip the diameter of a tube pin, making sure it doesn't touch the metal shield. You are now finished with the modification. No need to re-wire anything, just make a note of what you did. If you want to go back to the original configuration, it is very simple. Please don't re-wire these radios, there is no need for it. It would make it very confusing for the next guy, 20 years or so down the road. Hope this helps, and thank you, Dave Medley.

Date: Wed, 13 Jan 1999 10:40:52 -0600
From: "Dr. Gerald N. Johnson, P.E."
Subject: Re: [R-390] R-390A Ballast replacement ideas

You left out MY current regulator. It handles cold tubes, and regulates closer than the ballast ever could. I still can supply the circuit on a graphic by e-mail. I have not heard from users, though the circuit has gone around the world.

The halfwave rectifier stresses the transformer more than the tube load. The 7812 may not get out of ‘current limit’ from the low cold resistance of the tubes. Chuck Rippel has commented such a circuit doesn't work because of that. Regulator chips WILL oscillate if the input bypass is not close. 3" is too far for some. I prefer a small 0.1 disk with as short leads between input and common as I can get wrapped at the IC case. Otherwise you work too hard. The simplest way to replace the ballast is to replace the two 6BA6's with 12BA6 and short the pins of the ballast socket.

Date: Wed, 13 Jan 1999 13:26:34 -0500
From: "Newman, Edward"
Subject: RE: [R-390] R-390A Ballast replacement ideas

A cheap and dirty fix for your ballast: Years ago when my only ballast tube died I cut off the top, took some nichrome wire from an old pot, and replaced the ballast wire, using enough wire to get the right voltage drop (12V). The new wire was heavier than the original, so it probably doesn't regulate as well, but the fix looks OK and has operated for over 15 years. Just don't touch while the radio is on!

Date: Wed, 13 Jan 1999 18:38:19 -0800
From: "Phil Atchley"
Subject: Re: [R-390] R-390A Ballast replacement ideas

As I've mentioned before, a 12BY7 will do the job very nicely, but you have to jump two pins to the filament connection. And you want a 0.3A tube not 0.15. Your 5749/6BA6 has 6.3V 0.3 amp filaments.

Date: Thu, 14 Jan 1999 04:35:53 -0000
From: "Michael P. Olbrisch"
Subject: RE: [R-390] R-390A Ballast replacement ideas

If I remember, part of that mod was cutting a pin off of the replacement tube. There was a small danger of getting it in the socket wrong.

Date: Thu, 14 Jan 1999 02:33:39 -0800
From: "Glen Galati"
Subject: Re: [R-390] 3TF7 vs 3TF4

3TF7 (R-390A Ballast resistor) vs: 3TF4 (Unkown) Current Range: 0.04 to 0.26 Amps vs: 0.29 to 0.32 Amps Threshold Voltage: 10.2 volts AC/DC vs: 4.0 volt AC/DC All other characteristics are the same on Pin outs 2 and 7, 9 Pin minature, envelope type T-6-1/2. The 3TF7 Resistor, Current Regulating (Ballast) also has a Collins PN: 734-0003 and 734-0003-00 NSN: 5905-00-259-1964

Date: Thu, 14 Jan 1999 11:44:40 -0400
From: "Chuck Rippel"
Subject: [R-390] A Workable, Cost Effective Ballast Tube Solution

There is yet another easy way to solve the ballast tube problem. While this option would not come close to passing my personal muster, it is a reasonable work around. In the radios I have reworked, I note that after removing the labeling with mfg, value, wattage, etc.... from the component..... Rick Mish configures a 40 ohm, 10Watt Xicon Aluminum Housed Power Resistor in place of the ballast tube. He actually removes the tube socket for the ballast tube and mounts the resistor over the hole left in the IF deck. I think that I might mount the resistor to the side of the IF deck chassis and use a little heat sink grease to allow the chassis to help with the heat dissipation. The part is: Mouser Stock Number 284- HS10-40 an is $1.99 (800) 346-6873 or http://www.mouser.com
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Date: Thu, 14 Jan 1999 12:24:16 EST
From: SBJohnston ‘at’ aol.com
Subject: Re: [R-390] R-390A Ballast replacement ideas

Jerry wrote: The halfwave rectifier stresses the transformer more than the tube load. Is the transformer that supplies 25.2 vac running close to max capability? Does the addition of the mod bring it close to trouble?
>The 7812 may not get out of current limit from the low cold resistance
>of the tubes. Rippel has commented such a circuit doesn't work because of that.

Hmmm... I just set up a test circuit with the filaments of two 6BA6's in series driven by a 7812 fed from 25 VDC. In 25 cold start tests it never failed to supply the desired voltage. I tried five different variations of the 7812 regulator - all worked fine. The current-limiting feature of the regulator is not a problem, and it could even be considered a slight benefit, as it provides a limit to the inrush current on the tubes in the early moments after cold-start. The 300 mA drawn by the tubes is only slightly above the regulator's capability *without* a heatsink. They are spec'd for 1A on a heatsink. Mount it on the chassis and it should be quite reliable. You could go even further and select one of the 7812C regulators which is spec'd at 1.5 A with heatsink. Admittedly

the 7812 only puts a bit under 6v on each tube. This should not be a problem, but so for absolutely correct filament voltage, stand the 7812 up off ground with one silicon diode - then it puts out 12.6 vdc.
>you work too hard. The simplest way to replace the ballast
>is to replace the two 6BA6's with 12BA6's and short the pins of the ballast
>socket.
This is not much different from my "Plan 1" which I recommended over the three-terminal regulator "Plan 2" (except that the 12BA6 scheme costs more since you need to come up with the two new tubes). But if you need filament regulation and don't have or want to use a ballast tube, I'd say the three-terminal regulator option is valid.

Date: Thu, 14 Jan 1999 11:48:24 -0600
From: "Dr. Gerald N. Johnson, P.E."
Subject: Re: [R-390] 3TF7 vs 3TF4

So that current rating would make it appear that the oscillator tubes are being run starved at lower than rated current for a lower cathode temperature, lower emission, and perhaps longer life. Lower cathode temperature would mean lower heating of the adjacent frequency determining parts too. We assume that since the tubes are rated at 300 ma that they need 300 ma and that the ballast regulates at 300 ma like my solid state regulator. This rating appears different. Has anyone measured the current in that circuit with the 3TF7? And the effect of line voltage on that current? I keep wondering if there's more to the use of the ballast than simple voltage/current regulation at rated current.

Date: Thu, 14 Jan 1999 12:05:43 -0600
From: "Dr. Gerald N. Johnson, P.E."
Subject: Re: [R-390] R-390A Ballast replacement ideas

Peak current in a half wave is several times the DC output current which causes more wire heating. The the flux is unbalanced tending to send the transformer core more to saturation in one direction which raises the primary current and causes more primary wire heating. The combination is not extremely healthy for the transformer. I've not tested the current limiting of the 7812 feeding tubes. Chuck Rippel had that problem. Could easily be that he didn't have enough heat sink and the temperature limit caught him at a lower current. I believe that the inrush limiting may be as much or more benefit than the regulation. With the recent posting of the specs for the 3TF7 showing maximum current under 300 ma., I begin to wonder if the tubes aren't intended to be run at lower current to extend their life and reduce the heat applied to the frequency determining parts. And need the current regulator to make sure they stay just on the edge of working instead of falling with age as they would likely without the current regulation. I don't know the answer yet. 12BA6 should be a lot more available than 6BA6 since they were used in 100 Million 5 tube AC/DC table radios for the IF stage. And hence cheaper. Probably not many available in MIL spec though. Using a diode in the ground lead of the 7812 does indeed raise the voltage and also kills off a lot of the output regulation because the current in the ground lead varies with input voltage and the diode drop varies with both current and temperature. I

prefer the two resistor circuit because its more adjustable, and you dump enough regulated current from the output to the common resistor to make the changes in chip current negligible in the common resistor.

Date: Thu, 14 Jan 1999 12:44:16 -0800
From: "Phil Atchley"
Subject: Re: [R-390] R-390A Ballast replacement ideas

A few years back I modified a IF for an R-390A using a 7812 regulator mounted to the inside wall of the IF amp. Rectified/filtered the 25 VAC and used a small resistor at the input of the 7812 to bring the voltage to a safe input level for the 7812 regulator. (35VDC MAX) This worked very well with no problems of regulator overload etc. (it is a 1 amp regulator..... (this is essentially the Sherwood Modification). Now I probably wouldn't go to the trouble if 12BA6's and paper clip work ok. (or my choice is a 12BY7 wired to fit the socket.) You can put the wires right on the tube pins and not even bother re-wiring the socket) Fortunately I haven't needed to do that.

Date: Thu, 14 Jan 1999 17:01:16 EST
From: SBJohnston ‘at’ aol.com
Subject: Re: [R-390] Ballast replacement ideas

For some reason I am having trouble finding my documentation of the mods to my R-390A...this is very disturbing to someone like me, known as "Mr Organized". The basis of my mods was the article in Electric Radio magazine by Bill Kleronomos, KD0HG. I remember I did some extra stuff, but his design was clearly a winner... hold on... I'll consult the index and see what issue it was in... OK, the original article appeared in the October '92 ER, with corrections in November, '92. There was another article which described the use of different tubes in the February , '97 issue. Looking at the ER index I see that Bill also wrote an article on the use of a three-terminal regulator (in current-regulation mode) to replace the Ballast tube. It was in the February '95 issue.

Date: Sun, 07 Feb 1999 11:44:28 -0500
From: Mike Dinolfo
Subject: Re: [R-390] Current regulator tube availability...

I believe that the reason why a diode does, in fact, work OK is that the diode converts the 26.2 volts (or so) AC applied voltage to a half-wave DC voltage whose RMS value is about half that of the otherwise available 26.2volts. Hence, the targeted tubes (V505 & V701) get applied filament voltage (measured on an RMS value, which is what counts) which is within their allowable range. Note that this analysis ignores the forward voltage drop of the diode, but because the forward drop of maybe 0.7 -1.0 volts is a lot less than the applied voltages of which we speak, we can consider the net effect being that the filament voltage is cut in half (compared to what it would be if the ballast regulator were to be replaced with a short).

Date: Sun, 07 Feb 1999 11:38:03 -0600
From: "Dr. Gerald N. Johnson, P.E."
Subject: Re: [R-390] Current regulator tube availability...

This has been a topic of discussion here for more than a year. A single rectifier diode would cut the RMS value applied to the tubes in half. Hadn't thought of using that. A plain resistor works without regulating the tube heaters. Changing the two tubes to 12BA6 (commonly used in AC/DC radios for eons so more common than 6BA6) and replacing the ballast with a jumper works. My ballast replacement embeds a LM317 current regulator in a diode bridge so the AC current is limited by the pulsating DC the LM317 sees. Because of the relatively low applied voltage and the finite minimum voltage drop of the LM317 I had to increase the peak current to get the RMS value up to 300 ma. I'm unable to come to a conclusion what the purpose of the ballast tube is. Those that have converted to run without it are unable to detect short term instabilities or significant sensitivities to line voltage. I suspect it contributes to longer oscillator tube life and so to longer intervals between PTO calibrations. I also suspect it was in the receiver purchase specifications left over from Super Pro's with band switched tunable high frequency local oscillators that absolutely needed heater regulation to keep a signal within the pass band and other than a greater sensitivity to shock, it isn't detrimental to the receiver so the purchase specification was never challenged or changed.

Date: Sun, 7 Feb 1999 17:58:09 -0800
From: "Phil Atchley"
Subject: [R-390] Current Regulator Tubes.& Diodes.....

One thing I forgot to mention in using a diode is this..... Since you are effectively using only "half" of the waveform you are only dissipating about half as much power as heat. Instead of dropping 12.6VAC at .3 Amps which equates to 3.78 watts heat in the regulator tube you have approximately .7Volts at .3 amps which is approximately .21 watts heat. A considerable difference in close proximaty to the BFO. (A 18 to 1 ratio).

Overcoming the current regulator problem (by Dave Medley)

In the R390/R390A series of receivers a current regulator is used to regulate the heater voltage of V505 (BFO) and V701 (PTO) tubes. This was presumably to minimize frequency drift when the radios were used in a military environment where power supplies were unreliable but in the average ham or DXers shack this is hardly necessary. Besides which the 3TF7 tube is expensive to replace. There are several ways to deal with this problem.

1. If you are a purist you can replace the 3TF7 with a solid state current regulator. There is an article in Electric Radio on this subject (No 70, February 1995)
2. Replace the regulator with a 45 ohm 10 watt resistor.
3. This is the one I prefer. Replace the BFO and PTO tubes with 12BA6 tubes. These are cheap and easy to find. Then simply bridge out the current regulator. I make a bridge out of a paper clip and simply insert it in pins 2 and 7 of the tube socket. It is a good idea to put a label on top of the RF cover to remind you about this so you don't replace one of the tubes with a 5749 somewhere

down the track.

Date: Thu, 9 Dec 1999 21:10:05 -0500
From: "Walter Wilson"
Subject: Re: [R-390] Ballast tube replacement modification?
Thanks for the help, guys. I finally found the page I was looking for, and it mentions three options.
1. Jumper the ballast tube socket pins 2 & 7 and replace the 6BA6 tubes with 12BA6 tubes (probably my preference, but I don't have those tubes right now).
2. Put a diode across pins 2 & 7 of the ballast tube socket. This gives you pulsating DC of the right voltage.
3. Put a 40 to 50 ohm dropping resistor (5 to 10 watts) across pins 2 & 7.
I did this for now, and it seems to work. Perhaps not the best solution. I had a 50 ohm 10 watt resistor. Instead of the 12.6 VAC needed, I'm getting by with 12.0 VAC. But it seems to be working fine for now. I may eventually go for option 1 when I have a chance to pick up some 12BA6 tubes.

Date: Thu, 09 Dec 1999 19:30:37 -0700
From: "jordana ‘at’ nucleus.com"
Subject: Re: [R-390] Ballast tube replacement modification?

If I recall, there was a mod in an OLD 73 magazine that used a pair of Zener diodes to provide regulation on both the negative and positive sides of the voltage..the 12 volt tube trick may be the best way to do it, but I once used a 12BH7A tube (controlled Heater Char.) in place of the 3TF7, and it worked as well as the 3TF7 tube as far as PTO/BFO stability was concerned
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Date: Fri, 10 Dec 1999 11:36:59 -0600
From: "Anderson, Craig - Ext. 1365"
Subject: [R-390] Ballast Tube replacement

I don't know if it has already been mentioned but the KD0HG article in ER is the most elegant way in which to eliminate the ballast tube. It uses a LM117K (TO-3) mounted very neatly on the rear panel of the IF deck. I did this to my EAC R-390A and it worked great. It uses a few parts but it gives excellent regulation, something the ballast tube could never do. I changed only one thing and that was to add a finned heat sink to the LM117K. There was plenty of clearance for it and it really dropped the temperature of the TO-3 device. As written, Bill used the chassis as a heat sink. I went the extra mile for added reliability.

Date: Sat, 11 Dec 1999 19:55:28 -0500
From: "Howard Rawls"
Subject: Re: [R-390] Diode "ballasts", a Bad Idea

Gary, I may have started this "diode" idea. When my R390A failed I did the only thing I could to get it going again. (I live out in the boondocks, not many spare parts). I'm not a mathematician, so I just put the darn diode in and it worked..... voltage measured real close to "right" as I remember it. Recently I pulled the diode and put in some 12 volt tubes. As near as I can figure (I'm not a mathematician) that diode performed well for about 29 years.....and I honestly don't remember any problems with tubes. I hope I have not led anyone astray by reporting my experience with my "temporary" diode fix on the ballast tube problem.

Date: Sat, 11 Dec 1999 23:18:19 -0700
From: Wally Gibbons
Subject: [R-390] RE: ballast tube

My 1 cent, haven't been on the list long enough to warrant two. The r390 I just acquired had a 40 ohm resistor in place of the ballast, wired on a 9 pin test socket adapter. Plays great, no drift noticable. When the ballast in my 390A burned out, in went 40 ohms on another 9 pin test adapter plug. I'll leave them that way till I can replace the 6 volt tubes with 12 volt tubes. Great receivers, but we already know that!

Date: Tue, 14 Dec 1999 09:17:27 -0600
From: "Anderson, Craig - Ext. 1365"
Subject: [R-390] ER Article on Ballast replacement

Several people asked what ER issue contained the article on the LM-117K circuit replacement for the ballast tube in the R-390A. It is issue 70, Feb. 1995, p.24.

Date: Sun, 30 Apr 2000 19:26:09 -0500
From: Nolan Lee
Subject: [R-390] Tidbits from Amperite on Ballast Tubes

I originally posted the following message to the list here on Jan 27th of 1999. I've corrected a few spelling errors and added a few more comments to it with this posting. Al, you might want to replace the original message with this one at your R390A FAQ site. - ---------- OK, after listening to all of the hype and BS about the ballast tubes in the R390A, I figured I'd research it a bit an post my findings. Put your boots on bubba, it's gonna get deep... If one of you guys is saving stuff for an R390A FAQ, the info below would go well in it. Digging thru a 1982 Amperite AM-82 application guide, I found a few interesting things that I'll pass on to you guys. If you deal with a distributor that handles Amperite, get them to get you a copy, it's an interesting book. The resistance wire is usually iron, and the glass envelope is filled with either hydrogen or helium gas for heat conductivity. The glass envelope runs about 160 degrees. Since I'm one of those people that refuses to use the metric system, you know WHICH 160 degrees I'm talking about. It ain't Kelvin either. One of the posts I read today mentioned a shelf life with ballast tubes. I suspect that it's related to ballast tubes that use helium as the filler gas. Helium is famous for it's ability to pass thru the wall of sealed steel high pressure cylinders. I ain't no engineer or chemist but

have had some experience with high pressure gases and have see firsthand that helium will "disappear" from sealed bottles. If I'm not mistaken, the 3TF7 ballast tube is filled with hydrogen rather than helium. OK, back to my original post... Current regulation is usually within plus or minus 1%. They work with either AC, DC, or pulsating current. When the current in the circuit is increased to a high enough level for the regulating function to start working, only a small portion of the filament will glow. As the voltage across the ballast increases, more and more of the filament will glow. When the entire filament is glowing, you're at "max" and any additional increase will overheat the tube and shorten it's life. The rated life expectancy when operated as recommended within it's ratings is 2000 hours. Run it at "max" all of the time and it's only 1000 hours. Run it at 80% of max and it's 5000 hours. Here's a direct quote from Amperite AM-82 that you'll really find interesting: - ---snip--- DUTY CYCLE DEPENDENT If a steady voltage of a value in the middle of the operating range is applied to the tube continuously, it's life will be tens of thousands of hours. Opening and closing the circuit with the resulting expanding and contracting of the filament greatly reduces the life of the tube. Also, as in incandescent lamps, turning the unit on and off many times will reduce it's life especially if the unit if operated near it's maximum voltage. If full voltage is applied to the tube, the circuit may be opened and closed only a few hundred times before the current is outside of the limits or the filament is burned out. Thus the life of the tube will be determined entirely by it's duty cycle.- ---snip--- I figure that over the last 23+ years that I've had the old Collins, it's been on for "24 and 7" for at least 15 of those years. 15 years is 131,400 hours. That original 3TF7 is still going just fine. I'm not saying that it won't puke when I finish the overhaul of the receiver and power it up, but even if it did, it gave pretty damn good service. I finished my OH of my 67 EAC back in the middle of October of 1998. It's been running 24 hours a day and seven days a week since then. That's about 18 and a half months or more than 13,300 hours on the very same ballast tube that was installed in it when it was assembled back in 1968. If the gas hasn't leaked out yet, I suspect that it won't. Back to my original post... The folks at Amperite that I've dealt with have been a hell of a nice bunch. I needed some information on some odd "non standard" numbered ballast tubes. They transferred me to an engineer and I received all of the answers that I needed. Very sharp and friendly bunch of people. For what it's worth, there's another part number for the 3TF7 that was used for tubes that had different testing requirements than the standard mil-spec and was for a Govt contract in 1978, and not for civilian or commercial sales. After I corner the market on them I'll post the number. Just joking...a friend of mine found a stash of them and sent me three of them last week or so to research and experiment with. After talking to the engineer at Amperite a few hours ago, there's no need to experiment. I now know exactly what they are. The end flap of the boxes is labeled as follows: Amperite TJ311M01 The side panel is labeled as follows: 5905-00-681-4707 Resistor Current Regulating 1 ea. DLA900 78-M-T921 A 5/78 The tubes themselves are labeled as follows: (circled Amperite "A" with lightening bolt) Amperite TJ311M01 Ballast 820 So, if you spot any of these TJ311M01 marked ballast tubes, grab a few, they'll work just fine in your R390A. I'd be curious to hear from any of you that bought an R390A that contained one of these or any of you that have information on the contract number or the FSN for them, listed above. Nolan

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Date: Sun, 30 Apr 2000 20:37:27 -0400
From: "Dale Hardin"
Subject: RE: [R-390] Wacko Ballast Idea

Personally, I used the 12BH7A because it was so simple and easily reversible. Seems to work just fine and I must have four or five extra tubes just waiting for their turn if the lifespan isn't long enough.

Date: Sun, 30 Apr 2000 21:07:17 -0500
From: "Dr. Gerald N. Johnson"
Subject: Re: [R-390] Wacko Ballast Idea

Hydrogen penetrates the iron crystal lattice and causes imbrittlement. The government insistence on a ballast for the oscillators confirms my suspicions that it was needed in every other good radio of the era and so had to be in the 390 to make the radio acceptable for testing even if with the better inherent stability of the low frequency PTO and crystal first LOs in the Collins made it have no detectable benefit.

Date: Fri, 05 May 2000 08:53:08 -0500
From: Randy & Sherry Guttery
Subject: Re: [R-390] Wacko Ballast Idea

>...the 12BH7A, IMHO is just a little [kinder] because one would presume that its filaments
>would reduce the inrush current effects whereas the resistors wouldn't. Dale

The problem is that the 12BH7's filament when cold - presents a much lower resistance causing (until it heats) higher current through it and anything in series with it (the other filaments) - actually increasing inrush current over what it would be were the 12BH7 replaced with a fixed resistance. If you truly want to reduce in-rush in this circuit (over the already fixed resistance's contribution) - you could include an in-rush limiter (special type of Thermistor) in series with the fixed resistor - one that starts out (cold) at say 47 ohms - and drops to 0.5 or so at load current that will soft-start your tubes. These are available from digikey for around $2.50.

Date: Fri, 5 May 2000 11:50:39 -0400
From: "Tetrode"
Subject: Re: RE: [R-390] Wacko Ballast Idea

The series resistor would offer some current limiting during start up as its value is constant. A tube filament would not, as its cold resistance is much lower than its hot operating resistance, but that's fine since the other tubes in that filament string are doing the same thing. Reduced start up current in the BFO/VFO filament string is not a requirement, it's just speculated that its a benefit that the ballast tube provides. Probably doesn't matter either way.

Date: Fri, 5 May 2000 13:37:16 -0400
From: "Tetrode"

Subject: [R-390] Re: {R-390] Wacko Ballast Idea--12BH7

The tube may not be fully utilized in this application, but is a far cry from being wasted. It is providing the proper filament voltage to the 390 BFO/VFO tubes, a worthy cause for extra tubes rolling around in the junk box. I think the 12BH7 mod is a GREAT R-390 mod option. Simply by adding two wire jumpers to the ballast tube socket you now have the ability to use either the 3TF7 or the 12BH7 tube interchangeably in that socket. That's the beauty of the mod, when the 12BH7 is plugged in the filament voltage from the original ballast tube pins is harmlessly applied to its unused and isolated grids. Plus, the 12BH7 fills what might otherwise be a empty socket, its bulb size is nearly identical to that of the original tube, it will be good for a very long time since you don't care about its cathode emission, and it rewards you with a nicely glowing filament to see. I did this mod on the bench 391 that I'm working on as I needed a ballast tube and I wanted to keep my few good ones for my 'resto freak' R-390A. I say few good ones because the 3TF7 I originally plugged into the 391 was delivering 14 volts to the filaments, and another I tried was delivering only 10 volts. The 12BH7 was dead-on. (Some time I need to go back and look at these ballasts and check them out again, maybe some burn-in time would help them out or something. Anybody ever do this?)

>Instead go for a pair of 51 Ohm 3W or 5W MOX resistors in parallel and
>wire underneath.

That value is too low, you want 12.6/.3 = 42 ohms or so.

Date: Fri, 5 May 2000 16:03:21 -0400
From: "Tetrode"
Subject: Re: [R-390] Re: {R-390] Wacko Ballast Idea--12BH7

Yup, I'm in agreement with you, it is a series current regulating device of about 300 ma. But for a controlled set of identical test conditions (line and load) you should get identical voltage output (within device tolerances) as well. When I was making my measurements I kept the line voltage constant at 115 volts, and the load (the BFO/VFO filaments) was the same as well. From other emails it seems like the current spec is about +/- 20 ma, but my measurements on the two other tubes I mentioned indicated a +33 ma and -62 ma differences, which is why I flagged them as suspect and set them aside to take a closer look at some other time. Another couple I tested were pretty much right on the money. There may be other failure modes to these devices than just going open.

Date: Wed, 17 May 2000 07:05:54 +0000
From: "B.L.Williams"
Subject: Re: [R-390]

Nice find I have 2 R390A's, one with the jumper/12BA6 mod, and one with a good 3TF7. You aren't going to tell any differences between the two radios except that the non-3TF7 probably runs cooler in the rack. When the 3TF7 goes kaput I'm going to spend about 30 minutes putting

the jumper in between pins 2 and 7, and plugging in the12BA6s. That's it unless you want to realign since you are changing the PTO tube. NIB 12BA6's are dirt cheap and plentiful. I have a lot of junker $1 plastic tube radios in the basement and each has at least 1 maybe 2 in them for spares, but I don't think the supply is going to dry up. That is the nice thing about the AllAmerican-5-tube-lineup radios- they all had the 12BA6 in them. If you do the jumper mod then you don't have any more scarce tubes to worry about. It's a done deal without major mods or sand mods to ruin the radio. I checked my tube lists from some sources and none list the 3TF7, so I can't help you there. Conversely, the price on NIB 12BA6s are $3 each.

Date: Tue, 8 Aug 2000 18:54:13 -0400
From: "Walter Wilson"
Subject: Re: [R-390]

3TF7 bypass I've opted for using a 12BH7 with pins 2&4 and 5&7 jumpered together. The 12V heaters in this tube are rated at 300mA, and this has been suggested previously by others. I had originally used the 12BA6 tubes with the wire jumper in the 3TF7 socket, but that makes it hard to swap IF or PTO decks separately. The first time I forgot and swapped in an unmodified IF deck (which didn't work because of the 12BA6 in the PTO), I opted for the 12BH7.

Date: Tue, 03 Jan 2006 20:40:27 -0500
From: shoppa_r390a ‘at’ trailing-edge.com (Tim Shoppa)
Subject: Re: [R-390] SS VR replacement for 3TF7

Not exactly. Look up "RMS". Sqrt((25.2**2)/2) is not the same as Sqrt(12.6**2). Putting the diode in series gives you effectively 17.8V worth of heating (ignoring diode drop...) We've been through this at least three times before on the list in the past couple of years... Or did I again fall for the purposely-mistaken-fact-to-make-a-point? I'm always falling in that trap!

> I live with real weather and when my lights blink, ...

For fun, pull the ballast tube and count how many seconds until you start hearing the beat note drift. My ears may not be as sensitive as when I was young but it's many seconds until I hear the drift from zero filament current!

> Why have we not heard about this approach before?.....

I've seen it before many times over the past couple of years... again I think I fell for the trap

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From: "Drew Papanek"
Date: Mon, 23 Dec 2002 17:37:02 -0500
Subject: [R-390] Ballastubes (was inrush current limiters)

Snip start:
RMS voltage and current are what define heating power in a waveform (DC "waveform" included). Since what we are doing here is heating cathodes, peak or average current and voltage values do not apply (when peaks are within reason and waveform's period is much less than cathode's thermal time constant). RMS is what counts. One of my references lists RMS value of

a half wave rectified sinewave to be half the PEAK value. Peak voltage of the 25.2 VRMS winding powering the series ballast, PTO, and BFO tubes: (25.2)(1.414)=35.6v peak. The half wave rectified RMS value: (35.6)(.5)=17.8 VRMS. Hence, with diode in place of ballastube, each 6BA6 tube heater receives 8.9 volts instead of the 6.3 volts it was designed for. The single diode modification will work, but the life of the PTO and BFO tubes will be reduced.

Snip end.

Date: Wed, 18 May 2011 21:19:05 -0700 (PDT)
From: "Drew Papanek"
Subject: Re: [R-390] RF Module Adjustable

Has anyone tried keeping the 6BA6 PTO/BFO tubes intact and used a diode to replace the ballast tube ?" The radio will work with just a diode to replace the ballast tube, but the voltage to the PTO and BFO tube heaters will be too high - about 9 volts RMS on each of the two heaters. If you place a 20 ohm resistor in series with the diode, then all will be copacetic in Heatersville.

SUMMARY

Here's my summary of the Ballast tube section, starting with a post by Dave Medley.

Start:

Overcoming the current regulator problem (by Dave Medley)

In the R390/R390A series of receivers a current regulator is used to regulate the heater voltage of V505 (BFO) and V701 (PTO) tubes. This was presumably to minimize frequency drift when the radios were used in a military environment where power supplies were unreliable but in the average ham or DXers shack this is hardly necessary. Besides which the 3TF7 tube is expensive to replace.

There are several ways to deal with this problem.
1. You can replace the 3TF7 with a solid state current regulator. There is an article in Electric Radio on this subject (No 70, February 1995)
2. Replace the regulator with a 45 ohm 10 watt resistor.
3. Replace the BFO and PTO tubes with 12BA6 tubes. These are cheap and easy to find. Then simply bridge out the current regulator. I make a bridge out of a paper clip and simply insert it in pins 2 and 7 of the tube socket. It is a good idea to put a label on top of the RF cover to remind you about this so you don't replace one of the tubes with a 5749 some where down the track.

End.

There were a few posts about the merit of heat saving when using 2 12BA6's instead of the

ballast tube and 2 6BA6's (5749's). It reduces the wattage usage by 3.5 watts, which is 3.5 watts of heat saved. I don't think this is that much of a benefit for an R-390A, but it could be for an R-390. However, there are better ways of reducing the heat in an R-390 – the B+ rectifiers and B+ regulator.

But, there is a risk of using the 2 – 12BA6's and shorting out the ballast tube. If you forget about the change and install/swap an IF deck or VFO (that has a 6BA6 in it), about ¾ of the 25.2 VAC or 18.9 VAC is applied to the remaining 12BA6. I suspect that it being applied for a short term won't hurt it much, but you never know. If you pass a 390 (with this mod on it) on to someone, and they forget, this would not be a good situation. For these reasons, I don't care for this mod.

Another option is from Roger Johnson to use the 6.3 vac directly to the oscillators filaments. His post follows:

Start:
Date: Sat, 21 Feb 1998 21:58:48 +0000
From: "Roger D. Johnson"
Subject: Re: [R-390] Ballast tube in 390A

The ballast tube is there for the same reasons as the crystal ovens. This is a military receiver designed to operate under extremes of temperature and voltage. Many of these were used in mobile radio sets powered by generators (AN/GRC-26D for instance). In normal home useage, I'd turn the ovens off and power the oscillator filaments from the 6.3 volt line.
GL, Roger

End.

My preferred solution is close to this one by Patricia Gibbons posted on 1/10/1998:

Start:
Since one of the functions of the 3TF7 is to act as a series dropping resistor to allow 12 volts @ 300 ma for the two 5749 filaments. that are in series, I came up with a simple replacement for this ballast tube:

* move the wire on pin #2 of the 3TF7 socket to Pin #4...
* move the wire on pin#7 of the 3TF7 socket to Pin #5.
* Plug in a 12BY7A or 12BH7 tube into the socket in place of the 3TF7.

Kind of weird to have a tube with a cathode, grids, and a plate in it only being used for it's filament, but, hey it works and eliminates the need for a rare and expensive ballast tube. :-)

Patricia Gibbons <wa6ube 'at' aol.com>
City of San Jose - ITD-Communications Mobile radio repair shop supervisor
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End.

To me, instead of moving the wiring on the RT510 socket, I'd suggest adding 2 short jumpers so that

either tube can be used, the correct ballast or a 12BH7, etc tube. The jumpers woud be: pin #2 of the 3TF7/RT510 socket to Pin #4 and pin #7 to Pin #5.

The reason I like this mod is that the wiring change is easily reversible and trivial and it still looks original when done. Also, the low emission (worn out) 12BV7 (courtesy of W. Thomas Warren), 12BH7, 12BY7, 12BZ7, 12CT8, 12DQ7, or 12FX8 are usually free (but, the 12A4 and 12B4 can not be used because they short pins 2 and 7 internally). They also provide a small amount of filament regulation that the 42/45 ohm resistor does not. Another reason I like this mod is that it does not inhibit module swapping, as using the 12BA6's does. And then there's the stability factor – there were numerous posts saying that in our Ham and SWL environment it is not an issue.

I've done testing in this area and have found no need for a regulator of any kind. Stability is excellent without one. With a 12BH7 installed in the RT510 filament current regulator tube socket (instead of the 3TF7) works extremely well if your house power does not fluctuate much (as most do not). While zero beating WWV, I changed the 115 VAC power input with my variac between 110 and 120 VAC and there was no frequency variation while changing the input voltage.

There is also a benefit to using the 12BH7 – the resistance of the 12BH7 filament is lower when cold causing the 2 oscillator filaments to warm up slightly quicker than if using a resistor or regulator. This means that the 2 oscillators will be stable sooner.

One other note – do not substitute a diode alone for the 42/45 ohm resistor or any other option. The diode alone causes 8.9 volts to be applied to each 6BA6 filament.

Regards, Larry