**RECTIFIER TUBES**

 Originally by:

 Mike@MDBVentures.com

 http://www.MDBVentures.com

﻿**Five Volt Fullwave Rectifier Tubes**

Tube# Base. Fvolt. Famp Vdrop MaxPmA MaxPv Notes

5AR4/GZ34 5DA 5.0 1.9 17 250 450 low Vdrop 5U4/5Y3

5AS4-A 5T 5.0 3.0 50 275 450 improved 5U4

5AT4 5L 5.0 5.5 30 800 550 higher power 5U4

5AU4 5T 5.0 3.7 55 325 400 high power 5U4

5AW4 5T 5.0 3.7 46 250 450 long life 5U4

5AX4-GT 5T 5.0 2.5 65 175 350 high power 5Y3

5AZ3 12BR 5.0 3.0 44 275 600 compactron 5U4

5AZ4 5T\* 5.0 2.0 60 125 350 loctal 5Y3

5BC3 9QJ 5.0 3.0 53 300 500 compactron

5CG4 5L 5.0 2.0 ? 125 400

5DJ4 8KS 5.0 3.0 44 300 600 redesigned 5U4 (higher volts)

5R4-G/GY 5T 5.0 2.0 67 250  750 high voltage 5U4

5R4-GYA 5T 5.0 2.0 67 250 750 high voltage 5U4 (ruggedized)

5R4-GYB 5T 5.0 2.0 63 250 900 high voltage 5U4 (ruggedized)

5T4 5T 5.0 2.0 45 225 450 metal 5U4

5U4-G 5T 5.0 3.0 44 225 450 octal 5Z3

5U4-GA 5T 5.0 3.0 44 250 450

5U4-GB 5T 5.0 3.0 50 275 450

5V3 5T 5.0 3.8 47 350  425 higher power 5U4

5V3-A 5T 5.0 3.0 42 415  550 5V3 reduced filament current

5V4-G/GA 5L 5.0 2.0 25 175 375 octal 83-V

5W4-G/GT 5T 5.0 1.5 45 100 350 low power 5Y3

5X4-G 5Q 5.0 3.0 58 225 450 5U4 diff pinout

5X4-GA 5Q 5.0 3.0 47 250 450

5Y3-G/GT 5T 5.0 2.0 60 125 350 octal 80

5Y4-G/GT 5Q 5.0 2.0 60 125 350 5Y3 diff pinout

5Z3 5T 5.0 3.0 58 225 450 4pin 5U4

5Z4 5L 5.0 2.0 20 125  350 low drop 5Y3

80 4C 5.0 2.0 60 125 350 4pin 5Y3

83 4C 5.0 3.0 15 225 450 4pin mercury vapour

83-V 4C 5.0 2.0 25 175 375 4pin 5V4

1641 8E 5.0 3.0 44 250 450 rabbit ear 5U4

5931 5T 5.0 3.0 47 300 600 industrial 5U4

6004 2AJ 5.0 2.0 60 120 375 rabbit ear 5Y3

6087 5L 5.0 2.0 50 125 350

6106 5L 5.0 2.0 60 125 350

6853 8HE 5.0 1.7 60 125 350

RK60 8E 5.0 3.0 44 250 450 rabbit ear 5U4

**5U4 Compatible Fullwave Rectifier Tubes**

Tube# Base. Fvolt. Famp Vdrop MaxPmA MaxPv Notes

5AR4/GZ34 5DA\* 5.0 1.9 17 250 450 low Vdrop 5U4/5Y3

5AS4-A 5T 5.0 3.0 50 275 450 improved 5U4

5AU4 5T 5.0 3.75\* 50 325 400 high power 5U4

5AW4 5T 5.0 3.7\* 46 250 450 long life 5U4

5DJ4 8KS\* 5.0 3.0 44 300 600 redesigned 5U4 (higher volts)

5R4-G/GY 5T 5.0 2.0 67 250 750 ruggedized 5U4 (higher volts)

5R4-GYA 5T 5.0 2.0 67 250 750

5R4-GYB 5T 5.0 2.0 63 250 900

5T4 5T 5.0 2.0 45 225 450 metal 5U4

5U4-G 5T 5.0 3.0 44 225 450 octal 5Z3

5U4-GA 5T 5.0 3.0 44 250 450

5U4-GB 5T 5.0 3.0 50 275 450

5V3 5T 5.0 3.8\* 47 350 425 higher power 5U4

5V3-A 5T 5.0 3.0 42 415 550 5V3 reduced filament current

5931 5T 5.0 3.0 47 300 600 industrial 5U4

\*Extra connections on base may not be plug-in compatible in some circuits.

\*Higher heater current requirement may not work in many 5U4 circuits.

**5Y3 Compatible Fullwave Rectifier Tubes**

Tube# Base. Fvolt. Famp Vdrop MaxPmA MaxPv Notes

5AR4/GZ3 5DA\* 5.0 1.9 17   250   450low Vdrop 5U4/5Y3

5AX4-GT 5T 5.0 2.5\* 65   175   350high power 5Y3

5CG4 5L\* 5.0 2.0 ?    125   400

5R4-G/GY 5T 5.0 2.0 67   250   750ruggedized 5U4 (higher volts)

5R4-GYA 5T 5.0 2.0 67   250   750

5R4-GYB 5T 5.0 2.0 63   250   900

5T4 5T 5.0 2.0 45   225   450metal 5U4

5V4-G/GA 5L\* 5.0 2.0 25   175   375octal 83-V

5W4-G/GT 5T 5.0 1.5 45   100   350low power 5Y3

5Y3-G/GT 5T 5.0 2.0 60   125   350octal 80

5Z4 5L\* 5.0 2.0 20   125   350low drop 5Y3

6087 5L\* 5.0 2.0 50   125   350special 5Y3

6106 5L\* 5.0 2.0 60   125   350special 5Y3

6853 8HE\* 5.0 1.7 60   125   350

\*Extra connections on base may not be plug-in compatible in some circuits.

\*Higher heater current requirement may not work in many 5Y3 circuits.

**Six Volt Fullwave Rectifier Tubes**

Tube# Base. Fvolt. Famp Vdrop MaxPmA MaxPv Notes

6A5-GT 6S 6.3 1.2 50 125 350

6AX6-G 7Q 6.3 2.5 21 250  350

6BW4 9DJ 6.3 0.9 40 100 325

6BY5-G/GA 6CN 6.3 1.6 32 175 375

6CA4 9M 6.3 1.0 ? 150 ?

6W5-G 6S 6.3 0.9 24 90 325

6X4 5BS 6.3 0.6 22 90 360

6X5 6S 6.3 0.6 22 80 360

6Z5 6K 6.3 0.8\* ? 60 ?

6ZY5-G 6S 6.3 0.3 18 40 325

7Y4 5AB 6.3 0.5 22 70 325

7Z4 5AB 6.3 40 ? 100 325

84/6Z4 4C 6.3 0.3 20 60 325

5993 5993 6.3 0.8 ? 60 260

5852 6S 6.3 1.2 ? 65 300

6202 5BS 6.3 0.6 22 55 325

6203 9CD 6.3 0.9 22 77 325

6325 6325 6.3 2.7 ? 250 780

6754 9ET 6.3 1.0 ? 90 325

Misc Volt Fullwave Rectifier Tubes

Tube# Base. Fvolt. Famp Vdrop MaxPmA MaxPv Notes

0Z4 4R none none ? 110 880

82 4C 2.5 3.0  5 115  450

3DG4 5DE 3.3 3.8 32 400 325

12BW4 9DJ 126 0.4 540 100 325

12DF5 9BS 126 0.4 540 100 350

12X4 5BS 126 0.3 22 90 360

25X6 7Q 25 0.3 25 60 125

25Y5 6E 25 0.3 ? 42 250

25Z5 6E 25 0.3 22 75 235

25Z6 7Q 25 0.3 22 75 235

26Z5 9BS 26.5 0.2 22 50 325

28Z5 6BJ 28 0.24 40 100 325

50AX6-G 7Q 50 0.3 21 250 350

50X6 7AJ 50 0.15 22 75 235

50Y6  7Q 50 0.15 22 75 235

50Y7 8AN 50 0.15 22 75 235

50Z6 7B 50 0.3 ? 75 235

50Z7 8AN 50 0.15 21 65 235

117Z6 7Q 117 0.075 15.5 60 235

5690 5690 12.6\* 1.2 17 125 350

**Four Pin Fullwave Rectifier Tubes**

Tube# Base. Fvolt. Famp Vdrop MaxPmA MaxPv Notes

5Z3 4C 5.0 3.0 58 225 450 4pin 5U4

80 4C 5.0 2.0 60 125 350 4pin 5Y3

83 4C 5.0 3.0 15 225 450 4pin mercury vapour

83-V 4C 5.0 2.0 25 175 375 4pin 5V4

**Why use a different rectifier tube?**

Normally the best replacement tube is to use the same type tube number as

originally designed for the circuit. These days it is sometimes the case

that the original tube is not available, hard to find, or very expensive.

Many times substitutions can be used that may be more readily available,

or lower cost, yet still perform in the circuit as well as the originally

designated tube type.

There are two basic fullwave power rectifier tubes that you will likely

encounter. The 5Y3 family, and the 5U4 family. The 5Y3 family is the

oldest fullwave rectifier design. The 5Y3 design goes all the way back

to the 1920s (type 80 tube) and is still being made today. The original

design was the type 80 tube. When the octal base format came into use,

the type 80 tube had an octal base put on it and the type became the

5Y3. You can swap between the tubes using a base adapter.

The orignal type 80 tube came in a globe/balloon style. Later the type 80

was switched to the ST shape which is more rugged because it supports the

internal elements. Long after the end of design life for the type 80 tube,

it was made available in the GT style for replacement use. This was really

just a 5Y3GT with a four pin base.

When the 5Y3 came out, all they did was to put an octal base on the type 80

tube. At this time, the type 80 tubes were using the ST shaped glass, so

the first 5Y3 tubes, which were called 5Y3G, also used the ST shape.

Later on as equipment manufacturers demanded smaller tubes, the 5Y3 was

packed into the smaller GT style. Beyond that, the design remains

largely the same as when the type 80 tube was first introduced.

Origonally if more power than the type 80 tube could provide was needed,

you needed to design in two or more tubes. The main reason for requiring

two tubes was that the heat disipation for a fullwave rectifier of that

power would be too much to handle in the standard size tube.

To deal with this, the type 83 tube was designed.

The type 83 tube uses mercury vapour (the same gas in florescent lights)

to reduce the internal resistance. Doing so reduces the amount of power

dissipated by the tube and thus the heat generated. This allows a high power

fullwave rectifier to be placed in the same package as the original

type 80 tube.

The down side to this is that the mercury creates its own set of problems.

The toxic aspects of mercury were not considered to be as big an issue

at that time as it is now. However there are other problems. The primary

problem is that mercury is a liquid at room temperature. That causes it

to condense onto the internal tube elements. If voltage is applied to the

plates before the heater has warmed up the tube (and turn the mercury into

gas), the mercury can cause internal shorting or arcing to occur. This can

cause damage to the tube and to the circuits in which it is used.

Note: there is a tube type called 83-V. It is unfortunate that they

selected the "83" number for it as it is rather different than a type 83

tube. It is closer to a type 80 tube but with a reduced internal resistance.

The reduced resistance is achieved by placing the cathode/heater and

plate closer together. This makes it much harder to manufacture and

more susceptable to shorting out. A shorted power rectifier tube can cause

a lot of damage to the circuits in which it is used.

There were various attempts made to deal with the mercury problem in the

type 83 tube. One solution was the 5Z3 tube. The 5Z3 tube uses a larger

glass bulb and larger plates to handle the higher power. It also has a

bigger heater so that it can emit more electrons that are required for

the higher power levels. The end result is a tube with twice the plate

current as a type 80 or 5Y3 tube and slightly more plate voltage.

For high power amplifiers, radios and TVs, this was just what was needed.

The 5Z3 uses the same base and pin out as the type 80 tube, so it is

actually possible to put a 5Z3 in a type 80 socket. Normally this should

be avoided though, the 5Z3 uses a 3amp heater whereas a type 80 tube uses

a 2amp heater. Putting a 5Z3 in a type 80 circuit will likely cause the

power transformer to overheat and fail. Conversely, putting a type 80

tube in a 5Z3 circuit will likely overdrive the tyep 80 tube causing it

to fail very quickly.

Like the type 80, when the octal socket came into use, the 5Z3 had an

octal base put on it and it became the 5U4. The "G" style 5U4 is the

original 5Z3 ST shaped tube using an octal base. Also like the 5Y3,

the tube was reduced in size by using a GT bulb. The 5U4GT bulb is

much larger than the 5Y3GT bulb to accommodate the larger 5U4 plates.

There are two basic 5U4GT tubes. The 5U4GA and the 5U4GB. The GA is

simply the old 5U4G crammed into a smaller GT bulb. The GB is a GA

with an improved design (slightly more power output).

Originally the 5U4GB design was called the 5AS4 (ST version) and later the

5AS4A (GT version). Due to lack of sales and multiple inventory issues

for a tube that was essentially the same as the 5U4, manufacturers decided

to name it the 5U4GB and retire the 5U4, 5U4GA and 5AS4 tubes.

You will often see tubes labeled 5U4GA/GB or 5U4GB/5AS4A indicating

that they are intended for replacement of those tube types.

For new designs the differences are not normally a problem, and for most

radio and TV designs the differences are minor enough to not make a

difference. For some audio amplifiers the slight differences in design

can result in a shift of voltages enough to make a noticable difference

in the way the amplifier sounds. In a properly designed amplifier

the different tubes should not cause damage to the amplifier. Switching

between the various types can be a way to tweak the amplifier for a

different sound. The general rule of thumb is that a tube with more

voltage drop will make the amplifier sound more mellow and one with

less voltage drop will sound more firm. However the nature of the beast

is that the actual results will depend heavily on the amplifier design

and the other tubes used in the amplifier.

Another aspect is that a used tube can make a difference in the sound of

an amplifier. As a tube ages, the number of electrons emited from the

cathode is reduced. This has the effect of increasing the voltage drop

across the tube. The result is that an old amplifer with well used tubes

can sound more mellow than a new amplifier of the same design.

Over the years other tubes have been designed that take their history

from the original type 80 and type 5Z3 tubes. Some were designed to have

lower voltage drop, others to have more or less maximum plate current

and or plate voltage.

One of the more popular replacement versions is the 5T4 which is a metal

version of the 5U4/5Y3 tube. Because it uses a 2 amp heater but has the

voltage and current rating of a 5U4, the 5T4 can be used in place of

either a 5U4 or a 5Y3 in most circuits. The 5T4 tube is no longer made,

but there are still a lot of them available as the military used them

extensively. Because of the metal envelope, the tube is very rugged.

The main problem is that since it is metal, you cannot see inside

the tube to see if it is gassy, arcing or the heater is not working.

Also it is taller (the same bottle as the metal 6L6) than the 5Y3,

so it may not physically fit in circuits using the 5Y3.

Another popular replacement version with a 2amp heater that allows it

to be used in either 5U4 or 5Y3 circuits is the 5R4 tube. The 5R4 also

has a significantly higher plate voltage and a low loss base. The GYA

and GYB versions are highly ruggedized for aircraft use. The main

problem is that the higher plate voltage also means a higher voltage

drop across the tube. Also the GYA and GYB verisons have large heavy

bases as a part of the ruggedization.

A popular tube still being made is the 5AR4/GZ34. This is basically

an improved redesigned 5U4/5Y3 tube. It has a 1.9amp heater and plate

voltage and current similar to the 5U4 so it can be used in either

circuit. However it has a much lower voltage drop so care should

be used to be sure that the circuit can handle the extra current

surge. This tube is usually best used in a circuit that is designed

to handle the low voltage drop. The other potential problem with

this tube is that it has an internal connection on pin 1 which can

potentially cause problems with some circuits. Don't use this tube

unless you know that the circuit can handle it.

Another popular redesigned tube that is still in production is the

5DJ4. This tube is essentially a 5U4 with higher plate voltage and

current. It also has extra connections on the base which can be a

potential problem. Like the 5AR4, don't use this tube unless you

know that the circuit can handle it. Serious damage can potentially

occur in some circuits.

If you need the higher voltage or current of the 5DJ4 but the extra

connections on the base are a problem, consider the 5831. The 5831

has similar characteristics but with the standard 5U4 pinout.

Generally you should stay away from the 5AU4 or 5AW4 tubes as

replacements for a 5U4. These tubes have 20% higher filament

current which can cause the power transformer to overheat if it

is not designed to take the extra load. If you know that the

transformer can handle the extra current, then you can use them.

The 5AU4 is designed to have more current output and the 5AW4

is designed to have a longer life. Unless you have a specific need

for one of these tubes, you should consider one of the other tubes

as a substitute. Neither of these tubes is being made anymore.

The 5V3 is another one of the troublesome tube numbers. There are

two versions of the tube, the 5V3 and the 5V3A. The 5V3 should be

avoided as a 5U4 replacement because it has a 20% higher heater

current which can potentially damage the power transformer.

The 5V3A has the same heater current as the 5U4 and can be safely

used as a substitute. The main advantage of the 5V3 is that it

has a higher plate current and voltage. so it can be used in

more demanding circuits (or last longer in undemanding circuits).

However given the serious difference between the 5V3 and 5V3A

types, extreme care must be used that you don't accidently put

the wrong tube in a circuit that cannot handle it.

For circuits that use a 5Y3, there are a few more options

available for substitution.

For low voltage drop, as well as the 5AR4, there are the 5V4 and 5Z4

tubes. The 5V4 tube comes in the older ST style "G" glass and in the

newer "GT" style glass. The 5V4 is an octal version of the four pin

83-V tube. The 5Z4 also comes in the ST and GT styles, but has

slightly lower voltage drop (20v vs 25v). These tubes don't have

quite as much plate voltage as the 5AR4, but will work in a circuit

designed for the 5Y3 as long as the lower voltage drop is not a

problem. The 5CG4 is rare, but is essentially a 5V4 type tube in a small

GT package.

The 5W4 tube is a lower power version of the 5Y3. It uses less power

so it runs cooler and lasts longer, but it may not work in all circuits

due to the lower plate current rating.

There are also three special industrial/military versions of the 5Y3.

The 6087 is the same as the 5Y3 but is in a low loss base and rugged

construction for mobile and aircraft use.

The 6106 is a highly specialized version of the 5Y3 tube.

It is a Bendix Red Bank tube. These tubes where designed for the

military to withstand the most punishment that could be thrown at a

tube. These are the best 5Y3 tubes ever made.

The 6853 is an industrial version of the 5Y3. It has a lower filament

current so that it lasts longer. The rest of the characteristics are

the same as a normal 5Y3.

How to decide if you can use a different tube type.

The commonly used replacement tubes for the 5U4 and 5Y3 tubes

are listed in the 5U4/5Y3 Compatible Fullwave Rectifier Tubes

tables above.

The first thing to check is the filament voltage and current.

The replacement tube should have the same filament voltage.

The filament current should be equal to or less than the original design.

Lower filament current usually means the tube is not able to handle the

same power levels as the original design, but not always. The plate

characteristics need to be checked to see if it will work.

Higher filament currents should be avoided as they can cause the power

transformer to overheat and fail unless it is designed to handle the

higher current requirement.

Note: If the rectifier tube is used in a series strung heater circuit,

then the voltage and current ratings for the tube must be exactly the

same as the original tube. Generally for those types of circuits it

is best to stay with the original tube number. Normally you won't

encounter a series strung heater circuit unless it is a radio or TV.

Radios commonly used series strung heaters to reduce cost by eliminating

the power transformer. Some very low cost TVs did the same thing.

Normally though series strung radios used halfwave rectifier tubes

specifically designed for radio work and TVs that used series strung

heaters used solid state rectifiers instead.

Generally, if the rectfier is a 5U4 or 5Y3 tube, it is unlikely that

the circuit it series strung as the tube normally requires a power

transformer with a separate filament winding for the tube.

The next thing to check is the maximum plate voltage. The maximum plate

voltage should be at least as high as the tube you are replacing.

If you know the maximum voltage that will be encountered is less than

the tube rating, you may be able to use a lower rated tube, but care

must be used as an underrated tube may arc internally causing potential

circuit damage if the plate voltage rating is exceeded.

Next you will want to check the maximum plate current capability.

Like the plate voltage rating, the maximum plate current rating should

be equal to or greater than the tube being replaced. With plate current

there is greater flexability as often the maximum rating of the tube is

seldom reached. You may be able to get away with a lower rated tube.

The problem that can be encountered here is the tube may be over driven

causing shorter life for the tube and possible power supply collapse.

Usually this isn't as damaging as when the tube experiences internal

arcing, but in some circuits it may potentially be a problem. If you

are not sure, always go with equal to or better current rating for

the plates.

Finally, look at the tube voltage drop. This is normally a characteristic

that is not as much a problem. In radios and TVs it often has little or

no impact as they are typically designed to handle the varience.

In amplifiers, it can affect how the amplifier sounds. Especially

amplifiers that use fixed bias and little or no inverse feedback.

When considering the voltage drop, keep in mind that the rated voltage

drop is normally given for the maximum voltage and current rating for

the plate. The actual voltage drop in use will depend on the current

flow through the plate and the voltage applied. The voltage drop

for a given voltage and current will also depend on the construction

of the tube. Some tubes will have a higher variablity of the voltage

drop as the current changes and others will have less of a change.

Generally a tube with a lower voltage drop design will have less

of a change in the voltage drop with a change in the plate current.

A well used tube will generally exhibit a larger change in voltage drop

with a change in the plate current.

One of the characteristics of a gas rectifier (such as a mercury

rectifier) is that they tend to exhibit less of a change in the voltage

drop. Mercury vapour tubes are very stable in this regard (which is

the primary reason that Hickok used the type 83 tube in their tube

tester). Neon, Xeon, and Argon are other gases that are popular to use

in gas rectifiers.

The purpose of the gas is to provide a plasma inside the tube which

reduces the internal resistance during operation. This characteristic

comes with a price though. The gas will not ionize (turn into plasma)

until a relatively high voltage is developed across the tube. This is

typically between 50 volts and 150 volts. The exact voltage at which

the ionization starts is dependant upon a number of factors, including

temperature of the tube, the type and amount of gas used, and the

internal construction of the tube (distance between the plate and

cathode). Once the ionization occurs the tube resistance drops rapidly

(within microseconds). This causes a strong current surge which can

disrupt or harm the circuits if they are not designed to handle this

situation. This can be especially harmful to high value electrolytic

capacitors as the rapid incease in voltage can cause a high current

surge into the capacitor as the circuit tries to charge up the capacitor.

This can cause the capacitor to overheat which can result in it venting

some of all of its electrolyte. This damages the capacitor. Usually

resulting in the capacitance being reduced, or in extreme cases the

capacitor will explode. It is best to have inductive or resitive loading

in the recitfier circuit when using a gas rectifier to protect the

capacitor from being damaged by the current surge.

Solid State Fullwave Rectifier Tube Replacements

An alternative to using a vacuum tube replacement is to use a solid

state tube replacement. Most of the replacements available use a pair

of silicon diodes to replace the vacuum tube rectifier elements.

The silicon rectifier has several big advantages. One is that they

will normally last for the life of the device they are used in.

Also since they don't require a heater to boil electrons off the

cathode material, they use far less power and don't generate the

heat like vacuum tube rectifiers.

They do have one disadvantage though, they have very little internal

resistance. This can potentially cause trouble in some vacuum tube

circuits. The low resistance can cause higher surge currents in the

rectifier circuit which can shorten the life of electrolytic capacitors.

it can also cause an increase in hum bleed-thru since the internal

resistance of the vacuum tube rectifier is normally included as a part

of the power supply filtering in a tube circuit.

Some solid state tube rectifier replacements account for this by

including a resistor in the circuit to emulate the internal resistance

of the original tube. However the resistor is an added source of heat

and makes the replacement more expensive to make, so most do not include

the resistor.

If the circuit can handle the solid state rectifier, it can provide

more power because of the reduced power loss compared to a vaccum tube.

If you can handle a soldering iron, it is easy to make a solid state

5Y3 or 5U4 tube replacement. First get an octal plug. This can be bought

from a tube supplier, or can be obtained by removing one from a dead tube.

Next you will need two 1N4007 diodes. These are available from most

electronics suppliers. Just about any diode with a current rating of

at least one amp and a voltage of 1000V or higher will work.

Note: Diodes require higher ratings than tubes because they are not as

forgiving as tubes. A tube can normally withstand a momentary event

that exceeds it's rating without permanent damage. Solid state diodes

cannot, they will fail immediately. Because of that, the diode rating

needs to be selected such that it will never be possible for it to

be exceeded. The general rule of thumb is to use at least double the

voltage and current rating as the design calls for.

To construct the rectifier tube replacement, connect the anode of

one diode to pin 4 and the cathode to pin 8. Connect the anode of the

other diode to pin 6 and the cathode also to pin 8.

For a four pin rectifier, connect one diode anode to pin 2 and the

other diode anode to pin 3. Connect the cathodes of the diodes to pin 4.

Congradulations, you now have a solid state tube replacement.

However, you aren't done yet.

As was noted above, solid state rectifier tube replacements have much

lower internal resistance compared to vacuum tube rectifiers. This

can cause problems and potentially even damage to the circuits if they

are not designed to handle this difference.

There are two ways to fix this. One is to modify the circuit by placing

a resistor in series with the plate supply transformer center tap and

ground. The other way you can fix this is by adding the resistor in

series with the cathodes of the diodes and pin 8 (pin 4 on 4pin tubes).

The advantage of placing the resistor in the solid state rectifier tube

replacement is that you are not modifying the circuit so that you can

easily plug a regular vacuum tube in the circuit again without removing

the added resistor from the circuit. The disadvantage of placing the

resistor in the solid state rectifier tube replacement is that the

resistor will get hot and will have dangerous voltages on it.

It is strongly recommended that you properly insulate the solid state

rectifier tube replacement so that you do not accidently touch the

exposed lethal voltages on the connections.

Design note: The recommended design for 5U4 and 5Y3 tubes is to take

power off pin 8 of the filament. A few designs take the power from

pin 2. This may result in increased hum because of the filament voltage

getting into the DC power. To fix this, you can either rewire the

circuit to take power from pin 8, or move the cathodes of the diodes

in the solid state tube replacement to pin 2. Do not short pins 2

and 8 as this will short out the heater supply and damage the circuits.

For the four pin rectifiers, the wiring is even less consistent than

with the octal circuits. You may need to move the cathodes to pin 1

instead of pin 4. As with the octal tube replacement, do not short

pins 1 and 4 or you will damage the circuits.

While in some cases you may be able to get away without using the

resistor, in others it may be wise to use it to prevent damage to

the circuits or change in the characteristics of the circuit.

The chart below provides some suggested values to use.

As with all things like this, these are only suggested values.

The actual ideal values will be specific to the circuit and use.

Selecting the resistor for the solid state rectifier tube replacement.

5AR4    20 ohms  10 watts

5AS4    20 ohms  10 watts

5AU4    30 ohms  10 watts

5AW4    150 ohms 10 watts

5AX4    47 ohms  2 watts

5DJ4    100 ohms 10 watts

5T4     150 ohms 10 watts

5U4G/GA 150 ohms 10 watts

5U4GB   20 ohms  10 watts

5V4(all)100 ohms 5 watts

5W4(all)47 ohms  2 watts

5Y3(all)47 ohms  2 watts

5Z4     47 ohms  2 watts

80 47 ohms 2 watts

83 10 ohms 2 watts

83V47 ohms 2 watts

5Z3150 ohms 10 watts

Note: replacement of the 5R4 with a solid state tube replacement is

not recommended without careful review of the circuit in which it

is used. If the 5R4 is being used in a circuit where the 5U4 would

normally be installed, use the 5U4 resistor.

Note: Silicon rectifier diodes have a typical voltage drop of between

0.5volt and 1.0volt. This can be averaged to 0.75volts for the math.

Divide this by the current flow to get the effective resistance.

Thus for a 250mA tube circuit you would get 0.75 / 0.25 = 3 ohms.

This is much lower than the 44 ohms of a normal 5U4 tube.

Another way to determine the resistor is to install a new tube

in the circuit and set it up to use the maximum amount of power it

would normally use. Measure the voltage between ground and the power

take-off pin (typically pin 8 for octal, pin 4 for 4pin types).

Mark this voltage down as a reference.

Note: these voltages don't have to be super accurate. A 5% tolerance

for this type of work is more than adequate. Most tube circuits are

designed to handle tolerances of 10% to 20% or even more.

Remove the rectifier tube and install the solid state tube replacement

using a variable resistor with the appropriate wattage for the

resistor. Set the resistor value to the value listed in the table.

Again apply power and set up the circuit for the maximum normal load.

While measuring the power takeoff voltage, adjust the resistor to

achieve the same voltage as obtained with the new tube. Turn off

the power, remove the variable resistor from the circuit and measure

the resistance of the variable resistor for that obtained setting

(be sure not to disturb the setting). This is the value of resistor

that should be used with the circuit. (You can use the next closest

standard resistance value available.) The wattage is determined by

multiplying the square of the maximum current in amps times the

resistance. Then use the next higher wattage resistor.

Thus for a 5U4 circuit rated at 225mA using a 150 ohm resistor;

0.225\*0.225\*150=7.6watts. For this you would use a 10watt resistor.

Generally try to pick a wattage 20% to 50% higher to prevent the

resistor from overheating and burning up.

Do not use a resistor with less wattage or it will overheat.

Do not use a resistor with too high of a wattage either. A part of

the purpose of the resistor is to act as a safety valve in case the

diodes short out. The resistor should burn out before the shorted

diode destroys the rest of the circuits.

Always be sure to provide adequate ventalation for power resistors

so that the heat can escape. Also keep them away from other parts

that can be damaged by the heat.

Unfortunately, where the normal failure for a tube is to fail open,

the normal failure for a solid state diode is to short out.

This can potentially cause nasty damage to the circuits.

Warning: Use extreme caution when working with tube circuits.

Do not do this work if you are not qualified to do it.

The voltages in tube circuits are lethal and can kill you.

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