The Valve Wizard

How to design valve guitar amplifiers!

Home

Rectifiers

Bridge Rectifier

A bridge rectifier is used to rectify AC from a transformer with a single winding (i.e. no centre tap) or wh
conduct while the other two are switched off. Notice that all the diodes 'point' towards the positive outpu
You can either build a bridge rectifier from individual diodes or buy a single package. High-current bridg
The first capacitor in the power supply -the reservoir capacitor- will be charged up to the peak value of t
the smoothing page). Under light loading, the DC output voltage will be equal to:

Vdc = 1.4 × Vrms

However, at *full load* this will usually fall to about:

Vdc = 1.3 × Vrms

The difference is due to the AC waveform being somewhat deformed under heavy loading (the peaks g
voltage (Vrms) will *also* sag as the load current increases. Typically, when the loading is light the transfo
'advertised' value. Only when loaded to it's full capacity does the AC transformer voltage fall to its adver

For example, if you buy a transformer rated for "300Vac 200mA" then you can expect it to produce anyv
After rectification this will produce a DC voltage somewhere between:
1.4 × 315Vrms = 441Vdc, to 1.4 × 330Vrms = 462Vdc
If you need better accuracy then you either need to measure the off-load transformer voltage by hand o
some reason they don't put off-load voltages on data sheets).
When the transformer is fully loaded to its 200mA rating the AC voltage will fall to the nominal value of 3
1.3 × 300Vrms = 390Vdc
You will also lose two diode drops (about 1V each for power diodes), so the actual voltage may be close
voltage supply. However, on a low voltage supply (for DC heaters, say) the diode drop represents a sign

Don't forget about adding fuses!

Required Diode Ratings

The diodes in a bridge rectifier need to have an average forward current rating that exceeds the maximu
1N4007 is rated for 1 amp, which is far more than the maximum HT current in any guitar amp. However
have peak and surge current ratings, but you don't have to worry about these as they are always well in

The diodes must also have a Reverse Repetative Maximum (Vrrm) rating that excess the peak AC volta
peak AC voltage is equal to 1.4 × Vrms. The popular 1N4007 is rated for 1000V. This corresponds to an
variation in mains voltage, and knock off another 10% to allow for the transformer voltage being high if I
voltage is greater than 580Vrms. Fortunately, you don't see such high voltages in guitar amps. The story

Hybrid Bridge Rectifier

Ordinary full-wave valve rectifiers cannot be set up as a bridge since they have a single shared cathode
diodes to complete the bridge. Under light loading the DC output voltage will again be equal to:

Vdc = 1.4 × Vrms

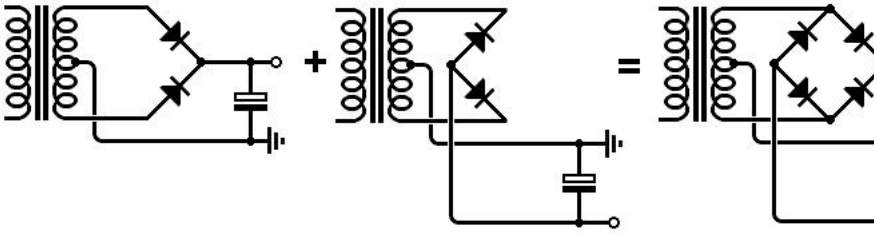
However, under heavier loading you will lose a lot more voltage across the valve diodes. As a rough app
normally be between 1 and 1.2 times the advertised transformer voltage. You can read about more accu

Valve rectifiers can't handle the high current levels that silicon diodes can. For example, the GZ34 is rat
sometimes also need current-limiting resistance to protect them (see shortly) from excessive ripple and
you only need one such resistor since it is shared by both valve diodes.

Two-Phase Rectifier

The two-phase rectifier is used with a transformer that has a centre tap. Really it is a pair of half-wave r
diode is on and the other is off. (Beginners sometimes call the two-phase rectifier a 'full-wave rectifier'. T
rectifier. There are others.)
Vintage power supplies used two-phase rectifiers because it requires only two diodes which could be in
only one heater supply. The vast majority of valve guitar amps still use two-phase rectifiers even when t
partly because a centre-tapped transformer makes it easy to generate a negative bias supply.

Two full-wave rectifiers orientated in opposte directions creates a bipolar supply (positive and negative
this looks like a bridge rectifier (and you can indeed use a bridge rectifier diode package), but it is best



The same basic principles hold for the two-phase as for the bridge rectifier. Under light loading, the DC

Vdc = 1.4 × Vrms

At full load this will usually fall to about:

Vdc = 1.3 × Vrms
Remembering that the transformer voltage will also sag by 5 to 10% between no-load and full load.

Required Diode Ratings
The diodes in a two-phase rectifier need to have an average forward current rating that comfortably exc
modern silicon diodes. Again, you don't have to worry about peak and surge current ratings, provided th

The diodes must also have a Reverse Repetative Maximum (Vrrm) rating that exceeds the **peak-to-pea**
bridge rectifier. This is equal to 2.8 × Vrms. A 1N4007 is rated for 1000V. This corresponds to an AC vol
another 10% for transformer regulation and we are left with about 290Vrms. In other words, we shoudln

What if the transformer voltage is higher than this? The best option is to buy diodes with higher voltage
1N4007. A classic alternative is to use two or more diode in series, so they share the burden. However,
roughly) equally. This can be done by adding a 10nF to 100nF capacitor in parallel with each diode. Hig
is a lot easier to find 1kV-rated ceramic capacitors than 1kV-rated resistors.

Valve Rectifiers
Ordinary valve rectifiers contain two diodes which share the same cathode (and heater), in one bottle. \
maximum *RMS* transformer voltage that the valve can withstand in an ordinary two-phase rectifier circu
modern data sheets. The GZ34 data sheet quotes 550-0-550Vrms (although personally I wouldn't trust
data sheet will also quote the maximum average DC current that the valve can handle. For the GZ34 th
transformer voltages up to 450-0-450V, but the limit is reduced for higher transformer voltages. The limi
don't use those, so you don't have to worry about it. Most valve rectifiers also need their own, dedicatec

In addition to the maximum AC voltage and DC current ratings, valve rectifiers have two other ratings th
capacitance, and minimum current-limiting resistance. These two limits are interelated and serve to kee
level. The bigger the reservoir capacitance, the more limiting resistance you need. The GZ34 data shee
you can, in theory, exceed this if you increase the limiting resistance proportionately. However, this incu
the manufacturer assumes no one would want to do it.
The total limiting resistance (per anode) in the actual circuit is the combnation of transformer resistance

Rlim = Rsec + Rpri × (Vsec/Vpri)^2 + any extra resistance

Where:
Rpri is the DC resistance of the transformer's primary winding;
Rsec is the DC resistance of *one half* of the transformer's secondary winding, i.e measured from one er
Vpri is the primary (i.e. mains) voltage;
Vsec is one half of the secondary voltage, i.e. measured from one end to centre tap.

The data sheet will present table or graphs showing the minimum limiting resistance needed for a given
requirement then you need to make up the deficit by adding resistors in series with each anode. These

P = (1.1 × Idc)^2 × R

Alternatively, you could use one resistor (with twice the power rating) in series with the cathode.

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