

## Construction Notes for the AV 800 watt MOSFET Power Amplifier

### Introduction

The 800 Watt AV amplifier is based on My 1kw Amplifier and shares the same topology and basic PCB layout.

The only real difference is the number of Output devices that the unit uses.

The 1kw design has 20 O/P devices, while the AV amplifier has 14 O/P devices.

This amplifier can be used for practically any application that requires High power, low noise, distortion and excellent sound. Examples would be Sub-woofer amp, FOH stage amplifier, one channel of a very high-powered surround sound amplifier etc.

The AV amplifier has four main stages of amplification. We will begin by looking at each stage in reasonable detail.

### The Error Amp Stage

The first stage is what I call an asymmetrical balance input error amplifier. It is a design, which allows only one single differential stage and yet has the ability to accept a balanced I/P source. An unbalanced source can be used if either the inverting or non-inverting I/P is tied to signal ground.

Now I will explain how each device in this stage works together.

Q6, Q7, R28- R29, and form the main differential error amplifier, which then has its collectors, connected to a cascode load. Q1, Q2, R13 and ZD1 form the cascode stage, which provides a constant 14.4 volts on the collectors of Q1, 2.

Q23, R42, R66, ZD2 and C19 form a constant current source, which supplies 1.5milliamps to the first differential stage. These modules form the first stage of the amplifier and basically set up how the whole amplifier is biased from front to back.

### The Voltage Amplification Stage

This next stage provides most of the voltage amplification that the next stage needs to drive the o/p stage to full power.

Q3, Q4, Q24, Q25, R3, R54, R55, R40, C2, C9, C16 form the second differential voltage amplification stage. Q54 and Q55 form what is known as a current mirror load for the second differential stage and basically force this stage to share the current supplied from R36, which is about 8milliamps.

The remaining components, namely the caps provide local frequency compensation for this stage.

### The Bias and Buffer stage

As the name suggests Q5, Q8, Q26, R24, R25, R33, R34, R22, R44, C10 form the Bias and buffer stages. Its main purpose is to provide the MOSFET Gates with a stable and compensated supply voltage and Buffer the Voltage amp stage from the high Gate Source capacitance. Which would without this stage cause the frequency response and slew rate to be very poor indeed. The down side of this is the extra stage does introduce an extra dominant pole in to the amplifiers feedback loop.

### The Output Stage or Current Amplification Stage

Once again as the name suggests this stage converts the voltage developed in the VAS and provides all the amperes needed to drive 8 or 4-Ohm loads. 2-Ohm loads are possible for several minutes at a time. In fact I have tested the 1kw amplifier to over 1600 watts RMS into 2 Ohms. But this would not be recommended as a long-term load at all. As it does exceed the SOA figures of the output stage.

### Power supply requirements for the 800 AV Amplifier

The power supply components for this amplifier are as follows and are expressed for One Channel or One power module only.

1 x Toroidal Transformer with a Core rating of 1KVA. Primary windings are made to suit your local mains supply. eg: for Australia One single primary winding with a 240VAC rating. For USA, 110VAC, 115VAC and I believe there is a 220-Volt AC mains supply in some areas of the United States. For the UK it would be 220 VAC to 240 VAC.

The secondary windings are as follows.

2 x 65 volts AC at full load.

One 400 Volt 35 Ampere, Bridge rectifier.

2 x 4.7K 5-Watt ceramic resistors

Minimum filter capacitor requirements would be 2 x 10,000uf 100 volt electrolytic.

Ideal capacity would be 40,000uf per voltage rail.

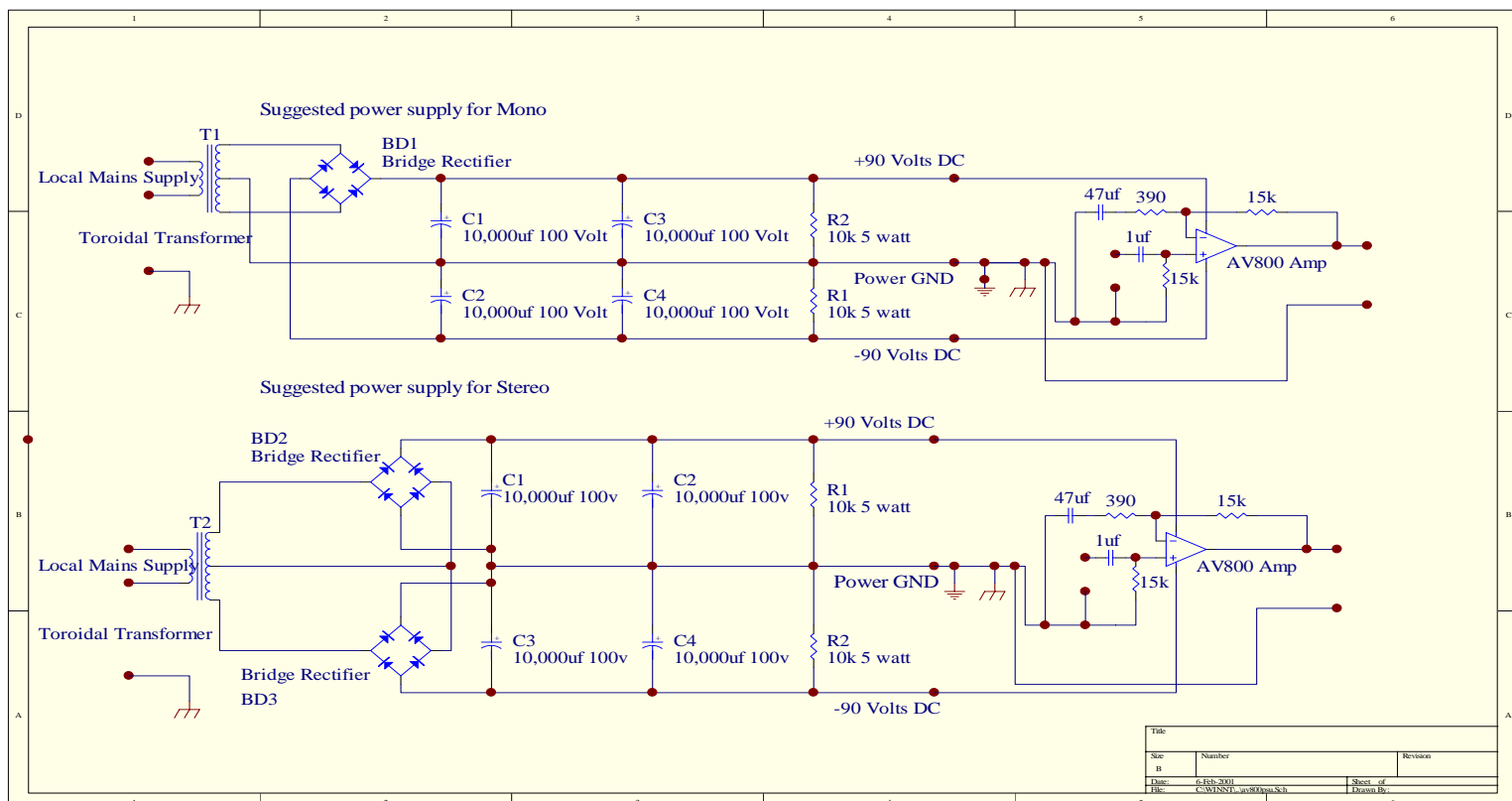
For stereo or dual mono operation the following power supply will be required.

1 x 2kva toroidal transformer with a core rating of 2kva

2 x 400 volt 35 amp bridge rectifier

4 x 10,000uf 100-volt electrolytic capacitors

2 x 4.7K 5-Watt ceramic resistors



## Assembling the Printed Circuit Board

One of the first things to do is to look at the PCB and see if all of the holes on the board are of the correct size for the components you wish to insert. The holes that have been drilled into the PCB should be OK. However it does pay to check before you start. If you find that some of the holes are not big enough then you will need to drill them out to the correct size. The standard holes sizes used for most electronic components are as follows.

$\frac{1}{4}$  watt  $\frac{1}{2}$  watt resistors = 0.7mm to 0.8mm

1-watt resistors = 1.0mm

$\frac{1}{4}$  watt to 1-watt zener and normal power diodes = 0.8mm

Small signal transistors such as BC546 of the TO-92 pack = 0.6mm

Medium signal transistors such as MJE340 of the TO-220 pack = 1.0mm

Power Output devices such as the IRFP240 require a hole size of 2.5mm

However on this PCB these devices are mounted on the copper side of the PCB facing down flat.

The next thing that needs to be done is the cutting out of the PCB section, which has the output stage devices screen-printed on top of the PCB. This needs to be done so the mounting of the o/p devices can be properly clamped to the main heat sink. The best way of cutting this section out is to either use an electric router or drill 5mm holes in each corner and use a coping saw to remove the unwanted fibreglass and file the inside edges clean.

Start constructing the PCB by inserting any wire links, which are shown on the component overlays as R5, R23, R41, and R45. The wire links are made from spare component leads such as from 5-watt ceramic resistors or  $\frac{1}{4}$  watt resistor leads. Once the links have been taken care of the insertion of all the resistors is next, followed by the capacitors and then the small signal semiconductors. You will need to cross-reference the parts list with the white screen component overlay on the PCB to see where to insert the required component. Be careful to always insert the polarised components in the right way as shown on the screen-printed overlay. Failure to do this will most likely result in the module not functioning properly or damaging one or more of the components in the module.

The output stage transistors and Q8, which is the IRF610 device, are to be left till last. The buffer stage transistors are to be mounted on 10 degrees/watt heats sinks with a one-inch pitch mounting.

The buffer stage devices do need to be insulating from the heat sinks, As they would be 180 volts across both of these heat sinks.

### Pre-flight test

OK at this stage I am assuming you have populated all of the PCB except Q8 and the main output stage devices IRFP240's and IRFP9240's

### Pre-flight test continued

It is important to test the function of the amplifier at this point in time so as to make sure it is working properly. This is achieved by soldering a 10-Ohm  $\frac{1}{4}$  watt resistor from the output of the amplifier PCB to one side of the 330-Ohm 1W resistor found at R38 On the screen-printed side of the PCB. What this does is to connect the feedback resistor R37 to the output of the buffer stage. In doing so it bypasses the output stage and turns it into a very low powered amplifier, which can be tested without damaging the expensive output stage. Assuming you have connected the resistor from o/p to the buffer stage. It is now time too connect the +-90 volt supply to it and power it up. Be sure to have 4k7 Ohm 5-watt bleeder resistors across the power supply capacitors. Now assuming that there was no smoke, with a multimeter on volts. Measure the following voltage drops across these resistors locations marked in blue and if they match to within +-10% then you can be sure that the amplifier is OK. When you have done the checks, be sure to power down and remove the 10 Ohm resistor.

R1~1.6 volts

R2~1.6 volts

R3~1.0 volts

R55~500mv

R56~500mv

Offset voltage at R37 should be close to 0 volts, but can be as high as 100mv.

### Completing the Module

Now we have come to the soldering in of the output devices. It is assumed at this point that you have all ready matched the output stage devices as outlined in the accompanying document on [How to match output devices](#).

If this is already done then you can proceed by getting the PCB and flipping it over so the copper side of the board is facing you.

Now identify which is the positive supply side of the PCB and start soldering the IRFP240 devices face down on the appropriate pads so the metal tabs on the back of the power MOSFET's are facing you.

Once all of the N-channel devices are done proceed with the IRFP9240 P-channel devices, in the same way

After completing this task the module for the most part is completed.

The only other thing you will need to decide is wether to use PCB stakes to solder the external wiring too or solder the cable directly into the PCB pads.

Now there is one device that requires some special attention. This is Q8 and this device is the VGS multiplier or bias compensation device, which needs to be mounted off board on a strip of 10cm x 2cm x 4mm thick piece of aluminium and it is this piece of aluminium that will clamp down the output stage. Q8 will need to be insulated with a TO-220 mica-washer kit from this piece of metal and flying leads need to be soldered from the Gate,

Source and Drain pins of the IRF610 to the appropriately marked pads on the PCB shown as Q8.

One other thing that needs to be done is to mount some 3mm high rubber feet on copper side of the front and back of the PCB. This is to hold the PCB off the heat sink, so as not to allow the PCB to touch the heat sink in any way.

### Completing the Module Continued

Now having completed the power module and tested the Error, VAS and Buffer stages and you are confident that it is working OK. Now its time to bolt it down to a suitable heat sink. Remember that all of the o/p devices must be insulated with either silicon rubber washers or mica -washers and heat sink compound. The type, size and shape of heat sink are left up to you and the local availability of heat sinks. But be sure to have a heat sink rated at 0.2 degrees/watt or 0.5 degrees/watt with fan cooling.

### Testing the module

So we have come to the point where we need to do a full test on the amplifier module. There are a few checks that need to be done first.

- The Drain pins on all the o/p devices need to be checked for S/C to the heat sink.
- The power supply wiring has been checked for correct polarity to the PCB.
- The Multi-turn pot P1 has been turned back to 0 Ohms, so that a measurement of approximately 4.7k is measured across the Gate and Drain pins of Q8 IRF610.
- When wiring up the power supply, be sure to have 8 amp fuses inserted on each of the supply lines.
- Connect a multimeter on DC volt range to the o/p of the amplifier.

Ok now that you are happy that the module is setup correctly apply power via a VARIAC if you have access to one, otherwise just power the amplifier up.

Looking at the voltmeter you should get from 1mv to 50mv offset voltage.

If this is not the case then power the amplifier down and check your work.

Assuming all is well then power the amplifier down and find a small flat blade screwdriver so you can be ready to adjust P1 for the biasing of the o/p stage.

But first connect the voltmeter across one of the o/p stage Source resistors using Alligator leads.

Now reapply power to the amplifier and slowly adjust P1 while watching the voltmeter, for a reading of 18mv.

Now check across the rest of the Source resistors and find the one, which has the highest reading, and adjust P1 till 18mv is read.

Now connect a load and signal source to the amplifier and with a CRO if you have access to one observe that the waveform is clean and free from noise and distortion.

If you don't have a CRO and Signal generator, connect a pre-amp and loudspeaker and have a good listen. The sound should be very clean and dynamic.

Congratulations, the amplifier is complete.

Best Regards

Anthony Eric Holton

8<sup>th</sup> February 2001

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### Specifications for the AV800 MOSFET Amplifier

All measurements were taken at an AC Mains input of 240 volts.  
And with a 2kva Toroidal Transformer powering the Amplifier module.  
Filtering with only 10,000uf per voltage rail  
One channel only was been driven.

Frequency response 10hz to 100khz  
THD measured at 100 watts into 8 Ohms 0.01% @1khz  
Power Output into 8 Ohms = 450 Watts RMS  
Power Output into 4 Ohms = 820 Watts RMS  
Damping Factor = 400

### Notes and Errata

**It has been shown on the first batch of PCBs sold that Q3 and Q4 silkscreen overlay has an error.**

**The B C E markings are in the incorrect place. They should have the same orientation as Q25 and Q25.**

**This error has now been corrected on the latest PCB version 1.0.5**

## Component List for the AV800 MOSFET Amplifier

All of the resistors are ¼ Watt metal film 1% tolerance unless otherwise stated.

Designators	Component Value
C1	100uf 160v RB
C2	10PF Ceramic
C3	47UF/100V RB
C4	47UF/100V RB
C5	47UF/100V RB
C6	47UF/100V RB
C7	47UF/100V RB
C8	47UF/100V RB
C9	10pf Ceramic
C10	1uf MKT
C11	2n2 MKT
C12	68pf Ceramic
C13	2n2 MKT
C14	220uf 25v RB
C15	47uf Bipolar
C16	100nf MKT
C17	100nf MKT
C18	47uf Bipolar
C19	47uf 25v RB
C20	47UF 100V RB
C21	47UF 100V RB
C22	47UF 100V RB
C23	47UF 100V RB
C24	47UF 100V RB
C25	47UF 100V RB
C26	100uf 160v RB
C27	100nf-x2/250vac Mains Rated
D1	1N4007 1 amp diode
D2	1N4007 1 amp diode
HS1	1 inch pitch, Min 10 Degrees/Watt
HS2	1 inch pitch, Min 10 Degrees/Watt
LD1	LED any colour
LD2	LED any colour
P1	5K POT Multi turn or 10 turns
Q1	2SC2240 TO-220
Q2	2SC2240 TO-92A
Q3	2SA1306 TO-220
Q4	2SA1306 TO-220
Q5	IRF610 TO-220
Q6	BC546 TO-92
Q7	BC546 TO-92
Q8	IRF610 TO-220
Q9	IRFP240 TO-3P
Q10	IRFP240 TO-3P
Q11	IRFP240 TO-3P
Q12	IRFP240 TO-3P
Q13	IRFP240 TO-3P
Q14	IRFP240 TO-3P
Q15	IRFP240 TO-3P
Q16	IRFP9240 TO-3P
Q17	IRFP9240 TO-3P
Q18	IRFP9240 TO-3P
Q19	IRFP9240 TO-3P
Q20	IRFP9240 TO-3P

Designators	Component Value
Q21	IRFP9240 TO-3P
Q22	IRFP9240 TO-3P
Q23	MJE340 TO-126
Q24	2SC3298 TO-220
Q25	2SC3298 TO-220
Q26	IRF9610 TO-220

**All of the resistors are ¼ Watt metal film 1% tolerance unless otherwise stated.**

R1	2k2
R2	2k2
R3	120
R4	100
R5	Wire LINK2
R6	0.22 3 or 5 WATT
R7	0.22 3 or 5 WATT
R8	0.22 3 or 5 WATT
R9	0.22 3 or 5 WATT
R10	0.22 3 or 5 WATT
R11	0.22 3 or 5 WATT
R12	0.22 3 or 5 WATT
R13	10k 1watt
R14	470
R15	470
R16	470
R17	470
R18	470
R19	470
R20	470
R21	47K
R22	100
R23	Wire LINK4
R24	100
R25	4k7
R26	4k7
R27	4k7
R28	47
R29	47
R30	4k7
R31	4k3
R32	10 Ohm 1watt
R33	1k
R34	100
R35	470
R36	390
R37	15k
R38	330
R39	470
R40	10k 1 Watt
R41	Wire LINK3
R42	10k 1watt
R43	100
R44	100
R45	Wire LINK5
R46	47K
R47	470
R48	470

Designators	Component Value
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Designators	Component Value
R49	470
R50	470
R51	470
R52	470
R53	470
R54	100
R55	100
R56	10k
R57	100
R58	0.22 3 or 5 WATT
R59	0.22 3 or 5 WATT
R60	0.22 3 or 5 WATT
R61	0.22 3 or 5 WATT
R62	0.22 3 or 5 WATT
R63	0.22 3 or 5 WATT
R64	0.22 3 or 5 WATT
R65	10 Ohm 5 WATT
ZD1	15v 1watt Zener Diode
ZD2	15v 1watt Zener Diode

Component Value	Quantity
<b>Misc</b>	
1 Inch pitch 10 Degree/watt heat sinks	2
Wire Links	4
<b>Resistors</b>	
0.22 Ohm 3 Watt Resistor	14
100 Ohm Resistor	8
100 Ohm Resistor	1
10k Ohm Resistor	1
10k Ohm 1watt Resistor	3
10 Ohm 1watt Resistor	1
120 Ohm Resistor	1
15k Ohm Resistor	1
1k Ohm Resistor	1
2k2 Ohm Resistor	2
330 Ohm Resistor	1
390 Ohm Resistor	1
47 Ohm Resistor	2
470 Ohm Resistor	17
47K Ohm Resistor	2
4k3 Ohm Resistor	1
4k7 Ohm Resistor	4
10 Ohm 5 Watt Resistor	1
5K multi turn POT	1
<b>Capacitors</b>	
10PF Capacitor	1
10pf Capacitor	1
100nf MKT Capacitor	1
100nf MKT Capacitor	1
100nfx2 250vac Capacitor	1
100uf 160v Capacitor	2
1uf MKT Capacitor	1
220uf 25v Capacitor	1
2n2 MKT Capacitor	2
47uf 100V Capacitor	12
47uf 25v Capacitor	1
47uf BP Capacitor	2
68pf Capacitor	1
<b>Semiconductors</b>	
15v 1watt Zener Diode	1
15v 1watt Zener Diode	1
1N4007 1 amp Diode	2
2SA1306 Transistor	2
2SC2240 or 2SC2546 Transistor	2
2SC3298 Transistor	2
BC546 Transistor	2
IRF610 Transistor	2
IRF9610 Transistor	1
IRFP240 Transistor	7
IRFP9240 Transistor	7
Light Emitting Diodes	2

## How to match Hexfet MOSFETs

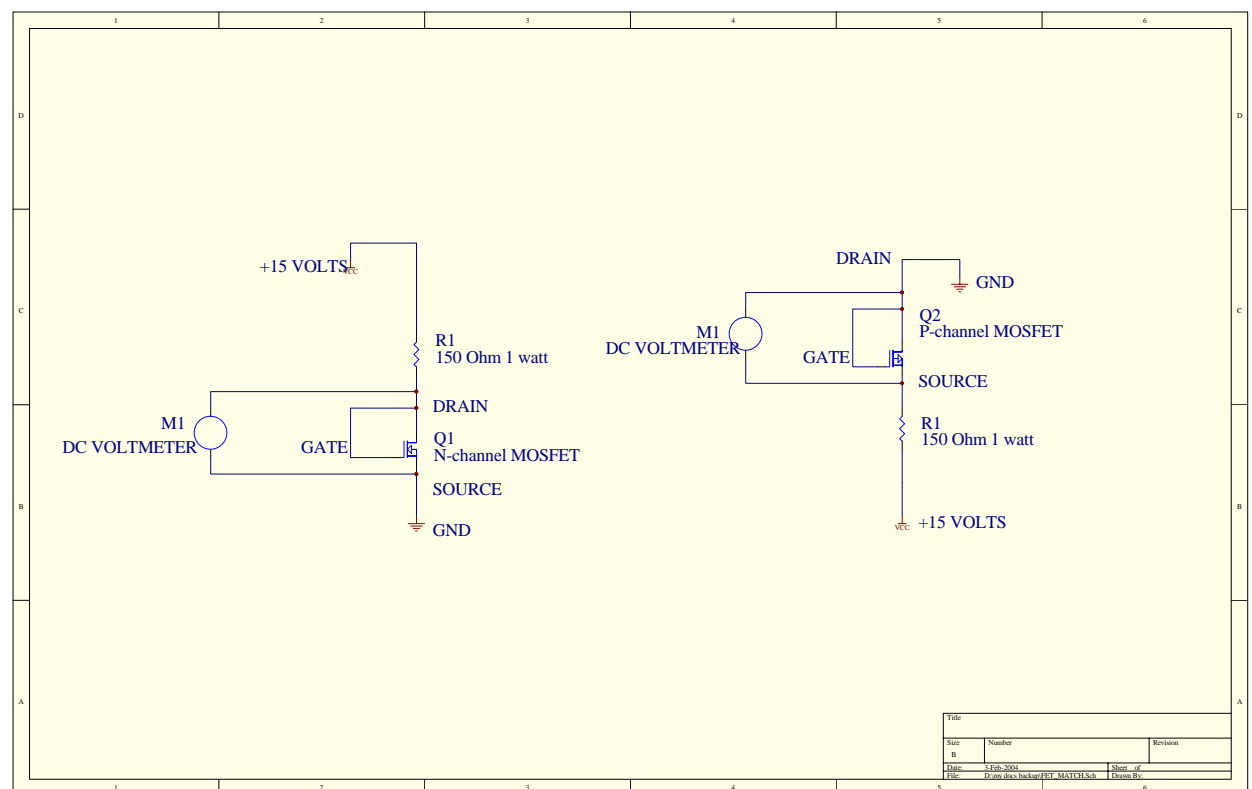
When using this type of MOSFET in the AV800 amplifier is strongly recommended that the output stage devices be matched. As it has been found that if this is not done then there is no guarantee that they will share the current under load.

The Source resistors provide only a bit of local feedback and don't in any way force the devices to current share.

The best method I have found to work very well utilises just a 150 Ohm 1 watt resistor and a +15 volt DC power supply.

If you look at the schematic below it shows how to connect and measure the N-channel devices and the P-channel devices.

With the devices connected, as shown measure across Drain and Source of Q1 and Q2 with a multimeter set to DC volts and measurement of between 3.8 volts and 4.2 volts will be shown. Simply match the device in-groups to a tolerance of +/- 0.1 to 0.2 volt. Please note that you only have to match the n-channel to the n-channel devices and the p-channel to the p-channel devices, not the N-channel devices to the P-channel devices.



# AV800 Schematic Build 03022004

To see this schematic in more detail use the zoom option in Acrobat Reader.

