First Watt SIT-3

Power Amplifier

OWNERS MANUAL

Introduction

The SIT-3 is the very latest example of single-ended / single-stage Class A amplifiers using the SIT (aka VFET) power transistor exclusive to First Watt. It is preceded by the successful SIT-1 and SIT-2 and very much follows their technical philosophy and construction.

There is a key difference in the SIT-3, which is that the Static Induction Transistor (SIT) that forms the heart of the circuit is operated in an entirely different mode, what is known as Common Drain Mode.

By way of explanation, any gain device with three pins can be used in one of three modes. For the Field Effect Transistor (FET), they are Common Source, Common Drain, and Common Gate.

The channels of the SIT-1 and SIT-2 consisted of a single SIT operated in Common Source Mode in which (conceptually) the signal comes into the Gate and appears amplified at the Drain pin, but phase inverted. The Source pin is grounded. The amplification with Common Source operation is both voltage and current, and the phase inversion is corrected by reversing the output terminals.

The SIT-3 goes in another direction, using Common Drain operation, where the signal goes into the Gate pin and comes out the Source pin and the Drain of the Fet is grounded (literally attached to ground). This mode only provides current gain – the voltage gain is provided by a high quality voltage step-up transformer which takes the input signal from a preamplifier (or other device) and boosts the voltage. It has no phase inversion.

In both approaches, the SIT does a good job of amplifying the signal without feedback, but Common Drain operation delivers the amplification with much lower distortion and noise and also a much better damping factor for the loudspeaker.

The trade-off is the addition of the input transformer, but I think you will find the compromise there is small with respect to the sound quality achieved.

Common Drain has the same simple spectral distortion character that graced the SIT-1 and SIT-2, and allows similar control of the amplitude and phase of the second harmonic content, but at a much lower distortion figure.

If like me you find 18 watts is enough power, then I think you will find that this is a really delightful amplifier.

Setup

The initial setup of the amplifier is very straight-forward. Place the amplifier in a well-ventilated location, as it draws about 150 watts and appreciates the opportunity to keep the heat sinks cool. You should be able to put your hands on the heat sinks during operation. If you can't do this for 5 seconds or so, they probably need more ventilation.

On the front panel there are two blue LED lights, one for each channel, indicating power to each channel. If the light is on, the power supply for that channel is delivering voltage. On the rear panel you will find pairs of RCA inputs, speaker outputs, a fuse holder, an AC power receptacle, and on/off switch and a label.

The label will indicate a serial number and also what AC line voltage the amplifier is set for. If the voltage is 120 VAC, then the fuse value will be a 3AG slow blow fuse rated at 2.5 amps. If the voltage is 240 VAC, then the fuse will be rated at 1.25 amps. Do not substitute a larger value fuse. Contact First Watt if you have any questions, or if you can't find a replacement fuse locally.

I'm assuming that you know how to attach the speaker cables to the 5 way output connectors provided. I recommend that you make all the connections with the amplifier power switch in the OFF position, but you will not damage the amplifier circuit by accidentally shorting the output or over-driving the input – this is more out of concern for any fragile loudspeaker you might be using.

The Red output terminal is the "plus" output, and the Black is ground, the same ground as the input RCA outer connectors. To avoid ground loops, the channel grounds are resistively isolated from each other in the amplifier, each having a separate power supply secondary. The only common ground they will experience is probably at the source equipment. Nothing crazy will happen if you connect the grounds together though, and you can parallel two channels inputs and outputs for more current if you want. It is safe to drive the inputs to a subwoofer amplifier, and it is safe to run the amplifier without inputs or outputs, but continuous or high level output into a short circuit may cause failure.

With everything connected up and the source equipment powered up first, you can proceed to turn on the power switch to the amplifier. Turn-on and turn-off thumps and noise are small in this amplifier and should not present any hazard to delicate drivers. At this point you should be able to listen to music.

Again, each channel of the power supply is isolated from the other channel and chassis/AC earth ground by power thermistors. These help to prevent ground loops, but stand by to conduct AC line current to ground in case of transformer or other such failure.

The input impedance is 200 Kohms, and the input capacitance is very low, so you will find it easy to drive with a high impedance source if you like.

It has less gain than the amplifiers you are used to, but you can clip the output with about 3 volts. It is, after all, an 18 watt amplifier.

The SIT-3 has enough damping factor at 30 to work well with general loudspeakers, but it has been designed around relatively high efficiency speakers, those having 88 dB sensitivity or greater.

The amplifier requires about 1 hour of operation to reach full normal operating temperature, but the bias comes up to the proper value shortly and holds to a tight tolerance. The amplifier's final adjustments were made after an hour, but the performance difference between 10 minutes and an hour is not much.

I do not personally see a reason to run the amplifier all the time, but you can do that if you want to. The power supply capacitors are likely to last 20 years or more, and while they will slowly dry out just sitting there, they will have a longer life if the amplifier is not run continuously. Practically speaking, it makes sense to shut the amplifier off if you aren't planning on using it for the rest of the day.

Again, the heat sinks on this amplifier run fairly hot, and you want to make sure that they get adequate ventilation. They will run at around 25 degrees C. above the ambient temperature, which puts them around 50 degrees in the average listening room. At this temperature you should be able to put your hand on them for about 5 to 10 seconds or so.

If you have any questions, contact First Watt.

I answer all questions, even if the answer is no.

and sometimes it takes a little while ...

www.Firstwatt.com nelson@passlabs.com

Introduction to and History of Static Induction Transistors

In the mid 1970's a special variety of Jfet invented in Japan called a *Static Induction Transistor* (SIT) found its way into the "VFET" power amplifiers produced by Yamaha and Sony. These amplifiers were produced for several years and then discontinued, but are still highly regarded in the high end audio community.

SIT devices have a unique characteristic which is of particular value for audio amplifiers. Quoting inventor Nishizawa's patent abstract, "(The) drain-current to drain-voltage characteristic simulates the anode-current to anode-voltage characteristic of the Triode vacuum tube very closely." They have found use in radar and other exotic applications, but after Sony and Yamaha ceased production, versions suitable for audio power amplification have been highly prized and difficult to obtain.

There has been renewed interest in SITs, partly because two companies have stepped up to the plate and spent the money required to fabricate new devices suitable for audio power amplifiers. The first of these is Digital Do Main in Japan, which has produced amplifiers based on newer versions of original Yamaha Silicon parts. The other is First Watt, which arranged for a production run of a new SIT device using a newer Silicon Carbide process by SemiSouth.

It is that "Triode characteristic" which makes the SIT so special. Your ordinary power Jfet or Mosfet is a voltage variable current source with a set of curves which looks like a Pentode tube:



By contrast, the SIT is a voltage variable resistor with a set of curves that look like a Triode:



Audiophiles often go to great expense to achieve as little as 5 watts of power using Triodes because of their specific sonic character. Unfortunately Triode performance is limited partly by the need to transform the high voltage / low current operation of the Triode down to the low voltage / high current domain of loudspeakers. This means a power transformer and the distortion comes with it.

Of course it would be nice if Triodes drove speakers without transformers.

It has been a goal of some designers to get transistors to sound like Triodes, with very limited success. Fets can sound like Pentodes, but it takes a particular set of gyrations to make a Fet do the Triode trick.

Then there are those who think that nothing less than a glowing bottle will satisfy tube aficionados. Perhaps that is true, but it isn't going to keep me from trying. There are two things we want out of a solid state device for this purpose. First, we want a "square law" input characteristic like that of tubes. Fortunately, Fets do that already – the current through the Fet is a good square law function of the Gate to Source voltage.

Second, we want a low Drain resistance, equivalent to the Plate impedance of the Triode. This is where gain device can be regarded as a variable resistor instead of a variable current source.

Why do we want this characteristic? Three reasons - first, it allows a single gain stage with both voltage and current gain, and having a high input impedance and low output impedance without a feedback loop or degeneration.

Second, this character allows "working the load-line" - the particular description of the path of the gain device through the voltage/current region in the course of amplifying into the loudspeaker. By choosing this line wisely, you can achieve intrinsically lower distortion. Pentodes and Mosfets aren't as good at this.

Third, like Triodes, SITs have a soft overload characteristic. When over-driven on peaks they present compressed, rounded waveforms instead of sharp clipping, the result being that they are more graceful under pressure.

The entire effort revolves around *simplicity and minimalism* in circuit design. Certainly you can get good objective performance with multi-stage circuits and negative feedback. What we want is the sound that can be had from a single gain stage operated single-ended Class A without feedback or degeneration. We want it with a high input impedance and a low output impedance, and we want it with reasonably low and simple distortion.

It is worth noting that the original efforts by Sony and Yamaha were not minimalist – they contained many parts in multiple gain stages and used a generous amount of feedback. Forty years later, the emphasis is on using the character of the SIT to achieve performance in a simple circuit.

There are several reasons for the push toward minimalism. The first is simply aesthetic – there is much to admire about an amplifier which performs well with only one transistor. And of course there is an attractive challenge, which is "How good can you make such an amplifier?"

There is another, more practical reason to explore simple circuits. It is generally agreed that if you are going to have distortion, you will want it in a low order harmonic form, kept to only second and third harmonic if possible. A single-ended Class A device is going to generally give you the simplest version of this.

Lots of audiophiles dislike the sound of negative feedback (or at least think they do). It is true that while negative feedback reduces the amount of distortion, it does tend to re-arrange it so that the character is more complex.

Minimalism is the raison d'etre for SIT devices in audio. With them you can get good objective and subjective performance from a single SIT in a very simple circuit.

The First Watt SIT Amplifiers

In 2010 when First Watt was buying power Jfets from SemiSouth to make the J2 amplifier, I was given the opportunity to have a custom run of SIT transistors made of Silicon Carbide. Without really knowing what I was going to end up with, an expensive bet was made and later that year I was in possession of a relatively small quantity of transistors that look like this:



Fortuitously, the designers of the transistor delivered parameters that were just about ideal if you are trying to deliver 10 watts into 8 ohms at minimum distortion.

In 2012 First Watt introduced two SIT-based products, the SIT-1 monoblock and the SIT-2 stereo amplifier. Both were rated at 10 watts per channel and used the SIT as the only gain device, operated without feedback in Common Source Mode, which delivers both voltage and current gain. The two amplifiers were the most successful in the history of First Watt and were made into 2017.

With the unfortunate demise of SemiSouth, there was not an opportunity to make more of these parts, but I still wanted to release a design which operated the SITs in Common Drain mode, where they act as followers, delivering only current gain.

That design is the SIT-3, a stereo amplifier using the SIT as the gain device delivering output current, mated to a voltage gain stage using a step-up transformer to deliver the voltage gain.

A slightly simplified diagram of the circuit looks like this:



You can see the input Jfet followers driving the auto-former, which develops voltage gain for the power output followers. You might notice the inverted power supply, which dramatically reduces supply noise seen by the SIT.

The SIT has a very unusual companion in the output stage, a P channel Mosfet whose Gate voltage is the mirror image of the N channel SIT, giving a selfbiasing characteristic for a push-pull follower. There is no bias circuit, no adjustment, and the bias current is very stable.

Unusual for push-pull, the distortion character is a fairly pure second harmonic:



This design requires careful selection of the characteristics of each SIT matched to the Mosfet – their Gate voltages must be carefully matched, and fortunately this SIT device falls into the range where such matching is possible.

The actual circuit is hardly more complicated, and includes a few new tricks to get both the purest square-law performance with solid stability.

As before, the simple circuits are operated without feedback, but it is in the nature of Common Drain operation that the distortion will be much lower, and the damping factor will be much higher. And so it is - approximately 10 times better. And the noise is lower.

Here are some performance curves:



Above we see the total harmonic distortion versus output watts for an eight ohm load, taken at 1 KHtz. The distortion is dominated by second harmonic with a "negative phase", the signature that we have come to prefer with the previous SIT amplifiers. Below we see the distortion curve into 4 ohms.



Here is the distortion versus frequency taken a 1 watt into 8 ohms.



And here is the frequency response.



If you are like most First Watt customers you are thinking, "Well that's all very nice, but I really only get excited about the sound." Me too.

You are possibly familiar with the sound of SET amplifiers employing a power Triode and an output transformer. This is going to have some similarity, as we have both a Triode-like device operated without feedback and a transformer changing the voltage ratios.

I hope you enjoy the SIT-3. I think it is the most interesting of the First Watt SIT amplifiers, and for about 250 people it will be the best.

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Summary of the nominal specifications:

Maximum output	18 watts @ 8 ohms
	30 watts @ 4 ohms
Input Impedance	200 Kohms
Gain	11.5 dB non-inverting phase
Damping Factor	30
Frequency Response KHz	5 dB @ 10 Hz, – 3dB @ 50
Output Noise	50 uV unweighted 20 - 20 Khz
Power consumption	150 watts
Fuse: 3AG slow blow type -	2.5 Amp for 120VAC
	1.25 Amp for 240 VAC
Weight	32 lbs
Dimensions	17" W 16" D 6.75" H

Warranty: Parts and labor for 3 years, not covering shipping costs or consequential damages.

www.Firstwatt.com nelson@passlabs.com

Now the following is for your protection –

Do not defeat the AC line Earth ground connection on the amplifier power cord. It provides an extra barrier to prevent potential shock hazard.

Do not replace the fuse with a type other than specified.

Do not operate the amplifier outside in the weather, or in and around water or anything resembling water. If you spill a drink in the amplifier or if your dog/cat/child urinates on it, turn it off immediately, unplug it, and do not operate it until cleaned by a qualified technician.

If something gets loose or rattles around inside or smells funny, or if you can't touch the heat sinks for 5 seconds or so, then turn it off, unplug it from the wall, and contact First Watt.

There are no user serviceable parts inside. Do not open the amplifier, and if you do anyway, don't operate it with the cover off. There are hazardous voltages inside. If you need to change the operating AC voltage, contact First Watt.

Once Again:

If you have a problem, contact First Watt. We are much happier helping you solve problems so that we can be certain that it's done properly. If you are far away and don't want to ship the product for repair, we will assist your technician with information and parts.

www.Firstwatt.com nelson@passlabs.com