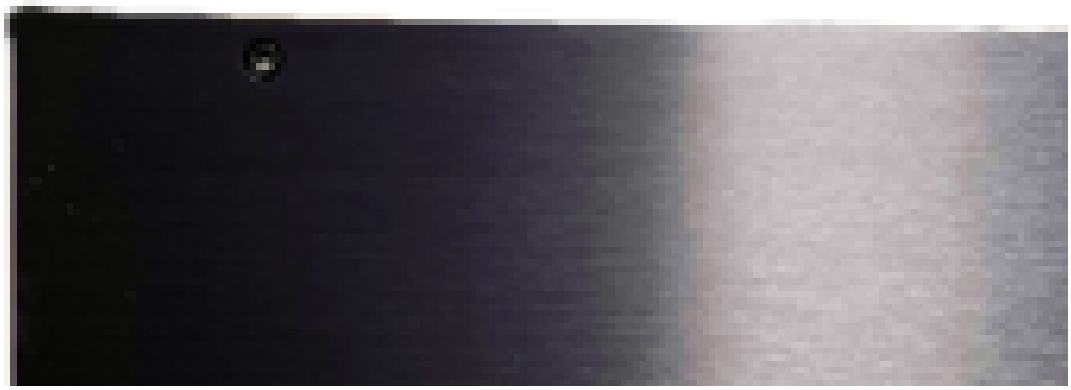
First Watt

SIT-5 Power Amplifier

OWNER'S MANUAL



READ ME FIRST

Heat and Ventilation - This amplifier consumes 200 watts and mostly converts it into heat. Pick a location where the amplifier can get some fresh air to help keep it cool, not in a closed cabinet. Give it some space.

Output Connection – Unlike the SIT-4 amplifier the Black output terminal is negative and the Red is positive, like other amplifiers. You can pretty much hook this amplifier up to any loudspeaker without danger of damage.

Warmup - The amplifier takes a little while to fully warm up. During this time you can listen to it, but you will find that the performance gets a little better inside a half hour or so.

OK, with that out of the way...

Introduction

The SIT-5 is the most recent amplifier produced by First Watt, and is the fIfth to use a Static Induction Transistor (SIT) as the power amplifying device. In 2011 we introduced our first SIT amplifier using a custom Silicon Carbide (SiC) transistor part made by SemiSouth. The amplifier also used a single power device, operating without feedback in single-ended Class A *Common-Source* mode to deliver 10 watts of power emulating the characteristic of a Triode, but operating at voltage and currents directly needed by loudspeakers, eliminating the output transformer.

The success of the monoblock SIT-1 led to the SIT-2, which offered similar performance at higher efficiency, and two channels in the same chassis. 2018 saw production of the SIT-3 which operated the SIT transistor in Common-Drain (follower) mode, again without feedback which was available until 2023.

Some years prior, SemiSouth suffered bankruptcy and we found ourselves unable to acquire more of this special part. However there was a company in Japan - Tokin, known for making industrial Silicon SIT parts suitable for audio use. Their production facility was destroyed in the Fukushima earthquake and tsunami, but we were able to acquire these parts from existing inventories of these devices over a period of several years. These large Tokin SITs enjoy that same Triode character, but at much higher voltage, current and power ratings than our original SITs.

A special variety of Jfet invented in Japan in the 1950's, in the 1970's SITs enjoyed popularity in the “Vfet” power amplifiers from Sony and Yamaha that are still highly regarded in high end audio. Ultimately the difficulty and expense of SIT manufacture made them less competitive compared to later bipolar transistors, and it is only more recently that their superior qualities have been recognized for high end audio.

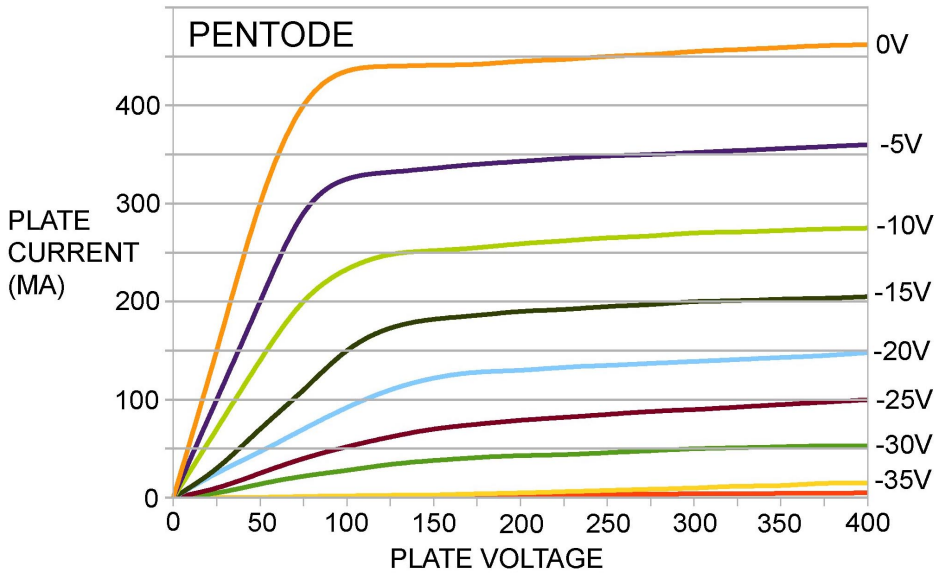
SIT devices have a unique characteristic which is of particular value for audio amplifiers. Quoting inventor Nishizawa's patent abstract, “(The) Drain-current to Drain-voltage characteristic simulates the Anode-current to Anode-voltage characteristic of the Triode vacuum tube very closely.”

As with Triodes, the characteristic curves of the SIT allow operation on Class A “load lines” that can determine the relative values of second and third order harmonics and have little in the way of higher order distortion. It is a now a common observation that the most appealing sound tends to come from a dominant second order harmonic character followed by a lesser values of higher order harmonics.

Historically SITs have been used in microwave, radar and other exotic applications, but found use in audio amplifiers produced by Sony and Yamaha in the 1970's and 80's. After that they pretty much existed as industrial parts from Tokin. Recently there has been renewed interest in these high power tube-like devices, partly because two audio companies stepped up and spent the money required to fabricate new devices suitable for audio power amplifiers.

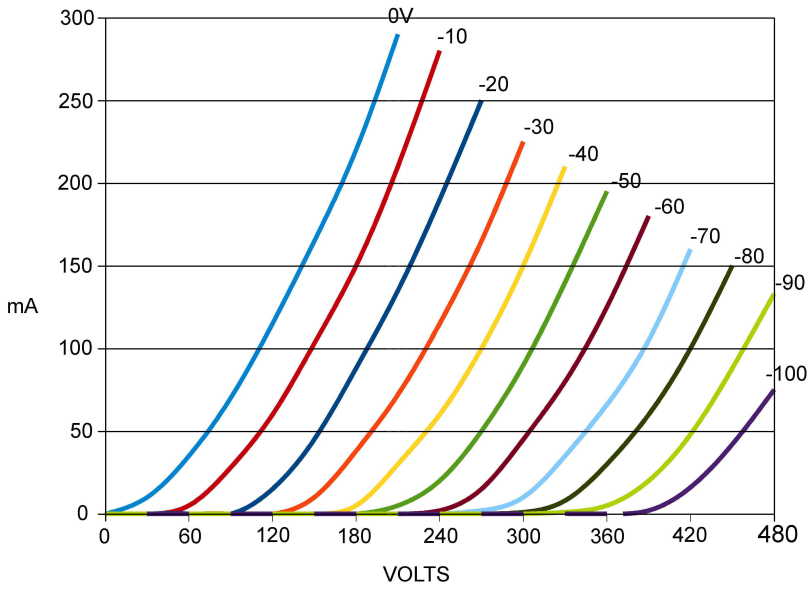
The first of these was Digital Do Main in Japan, which produced at least two audio amplifiers based on newer Tokin versions of original Yamaha parts. The other was First Watt, with the custom SemiSouth Silicon Carbide SIT for the SIT-1, 2 and 3. The SIT-4 and SIT-5 amplifiers use the Tokin THF51s rated at 600 volts, 30 amps and 400 watts in a 10 watt/ch amplifier.

To see what's special about SITs, we start with a look at the curves of a Pentode tube. This graphic describes the amount of current which will flow through a Pentode as a function the Plate to Cathode voltage with eight different values of the Grid control voltage:



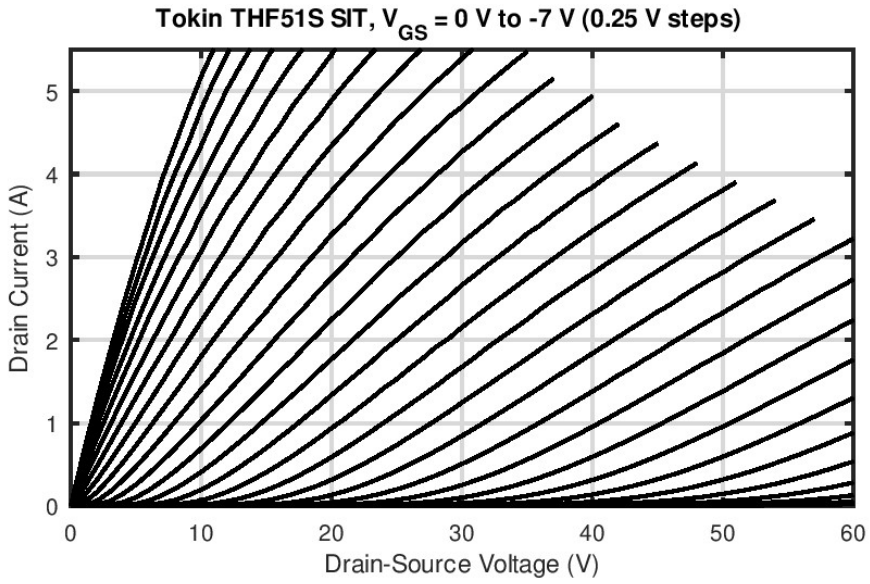
The behavior of an ordinary Jfet or Mosfet is very similar. As with the Pentode, the current flowing from Drain to Source in a Fet will flatten out as the voltage between those pins increases. In this regard Mosfets have a similar shape to the curves of Bipolar transistors, except that Bipolars use input current for control instead of voltage.

By contrast, Here is a set of Triode (300B) curves:



300B TRIODE

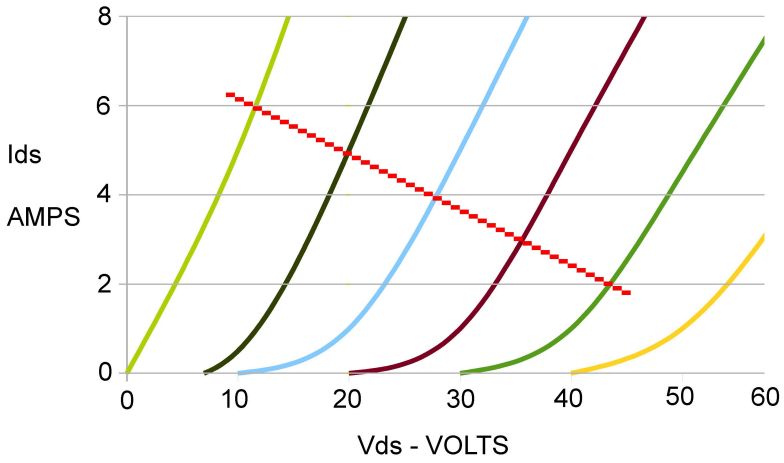
Much as with a Triode, with a SIT the current through the device depends not only on the control pins but also the voltage across the device, similar to a resistor whose value is controlled by the grid voltage. Here is the SIT used in the SIT-5:



Audiophiles have gone to great expense to achieve as little as 1 watt 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 an output transformer and the limitations/expense that come with it.

It has been a goal of some designers to get transistors to sound like Triodes, with limited success. Fets can sound like Pentodes, but it takes some gyrations to make a conventional Fet to resemble a Triode. There are two things we want out of a solid state device for this purpose. We want a “square law” input characteristic like that of tubes (which Fets are good at) but also a relatively low Drain resistance, equivalent to the Triode's low Plate impedance.

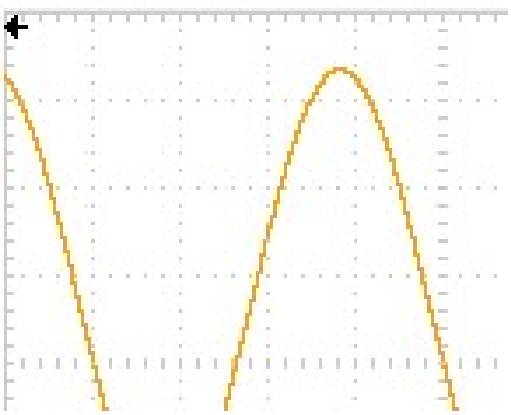
This allows for a single gain stage with both voltage and current gain, and having a high input impedance and low output impedance without a feedback loop or degeneration. It also allows “working the load-line”, which describes the path of the gain device through the region of voltage vs current in the course of amplifying the musical signal driving the loudspeaker. By altering the load line, you can lower the distortion or create a particular distortion character.



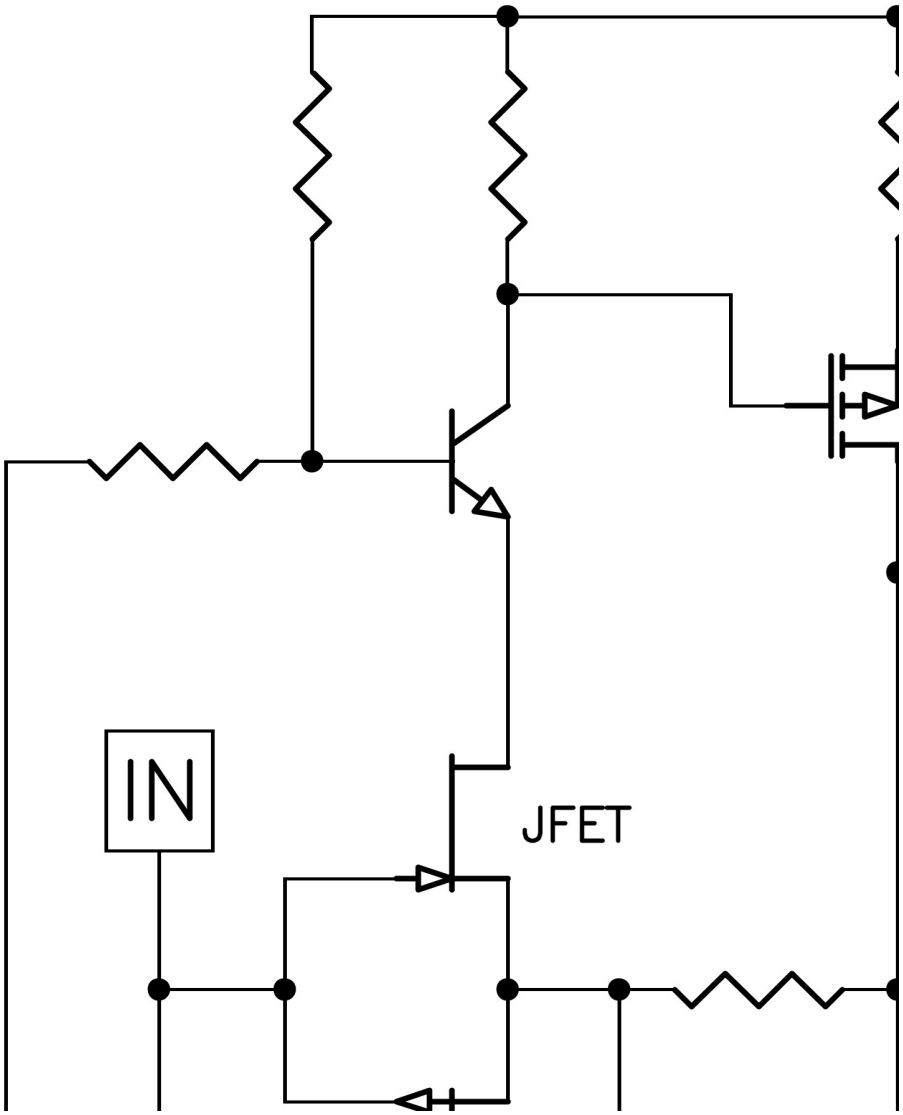
LOAD LINE EXAMPLE (IN RED)

In the original SIT-1 amplifier we put a knob on the front which gave users some control over the load-line setting. It revealed a common preference for what we call a “negative phase 2nd harmonic distortion character”. We have settled on this sonic signature as the standard for our SIT amplifiers.

This is what that signature looks like on a distortion analyser, where you can see that the distortion is at twice the fundamental (2nd harmonic) and peaks negatively for all peaks of the fundamental:



Below is a simplified diagram of the circuit of the SIT-5. It shows a single-ended RCA input to a push-pull voltage gain stage using complementary, mostly single-ended Class A output stage using a high power SIT in Common-Drain (follower) mode without feedback. This SIT is rated at 600 volts, 30 amps, 400 watts with frequency response to 50 MegaHertz.

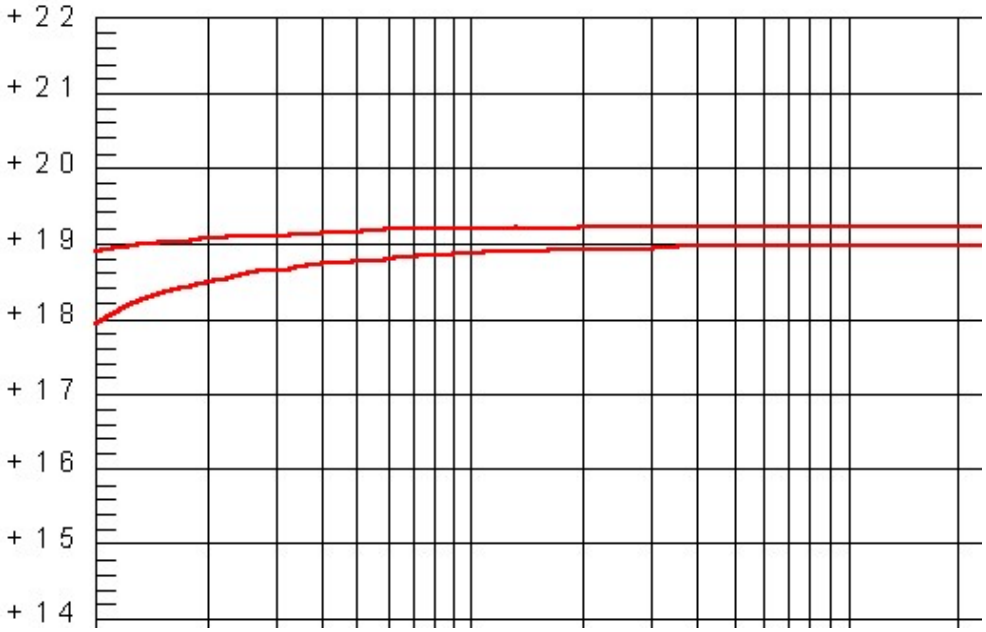


It is current biased by a negative 60 volt supply rail through a P channel Mosfet rated at 500 volts, 40 amps and 890 watts. This arrangement is unique in that the SIT is given a single-ended Class A bias current by the P channel Mosfet which is allowed to make a smaller contribution to the output, typically about 20%. This is seen on the right hand side of the schematic where the output goes through two sets of power resistors and capacitors.

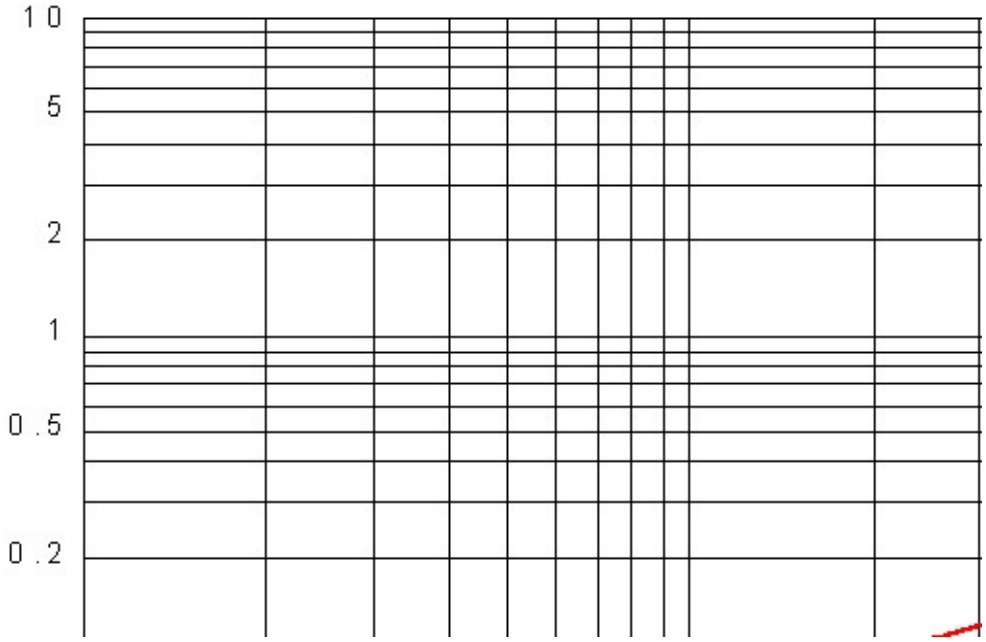
By adjusting the ratios of these power resistors, through the two output capacitors, we can trim the load line of the SIT so that it dominates the output character, adds a little to the output power, but mostly gives a consistent character across a population of SIT devices.

Here are some performance graphics, achieved with a single-stage output circuit without negative feedback.

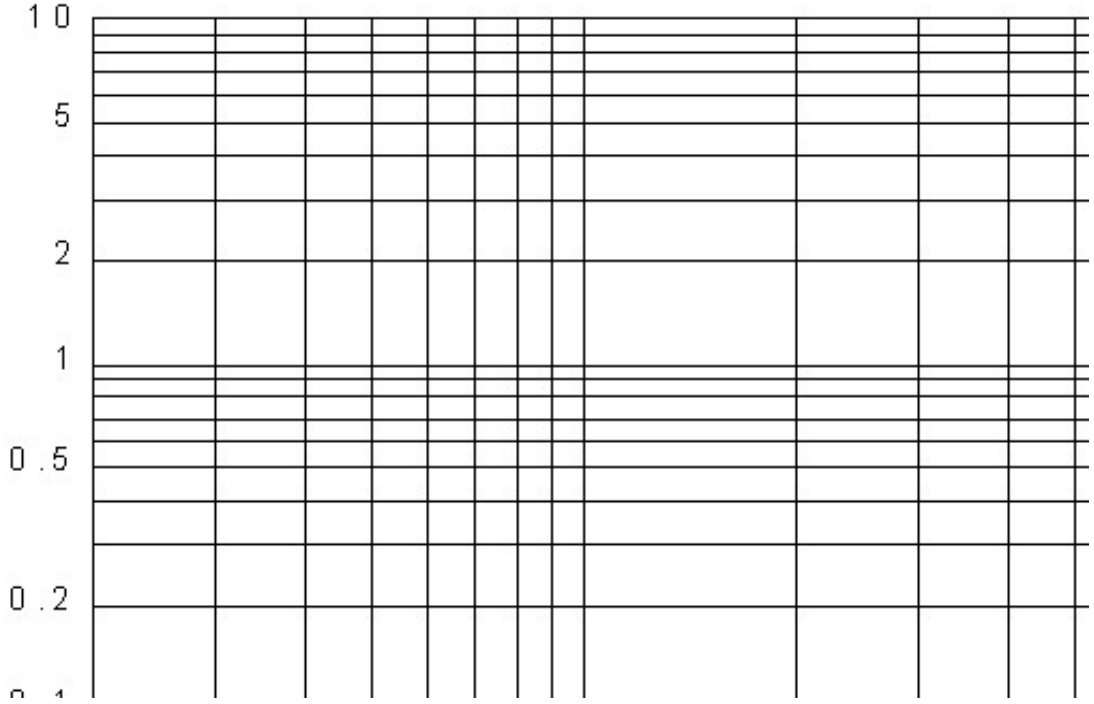
Below, the frequency response curve, showing bandwidth as -3 dB at 200 Khz. The lower curve is 4 ohms, and you can see the slight effect of the 0.2 ohm output impedance.



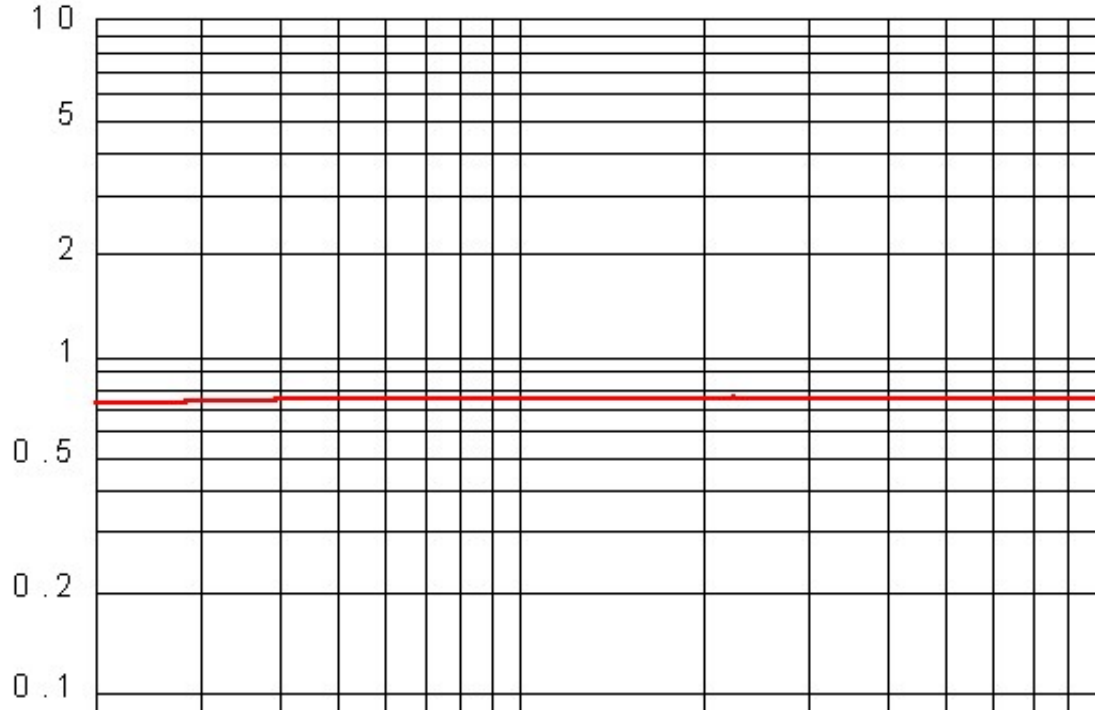
Distortion vs output watts into 8 ohms at 1 Khz:



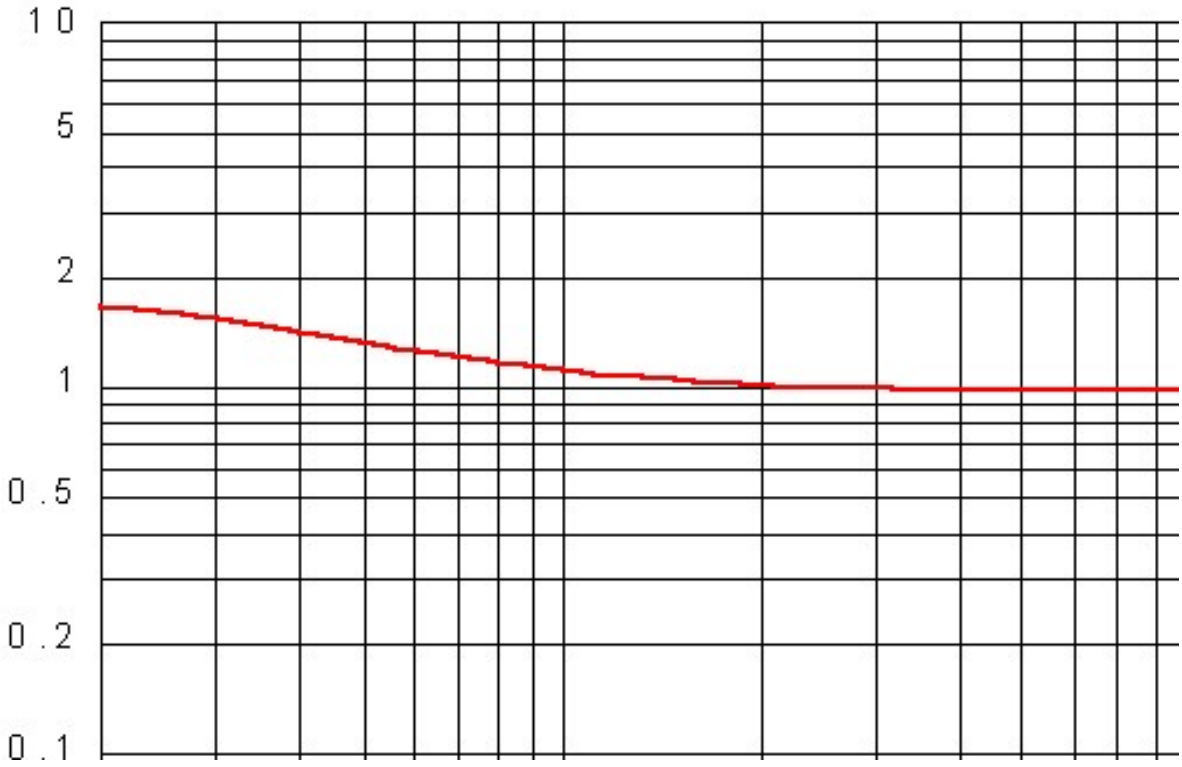
Note that the distortion is a pretty straight line on this logarithmic graph, characteristic of pure 2nd harmonic. This starts to deviate significantly above the power rating with the addition of some 3rd harmonic content.
Here is that same sort of curve, but with a 4 ohm load. You will note the consistency of character between this and the previous curve.



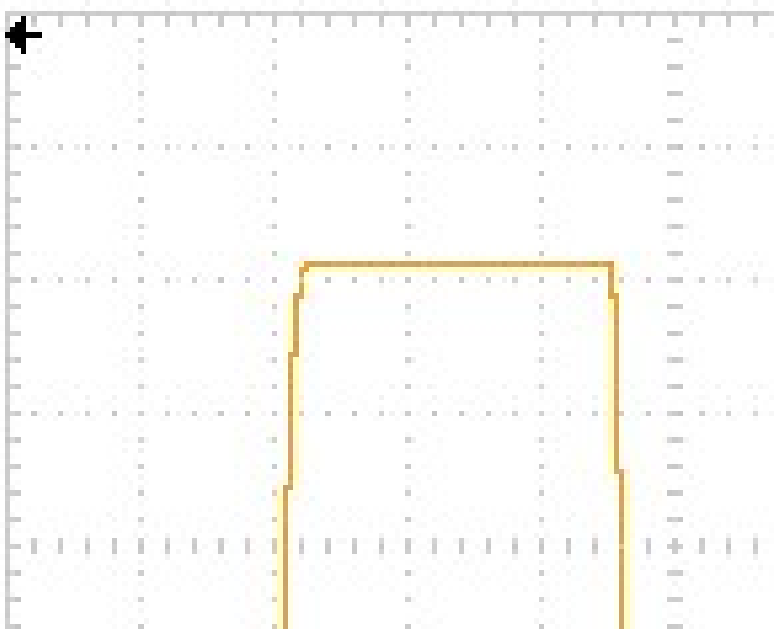
Below is the distortion vs frequency curves into 8 ohms at 1 and 35 watts. Again, the character remains quite consistent over the range.



Below are the distortion vs frequency curves into 4 ohms at 1 and 60 watts:



Finally, the square wave at 20 Khz at 10 watts, into 8 ohms:



Those little jags in the lines are the digital scope. Too bad analog scopes don't put out digital files....

Personal Comments...

The comparison between the SIT-4 and the SIT-5 is not simply about power, although there is significant difference there. The SIT-4 has the SIT operated in Common-Source mode, where it supplies both voltage and current gain. The SIT-5 operates the SIT in Common-Drain mode where it only has to follow a voltage, giving it an advantage in lower measured distortion, bandwidth and output impedance. You should not expect them to sound the same.

My experience is that people to like 5 or 10 watt Triode tube amps driving efficient/high impedance loudspeakers will have an appreciation of the SIT-4 that is different than that of the SIT-5, designed with higher power around less efficient/low impedance loudspeakers.

It's not merely about watts, but human taste and the relationship the amplifier has with the loudspeaker. In any case, it's worth experiencing both sides, and you can actually do that with the same single gain device...

I always keep in mind that the graphics and numbers only hint at the sonic performance.

It's interesting to compare the test data to the listening experience. Sometimes the two line up well (for good or bad), but sometimes an amplifier that tests well still leaves critical listeners disappointed. Sometimes the reverse is true.

Objective amplifier tests don't necessarily tell the whole story (but are at least reliably repeatable) but they main thing is that they are in service to the listener's experience.

Human perception is perhaps not the most reliable, but humans are the customers, and I rely on whatever information I can get, having developed some sense of the relationship between design, measurements and listening over the last 57 years.

I design mostly for myself. Only a few make it to market, but I am happy with all of them.

It's a lengthy task, but the process is simple: Think, Build, Measure, Listen, repeat.

For the SIT-5 this process began in 2020, and the design is now finished as we enter 2024.

These particular amplifiers are aimed at those audiophiles who appreciate detail, warmth, depth and imaging. They aren't for everyone, although they seem to have considerable acceptance in the audiophile community.

Anyway, I hope you enjoy them as I do.

- Nelson Pass 10/29/24

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. 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.

Summary of the nominal specifications:

Measured at 120 V AC and an 8 ohm load:

Distortion @ 1 watt	0.07%
Input Impedance	100 Kohm
Gain	19 dB
Damping Factor	25
Output power	35 watts @ 1% THD, 8 ohms
Frequency response	5 Hz to 200 Khz (-3 dB)
Noise	30uV unweighted, 20-20 KHz
Power consumption	200 watts
Fuse	3AG slow blow type - 2.5 Amp for 120VAC 1.25 Amp for 240 VAC
Weight	32 lbs
Dimensions	17” W x 15” D x 5” H

Warranty: Parts and labor for 3 years, not covering shipping costs or consequential damages. Warranty work is provided by authorized distributors outside of the U.S. And by First Watt within the U.S. Amplifiers under warranty outside of the U.S. not purchased from an authorized distributor can be serviced in the U.S. by First Watt at the cost of freight and customs charges.

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