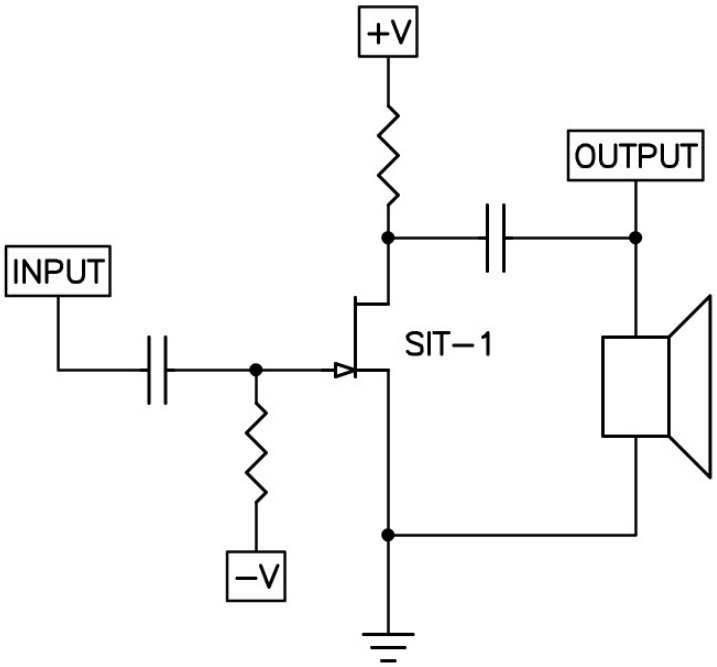
First Watt

SIT-1 Power Amplifier

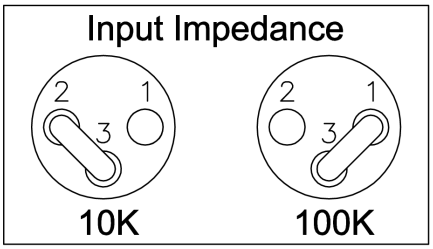


Read Me First

I fully realize that many, if not all, owners will rush to hook up the amplifier without reading this operating manual. I don't blame you – I don't read them either. However, this amplifier is different in a number of ways, and if you only read this page you will probably save us both some time and trouble.

Heat and Ventilation - This amplifier consumes 200 watts all the time and converts it into heat. Pick a location where the amplifier can get some fresh air and blow off the heat. Do not enclose the amplifier in a closed cabinet. Don't set it on the carpet. **Give it lots of space**.

Input Connection and Input Impedance - The SIT-1 takes a single-ended (RCA) input. The input impedance is selectable between 10 Kohms and 100 Kohms by gold jumpers which plug into XLR connectors near the RCA input:



I suggest you start with the default 100K setting which will work with anything. Later you may wish to try driving the Gate terminal of the SIT device more directly by removing the gold jumper and inserting it in the "10K" input position as shown. If you are running a low source impedance, you won't find much difference (at least I don't), but you can enjoy the concept of running through the absolute minimum of circuitry. In either case, use whatever sounds best to you. – **The XLR panel connector is not an input connector –**

Output Connection - You can hook this amplifier up to any loudspeaker without danger of damage. Note, however that the (+) Red output connection is actually grounded. The (-) Black output terminal is the live connection. This can be important when you are hooking up active subwoofers to the output of the amp – treat the Red output as ground, and the Black as active.

Initial Operating Point Setting - The front panel has a meter and knob to control the exact operating point of the SIT device. Use the knob to initially set the meter to the center position. This position is calibrated to my favorite setting for 8 ohm speakers, and is the same as the fixed setting of the SIT-2. You can play with it later, but I suggest that you read the material presented later for some hints as to how to use this.

For maximum reliability, do not run the meter outside of the green zone.

Warmup - The SIT-1 takes a while to fully warm up. During this time you can listen to it, but you will find that the initial operating point will drift a bit and will require some readjustment.

OK! You can go play now.

Introduction

I have been building power amplifiers for over forty years now, and at this late date I wasn't expecting much in the way of surprises. In the past few years at First Watt I had been working with low power designs using some of the new power Jfet transistors from Lovoltech and SemiSouth which offered some performance improvements with simple circuits, so at least I felt like I was still making some incremental progress.

The problem was, however, that while you can make really good sounding amplifiers with simple linear circuits, it tends toward a certain amount of sameness as they measure better. It is difficult to create something subjectively magical " about the sound, something that makes people wake up and say "**What the hell is that?**"

As a tradition, there is really no formula for such a thing, as you are dealing with the incredibly complex neural system that sits between people's ears, and it doesn't respond to sound in the same way as our distortion analyzers and oscilloscopes.

If you have experienced ears and if you know what you like when you hear it, then the approach that works is to try everything. That is largely what I do, remembering Edison's dictum "invention is 2 percent inspiration and 98 percent perspiration."

Sometimes, though, things just fall into your lap. A couple years ago I was talking to Jeff Cassidy at SemiSouth and he mentioned that at one time they had made a special run of *Static Induction Transistor* devices on some kind of military/industrial contract, and that one of their technical people had remarked that they were nearly ideal for use in audio amplifiers.

"*Really*", says I, "*Do you have any of them left over?*" No the customer scooped them all up, but they would be interested in making more. The price of a small run was astronomical (to me, at least) and I spent quite a bit of time pondering the risk.

And then I wrote the check and didn't look back.

After a few months I had a small batch of SITs with my name on them, and I started playing. It took about a year and a half to arrive at the designs of the SIT-1 and SIT-2 amplifiers, and it has been a revelatory experience.

The SIT devices allow operation with only one gain stage. In fact the SIT-1 has only one transistor in the entire amplifier, without feedback and even without degeneration. It's as simple and raw an amplifying circuit as you could imagine.

I have built such simple amplifiers before using Mosfets and power Jfets, but I was not at all prepared for the quality of sound that I got with the SITs. It was like magic.

The SIT-1 and SIT-2 are special amplifiers. They have single gain stages – the input signal goes into the Gate of the SIT and comes out the drain amplified and driving the loudspeaker. There is no feedback or degeneration. They run single-ended Class A, and the SIT-2, biased by a current source, has an efficiency of about 10%, and the SIT-1, biased through 800 watts of power resistors, has an efficiency of about 5%.

Both amplifiers deliver about 10 watts output per channel. The SIT-1 is a monoblock drawing about 200 watts, and the SIT-2 is a stereo amplifier also drawing about 200 watts.

So what's the difference?

First off, the SIT-1 gain device is surrounded by passive components, giving it a lower efficiency of around 5%. It is biased through 800 watts of power resistors mounted on the heat sink. The SIT-2 is biased by a constant current source created by another FET device, and it has an efficiency of about 10%. While these two approaches give nearly the same sound at the default setting, I have always been intrigued by the sound available from the SIT without any other active devices involved. I suppose you could think of it as slightly more purist, if twice as impractical.

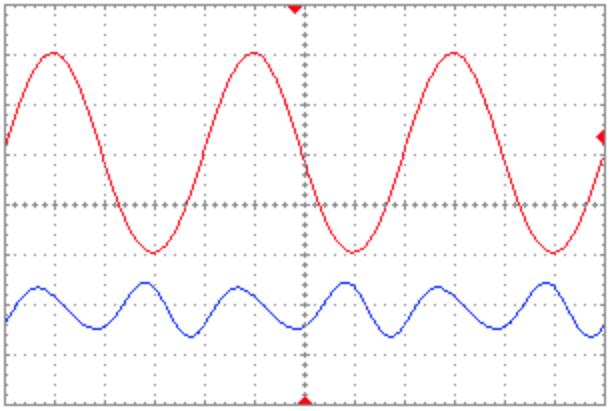
The SIT-1 has a knob and meter on the front panel which allows the user to adjust the load line setting of the SIT device to tweak it into the most preferred setting for different loudspeakers and listening taste. It also helps compensate for small variations in AC line voltage.

The SIT-2 operates a fixed operating load line as determined by listener's preferences in various systems. This setting corresponds to the middle position setting on the SIT-1. Being biased by a constant current, it does not need compensation for AC line variations.

Apart from these, they are very similar. I live with both happily.

The Harmonic Structure

The SIT device allows the possibility of arbitrarily deciding on the specific harmonic structure of the distortion of the amplifier. Like Triodes, the characteristic curves of the SIT device allow operation on load lines which can set the relative values of second and third order harmonics. My own experience echoes that of Jean Hiraga, which is that the best sound tends to come from a dominant second order harmonics followed by a lesser value of third harmonic and essentially no harmonics above those. It looks a lot like this:

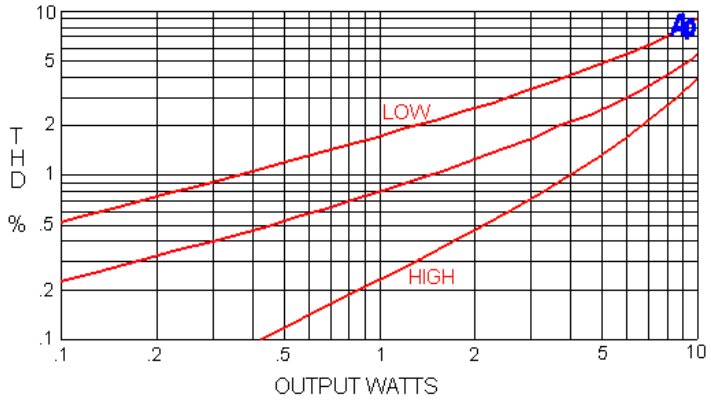


SIT-1 DISTORTION WAVEFORM

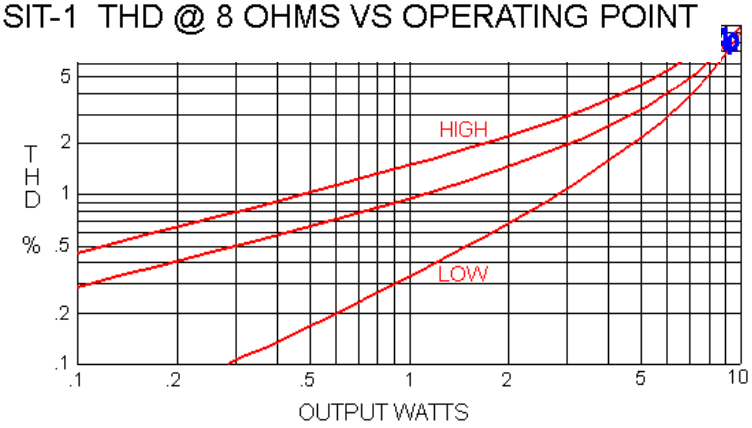
The knob on the SIT-1 is used to adjust the operating point of the SIT load line, and is useful for a number of things, but in the end, you simply put it at any value within the green zone on the meter which sounds best to you.

As a concept, you will probably find that the area to the left of the center of the green zone is best for low impedance loads or when you are looking for a richer second harmonic character. If the load impedance is greater than 8 ohms, you will tend to put the meter needle on the right side of the green zone.

There is no correct setting, only the one that you prefer. Here you see the distortion vs output power for the low, middle, and high positions of the meter for both 8 ohms and 4 ohms:



SIT-1 THD @ 8 OHMS VS OPERATING POINT



SIT-1 THD @ 4 OHMS VS OPERATING POINT

Try not to let this stuff drive you crazy. You will find that things settle in with time.

The variations in AC power line voltage will alter the bias setting. Allowance has been made in the range so that you can compensate for this, but if you can't set the operating point to the top of the green zone then the AC line voltage is too low. Conversely, if you can's set it to the bottom, then the line voltage is too high. If you can't operate the amplifier in the desired portion of the green zone, contact your dealer or distributor.

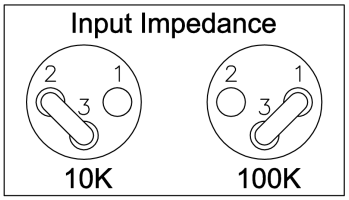
You should not adjust the operating point into the red zone. Doing so will compromise performance and can result in shortened life span of the SIT device.

The Input Buffer Option

The SIT-1 and SIT-2 amplifiers can be driven in “direct mode” where the source components looks directly at the Gate of the SIT without other active components in between. This is desirable, but in this case the input impedance is 10 Kohms and plus the capacitance of the Gate which is greater than the 1,000 pF of the IHF standard. If you have a preamp or source component with an output impedance of 1,000 ohms or less, you should not have a problem, but with “passive preamps” and some tube designs which have very high output impedances, this limits the bandwidth and could be a performance issue.

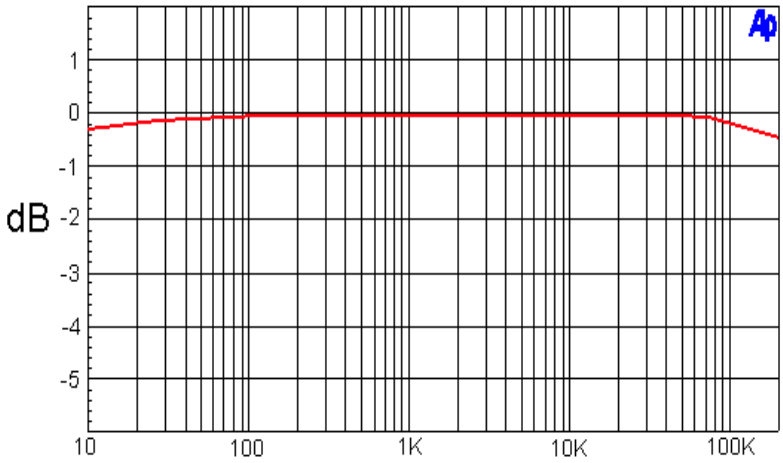
To address this, There is the option of a simple P channel Jfet follower on the input which raises the input impedance to 100,000 ohms and about 10 pF. Anything will drive this without problems. The distortion of the P channel Jfet is incredibly low, and doesn't alter the sound in any significant way, but it assures no impedance interation and a bandwidth to 500 Khz.

The choice of input impedance is made on the jumper of the XLR female connector associated with each channel on the back of the amplifier next to the input connector. Just put the gold jumpers into the pins as shown.



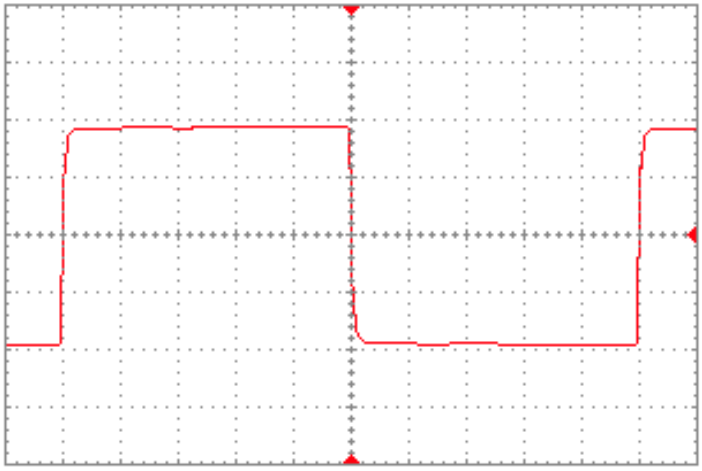
You will not damage the amplifier if you change these settings while the amplifier is running, but I suggest that it's still a good idea to power the amplifier down.

Speaking of frequency response, here is what the amplifier response looks like with the buffer or with a 25 ohm source in direct mode:



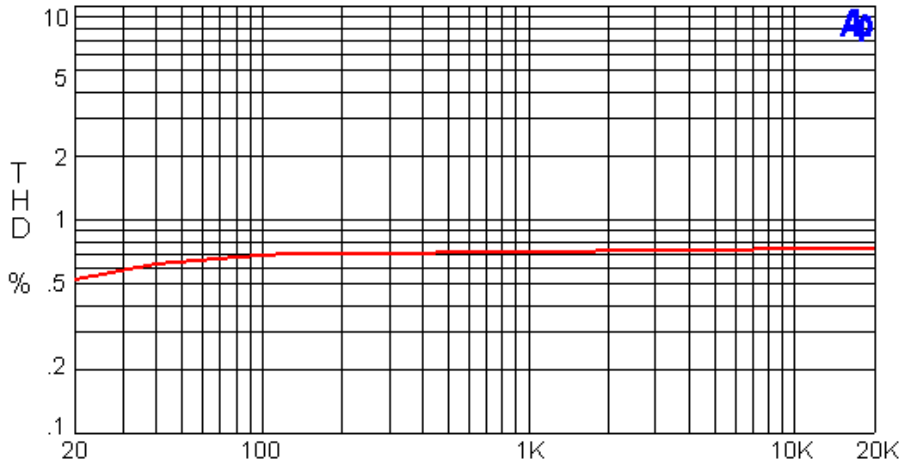
SIT-1 FREQUENCY RESPONSE

This wide bandwidth is also reflected in the square wave response of the amplifier, here shown at 20 Khz. The rise times are very fast, and there is no ringing or overshoot.



SIT-1 20KHz SQUARE WAVE

Lastly, a plot of the distortion of the amplifier versus frequency shows a consistent character across the audio band:



SIT-1 THD VS FREQUENCY

This consistency of performance over the audio band is an important element to the sonic character of the SIT-1 and SIT-2. The frequency and phase response is flat, distortion harmonics are consistent in amplitude and phase relationship, and the damping factor remains the same.

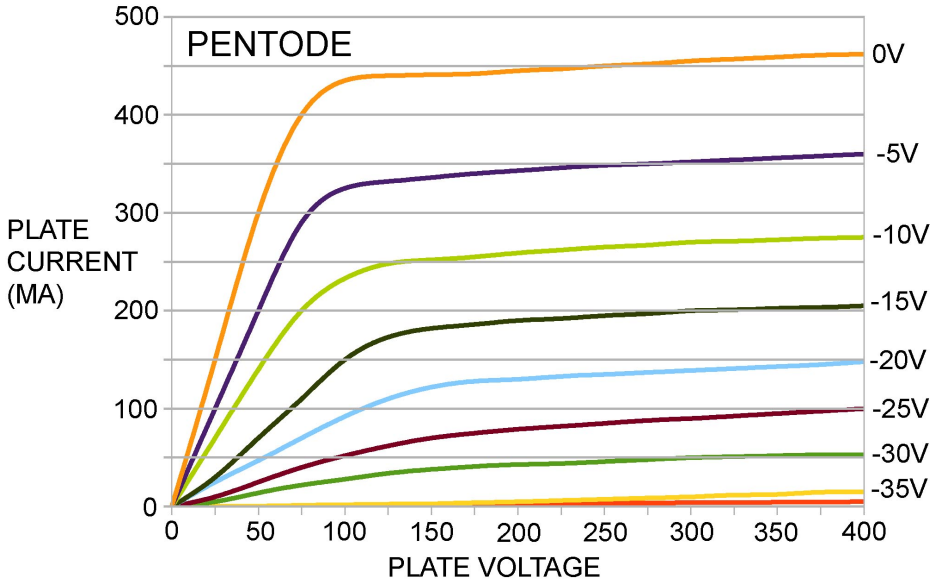
A Short Introduction to Static Induction Transistors

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.

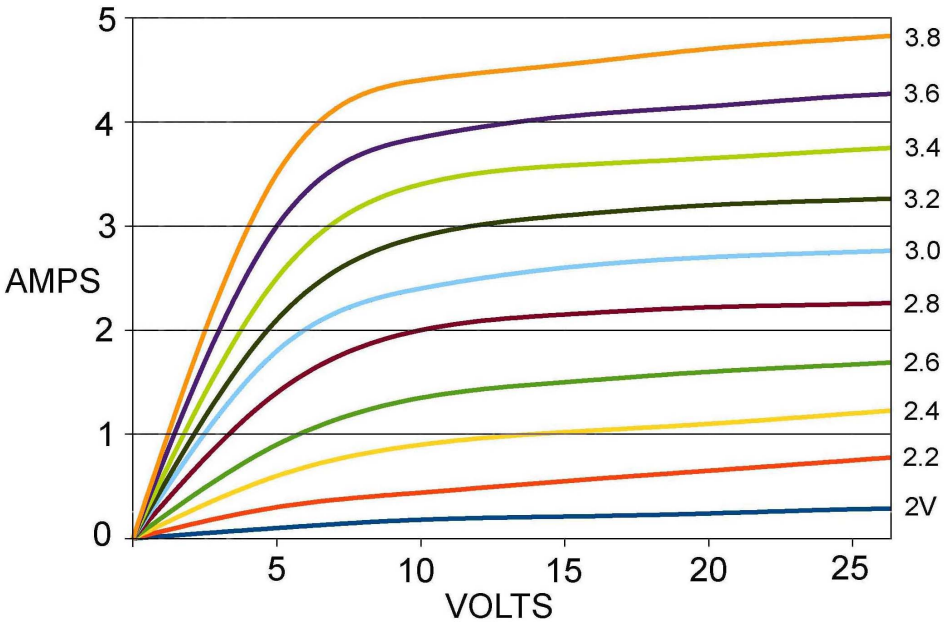
Recently there has been renewed interest in SITs, partly because two audio companies have stepped up to the plate and spent the money required to fabricate new devices suitable for audio power amplifiers. The first of these is Digital Do Main in Japan, which has produced two audio amplifiers based on 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.

To see what's special about SITs, take a look at the curve of a Pentode tube:



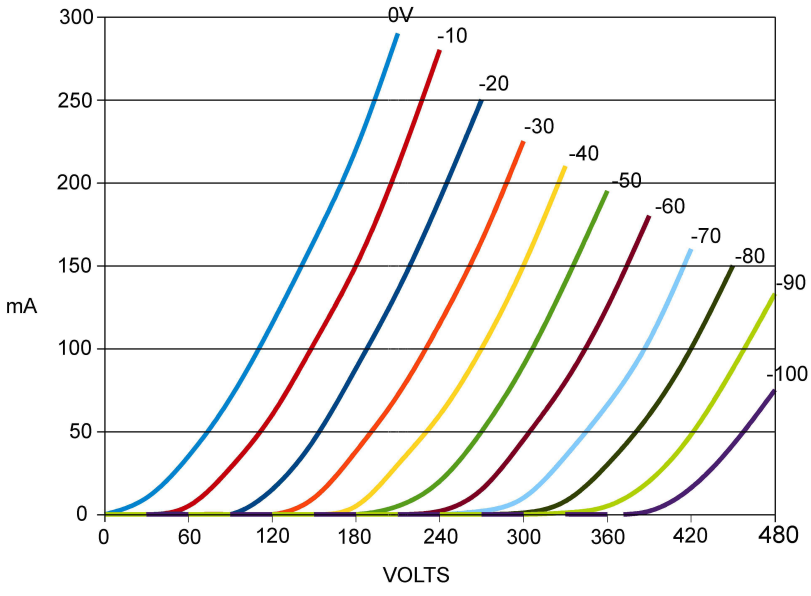
Here we see a graphic describing the amount of current which will flow through a Pentode as a function the Plate to Cathode voltage and eight different values of the Grid control voltage.

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.

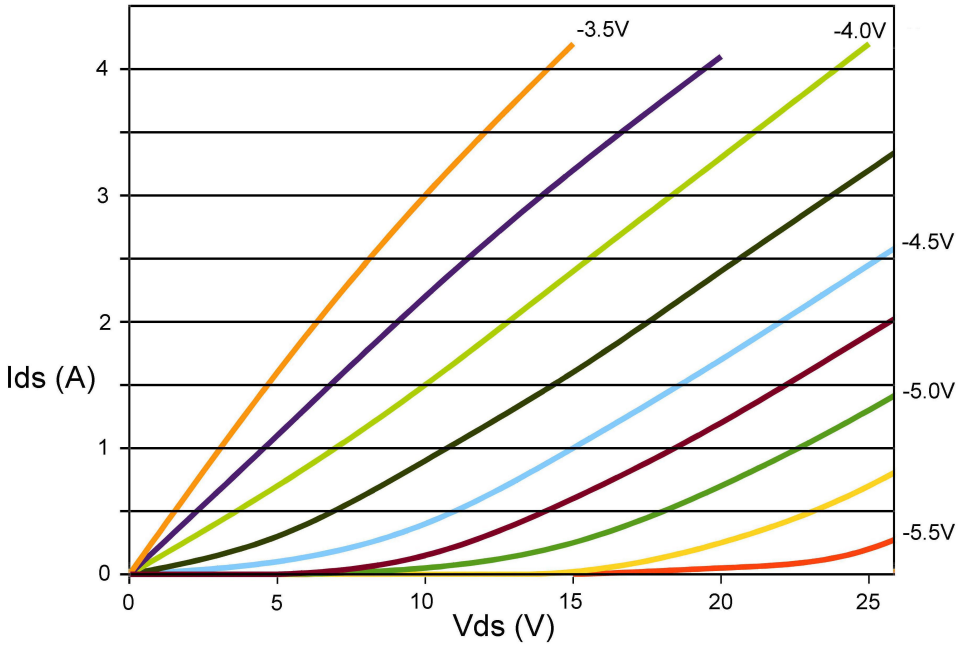
By contrast, Here is a set of Triode (300B) curves:



300B TRIODE

In a Triode the current through the device depends not only on the control pins but also the voltage across the device. In this sense the gain device acts in a manner similar to a resistor whose resistance value is controlled by the grid voltage.

Similarly with the SIT device seen below:



As with the comparisons between Pentodes and Fets, the curves have a similar characteristic, but the scales have been altered by a factor of about 10, so that the voltages are much lower and the current is much higher.

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 transformer and all 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.

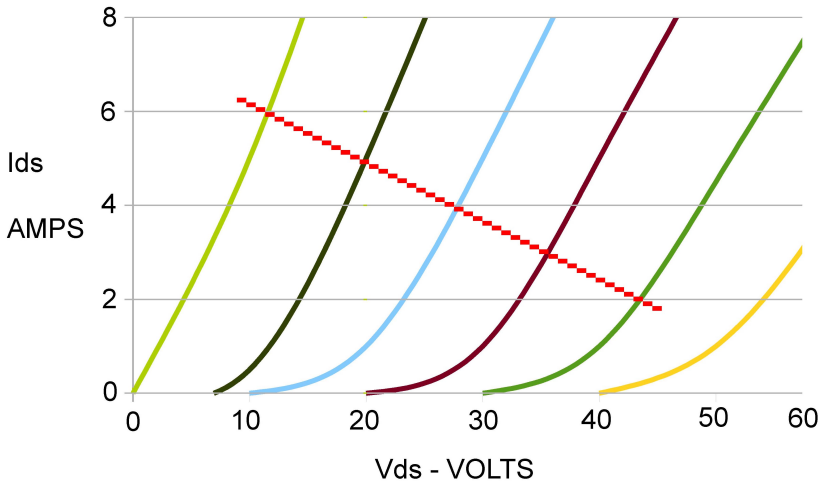
There are two things we want out of a solid state device for this purpose. First, we want a “square law” input characteristic like that of tubes. Fortunately, Fets do that already – the current through the Fet is a good square law function of the Gate to Source voltage.

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 very good at this.



LOAD LINE EXAMPLE (IN RED)

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 giving both voltage and current gain operated single-ended Class A without feedback or degeneration, and we want it with a high input impedance and a low output impedance. And we want it with reasonably low distortion with a simple low order character.

We can try this with Pentodes or Mosfets, but the results don't measure well, and they don't sound as good, a clear-cut case where measurements and subjective performance agree.

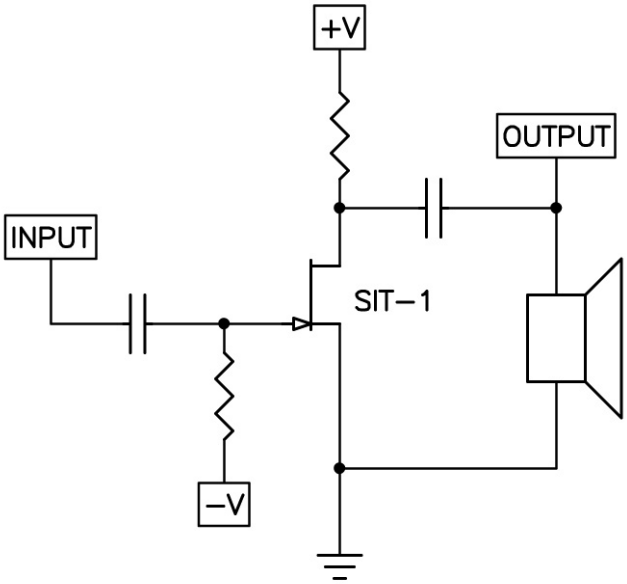
It is worth noting that the original efforts by Sony and Yamaha were not minimalist – they contained many parts in multiple gain stages and used a generous amount of feedback.

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?”.

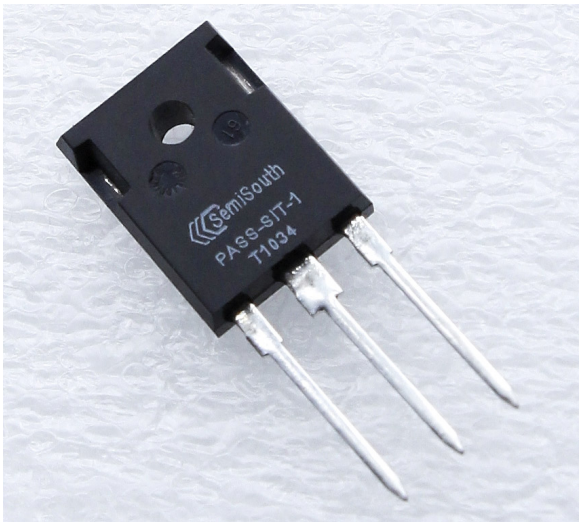
There is another, more practical reason to explore simple circuits. It is generally agreed that if you are going to have distortion, you will want it in a low order harmonic form, kept to only second and third harmonic if possible. A single-ended Class A device is going to generally give you the simplest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



Here is a picture of First Watt's SIT device:



Of course the audience for such an amplifier will only want to know about the sound. How does it compare with SETs from a subjective point of view? Having made a variety of these amplifiers at this point I can say that first off, they can be made to sound exquisitely in many of the systems that would enjoy the performance of a SET amplifier.

These would be your high sensitivity loudspeakers featuring compression drivers or “wide band” drivers with big magnets and light paper cones.

Here is a comment made by a listener who lived with a simple prototype SIT amplifier driving Lowthers:

The amp sounds "big". There is a large, open sound stage that fills the room, that is the first thing that you notice when the amp is plugged in. The effect is a little intoxicating. ...the SIT seems to bring a lot more control & detail to the speaker. The tube sweetness is present, yet the presentation is very clean. This is like a very nice low distortion SET. The SIT presents details, but with proper dynamic contrast. Details do not poke you in the eye, they just naturally unfold as part of the music.

Do simple SIT amplifiers sound the same as single-ended Triodes (SETs)? That would be a matter of opinion. Without an output transformer with its significant limitations, the SIT has a bandwidth and distortion edge. On the other hand, some people like the sound of their transformers.

Me, I like to listen to the *sound* of different amplifiers. I don't see a practical point in actually duplicating a SET amplifier. The SIT gives me an opportunity to listen to the best that a single gain device can do. Surrounded only by a few well-chosen passive parts, this transistor speaks with a single voice.

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	0.7%
Input Impedance	10 Kohm / 100 Kohm
Gain	18 dB
Output Impedance	4 ohms
Output power	10 watts @ 5% THD, 1KHz
Frequency response	4 Hz to 500 Khz (-3 dB)
Noise	150 uV 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
Colors:	Available in Black or Silver

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.

www.Firstwatt.com

nelson@passlabs.com