White Paper

Carver

The Magnetic Field Power Amplifier Story, Parts I, II and III

High Current/High Voltage	I
Magnetic Field Power Supply	II
Transfer Function Modification	III

CARVER

$2.00

What you're about to read may challenge some long-held beliefs about how power amplifiers work and what makes them sound the way they do.

While science is at the heart of electronics, long-perpetuated myths enshroud many of its basic principles. This paper is intended to de-mystify several critical power amplification issues. It is by no means an attack on

SYNOPSIS: Cutting to the Chase

Just four factors determine the sonic characteristics of an amplifier:

1) Current output, **2)** voltage output, **3)** power output and **4)** frequency response at the loudspeaker terminals (transfer function) are what distinguishes one power amplifier's "sound" from another (assuming low distortion).

Period. These are ALL that we hear in spite of what you have been told by audiophiles and underground publications. These four factors ARE the measure of an amplifier. Tubes vs. solid state, MOSFETs vs. bipolar, Class A vs. Class AB are merely hardware manifestations. An amplifier can have any combination of entertaining nonscience variables such as Litz wire, esoteric capacitors, bricks stacked on top of the amp, half-inch-thick gold-plated front panels or shock-absorbing bases, but the four factors mentioned above are what determines its sound.

To reproduce music, an amplifier must be able to simultaneously produce high current and high voltage.

A preponderance of one without the other is useless. Specifically, high voltage without high current can satisfy FTC ratings when tested with a resistive load, but can be meaningless when reproducing the sound of live music. See page 4.

A conventional power supply has to be expensive to produce simultaneous high current/high voltage.

It takes VERY large transformers and capacitors. They are by far the most costly electronic components in an amplifier. When you consider statements 2 and 3 together, you begin to understand why $300 "200-watt" amplifiers and $8,000 200-watt amplifiers can exist in the marketplace at the same time. The $300 amp is incapable of simultaneous high current/high voltage output; the $8,000 model IS capable — but at the price of having to use a massive conventional power supply. See page 14.

Carver's regulated Magnetic Field Power Supply can deliver extremely high simultaneous current and voltage more efficiently and effectively than conventional power supplies.

The benefits are two-fold: We can pack more power into a reasonably-sized chassis.

conventional designs, but rather a clarification of what differentiates Carver technology. Hopefully, when you get through reading this paper, you will appreciate why both types of power amplifiers succeed in their own right.

Throughout history, science has been most threatening to those who make their living endorsing myths and magic. Because myth and magic are more fun and exciting than science and reality, you shouldn't be surprised when certain underground publications loft some pretty aggressive refutations to this paper. In the face of good science, much of what these magazines write about differences between various power amplifiers is at best, extraneous, and at worst, incorrect. Because of their belief systems and editorial stance, to do otherwise would, in effect, eliminate the need for much of what they print.

We welcome honest, factual debate presented in the spirit of advancing the science of accurate musical reproduction. We are wearied by renewed invocations of old, un-provable, intangible myths and opinions. It is hoped that, after reading this paper (and the inevitable reactions by audio's more metaphysical soothsayers), you will appreciate the refreshing differences between fact and fancy.

Bob Carver

And you pay less for a high quality power amplifier. See page 15.

The "sound" of a power amplifier is its frequency response when connected to speakers and speaker cables.

Not the specified bandwidth (an irrelevant figure which may be "DC to light"), but the real world measurement at its speaker terminals, when playing music through cables and loudspeakers. This response curve is decidedly NOT flat. It is as distinctive as a fingerprint and determines the amplifier's warmth or harshness, bass quality, upper register definition, depth and breadth of soundstage, ability to define individual instruments and transparency. See page 22.

Through Transfer Function Modification, the "sound" (frequency response) of an amplifier can be changed virtually any way the designer desires.

That is how our TFM-45 and TFM-42 can duplicate the Transfer Function of the $20,000 Silver Seven to within 99 parts out of a 100. And why our TFM-22, TFM-25 and TFM-15 have a warm "tube" sound with rich, rolling bass and soft yet detailed treble. Transfer Function Modification is a painstaking process and can only be achieved when the amplifier's current and voltage performance are extremely good. See page 21.

Carver's unique Magnetic Field Power Supply and Transfer Function Modification technologies have a direct and positive effect on the only four factors which determine the sound of a power amplifier.

The result are amplifiers which represent the best values available today. Yes, that's a tall claim. In the next pages, we will expand on the six quick points we've just made and put some scientific basis behind this claim.

Still, your ears are the final determining factor. We can tell you what we hope you'll hear. Friends can tell you what you should hear. Reviewers can tell you what they thought THEY heard.

But it all gets down to you, some familiar music over familiar speakers and a keen interest in making up your own mind.

In the meantime, let's replace a few of the myths and half-truths which pervade audio with a little science . . . hopefully made easy.

PART I: Simultaneous High Current/High Voltage

Carver's TFM series stereo power amplifiers and the Silver Seven-t monoblock are capable of exceptionally high current and voltage output into a wide range of speaker impedances.

This White Paper segment will discuss the important inter-relationship between current, voltage and impedance as it pertains to modern amplifier designs. Part II will explain in detail why the Magnetic Field Amplifier design is especially well suited to meeting the real-world demands of both dynamic and reactive loudspeaker loads. Part III addresses Transfer Function, the final ingredient in the sound of a power amplifier.

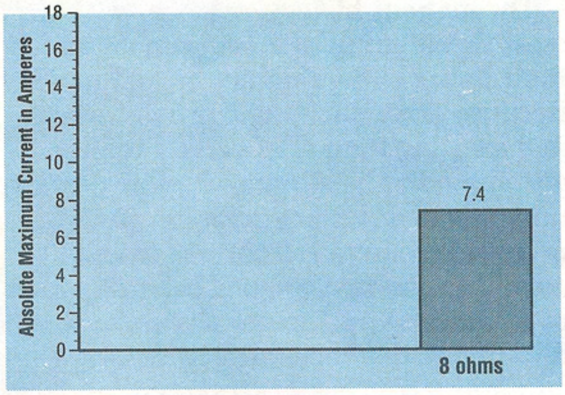
The issue of high current.

There is an increasing awareness of the need for high current amplifier capabilities. It's starting to show up as a "buzz word" in our competitor's literature. Dealers tell us that customers ask about amplifiers' current capability.

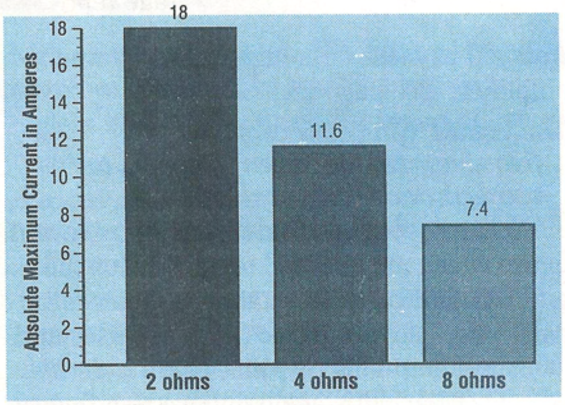
High current output is indeed a valid concern.

However, it can be close to meaningless as an abstract printed specification, unless two other factors are taken into consideration. Those factors are voltage and impedance. All three — voltage, current and impedance — are linked together in ways which often defy tidy specifications.

Simply put, current without voltage means low power, especially at low impedances. Here are several graphs showing a typical amplifier rated at 100 watts per channel into 8 ohms. It puts out "OK" current at 8 ohms.



The Marketing Department sends Engineering a memo to the effect that *"high current into low impedances"* is the hip thing nowadays. Engineering tests the same amp at 4 ohms and 2 ohms. *Voila*! the following graph.



Marketing is delighted and puts "high current/low impedance drive" into their literature. What's the point? Is there something deceptive here?

No. But the graph shown above does not, in fact, illustrate impressive increases at low impedances. It really shows the amplifier's failings at higher (normal) impedance! The amplifier can't deliver as much power at 8 ohms as it does at 2 ohms because this typical design cannot maintain anywhere near simultaneous high current AND high voltage output over a wide range of impedances.

In other words, it's relatively easy to get ample output into low impedances, but very HARD to create a design which can deliver extraordinary power into all loads from low to high.

That means you should never simply accept a manufacturer's claim of high current without knowing the VOLTAGE and the IMPEDANCE at which their measurement was made. In fact, you can leave many factory representatives and even amp designers slack-jawed simply by saying, *"Fine, but how much VOLTAGE does it put out at each of those impedances?"*

"My car can rev up real fast."

A good analogy is car engine specifications. Horsepower, torque and RPM are all inter-related (just like voltage, impedance and current are all inter-related).

In fact, you could say that voltage represents RPM, torque represents current and horsepower is amp output power in watts.

Thus it's very hard to impress your friends by stating that your car's engine revs up as far as 6000 RPM. *"But what's the torque curve look like?"*, *"What horsepower does it produce?"*, they'll ask. They must understand the RPM/torque/horsepower inter-relationship before your statement makes any sense.

By the same token, saying that an engine can do 6000 RPM is much like saying an amplifier can "drive 2 ohm loads." Torque (current in our analogy) and horsepower (power in watts) are tied not only to RPM but obviously each other as well.

Rating standards.

The international car industry has standardized methods of measuring torque, horsepower and RPM. Unfortunately, there are no industry-wide standards for expressing current ratings.

Generally *peak current* (A_{pk}) is stated, which is perfectly acceptable as long as one considers that it is 1.4 times *RMS current* (A_{rms}).

However, it's possible to take advantage of either specification, much the way *% THD* ratings COULD be "fudged" with less than 20Hz -20kHz frequency bandwidths. They aren't because the Federal Trade Commission makes rules about expressing power and total harmonic distortion. There are no such rules about amplifier current specifications.

Some manufacturers take advantage of this by measuring current over an unrealistically short period of time (for example, ONE 10-millisecond burst) and at a single high frequency such as 10kHz. The result is an impressive if somewhat pliable and easy-to-exaggerate specification, rather like "peak power" was many years ago.

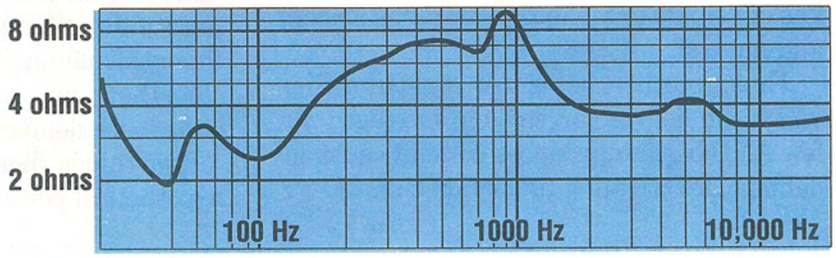
Carver, on the other hand, measures current using a continuous series of 80 millisecond pulses which simulate musical peaks.

Speaker impedance variations.

Impedance makes up the critical third part of any overall evaluation of power amplifier capability: Voltage and current must be considered in terms of impedance to be meaningful.

So, if most speakers have nominal ratings of 4-8 ohms, why is everyone so concerned about "low impedance capability?" It can't be because lots of customers are hooking up three sets of speakers at a time.

No, low impedance output is important because real world speaker impedance is somewhat of a moving target. While a speaker is nominally rated at a single impedance, its real impedance may actually vary wildly over the 20Hz to 20kHz frequency range. — as much as 40ohms in some current designs! Here is a graph of a very popular 3-way loudspeaker's true impedance



curve. Believe it or not, the manufacturer claims this speaker has a nominal impedance of 6 ohms!

In reality, it varies almost 10 ohms in the range between 20Hz and 20kHz.

Note also that it takes its most serious dip in the lowest frequencies. Low-to-mid bass just happens to also be a part of the frequency spectrum which requires the most amplifier power just to CREATE a sound. Imagine what happens when a bass drum beat occurs on a well-recorded compact disc. So not only will an amplifier have to put out a huge burst of power to move the speaker's woofer, but is suddenly and unexpectedly playing into a very low impedance load. Surprise!

What happens when a speaker's impedance dips into the 2-ohm range regularly during a musical selection depends on the amplifier design and the type of protection it uses.

It may experience voltage clipping (which we're all familiar with); it may blow its fuse, or it may create *current clipping*. This isn't clipping in the same sense as voltage clipping. Current clipping is caused by the activation of protection circuits called current limiters. They essentially shut the amplifier down for a split second, wait to assess current demand and then turn the amp back on if demand has waned. The result is an excruciatingly harsh sound throughout the frequency spectrum, not just at high frequencies.

Because music has a wildly varying frequency distribution (and listeners have wildly different opinions of what to do with bass and loudness controls), problems stemming from low speaker impedance can be frustratingly intermittent.

Now note the impedance BUMP in the above graph. At around 1kHz, the speaker's impedance EXCEEDS 8 ohms. At this high impedance, the speaker desperately needs lots of voltage to make the midrange smooth and natural.

Thus, your best bet is to own an amplifier which can deliver current AND voltage into low AND high impedances without causing damage or activating protection circuits.

The relationship of current, voltage, power and impedance.

Two important formulas must be considered to understand how current, voltage, power (watts) and impedance interact.

$P = I^2R$ and $P = VI$

Where P equals power, I equals current, V equals voltage and R equals speaker impedance. The first formula is often cited, the second, however, is equally important and much more obscure.
It simply states that power is the product of voltage times current. For example, 100 watts (P) equals 20 volts (V) times 5 amps (I). 100 watts also equals 10 volts times 10 amps. Or 2 volts times 50 amps. Herein lies the difference between amplifiers which have the same power rating.

Theoretical examples.

To better understand these relationships, let's consider three hypothetical power amplifier designs which represent opposite ends of the design spectrum. They are valuable to illustrate not only extremes, but how impedance, voltage and current interact according to the $P=I^2R$ and $P=VI$ formulas.

Amp A (Figure 1 on the next page) is our imagined version of the "ultimate high current" design. Voltage stays CONSTANT. Thus (as per the two formulas above, Amp A puts out increasing current as impedance goes down (just what many designs strive for). Engineers would consider it an ideal voltage source. In this design, power and current drop in half as impedance doubles. The output stage is essentially being pushed hard at low impedances and loafing at others. This design is workable but cannot put out high power unless the speaker impedance dips low.

Amp B (Figure 2 on the next page) is an ideal current source, where current stays constant at all impedances but voltage changes, making it a "high voltage design". Note that power and voltage DOUBLE as impedance doubles.

Two things should be noted about these hypothetical power amplifiers. The first is

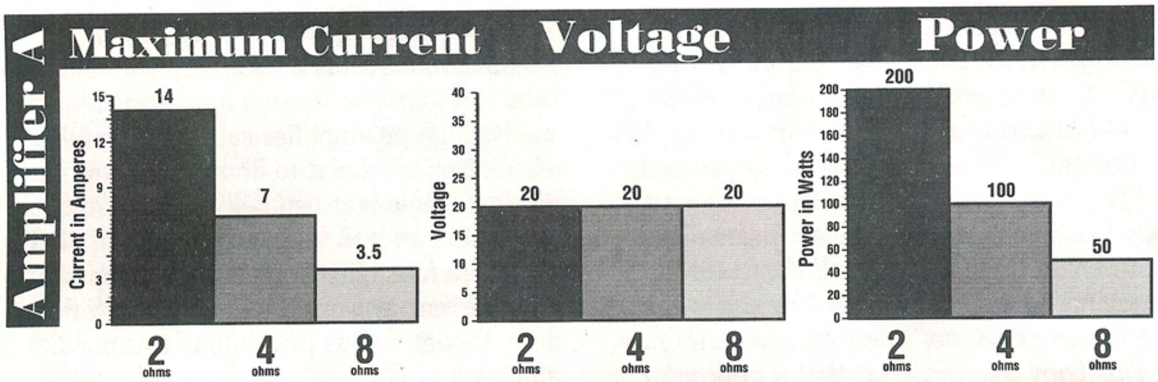


Fig.1 Constant voltage/high current design. Note that power falls precipitously at higher impedances.

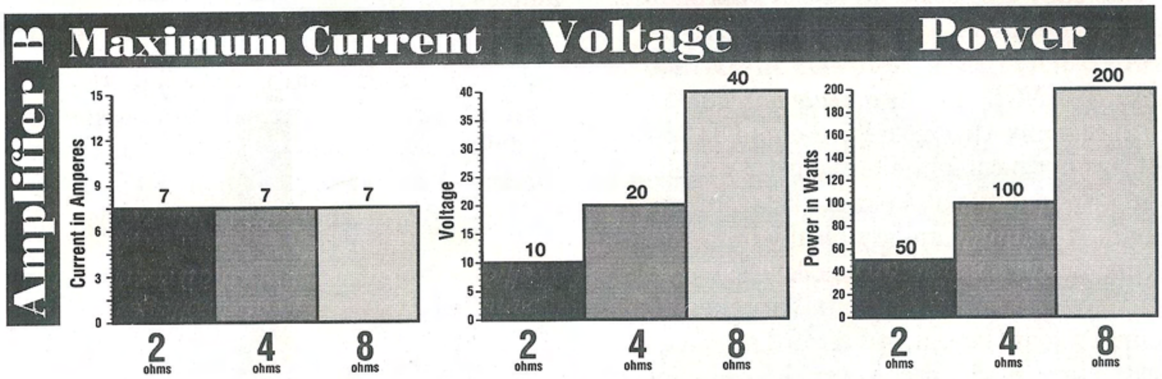


Fig.2 High voltage/ constant current design. Note the low power at low imped- ances.

that the two wildly dissimilar designs both have the same specifications at 4 ohms. Yet both are also terribly inefficient at opposite impedance extremes.

The second is that neither set of 4-ohm and 8-ohm specs seem very unusual. Amp A delivers 50 watts into 8 ohms and 100 into 4 ohms. Nothing at all unusual about that. Two hundred into 8 ohms with a drop to 100 watts at 4 ohms is somewhat stranger but not totally implausible. In other words, either Amplifier A or Amplifier B could be production models and one would have little idea of their true characteristics from the FTC specifications.

Amp C (Figure 3 on this page) is completely hypothetical. It's a design created to illustrate the extreme of P=VI, the ultimate example of the law that current without voltage means low power. This is the power amplifier to delight the hi-fi salesperson who pushes high current to the exclusion of all else and/or the customer who has been so convinced .

"Awesome, dude," the salesperson intones, *"This baby is so powerful that it puts out over A THOUSAND AMPS and FIVE THOUSAND WATTS into 1/200 OF AN OHM IMPEDANCE! Is this a brute or what?"*

Not really. Because the 8-ohm FTC rating of this mythical amplifier is just 3 watts! And just 6 watts at 4 ohms. Take our word for it, it would sound mythically bad at anything but background music levels.

We've postulated an amp that takes high current to its logical and absurd extreme by extending impedances lower than existing speakers go (although one popular design *does* take a dip below 1 ohm, making our chart less absurd than it might seem). Here is an amplifier capable of awesome output into impedances approaching zero. The dream amp for sadistic speaker designers.

Yet its FTC rating would be dismal. Why? Because voltage has not kept up with current.

Although no amplifier such as Example C exists, we included it to illustrate the ongoing struggle between delivering simultaneous current and voltage that all amplifier designers face. If voltage cannot "keep up" with current, power at 4 and 8 ohms will drop, though not as precipitously as our Examples A or C.

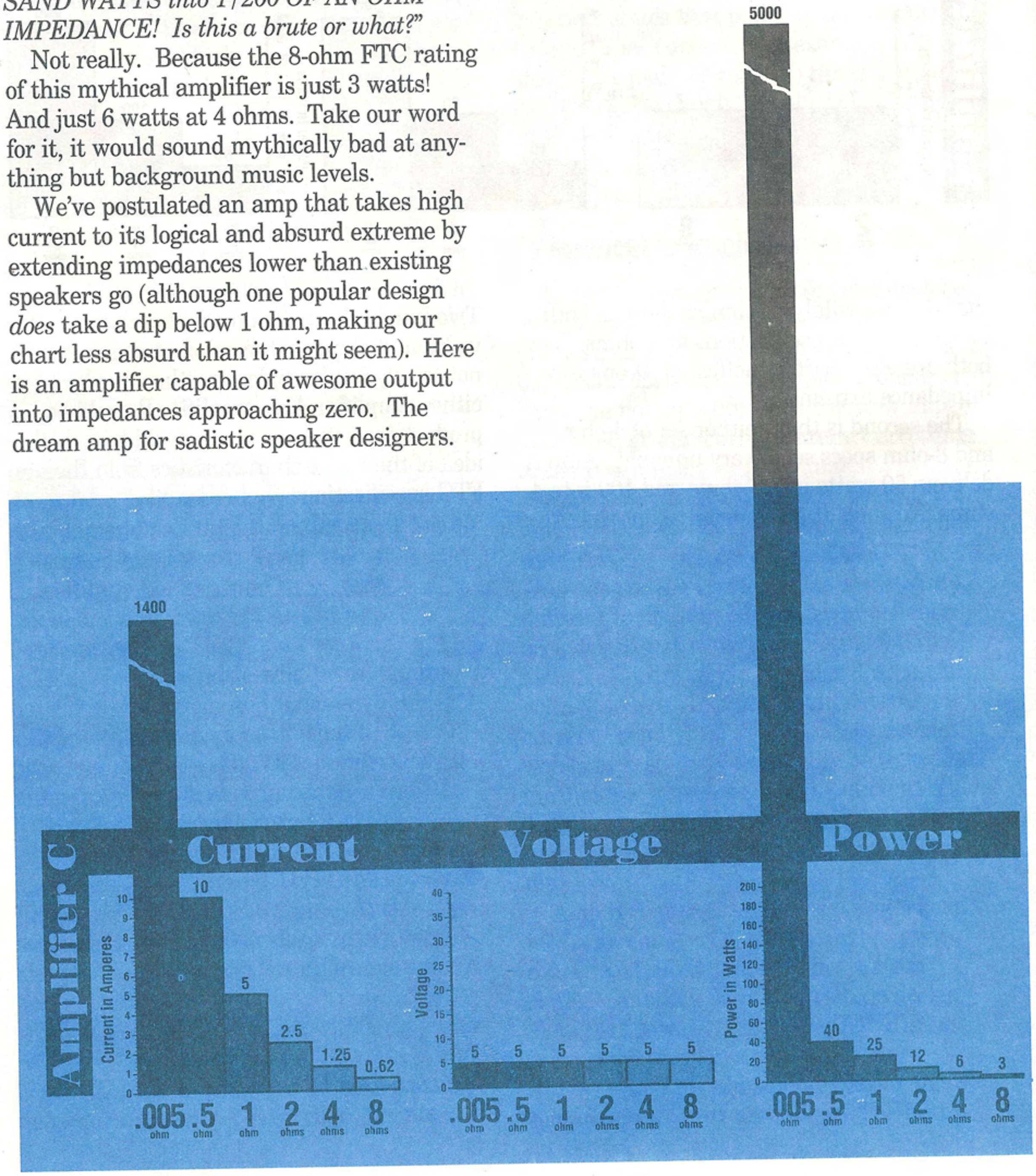


Fig. 3 Gargantuan current output at low impedances — but without corresponding voltage increases — results in very low power output at normal operating impedances such as 4 and 8 ohms

Interestingly enough, several "esoteric" power amp manufacturers have, in the past, emphasized high current so strongly that their amplifiers' power ratings seemed relatively unimpressive — sort of a mild version of our Amplifier C. This is due in part to the fact that in conventional designs, delivering BOTH high current and high voltage is a very difficult proposition as we will learn farther on.

Power curves.

Note that in all of these charts we have expressed impedances in ascending order. That's because the issue here is the ability of an amplifier to deliver power (and current) into potential 2-ohm loads.

A more common way to express the relationship which results from changes in impedance is with the chart shown below. As useful as they are, they don't take into account the critical voltage factor. Still, because several of our competitors flaunt them, we've included this type of chart — and our amplifiers' performance looks GREAT when shown this way. Just to set the stage, here are the power curves of our three, theoretical amplifiers (Figure 4 below left).

Real world examples.

It is common to compare one's products only with competitive designs which have poorer performance. However the objective of this paper is not to denigrate other manufacturers, but establish the importance of simultaneous high current and high voltage to a good-sounding design. As proof, we offer the fact that many ultra-high-end companies also consider simultaneous high voltage/high current of paramount importance and have addressed it in their amplifiers.

Indeed, several esoteric solid state amplifiers have done an admirable job of managing the current/voltage trade-off using relatively conventional approaches. The solution has, however, required brute force in the form of extremely expensive power supplies (see Part

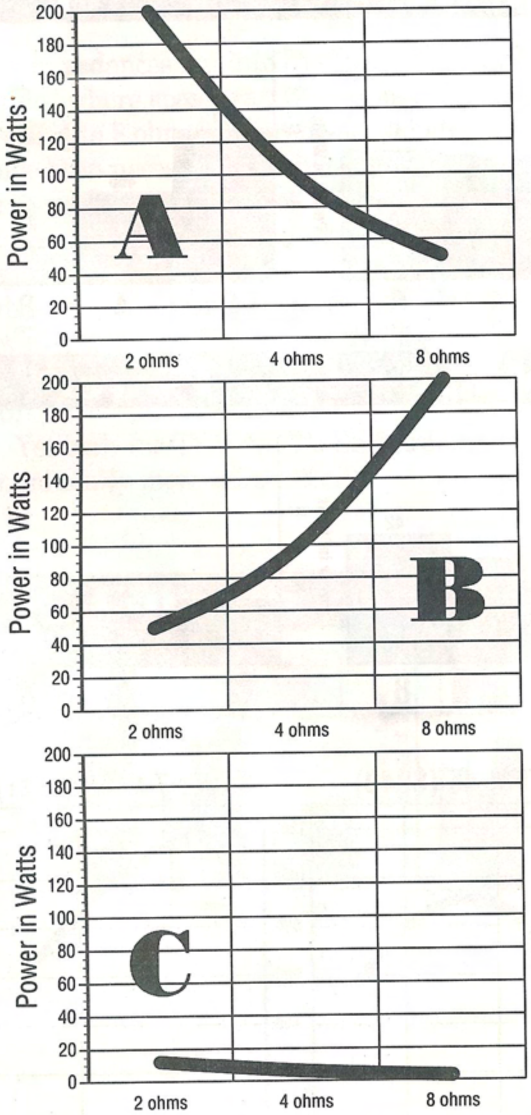


Fig. 4
Many of our competitors are fond of showing power this way (although it begs the topic of current and voltage). Here are power curves of our theoretical examples. Farther on are some real amplifier power curves.

II of this White Paper). Consider "Real World Amplifier 1", a highly capable design in the $5000+ range (Figure 5).

These figures may be considered a sort of bench mark for exceptional current and voltage output at low impedances. "Extreme" though conventional design measures were taken to achieve this current/voltage performance, and the consumer necessarily pays a price for the high performance.

Let's compare it with "Real World Amplifier 2", a popular competitor of ours which sells in the $700+ range (Figure 6).

At first look, Amplifier 2's current and voltage seem a lot less than Amplifier 1. And they are less, which results in considerably less power.

Carver simultaneous high voltage/high current.

Our theoretical amp charts were intended to make it obvious that current AND voltage are necessary to drive high impedances unless you want an amplifier which has very little power at 4 and 8 ohms. Because of the P=VI rule, we've seen that a change in voltage can severely affect the power ratings of a "high current" amplifier.

When viewed in these same rigorous terms, the sheer "muscle" of Carver's latest Magnetic Field Power Amplifier designs becomes apparent.

As you can see by Figures 7 and 8, both Carver examples deliver impressive current and voltage simultaneously. Not only into

Fig. 5 Power output this good costs money.

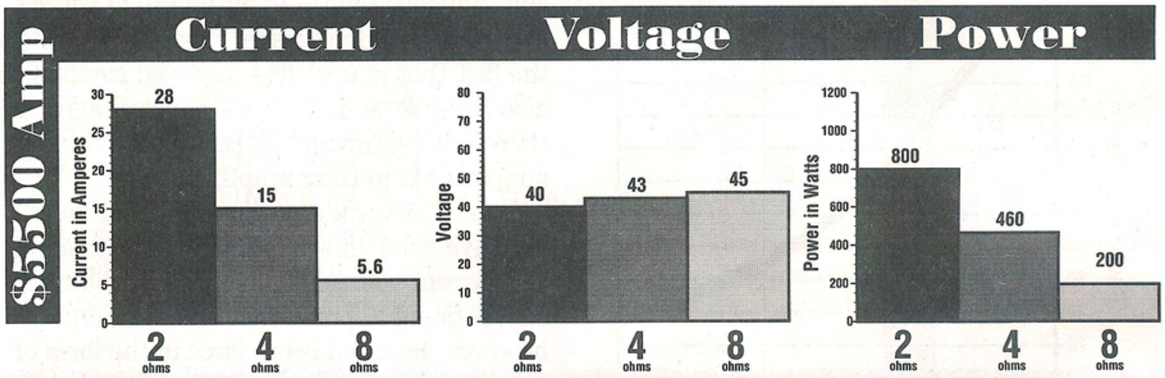


Fig. 6 Lower-priced amplifiers aren't capable of the same output.

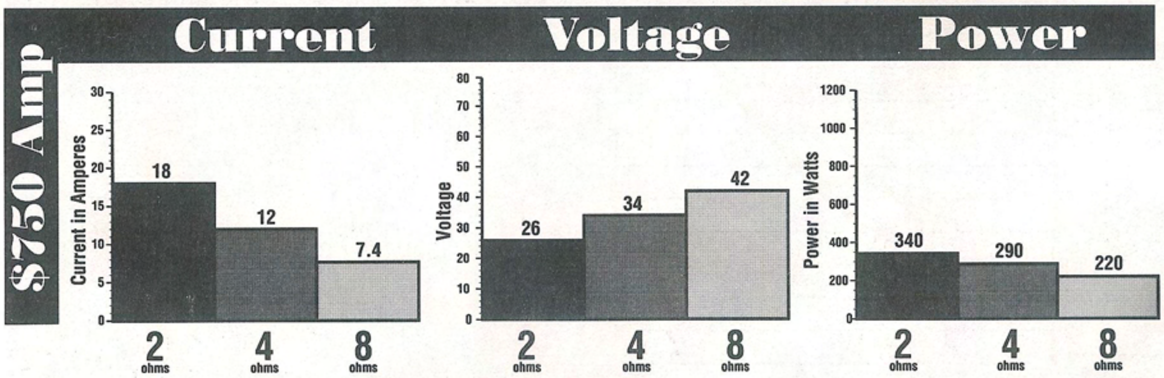
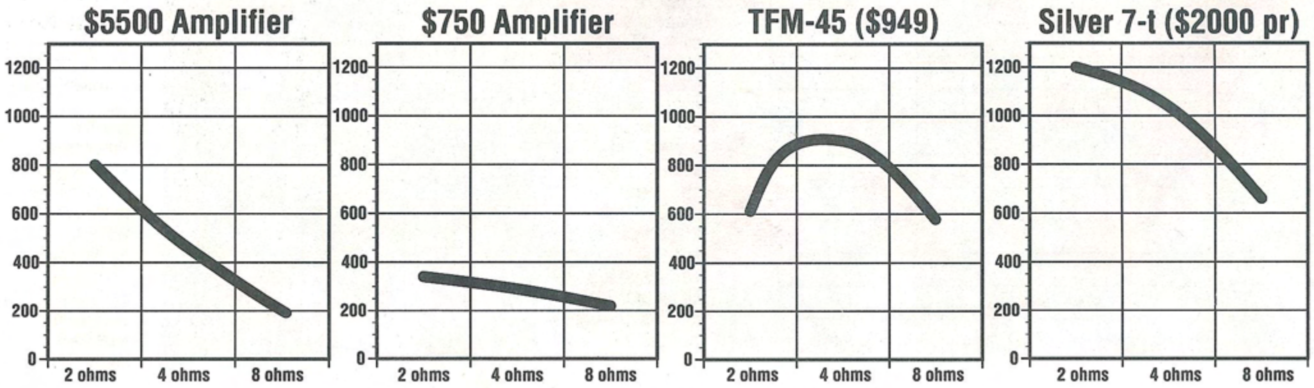


Fig. 9 Here are power curves for our amplifers versus the competition. Even at 2 ohms,our $949 TFM-45 gives the $5500 amp a run for the money and actually outdistances it at 4 and 8 ohms!



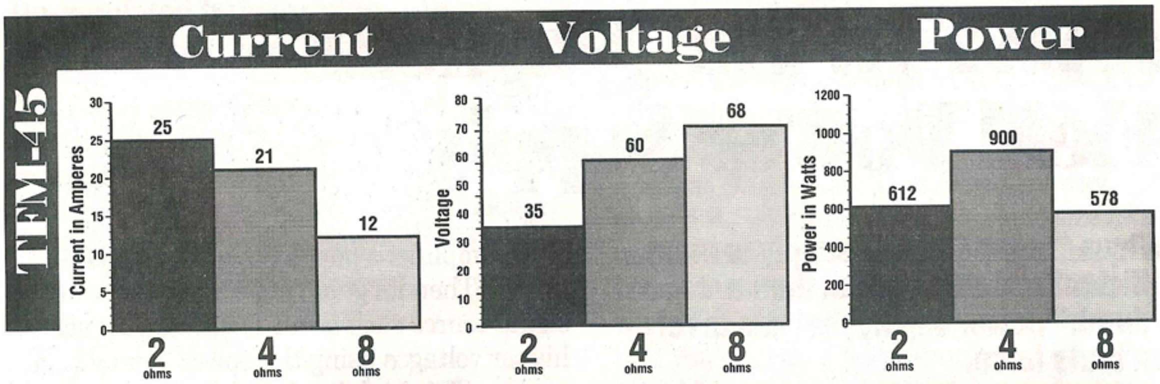


Fig. 7 Note the broad power curve and robust output at all impedances. Power does not drop precipitously at higher impedances.

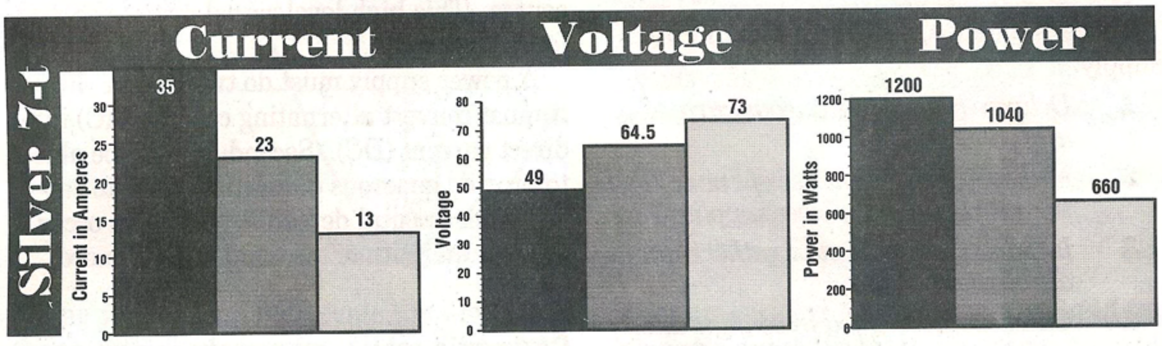


Fig. 8 The SS-t practices what we preach: VERY high current and voltage output along with awesome power at all impedances.

low impedances but into the "real impedance world" where speakers live most of their lives: 4 to 8 ohms. No trade-offs whatsoever have been necessary to achieve low impedance performance. In fact, when directly compared, the TFM-45's currrent/voltage figures rival those of the $5000+ amplifier -- while the Silver Seven-t completely blows it away (Figure 9). Note , also, the distinctively aggressive power curves as shown in Figure 10.

Yet both the TFM-45 and SS-t are emminently more affordable.

The key to Carver Magnetic Field Power Amplifiers' capabilities is, needless to say, their power supply. Its regulated design, a rarity in the audio world though common in extremely high precision aerospace electronics, enables it to surmount the problems of providing simultaneous high current and high voltage without resorting to solving the problem with expensive "overkill".

Moreover, they simply outperform similarly-priced amplifiers of conventional design on all counts, making them an exceptional value for the music lover who desires the best possible sound from any speaker design.

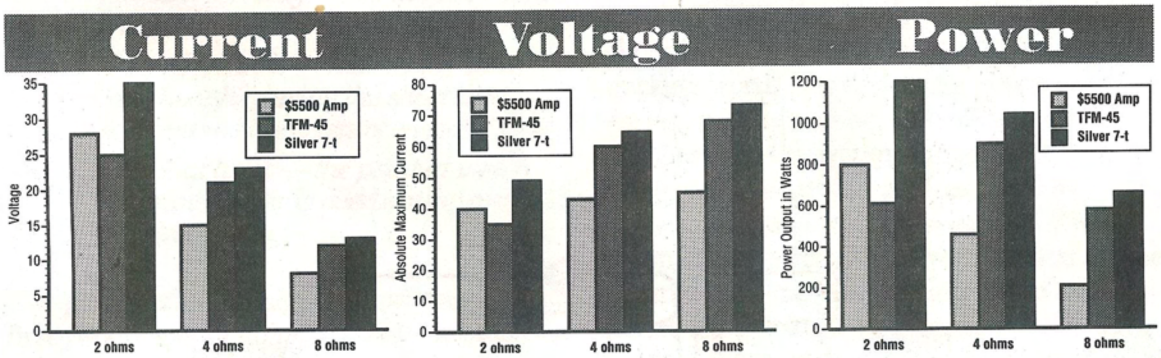


Fig. 10 These comparisons speak for themselves. Our unique power supply is the key to providing this much current and voltage at affordable prices.

PART II: The Magnetic Field Power Supply

Why a "smart" power supply is more efficient and economical than a "dumb" power supply that has to rely on brute force.

Carver's patented Magnetic Field Power Supply:

1. *Delivers high simultaneous current and voltage*
2. *Makes more efficient use of line voltage than conventional power supplies*
3. *Is "smart" and adaptive rather than dumb and passive*
4. *Can be implemented in configurations which are both reasonable in size and price.*

What is a power supply?

Let's start with the really basic basics. Electricity comes from wall sockets. Speakers turn electricity into music. Amplifiers are placed in between to convert what comes out of the wall into an amplified version of musical input.

Alternating current from a wall receptacle has a fixed voltage (theoretically anyway) and a fixed frequency. Loudspeakers require direct current with varying voltages and frequencies.

An amplifier's power supply converts AC to DC. Then its gain stages replicate a weak signal source such as a CD player at much higher voltages using the power supply as a source. This high-level signal drives the loudspeakers.

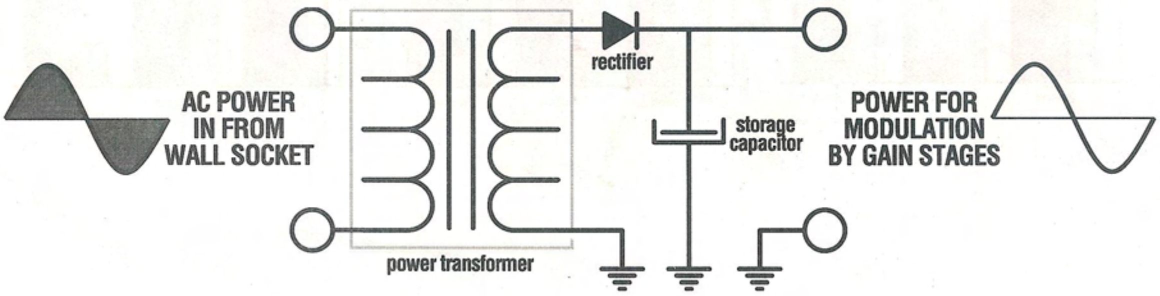
A power supply must do two things: First, it must convert alternating current (AC) into direct current (DC). Second, it must be able to provide generous quantities of DC to satisfy peak musical demands which can occur every hundredth of a second or even more often.

Conventional power supply operation.

Conventional power supplies consist of **1)** a transformer, **2)** a rectifier, **3)** storage capacitors (See Figure 11 below). The transformer steps the 120-volt wall socket source up or down to fit the power requirements of the amplifier.

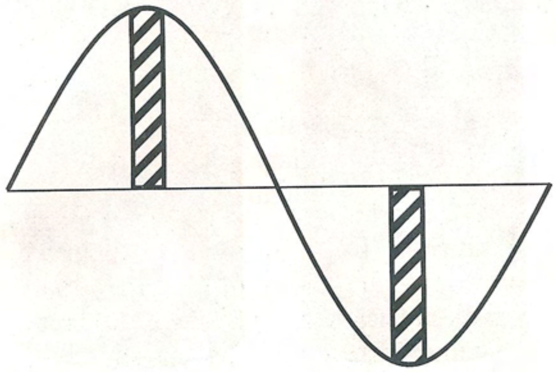
The rectifier converts alternating current to pulses of direct current. The storage capacitors act as a reservoir, storing up the the DC pulses. This is a rather oversimplified account of power supply operation but since the differences we're concerned with are major, it will suffice.

Fig. 11
Conventional Power Supply: A lumped-capacitance system.



Un-regulated transformers — why they're the size they are.

A power supply transformer does not constantly "transform" and pass on electricity. It only lets current pass when the voltage reaches a certain peak — a short "window of time" during each half of the AC cycle:



The shaded area represents the time when the transformer is passing current on to the rectifier and storage capacitors — about ONE FIFTH of the entire AC cycle. The rest of the time, it has to "stand off" the voltage from the wall socket.

The fact that 4/5ths of a conventional transformer's resources are devoted to basically doing nothing but resisting, is a very important concept. It directly affects the size (and thus COST) of the transformer.

Theoretically, transformer size is determined/limited by three factors:

1. *Regulation limit. The level at which the transformer "droops" and cannot function correctly. We'll discuss this in a minute.*
2. *Volt-Time limit — how many volts "get though" during the short time segments at the crests of each AC cycle.*
3. *Thermal limit — the point at which the transformer is overheating and self-destructing.*

A power supply designer must weigh the first two factors in order to specify a transformer which can produce enough voltage to meet the desired power rating of the amplifier. It boils down to this: The more powerful the amplifier, the larger the transformer must be to achieve that voltage. Conventional amplifiers in the 300-watt range have gigantic transformers weighing as much as 50 pounds! There's just no way around it. (Because of this massive size factor, thermal limitations are rarely a factor except in very cheaply-designed amplifiers — which will have other problems anyway).

If you're getting the picture of a big, "dumb" passive device which has to be five times larger than it needs to be — since it spends 4/5ths of its time "standing off" or holding back the AC line — you're absolutely correct.

This is what we call an UN-regulated power transformer, a key part of a conventional UN-regulated power supply.

Why un-regulated transformers lead to gigantic capacitors.

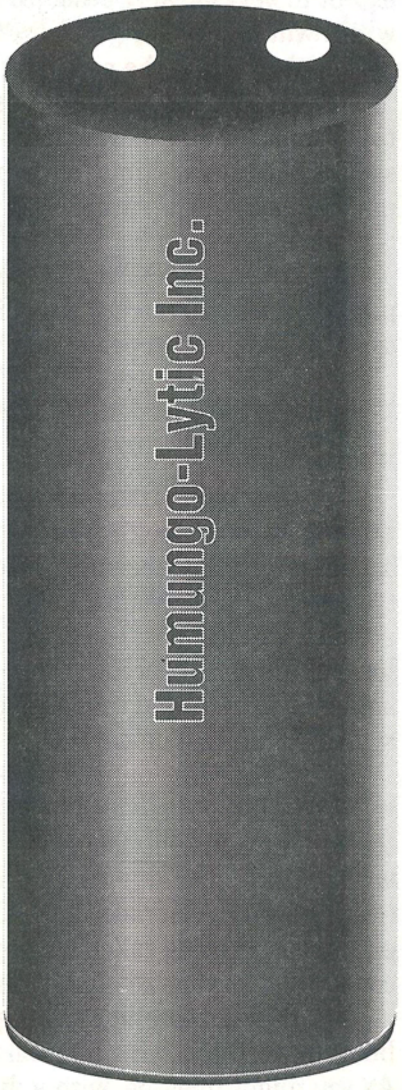
The other hallmark of impressive conventional power supplies are enormous storage capacitors. Remember that, since the power transformer only "conducts" during a short period each AC cycle, the storage capacitors have to act as a reservoir. They "collect" the spurts of current and then deliver it in response to musical demands.

It's time to bring out our time-honored water analogy. Imagine a tub. At one end the tub (capacitor) is constantly being filled with water (current) one quart at a time (pulses from the transformer). On the other end, water is being taken out regularly but in constantly varying amounts: Sometimes a shot-glass full, sometimes multiple 5-gallon buckets worth (varying musical demands). As you might imagine, with a disparity like this between the volume going in and the volume going out, the tub has to be very large to contain adequate reserves. Even when water is going out five gallons at a time it can only be replenished a quart at a time. These big demands only happen occasionally, so if the tub is big enough, it won't run dry and will have time to refill during off-peak times.

If you've ever examined capacitors (this is expecting a lot), you'll notice that small values such as .047 microfarads are tiny —just little round wafers.

And that large values, such as 4700 microfarads are big cylinders.

4700
microfarads



.047
micro
farads

The more microfarads of capacitance, the larger the "storage tub". Which is why big amps have physically big capacitors.

While that's the most obvious reason why conventional un-regulated power supplies require large capacitors, there's another one, too. Amount of capacitance is only one factor in the size of a capacitor. Its voltage rating also affects size. The higher the voltage rating, the bigger a capacitor of any given value will be.

4700 microfarads 125-volt rating | **4700 microfarads 200-volt rating**

An un-regulated power supply cannot control (regulate) the incoming voltage. Instead, the designer of a conventional power supply must specify capacitors that have a higher voltage rating, one that provides "headroom" for peak capacitor charging during time periods when the amplifier does not demand current. This also adds to the capacitors' size.

The price of a conventional power supply.

If you've been involved with audio for any length of time, you've "learned" that the bigger the power transformer and storage capacitors are, the more robust the amplifier is. Yes, that's the end result.

But you should also view monster transformers and capacitors the way you would a large, antique steam engine: extremely powerful, but very inefficient. In other words, impressive transformers and storage "caps" are symptoms of the overkill that's required because the power supply is both conventional and un-regulated: Because it's dumb, it's gotta be big.

Big means expensive. More iron and copper in transformers, more dielectric material in capacitors. Not produced in as large of quantities because of less demand . . . all of these factors contribute to the very high cost of a good conventional power supply. For the solid reasons we've just gone over, there's no way around this. In fact, it's tempting to say that *"there's no free lunch"*.

But that's not wholly correct.

There IS a way to get MORE lunch at a far more REASONABLE price.

The regulated Magnetic Field Power Supply.

Let's consider that diagram of a conventional power supply again along with how it obtains current during momentary AC crests (Figure 13 below).

Carver's Magnetic Field Power Supply also has a transformer, rectifier and storage capacitors. But it has a special regulating device BEFORE the transformer (Figure 14).

It's called a *triac*. Its job is to regulate incoming current based on demand and it is one of the reasons Magnetic Field Power Amplifiers are said to have "smart" power supplies.

There is considerable precedent for the superiority of a regulated power supply such as ours.

Virtually all good preamplifiers use regulated power supplies.

CD players use regulated power supplies.

Top quality measurement instruments use regulated power supplies.

Aerospace electronics use regulated power supplies.

In short, any time precision and finesse are needed, designers turn to regulated power supplies which don't require gigantic transformers to stand off voltage.

Why don't our competitors use regulated power supplies on THEIR power amplifiers? They don't have OUR patent. It allows us to economically achieve power supply regulation at the high voltage/current levels necessary to drive a loudspeaker.

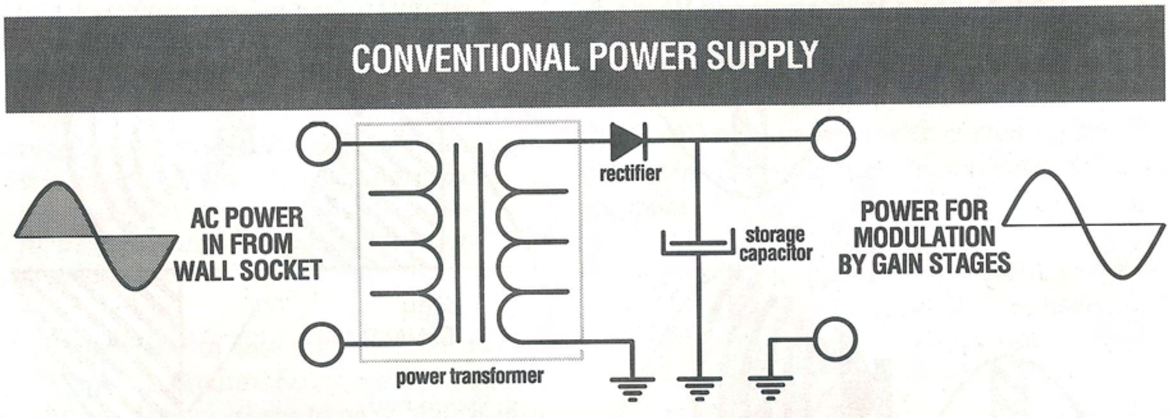


Fig. 13 Lumped capacitance system. This typical UN-regulated power supply must stand off line voltage 4/5ths of the time.

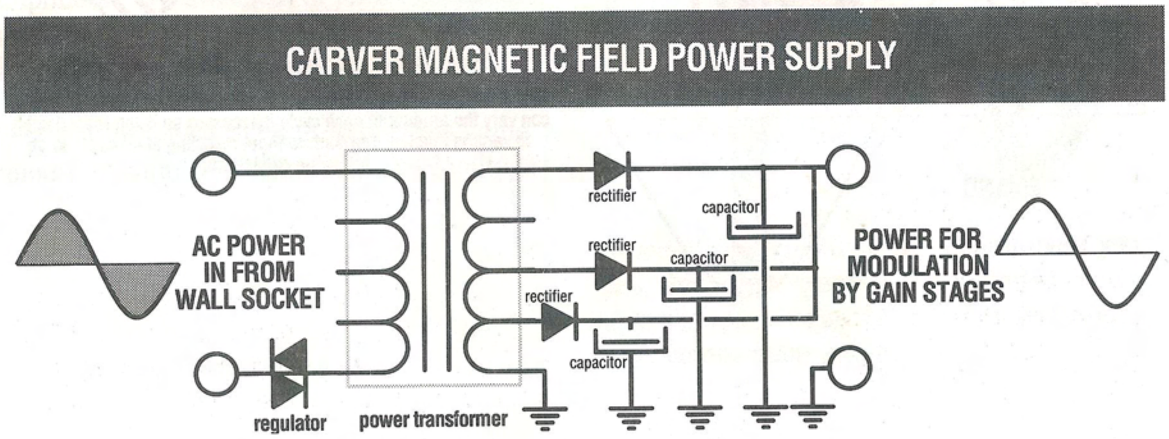


Fig.14 Distributed capacitance system. Carver's regulated power supply is flexible and can use much more of each cycle.

II

The Magnetic Field Power Supply in action.

Because the triac can regulate current inflow to the transformer based on demand, the transformer is no longer limited to a single, narrow "window of opportunity". Nor does it have to "stand off" the line voltage 4/5ths of the time. In a Carver Magnetic Field Power Supply, the length of time during which power can flow to the storage capacitors can be increased by the triac as necessary (Figure 16 at right).

Let's compare that to how much current a conventional power supply would be admitting during the same period of peak demand (Figure 15 below). When there's more demand, the supply cannot be increased.

CONVENTIONAL

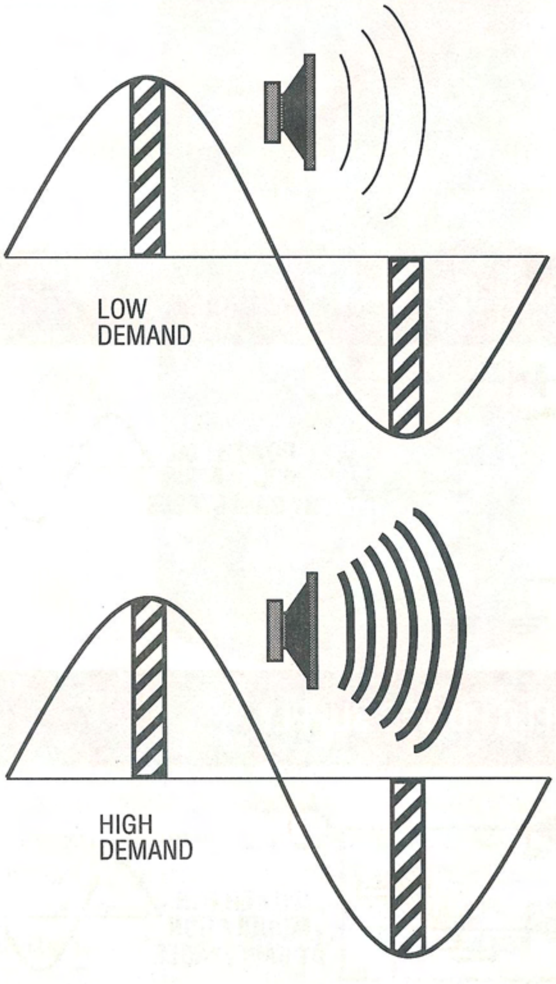


Fig. 15
Because they employ diode conduction, conventional power supplies cannot vary the brief amount of each cycle they can use. 4/5ths of the time, power must come from storage capacitors only.

CARVER MAGNETIC FIELD SUPPLY

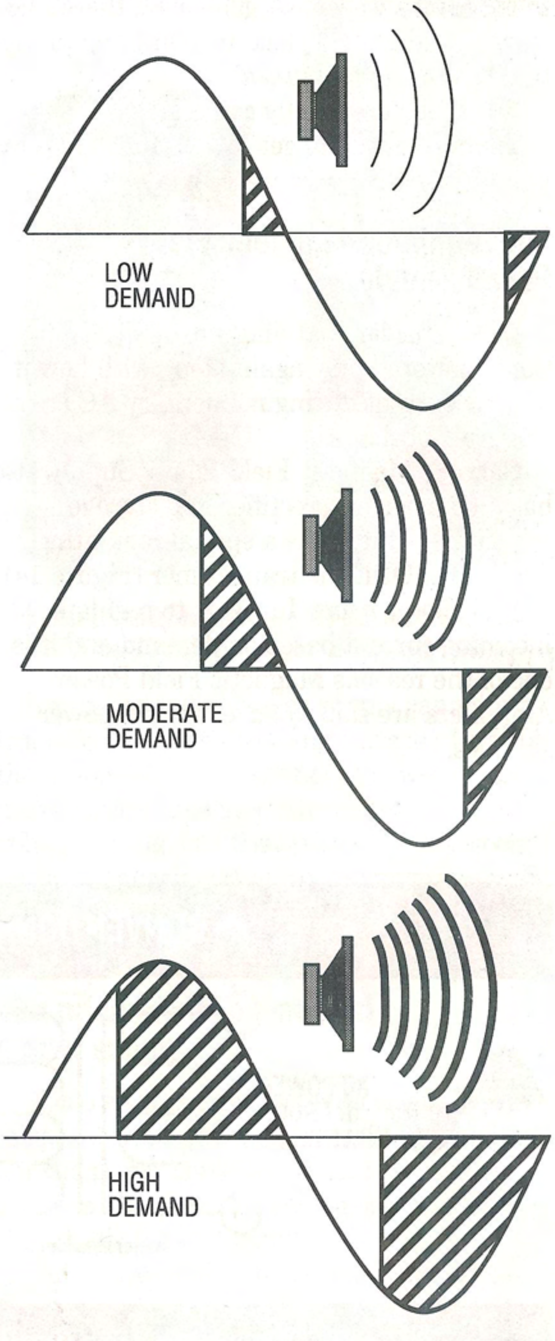


Fig. 16
Because it uses triac conduction, the Magnetic Field power supply can vary the amount of each cycle it accesses so it can react flexibly to varying musical demands without resorting to absurdly-large storage capacitors.

CONVENTIONAL POWER SUPPLY

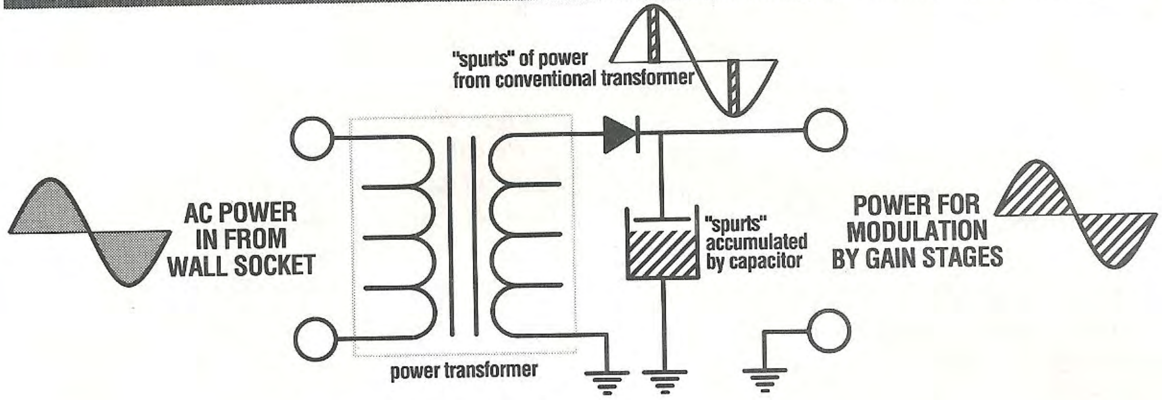
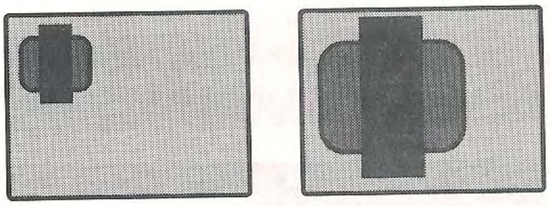


Fig. 17
A conventional power supply has one capacitor per channel to accumulate and deliver power at all levels.

If you review why conventional transformers and capacitors are as big as they are, you can now understand why it's not magic but sheer practical science that allows a Carver Magnetic Field Power Amplifier to deliver MORE CURRENT and MORE VOLTAGE.

- *Voltage-Time limitations are gone, reducing the size of the transformer.*
- *Passive regulation is not necessary, reducing the size of the transformer.*
- *Storage capacitors can receive sufficient current when they need it, reducing their size.*
- *Since the triac regulates voltage, capacitors in a Magnetic Field Power Supply can be specified to the EXACT voltage needed (instead of over-sized to handle surges), further reducing the storage capacitors' physical size.*

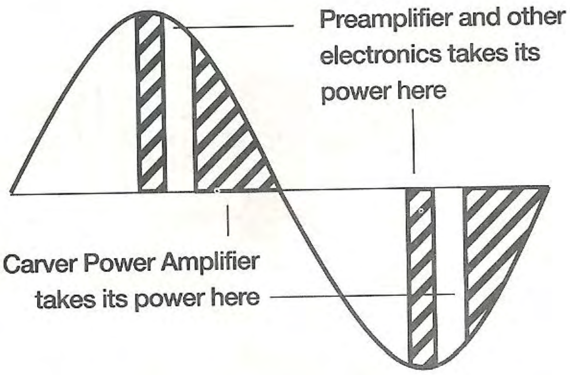
It's important to note that we don't use space gains to produce eensy weensy power amplifiers. We use them to pack MORE into a reasonably-tall, 19-inch chassis. Compare the actual size of the transformer in our TFM-45 with how large a conventional transformer would need to be to deliver the same amount of simultaneous current and voltage.



Not surprisingly, this is about the size of the transformer in that $5000+ design whose performance is shown in Figure 5 back on page 10.

A small but important added benefit.

When you compare current in-flow, you'll notice that a Magnetic Field Power Supply "tops off" its capacitors with current much longer in each cycle than do conventional supplies.



Depending on what type of equipment you own, this longer current "time window" can have a small but positive effect on how your other components perform.

At high volumes or during bass-heavy musical peaks, any power amplifier demands an incredible amount of current — enough in some cases to actually dim room lights in time to the bass beat. With conventional amplifiers, this tremendous cyclical in-rush of power means that all of your other components — preamplifier, CD player, cassette deck, etc. are competing for their power needs at the same instant.

Because the Magnetic Field Power Supply takes its current from the "back of the cycle", it rarely creates a conflict with other component's current needs because they replenished their power supplies at a different time in each AC cycle except for very occasional mega-peaks.

Just how much benefit this is to you will depend on what components you own.

Multi-Rail Switching — Another Magnetic Field Advantage

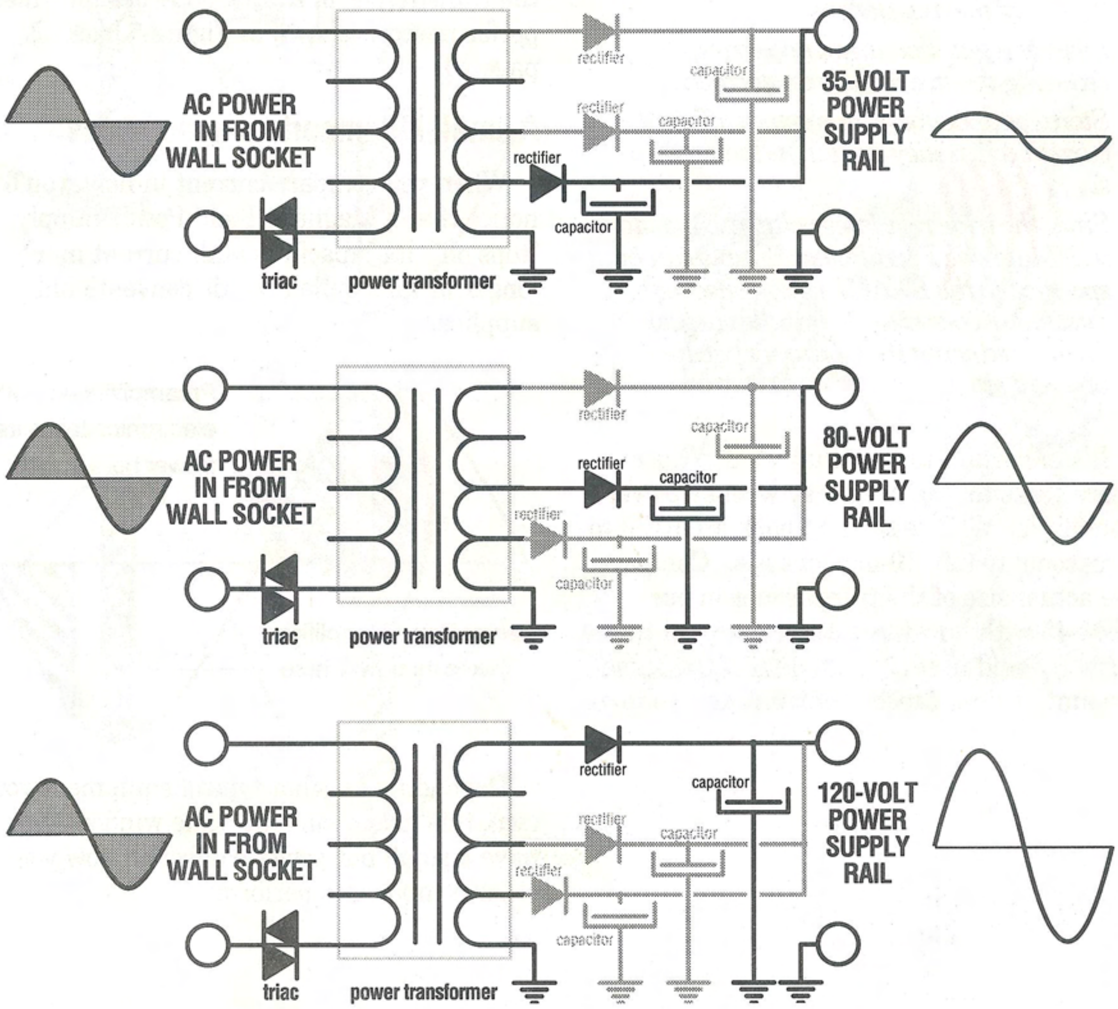
Notice that along with the triac ahead of its transformer, the Magnetic Field Power Supply has two or three sets of rectifiers and storage capacitors.

We call these "rails". You might think of them as different gears in a car transmission. They let Carver power amplifiers tailor their output to musical demands.

In our example below (Figure 18), the amplifier uses only its 35-volt rail at average listening levels. When you turn up the volume or when the music is extremely bass heavy, the Magnetic Field Power Supply "shifts gears" and switches to the 80-volt rail. To satisfy really demanding momentary dynamic peaks, it again shifts, this time to the 120-volt rail.

Fig. 18 Rail switching in action. As musical content demands more power, higher-voltage rails are used.

3-RAIL MAGNETIC FIELD POWER SUPPLY



The "gear shifting" is done electronically by monitoring the incoming signal from the preamplifier and switching accordingly when it senses increased power requirements.

Besides the beneficial effects on capacitor size, this scheme also makes the actual amplifier much more efficient, thus reducing heat sink size and overall weight, power consumption (including light dimming) and ultimately making the amplifier more affordable.

Our TFM-42 and TFM-45 employ three rails, at the voltages mentioned above. The TFM-22 and TFM-25 also use three rails, at 25, 50 and 100 volts, respectively.

The benefits of a demand-responsive power supply.

A Magnetic Field Power Supply has two capacitors per channel for each "rail", or level of output. Most of the time, only the first rail (and thus the first set of capacitors) is being used. Thus the storage capacitors which are part of the higher-voltage rails are "topped off", ready to deliver instantaneous current when it is needed.

During one of these demanding musical peaks (when the third, highest voltage rail/storage capacitors are being called upon), the first and second rails/storage capacitors are "re-charging", so that they're ready to handle

3-RAIL MAGNETIC FIELD POWER SUPPLY

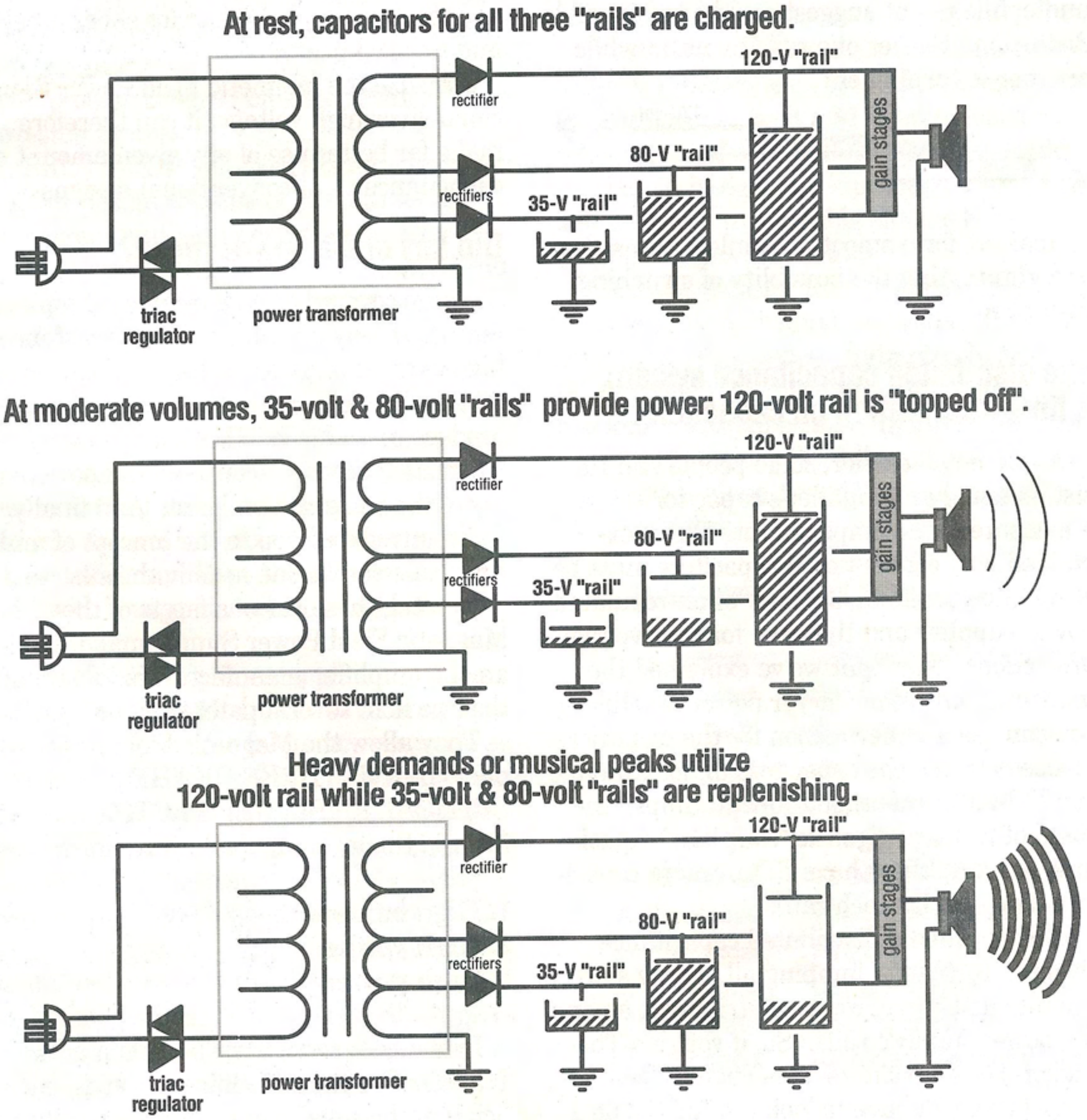


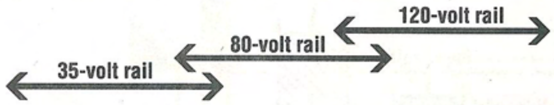
Fig. 19
While one rail's capacitor(s) are discharging, the other two rails are charging, leaving no "droops" as are possible with just one capacitor per channel.

lower-level musical power requirements IMMEDIATELY after the peak has subsided. Or to put it another way, while one is being sucked dry, two are filled and waiting.

A conventional power supply, on the other hand, only has one set of capacitors (remember our tub-of-water analogy?). When they're nearly "emptied" by a big bass drum boom or orchestral crescendo, there is no time for them to "fill up" again. This single set of capacitors must rely on the remaining current left over from the musical peak — leftovers, so to speak — which will only be enough if the power supply's capacitors are very, VERY large.

Seamless transitions.

It is important to note that multi-rail Magnetic Field power supplies do not actually SWITCH between rails, which the astute audiophile might suggest could cause audible distortion. Rather one rails turns on while another is turning off:



. . .making for a smooth, seamless transition and eliminating the possiblity of switching distortion.

The distributed capacitance system: A final observation on capacitors.

As we noted earlier, some people still insist on using an amplifier's capacitor size as a measure of the amps output. We've explained why conventional capacitors must be so big (due to the inefficiency of un-regulated power supplies and the need for over-voltage protection). Now that we've explained the multi-rail nature of Carver power amplifiers, you can see another reason for the disparity in size between the capacitors in, for example our TFM-25, and other 200-watt amps. Instead of just two gigantic "soup can" capacitors, our amplifiers have SIX or more capacitors (two sets for each rail).

This is called a distributed capacitance system. Instead of lumping all energy storage into just two caps, we distribute it among the power supply's rails. So, if you're a The-Bigger-The-Capacitors-The-Neater-The-Amp-Type, you have to look around inside a Carver power amplifier chassis.

And even then, you're basically looking for the wrong thing.

The point of power supply capacitors is energy storage. Capacitance, measured in farads, is only one part of the equation and is far less significant than voltage at that. Inspect this equation:

$$E = 1/2CV^2$$

where E equals energy, C equals capacitance and V equals voltage.

Here's voltage again, rearing its realistic head and displacing other measurements which have become dear to audiophiles. Capacitance — lots of microfarads in those big soup cans — is considerably less of a factor than voltage. Doubling capacitance only results in a 100% increase in output energy. Doubling voltage results in a 400% increase in output energy available for sheer muscle and musical peaks.

Because the Magnetic Field Power Supply can deliver high voltage, it can therefore make far better use of any given amount of capacitance than conventional designs.

Did any of this make sense?

We've covered quite a number of topics so far. First we built the case for simultaneous high current and high voltage. Then we explained how our regulated power supply can produce up to FIVE TIMES as much power when compared to a conventional power supply of the same size and cost. And finally we've introduced you to the concept of multiple rails versus one behemoth rail.

In total, these various facets of the Magnetic Field Power Supply make it unique among amplifier manufacturers. So unique that we hold several patents on its operation.

They allow the Magnetic Field power supply to provide THREE OF THE FOUR CRITICAL AMPLIFIER FACTORS we set forth in the introduction to this paper:

1. High current
2. High voltage
3. High power

In the next section, we'll explain how Transfer Function Modification adds the "icing to the cake".

Part III: TRANSFER FUNCTION

How our "t-modification" process achieves better sound in today's Carver power amplifier designs.

Our TFM series power amplifiers come closer to achieving the warmth and richness of "tube sound" than any previous Carver solid state designs. In the opinion of many serious listeners, these amplifiers deliver tight, effortless low bass and loft a wide spacious sound field of the type you'd rightfully expect from an expensive and esoteric vacuum tube design. The purpose of this paper is to explain why these sonic characteristics can be realistically replicated in a solid state design.

The process is based on solid science, using a two-step process:

1. BRUTE FORCE. We created a powerful amplifier design capable of simultaneous high current and high voltage output for the requirements of today's dynamic sources and demanding speaker loads. It takes advantage of Magnetic Field technology's ability to convert more of the incoming AC cycle into raw power and then provide more joules of energy for peak music demands than conventional designs. Several of our new designs' ampere current output actually exceeds that of all but the world's most expensive high-end, esoteric amplifiers. In other words, we began with a rugged, rock-solid amp configuration.

2. FINESSE. We then applied the Transfer Function Modification technique to create F_t (our term for frequency response as measured at the speaker terminals) characteristics which emulate those of an esoteric tube amplifier. By analogy, you might think of the basic TFM/Magnetic Field Amplifier design as the well-blended ingredients for a cake: flour, eggs, etc. Transfer function would then represent the flavoring — chocolate, lemon, vanilla. The essence which gives the overall creation its distinct character. Possessing this *quantitative* information about the *qualitative* sound of an amplifier gives the designer remarkable flexibility in determining its overall sound. To return to our analogy, it is as if we have a whole spice rack to choose from for mixing a unique creation or closely emulating an existing recipe.

What is transfer function?

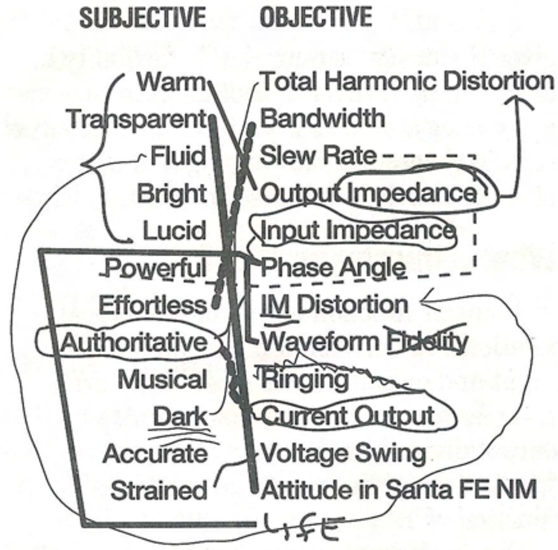
Transfer function is the mathematical relationship between a power amplifier's input and output. In its most basic terms, transfer function can be thought of as the output divided by the input. Thus the "perfect" amplifier would have a transfer function of 1.

Due to the realities of electronics, a perfect transfer function is as yet unattainable. Every amplifier — be it a $17,000 monoblock tube model, or a $129 solid state loss-leader special — changes the input signal internally and creates a measurable change between amplifier input and output.

Thus the transfer function of an amplifier is its unique, individual character. Its sonic signature. Its essence. Subjectively or objectively classifying these unique "fingerprints" has kept audiophiles and engineers busy for decades. Consider the following left-brained and right-brained descriptions of amplifier characteristics.

SUBJECTIVE	OBJECTIVE
Warm	Total Harmonic Distortion
Transparent	Bandwidth
Fluid	Slew Rate
Bright	Output Impedance
Lucid	Input Impedance
Powerful	Phase Angle
Effortless	IM Distortion
Authoritative	Waveform Fidelity
Musical	Ringing
Dark	Current Output
Accurate	Voltage Swing
Strained	Attitude in Santa FE NM

Each term, in its own way, is a description of how a signal is modified on its way through an amplifier. Give these two lists to groups of engineers and/or audiophiles, ask them to make correlations and witness the chaos!



No one doubts that Column A's subjective sonic qualities result from Column B's objective qualities in amplifier performance. The controversy comes from trying to make exact correlations. Engineers come up with new measurements, strive for more precision in their old measurements, etc.; audiophiles coin new descriptive terms and things go round and round.

We think that both sides are right. As trained and discriminating listeners, we certainly accept the subtle sonic differences between amplifier designs and models and can whip up a batch of adjectives as well as the next audiophile. As scientists, though, we have the desire to wade in with a squad of test instruments and express the whole thing in a page of equations, numbers and graphs.

What's the point of either exercise? Comparison. A way to express differences between designs. A way to explain why one sounds "better" than another.

What's really different.

The fourth and final important factor in the sound of an amplifier is

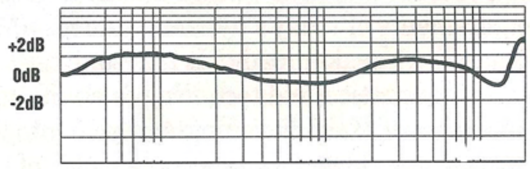
frequency response as measured at the loudspeaker's terminals.

Period. Nothing more. It is responsible for all of the terms in the descriptions above. The "warmth" of the speaker's sound, its bass quality, its upper register definition, its soundstage dimensions. EVERYTHING!

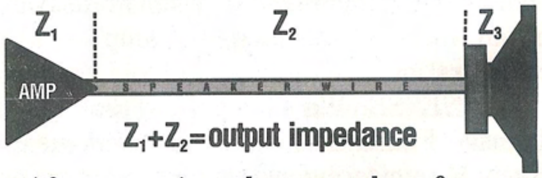
Before you start scoffing, understand that the frequency response of an amplifier as measured at a loudspeaker's terminals is NOT the same as the rated frequency response or bandwidth of the power amplifier.

Open up *Audio* Magazine's definitive *Annual Equipment Directory* to the amplifier section and peruse column 10 (Rated Full-Power Bandwidth Hz-kHz). These figures are impressive but have nothing to do with what we're talking about. Our amplifiers, for example, are rated 20-20kHz. And, on a test bench, they're ruler-flat across that frequency range. Many other companies get carried away and show specifications like 0.5Hz to 100,000 Hz. We don't doubt this figure, when connected to a test load in a laboratory. It can graph out ruler-flat.

But the same power amplifier connected via heavy, 12-gauge speaker cables to a pair of 3-way loudspeakers might look like this:



This represents the amplifier's interaction with the loudspeaker and cables. It is a factor of the amplifer's output impedance PLUS the speaker wire and, ultimately the speaker:



After surveying a large number of power amplifiers, we have found that output impedances (Z_1) range from 0.15 ohms to 1.5 ohms (although there are a few eccentric exceptions).

Refer to the graph above again. Note that there are peaks and dips. Independently and collectively, they create the amplifier's sound under those given circumstances. In this hypothetical case, the amplifier would have prominent mid-bass, forward midrange and a wide soundstage. The depth of the stereo soundstage as well as how instruments appear within it is also affected by the F_t curve.

Frequency response????

This may be a hard concept for many of you to become comfortable with. At first, it sounds like an oversimplified panacea. But let's examine frequency response more closely.

Audiophile A and Audiophile B compare two amplifiers. They both agree that the DynoWhizMatic has a deeper sound stage and better ambience retrieval. They're not hearing things. There really *is* a difference.

Audiophile A attributes this to **1)** Hummungo-brand wonder capacitors, **2)** the over-100-pound weight of the amplifier and **3)** a magic brick which has been placed on top of the amplifier (with care to make sure the alignment is congruent with the Bermuda Triangle).

Audiophile B knows that the frequency response of the DynoWhizMatic varies ±1dB from the other amplifier in the frequency range between 100 and 400Hz where most ambience information lies (due to interaction with cables and amplifier).

"*Pishposh!*," sniggers Audiophile A, "*That's a microscopic difference. What possible effect can a ±1dB variation in response over a couple octaves have on something as audible as ambience retrieval?*"

Audiophile B goes to the blackboard (kept in another room to prevent live-end reflections) and writes the following:

±1dB = 2dB total variation
2dB = 1.25
or a 25% variation in voltage at the speaker 's terminals

Power (energy) varies as a function of voltage squared. So . . .

$(1.25)^2 = 1.58$
or 58% MORE ENERGY delivered into the listening room in the 100Hz to 400Hz range.

Which is precisely the range where ambience information lives both in live concert halls and in recordings.

"*Hmm. FIFTY-EIGHT percent more energy from a ±1dB variation, huh?*" (Audiophile A is suddenly interested) "*That could be audible as better soundstaging and ambience retrieval. 1dB. Never woulda thought it.*"

Once you, like Audiophile A, understand that miniscule changes in frequency response (*as measured at the speaker terminals*) have a direct effect on audible sound characteristics, a lot begins to fall into place. That favorite amp of yours has a soft, silky high end? A roll-off of as little as 0.75dB at 15kHz will result in a **20% reduction** in high treble energy. Awesomely solid bass from that Macho 5000 amplifier? Many 4-ohm speakers exhibit an impedance jump to 45 ohms right at their resonant point. If, for example, amplifier output impedance is 1.1 ohms (not uncommon), the resulting energy balance variations will boost power **55%** in the 20-40Hz range! VERY audible!

Another interesting phenomenon.

Heated debates about speaker-amplifier interconnects (or just plain wire, if you're not a purist) have raged for decades now. We're NOT here to tell you that it's all in your head and that there are no differences. Instead, that the wrong characteristics are being scrutinized.

No one denies that different kinds of speaker wire have different impedances. When you realize the importance of F_t — and that F_t is the combination of the amplifier's output impedance AND the speaker wire's impedance (that's why we keep adding the qualifier "*as measured at the speaker's terminals*"), you suddenly understand how different interconnects CAN have an effect.

In the middle ages alchemists and magicians would use one magnetized disc to move another. They — and the people they amazed with this phenomomenon — ascribed the "levitation" to black magic. Centuries later, the effect was correctly explained as repulsion of magnetic poles. Science had replaced myth.

This analogy directly applies to speaker interconnects. Yes, there ARE differences. No, they're NOT attributable to interweaving geometry or diameter of strands. But the overall make-up of the cable *can* help change overall energy balance in various parts of the frequency spectrum by as much as 100%. That's science, not superstition.

While the concept of F_t variations is a simple one, measuring F_t and changing it is far more difficult. It can't easily or accurately be done with a simple charting instrument and a graphic equalizer.

The Carver Null Test, a laboratory standard.

We have concluded that it would be far more useful to derive an evaluation technique that would COMPARE the sound of two different amplifiers than simply measure one in the abstract. This comparison test would contrast Amplifier A's transfer function against Amplifier B's transfer function and express the differences between them, thus pinpointing dissimilarities. Instead of applying numbers to individual measurements of just one amplifier, it would use those same numbers to express differences between designs while connected to speaker cables and loudspeakers.

The test configuration is remarkably simple (Figure 20 below). Two amplifiers are driven simultaneously in an externally bridged hook-up. Both receive the same input signal, which may be music, white noise, pink noise, sine waves, etc. Both are connected to carefully matched loudspeaker loads that are totally isolated from the test environment (they are used solely as loads, not as a listening source so they're literally in another room or outdoors during the test). The positive output terminals of both speakers are bridged to the outputs of a THIRD speaker.

If, at any given instant, the two amplifiers are not processing the signal in an identical manner, the positive outputs will not be at the same potential. Current will flow through the monitor speaker. The listener will hear the difference between the amplifiers' transfer functions (i.e. differences in frequency response when under load).

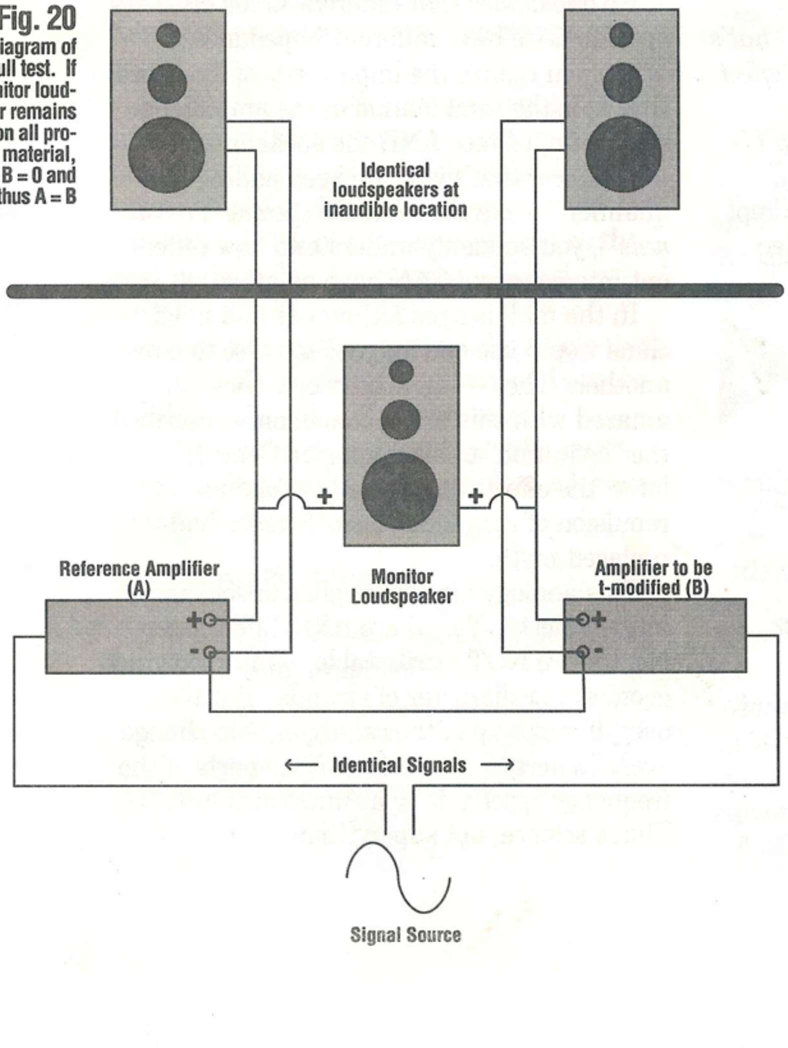
If both amplifier F_t's are close (and both amps are linear), there will be little or no sound and what there is will be musical. If the monitor speaker's output sounds distorted and unpleasant, at least one of the amplifiers has a non-linear transfer function.

In general, the more sound from the monitor speaker, the greater the difference in transfer functions between the two amplifiers. This Null Test set-up allows two amplifiers to be compared with different speaker impedances and many different musical sources which is important if the test is to reflect the real world.

A second Null Test configuration is also used to evaluate the transfer function of a single amplifier. The input and output of the design are nulled against each other to "compare and contrast" the linearity of the signals, and thus the transfer function of the amplifier. This is a more controversial test, since time delay between the input and output signals may be present. Nonetheless, it can provide valuable test data.

The tests we've just described are not unique, secret or patented. What keeps them from being just an amusing curiosity, is the ability to use the Null Test results to modify transfer function.

Fig. 20
Block diagram of Carver null test. If the monitor loudspeaker remains silent on all program material, then A – B = 0 and thus A = B



First, an amplifier with an excellent transfer function is selected as the "model" to which another amplifier is to be compared.

The Null Test Reference Standard.

Currently, that reference amplifier is the Carver Silver Seven Vacuum Tube Monoblock. To quote The Audio Critic magazine, *"Imagine you are canvasing the farest-out fringes of the high-end audio cult and asking the freakish, tweakiest and richest equipment fetishists what they would consider to be the absolute ultimate power amplifier regardless of cost or practicality. Almost certainly they would ask for a vacuum-tube design...but much more powerful than any currently available, maybe 500 watts per side, monophonic of course, made with a whole forest of 6550's (the most expensive output tubes), bigger transformers than the world has ever seen, various cultishist brand polypropylene capacitors, Van den Hul silver cables throughout.....*

"We were completely flabbergasted...when we found out about the Carver Silver Seven, which is exactly the power amplifier hypothesized above, but very much a reality — and priced at seventeen and a half kilobucks the pair!"

The next step is to select an amplifier which will be "t-modified" to closely replicate the reference amplifiers' transfer function. Note that we say "closely replicate". At least a 40dB null between the amplifier designs is desired, which means that the two designs would differ only 1 part in 100, or to consider it the other way around, 99% the same. This is excellent considering that the average mid-fi amplifier only has about 30dB of null between the outputs of its own two channels!

The silk purse and the sow's ear.

Assuming we can indeed replicate transfer functions, it would be easy to get the impression that just about any amplifier could be t-mod-ed into any other. This obviously isn't so. We are not suggesting — nor have ever meant to suggest — that some ultra-cheap, badly-designed, poorly-made solid state design can be made to sound like the Silver Seven, or any other good amplifier for that matter. Transfer function replication must begin with a very robust power amplifier, one which in many ways MUST be as good or better than those of the reference design! At the very minimum, the following fundamental parameters must be equal to or actually exceed those of the reference amplifier:

Noise Floor
Input/Output Impedance
All forms of Distortion
Voltage Output
Current Output

When these conditions are met — and ONLY if these conditions are met through good basic amplifier design, can both models be hooked up to the Null Test configuration.

The really hard part.

While the actual t-modification process relies on every conceivable electronic test instrument, the key is having electronic engineering skill, excellent hearing and a stubborn approach to problem solving. As we noted before, it takes far more than a graphic equalizer to change the kind of frequency response curve which output impedance represents!

Rather, it entails hundred of hours of tedious cycles of meticulous and precise measurement, modification, verification, remodification, etc., repeated hundreds of times. To quote one writer, *"The difficult part is not the precise definition and quantification of the difference between two amplifiers, but what to do next to cut down and finally eliminate those differences. Bob knows how to nudge a circuit a step closer to the desired measurement. It requires experience and patience."*

Global and local tests.

There are hundreds of possible tests which can be performed on an amplifier. Some measure a facet of overall output, others measure individual stages within the design, and still others concentrate on a single component such as a resistor or transistor. Clearly making all possible measurements would not only be unrealistically time consuming, but would lead to a huge body of data which could not be intelligently correlated.

Through years of experimentation, Carver has developed a series of inter-related tests which can lead him to specific facets of amplifier performance that affect transfer function.

This system is essentially a logic tree of nested tests up to ten layers deep, all relating to the basic Null transfer function test. Global tests serve as benchmarks and pointers to still more measurements. These local tests in turn become the global test for another series of local tests (Figure 21 below).

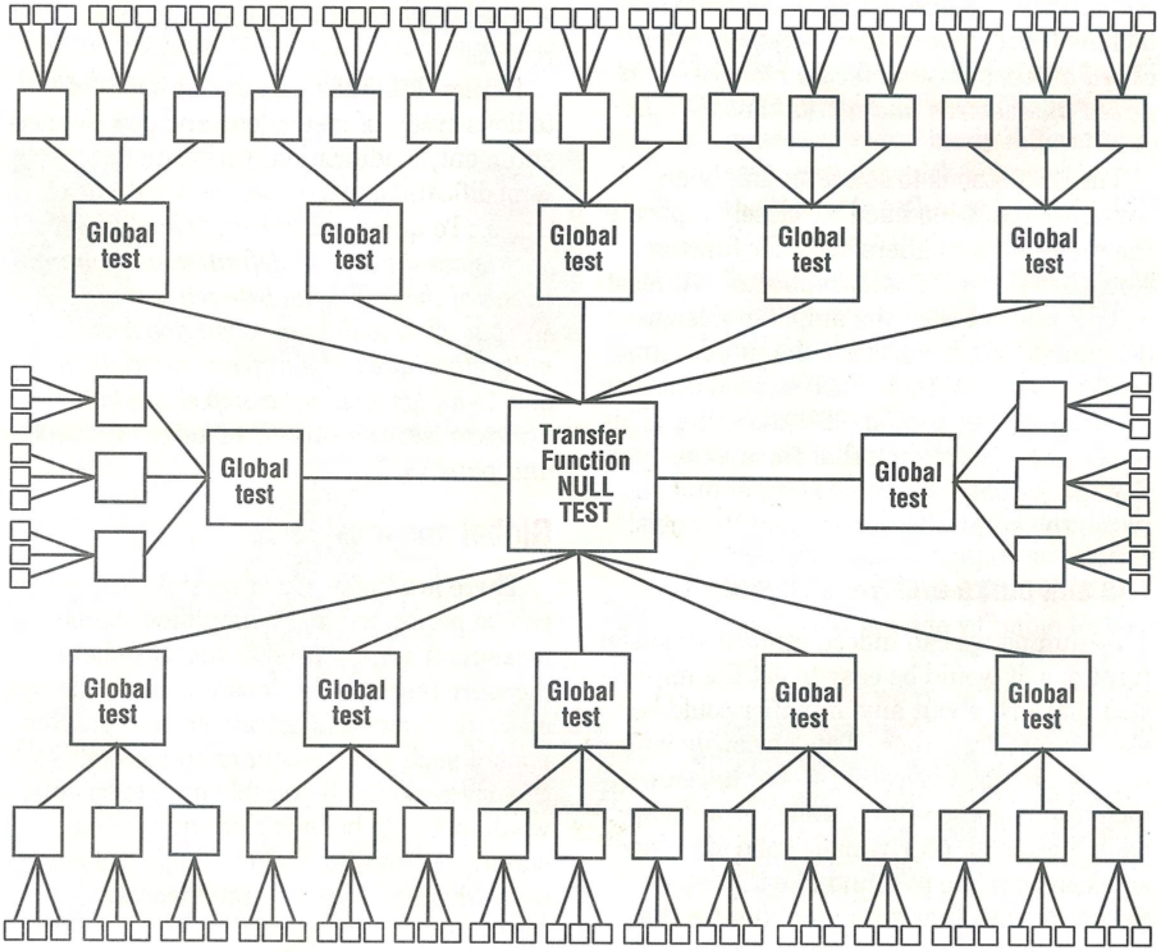
This multi-layer inquest (with an almost infinite number of branches) continues until we have identified all those parameters which contribute to the amplifier's transfer function have been identified, and changed them to achieve the target null with the reference amplifier. In every case, changes made at global and local stages are referenced to the main Null test, time and time again.

The process at work.

Another perspective was published several years ago in Stereophile Magazine, an audiophile publication which invited Bob Carver to visit them and perform a t-modification on a Carver design using a reference amplifier of the magazine's choice. The editor, J. Gordon Holt wrote, *"I had assumed that Bob would simply listen at length to our reference amplifier, make a measurement or two and then try various means to duplicate what he had heard and measured. His approach turned out to be much less scattershot than that.*

"The hotel room was a shambles! Across one end was a long table buried in oscilloscopes, distortion analyzers, voltmeters, white noise generator, a half-dozen partially-drained Diet Coke cans and perhaps 50 feet of audio cables, test leads and clip-lead interconnects. The adjacent sofa and table were covered with countless little bags of capacitors

Fig. 21
How many small tests comprise a larger one.



and resistors, several schematic diagrams and sheets of paper crammed with arcane numbers and calculations".

What transfer function means to you.

Carver's TRANSFER FUNCTION CALIBRATED power amplifier designs have been t-modified to create F_t response curves which emulate the characteristics of tube amplifiers. In the case of the TFM-42, TFM-45 and Silver Seven-t, the Silver Seven Vacuum Tube Monoblock design was used as a benchmark. In the case of the TFM-22, TFM-25 and TFM-15, F_t information from Null Tests was used to create a unique sonic signature with tube-like rich, rolling bass and soft yet detailed treble.

The fact that sound quality of this caliber can be obtained in extremely affordable designs is due to their ability to provide simultaneous high current and high voltage without resorting to excessive massive and expensive power supplies. Thus, with a highly capable amplifier base from which to expand, Bob Carver's painstaking final Transfer Function Calibration simply makes an excellent amp into a great one.

Selected Reviews

SENSIBLE SOUND MAGAZINE CARVER TFM-45

Considering that this solid-state power amplifier from Carver is rated at 375 watts per channel and weighs in at a trim 23 pounds, it should arouse the interest of audiophiles based on just those specifications alone. With the added mystique of Carver's claim that the amplifier is designed to duplicate the transfer function, and thus the sound of the 8-ohm tap of Carver's no-holds-barred Silver Seven tube amplifier, the TFM-45 becomes even more intriguing. Face it - if you can buy 375 watts per channel in a package that runs cool and weighs only 23 pounds for only $949, and if it sounds decent, not driving you out of the room or blowing up your speakers, you are going to be pretty happy. The idea that this amp could be the sonic clone of perhaps the world's most exotic tube amplifier is intellectually interesting, makes for great marketing copy - but has very little to do with the real value of the amplifier itself, so let us take a look at the design of the TFM-45.

The main reason that the Carver is able to offer so much power in a compact, relatively inexpensive amplifier is the magnetic field power supply. A look under the cover of the TFM-45 reveals that the "magnetic field coil" in this amplifier is actually a pretty healthy hunk of iron, but still relatively modest in mass when compared to the transformers one finds in even much less powerful power amplifiers. Carver ads imply that the amplifier does not store any energy, but there do seem to be some power supply capacitors in the unit - a couple of fairly large ones, in fact, take up a noticeable part of the interior space. In any event, the power supply seems to work quite well, as the amplifier packs plenty of wallop and is capable of controlling the bottom end of large loudspeakers.

The owner's manual warns that the amplifier should not be turned on unless all input and output connections have been made, and advises against disconnecting anything until a minute after the amplifier has been switched off. This seems reasonable - if a bit ominous. The amplifier runs relatively cool, despite the small internally-mounted heat sinks, and except for a bit of buzzing when first turned on, it runs quiet.

The speaker outputs will accept bananas, but not spade lugs: they are somewhere between five-way binding posts and some of the Japanese output connectors, and except for those audiophiles who insist on using speaker cables resembling garden hose, these output connectors should serve quite well.

The front panel has an on-off switch and an LED power display.The power display cannot be defeated, but only starts dancing when the music gets really loud. When I first put the TFM-45 in my system, driving the JSE2s, I thought the LED display must not be working. Only the bottom two LED's, which are pilot lights for the two channels, ever illuminated, even though I kept cranking the music up to levels louder than I really wanted to hear. It was not until I got really carried away that one of the power indicator LED's began to flicker occasionally, and I began to realize that the problem was the efficiency of the speakers, not the LED display itself.

Now that I am more familiar with the amp, I occasionally light two or three power LED's when listening to the JSE's, and three or four with the Carver Amazings - but in general, the LED's are not a distraction because they are usually nothing more than pilot lights. Unfortunately, Carver has chosen a lettering scheme for this amp that is something along the lines of silver on pewter - it is almost impossible to read the power levels unless your eyeballs are three inches away from the faceplate at the proper angle on a sunny afternoon when you have your drapes open. No, I don't want to see Carver change the lettering to the old G.A.S. style, but a bit more contrast would be appreciated, at least by these tired old eyeballs.

OK, OK - how does the darned thing sound?? Glad somebody finally asked me that obvious question...In discussing the sonic performance of the TFM-45, I would rather ignore the controversy surrounding Carver's past record of trying to make his amplifiers sound like more powerful clones of other designs. This time, at least, Carver is copying himself. If making a $17,500 pair of ultra-exotic mono tube amps is what Carver wants to do in order to establish a sonic target for his $949 solid-state stereo consumer-oriented amplifier, then more power to him. I am not really all that interested in how the Silver Sevens sound, I would not want a pair of the things in my home (if my insurance agent got wind of it, my homeowner's insurance would probably skyrocket, given that the amplifiers would nearly double the value of my house!), but I was certainly curious about the sound of the TFM-45.

To be quite honest, I had no idea what to expect when I hooked this amplifier in to my reference system and connected it to my trusty old JSE 2s. How could an amp that cost so few dollars for so many watts actually sound any good? Didn't some corners have to be cut?

Well, maybe some corners were cut - but the amplifier surely didn't sound like it. It sounded good - really good, in fact. My first reaction, skeptic that I am, was that the amplifier must be colored, and that I was reacting favorably to something that would prove tiring over the long haul. Four months later, however, the TFM-45 still sounds really good; moreover not only is it on an overall basis the best-sounding amplifier I have ever auditioned in my own system, it is more powerful and less expensive than its chief sonic challengers.

The main thing that really seems to impress those who have auditioned the amplifier here is that the TFM-45 seems to serve the music so well in terms of dynamics, transparency, and imaging. The system just seems to come alive when the TFM-45 is inserted into it. The ease with which the Carver reproduces complex orchestral passages, even on inefficient speakers (yes, the JSE 2s are rather efficient -but not so the Apogee Calipers or Carver Amazings), is truly impressive. But this dynamic ability does not come at the expense of delicacy and subtle shading. The Carver sounds clean and detailed without sounding etched or electronic, and the music somehow just comes across as more real with the Carver amplifier in the system. For lovers of big orchestral music - Bruckner, Mahler, Wagner, Berlioz, Shostakovitch, John Adams, etc. - the muscular yet delicate sound of the TFM-45 offers a way to get power without hardness or glare, even with inefficient speakers.

Describing the sonic spectrum from bottom to top, I would opine that the TFM-45 has a powerful bottom end, perhaps a shade on the warm side, but always in control. It did a fine job of driving the bottom end of both the JSE 2s and the Amazing Silver Editions, two speaker systems with impressive but different-sounding bass capability. (I promised to avoid Silver Seven comparisons, but I cannot restrain myself from pointing out that this is not the kind of bass I would associate with tube amplifiers, but looking at pictures of the output transformers on the Silver Seven leads me to believe that the Silver Seven probably does not offer "tube bass" either).

In the midrange, the Carver is remarkably detailed and open, but without the feeling that midrange detail is actually being provided courtesy of an overly-sharp presentation of treble information. If anything, the top end of this amplifier is on the soft and forgiving side, but it does not sound rolled off or veiled. In fact, the midrange and treble produced by the TFM-45 is remarkably transparent and detailed. In comparison to the AVA Transcendence 280, for example, the Carver sounds slightly soft on the top end -or does the Transcendence sound slightly etched and electronic? Choosing between the two may be at bottom a question of taste, but the more I listen to the two amplifiers - both very fine products - the more satisfied I am with the sound of the Carver, although I sometimes have the sneaking suspicion that the AVA may be a touch more accurate in terms of objective measurements.

This sweetness and clarity in the midrange and treble regions is the sonic attribute of the TFM-45 that reminds me of tubes. My experience with tube power amplifiers is limited, but my experience with tube preamps tells me that this kind treble performance is on the tubish side. Realize, however, that the effects that I am trying to describe are subtle. Indeed, what is so impressive about the TFM-45 is that there is really nothing about its tonal balance or overall sonic character that calls attention to itself, not even the treble performance.

What does call attention to itself, as I mentioned above, is the music, which is presented with a feeling of authority and rightness that makes you quickly forget about the power amp and get caught up in the melody instead. This is one of those audio products where the musical whole is greater than the sum of the sonic parts.

I have listened to some very good power amplifiers over the last year or so, and have recommended many of them in these pages. All of these amps offer good sound and good value, but when push comes to shove, I prefer the sound of the Carver to any of them, at least on an overall basis. When I consider that the Carver offers more power than any of these amps, and is cheaper than most of them, I have to conclude that the Carver is potentially one of the better values in audio.

One member of my listening panel, a person who listens to just about everything that I do, recently spent some time with his Acoustat TNT-200, the AVA Transcendence 280, and the TFM-45. He found the AVA amp to be preferable to the Acoustat, but the price of the AVA kept his enthusiasm in check. After a weekend with the Carver, he visited a local dealer to trade in his TNT-200 on a new TFM-45 to drive his Apogees. More than a month later, he still thinks he got a superb deal.

Do I hear someone objecting that he or she does not need 375 watts per channel (switchable to 1000 watts in mono, by the way), and is therefore not interested? Don't worry about the 375 watts -remember, this amp weighs 23 pounds and runs cool. A 100-watt amp that sounded this good for $799 would be considered quite a bargain, so you can look at the extra 275 watts per side as a little extra bonus. —KWN

FANFARE MAGAZINE SILVER SEVEN-t Recommended Audio: Bob Carver's Lightweight Brutes

To judge from the evidence, upon which I gaze contentedly, Bob Carver likes to keep busy. I bring the reader news of a second solid state mimic of the $17,500 Silver Seven, a tubed, four-chassis assault on liquidity standing in relation to home electronics about where Faberge' stood among Easter eggs. The initial mimic goes by the relatively prosaic handle of TFM-45. Carver calls this one the Silver Seven-t, "t" for transfer function-in other words, the cloning technique. The Silver Seven-t operates in mono pairs, and strikes me as one of the best-looking audio components on the scene: a one-&- three-quarter-inch-slab, 14" deep by 11" wide, supports across its rear a 4-1/2"-tall oblong box, and in front of that, a smaller enclosure whose sloping face frames a (happily unlighted) VU meter. The electrical assemblage beneath the sculpture is tidily put together and cleverly arranged. Each lustrous, slate-grey SS-t sits on its faux- slate pallet. Actually, the monoblock is intended to resemble the Silver Seven's power supply-that's the part without the tubes. The SS-t costs $2000 the pair, and is available singly.

Anyone living within a mile of a fellow being is unlikely ever to call upon the monoblock's full-tilt potential: 575 watts RMS into eight ohms, 1000 into two, conservatively rated, with headroom yet! I've driven neighbors into the streets (and one, once, into convulsions) without having come anywhere near the TFM-45's lesser limits. What the SS-t does provide that the TFM-45 cannot is current sufficient to drive one-ohm loads at high levels. Carver obviously wants the SS-t to compete with the fabled gear audiophiles buy, or dream of doing, to deal with difficult tasks. As a high-end rule of thumb, high-current amps share two features-a big price and avoirdupois. A pair of $16,000 Krells, for instance, weighs 250 pounds. By virtue of Carver's proprietary power supply, a pair of SS-t's weighs together thirty-two pounds-something, I shouldn't wonder, of a prima facie bummer for a clientele accustomed to seeing its amplification delivered by forklift. Should the high-end fantasy mills charge the Silver Seven-t with hubris and throw away the key, as I've little doubt they will (God only knows what they'll think they're hearing), Carver would do well to initiate listening tests wherein his critics are encouraged to specify the hardware against which they'd like to hear the monoblocks compared, along with whatever else they fancy. So long as the procedure's carried out in an objective fashion, I'll make book now on the outcome. (At the time of this writing, one fantasy mill has already conferred upon the Silver Seven classic status, placing it among the Small Handful of Greats).

As to one's own fantasies: removing the TFM-45 for the Silver Seven-t's, and playing these with the Carver CT-Seven Sonic Hologram tuner-preamp, Yamaha 111OU CD player, Signet PCOCC cables and speaker wires, and two pairs of back-to-back Allison IC 20s, I heard a palpably tighter low end, and what seemed an expanded dynamic and better- focused, better-etched image-fulfillment, in short. However, with speakers that require little in the way of acrobatics of the amps that drive them, both the TFM-45 and SS-t ought to have sounded alike: the (in)famous "t." I conveyed my incomprehension to the perp, who explained patiently, in the manner of one long accustomed to dealing with creative listeners, that apart from a ten percent difference in output impedance, which would exert the slightest of audible effects (if any) on low-end response, the circuits of the TFM-45 and SS-t are essentially the same, and that little scientific justification exists for those differences I thought I heard. He also urged me to enjoy myself.

And so I shall. I could easily reinstall the TFM-45 and compare it directly to the SS-t's, but I'm not going to. For deep down in my bones, clinging there to the tip of the coccyx, I've a need to play the subjectivist. I want to have some goddamn fun! Additionally, I've the quite unscientific urge to let sleeping dogs lie. The system has never sounded better.

STEREOPLAY (Germany) SILVER SEVEN

The most beautiful audiophile components still warm the souls of their devoted congregations of listeners with the glowing power of suggestion conveyed by shining tubes. The decades-old victorious march of the semiconductor has made no change in that.

Bob Carver, from the State of Washington in the U.S. knows that too: The man does, after all, belong among the most influential personalities of the American High-End Scene since 1973. But when, a year ago, he attempted a major tube project for the first time, he had other things in mind than pastoral concerns: Simply the best final stage in the world was going to be created in his laboratory.

Just the same, it won't bother Mr. Carver particularly that the very appearance of his now completed opus by the name of Silver Seven takes the breath away - and not only that of disciples of the sublime study of acoustics: As in a movie backdrop to Fritz Lang's classic science-fiction epic "Metropolis", four collossi embodying the technical charm of the age of steam engines are spread out, solid black cyclops from another hi-fi world. Two of them carry, as if lined up for roll call in files of five, veritable columns of big-bellied glass flasks with silver heads on their upper deck. The two other blocks stare straight ahead through antique round dial instruments, as if they were port holes. The entire ensemble rests in stoic gravity upon a polished base of shining black granite.

The fact that this picturesque machinery is to serve no other calling than that of base amplification of electrical vibrations, irritates absorbed viewers usually more than the casually mentioned DM 60,000 price of the Carver Electronic Quartet. And yet, all details indicate this sober functional purpose. Through separate channels these port-hole equipped blocks deliver the supply voltages and currents via electric umbilical cords with nine arteries to their two monoblock partners, including the perilous 660 volt high plate voltage for the power tubes. Massive transformer superstructures, squeezed between stable cast covers, handle that. The built-in ammeters monitor the complete energy transfer: They provide information about the condition of the output tubes and about the correct quiescent current when the music pauses.

The decorative glass flasks atop the amplifier decks enter the game only at the next to the last stage. The electrical upbeat is supplied in each monoblock by an unpretentious little tube with the type designation of 12BY7. This first stage of electronics amplifies the still weak signals from the preamplifier in one stroke to quite respectable amounts of several volts. The input triode's filament supply is provided with DC voltage, especially to guarantee that this first amplification will occur without disturbing hum noises.

Thus amplified, the musical vibrations are then taken care of by three handy tubes, the parallel connected driver pentodes 12BH7. They raise the voltages some more and, simultaneously, supply the suitable and quite substantial currents for driving the power stage. In addition, the glass trio is responsible for a trick called phase reflection: Two oscillations with exactly opposite directions are generated at the output of the driver stage. When one of them reaches its peak voltage, for instance, the other will pass through its nadir.

Each of these signals of opposite phase controls a group of seven fat power pentodes of type 6550A - while the 15th of the type on the amplifier deck stabilizes the screen-grid voltage of its colleagues. The two factions of these shining tough guys work according to the push-pull principle, back-to-back: If one amplifies positive oscillations the other will do the exact opposite. Together they put the squeeze on the primary windings of the huge output transformer: When one group of seven pushes electron thrusts into the winding the opposite team pulls by the same amount from the other end and vice versa.

Among the extras of the Carver powerhouses are expensive ingredients, such as the Wondercap capacitors prized highly by insiders for their acoustic quality and pure silver wiring. On special order, Carver will deliver his Silver Seven with the classic models among power pentodes, the widely praised KT88B from House Goldlion. He does, however, expect better reliability from the standard equipment. Carver offers a five year guarantee for the set of 6550-A tubes.

The powerblocks with standard tube equipment commanded respect in Stereoplay's test laboratories: For 8-ohm loads, each of them provided a smooth 480 W; 4-ohm loudspeakers can count on 400 W and for 2-ohm enclosures there are still 270 W - but only from the 4-ohm tap of the output transformer. The 1-ohm winding is of use only with those exotic loudspeakers whose impedance comes pretty close to a short circuit. But even such transducers don't bring the Silver Seven to its knees by any means and the monoblocks do not capitulate even in the face of complex loads.

The duo also exceeded specifications familiar from tube amplifiers with its short rise time of 3.5 microseconds and its top cutoff frequency of 110 kHz. Harmonic distortion values, however, proved that even a Carver is no magician. But it is true that the illegitimate harmonics identified in the laboratory are so well distributed over the spectrum that the testers did not expect any acoustic disadvantages of them as they brought the full force of the quadripartite output stage to bear in the auditorium.

There, the highly sensitive tape recording giants Apogee Diva were ready to show up each shortcoming of the black beauties were it ever so small and also ready as sparring partners were the new M6 Pioneer monoblocks, undoubtedly "among the finest output stages in the world tested by Stereoplay" (see issue 7/1989). But the Carver constructions yielded nothing to the Stereoplay world champions - absolutely nothing.

Where the testers had three months previously attributed the most intensive interest in even the most subtle musical petitesse to the Japanese transistor fireballs, they now had to acknowledge with admiration that the American tube battleships sketched musical filigrees into the air with less gravity and even more delicate and precise. For instance, the tube monsters let the with virtuosity -calculated stroke noises of a violin bow float through the auditorium with a lightness as if they were trying to create an ironic contrast to their own rooted corpulence - the Pioneers had to pass on that one.

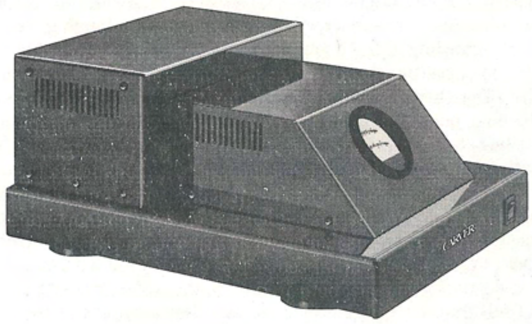
The transistor representatives did win some ground, however, when luxuriant orchestral work demanded sovereign fullness of tone: then the cellos hummed with seemingly fuller bodies, trombones and horns made their coiled air columns vibrate stronger by a nuance and low-pitched woodwinds developed their warmth a trifle more convincingly.

Still, the Carver blocks differentiated between the innumerable tone quality shades of orchestral exploits always a bit better than their protagonists from the semiconductor guild and they even outdid them in disciplines that are properly in the domain of transistor amplifiers. Instead of wrapping the anguished noises of wearily touched piano strings, of bonehard beaten bass drums or thumb-whipped electrobass retinues, into the proverbial charm of tubes and releasing them as a plush version into the auditorium, no attack was too hard for the Carver blocks and no pulse too steep. They copied violent chords and impetuous bass orgies with the highest fidelity and precision that this author has ever heard from a tube output stage.

The Carver blocks thus combined refined elegance, so characteristic of tubes and temperamental freshness with the stability and discipline of first class transistor amplifiers. Can one expect more from one of the greatest final output stages on this planet?

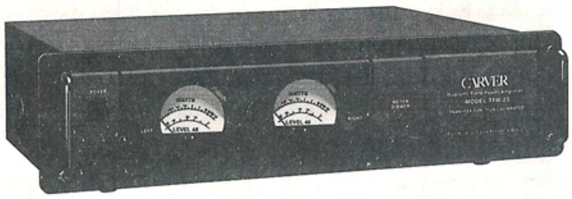
—Wolfgang Tunze

Carver Power Amplifiers, Fall 1990



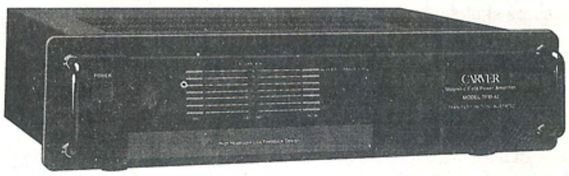
Silver Seven-t Mark II

Simultaneous High Current/High Voltage Monoblock Reference Magnetic Field Power Amplifier sets standards for sonic quality and robust output at any impedance • Silver Seven Transfer Function Modified • 555 watts into 8 ohms, 20-20kHz with no more than 0.5% THD • 900 watts into 4 ohms, 20-20kHz with no more than 0.5% THD • 1000 watts into 2 ohms, 20-20kHz with no more than 0.5% THD • Lighted analog power meter • Shock-isolation mounting • Black finish • 2 required for stereo • Capable of high output into very low impedance loads for sustained periods.



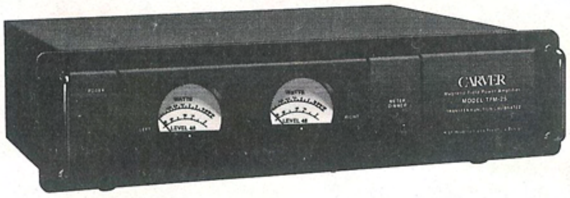
TFM-45 Simultaneous High Current/ High Voltage Magnetic Field Power Amplifier

One of our two most powerful stereo amplifier designs, the TFM-45 can bring any speaker system under tight, authoritative control, yet with a warmth that rivals tube designs • Silver Seven Transfer Function Modified • 375 watts RMS/channel into 8 ohms, 20-20kHz with no more than 0.5% THD • 500 watts RMS/channel into 4 ohms, 20-20kHz with no more than 0.5% THD • analog power meters



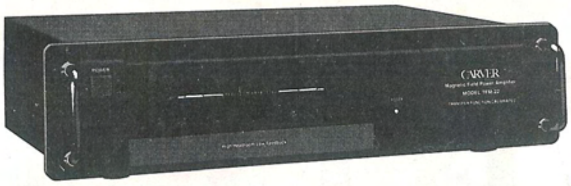
TFM-42 Simultaneous High Current/ High Voltage Magnetic Field Power Amplifier.

Electronically identical to the TFM-45 but with "ladder" LED power display • Silver Seven Transfer Function Modified • 375 watts RMS/channel into 8 ohms, 20-20kHz with no more than 0.5% THD • 500 watts RMS/channel into 4 ohms, 20-20kHz with no more than 0.5% THD



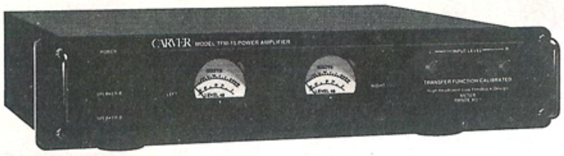
TFM-25 Simultaneous High Current/ High Voltage Magnetic Field Power Amplifier

—is designed to drive many popular speaker designs whose overall impedance fluctuations can tax conventional amp designs • Transfer Function Modified • 225 watts RMS/channel into 8 ohms, 20-20kHz with no more than 0.5% THD • 350 watts RMS/channel into 4 ohms, 20-20kHz with no more than 0.5% THD • LED power overload/clipping indicators



TFM-22 Simultaneous High Current/ High Voltage Magnetic Field Power Amplifier

—is electronically identical to the TFM-25 except with clipping overload meters • Transfer Function Modified • 225 watts RMS/channel into 8 ohms, 20-20kHz with no more than 0.5% THD • 350 watts RMS/channel into 4 ohms, 20-20kHz with no more than 0.5% THD • LED power overload/clipping indicators



TFM-15 High Headroom/Low Feedback Stereo Power Amplifier

100 watts RMS/channel into 8 ohms, 20-20kHz with no more than 0.1% THD, 140 watts RMS/channel into 4 ohms, 20-20kHz with no more than 0.1% THD, 200 watts dynamic power into 2 ohms • Dual analog meters with level selection • A/B speaker switching • L/R input level controls

AV-Sixty Four 3/4-Channel Special Applications Magnetic Field Power Amplifier

—is designed for surround sound, multi-room and satellite/subwoofer use • Built-in 2-way 18dB/octave electronic crossover w/75Hz turnover point • 60 watts, 4 channels driven into 8 ohms, 20-20kHz with no more than 0.5% • 100 W x 4 into 4 ohms, 20-20kHz with no more than 0.5% • 3-ch. operation: 180 W ch. 1/2 bridged, 60W x 2 ch. 3 & 4 output • Rear panel trim/balance controls

Call 1-800-443-CAVR for more information and/or the Carver dealer nearest you.