PILLARS OF PERFORMANCE – Why KICKER Electronics Are the Best You Can Own

At Stillwater Designs, we spend a huge amount of time testing and developing products that are designed to not only outperform our specifications, but also to work reliably for many years after the warranty has passed. For this reason, we overbuild our products making sure they can stand long-term use and abuse, as well as operate safely inside the harsh environment that comes with being installed in a moving vehicle in the field. To accomplish that, we created a set of criteria that have become the "Pillars-Of-Performance", insuring that we meet the performance and reliability standards consumers have come to expect from our KICKER products. The Pillars are as follows:

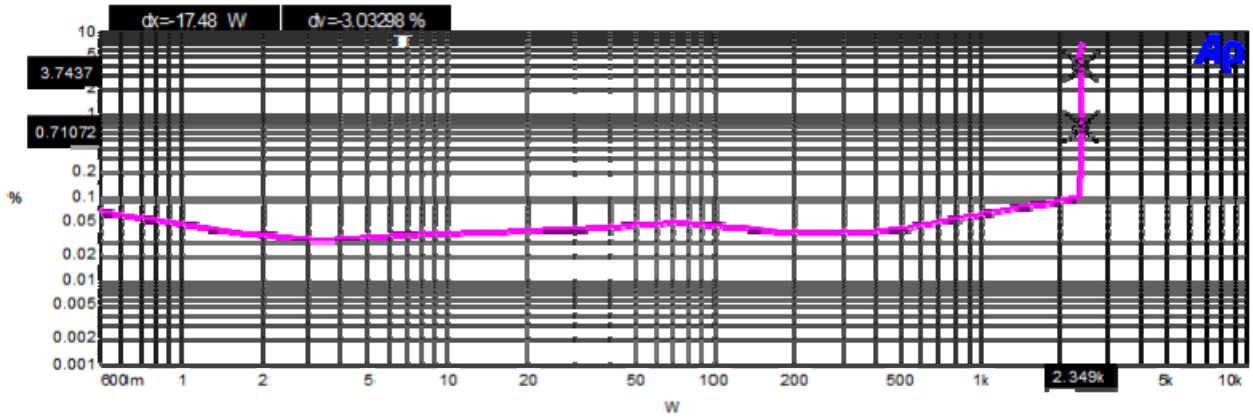
- Power (RMS and Dynamic)
- Signal-to-noise (SNR) and Total Harmonic Distortion (THD)
- Noise Rejection from external sources (CMRR)
- Reliability (TTT, PSS, CDOCP, OVP, UVP)
    - Time to thermal
    - Power Supply Short-Circuit Protection
    - Class D Over-Current Protection
    - Over-Voltage Protection
    - Under-Voltage Protection

In addition to the basic requirements of our products being as sonically accurate as possible, the four pillars above are at the core of what we believe is necessary for an amplifier to carry the KICKER name.

We are often approached with the question about what the main differences are between KICKER amplifiers and what is commonly being referred as the "Brazilian designs". To shine a light on this matter, we wanted to lay out how we test amplifiers: why we do it the way we do, and the differences between a KICKER amp and the "other guys".

**Pillar Number 1 - Power**

In our state-of-the-art test labs located in Stillwater, Okla., we use industry-standard Audio Precision® audio analyzers to validate our designs. With these, we run roughly 20 different tests designed to make sure that the amp both sounds great, and makes the power specified. For the power tests to be accurate, we use fixed resistive loads attached to the amplifier, as it remains constant no matter what frequency is being played into it (unlike reactive loads such as speakers, that react differently at different frequencies). Once we connect the amplifier to the fixed load(s), we then perform a "Power vs. THD" sweep. This test shows how distortion levels can vary across the complete power range of the amplifier. The resulting graph will look something like the image below. When the plotted graph from the amplifier crosses the 1% THD mark for the first time, that is what the industry calls "RMS Power" or "Rated Power".




| Sweep | Trace | Color | Line Style | Thick | Data | Axis | Comment | Cursor1 | Cursor2 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | Magenta | Solid | 4 | Anlr.THD+N Ratio | Left | | *0.71072 % | *3.74370 % |

THD vs Power50Hzat2

In the graph above, you can see that this amplifier has very good THD, as it is significantly below the 1% limit all the way up to its RMS/Rated output power. This is important to note, because the average customer does not run at full output all the time when listening to their music. Low THD across the power bandwidth guarantees great sound quality at most power levels. Such graph is very typical of a KICKER amplifier, and you can see that the THD is normally below 0.1% up until it approaches clipping. This "Power vs. THD" sweep usually takes about 60 seconds to complete, and is where we have seen many of the "other guy's" amplifiers fail before reaching full output.

**The next power test is also a reliability test (Full Power Test)**

The **Full Power test** is designed to make sure that the amplifier is robust enough to survive in the real world, even if it is being driven into clipping constantly. This test is set up in a similar way to the "Power vs. THD" sweep, where the amplifier is hooked up to a fixed resistive load at its lowest rated impedance. Instead of "ramping up" the signal, we regulate the output of the Audio Precision analyzer to a point where the amplifier is pushed all the way into full clipping. Once regulated, we watch the temperature of all the components in the amplifier, ensuring nothing exceeds temperatures higher than they are rated for and that nothing fails.

This test is extremely difficult on an amplifier, as it will typically draw about 60% more current when compared to a "real world" setup with reactive speaker loads and playing music. This is an important test for all amplifiers, but even more so for subwoofer amps in particular, as the subwoofer's impedance will not always be above its nominal impedance during operation. What this means is that, on certain bass notes, your amp will actually detect the lowest possible impedance a speaker can be, whereas a full-range amplifier will essentially never see this. To pass this test, the amplifier must be able to play a sinewave at full power for a minimum of 60 seconds, without failure.

Most KICKER amplifiers will perform like this for much longer, all the way until their heatsink becomes saturated and reaching temperatures high enough to enter thermal protection. At this point, the amplifier will safely shut off to cool down roughly 10 degrees Celsius, before turning back on automatically. This test is usually where we see the "other

guy's" amplifiers catastrophically fail, that is, if they have passed the "THD vs. Power" sweep test in the first place.

**The final power test is the AMP DYNO test (Dynamic Power):**

As the SMD amplifier dyno (AD-1) has become increasingly popular with online video creators, we have also begun to run our amps through the Dyno to record the results. This test is very short and not very hard on the amplifiers, so it is rare to see an amplifier fail on this test. We now also incorporate a similar "Dynamic Power" test during our AP testing, with the Audio Precision audio analyzer on all KICKER amplifiers.

**Pillar Number 2 – Signal-to-Noise/Total Harmonic Distortion (SNR/THD):**

When it comes to audible "hiss" noise, our limits are very strict and low noise floor is a must. Provided that the gain potentiometers are set correctly in your system, you should have little-to-no audible hiss at all. This test is extremely important, as it quantifies with precision the noise floor and signal-to-noise ratio of the amplifier.

This test is more relevant for full-range amplifiers than for subwoofer amplifiers, as the noise you hear is typically in a higher frequency—but noise can be heard in both lower and higher frequencies in certain cases, "humming" and "hissing" as we call it. To design an amplifier with great SNR, it takes a combination of many successful challenges, including both a good circuit-board layout, optimal electronic design, and proper component choice—all of which is critical.

The industry standard is to test SNR at 1W of output; this is because when using a 50W full-range amplifier to power your full-range speakers, your average power output with music is somewhere between 1W and 10W, depending on the type of music you are listening to.

We require our subwoofer amplifiers to have a minimum SNR of -70dB at 1W, and our full-range amplifiers -75dB at 1W or better. If you look across the lines of KICKER products, you will see SNR that is much higher on some products, as you go up the "Good -> Better -> Best" path. In a real-world setting, for the average consumer anything better than -70dB at 1W will be more than enough to keep audible hiss out of the system—when the system's gains are set properly.

**NOTE: Be careful when comparing SNR numbers, as some companies will post full power SNR. This number will almost always look good, as it is referenced at a much higher power level (e.g. 100W) and has no real use in telling you whether the amp will be silent when installed in a vehicle or not.**

**Pillar Number 3 - Noise Rejection**

The ability of an amplifier to reject unwanted noise is measured by a test called CMRR (Common-Mode Rejection Ratio). This measurement is how you can tell if the amplifier you are purchasing will be good at rejecting pops, clicks, and engine noise from the electrically noisy environment of a vehicle. To perform well at this test, balanced inputs with high noise immunity are required. There is an industry standard test (IEC) that consists of applying a 10-Ohm imbalance to the amplifier's inputs, injecting a signal, and measuring the results. Because we have seen imbalances in the car-audio environment of up to 1-kOhm, which is much more critical, we run this test twice: once with a 10-Ohm imbalance (standard) and then with a 1-

kOhm imbalance (our higher standard). With this higher imbalance, we require our amplifier to reject up to 40dB of noise, which assures extremely efficient noise rejection / immunity when installed in your vehicle, regardless of the audio source.

**Pillar number 4 - Reliability Testing**

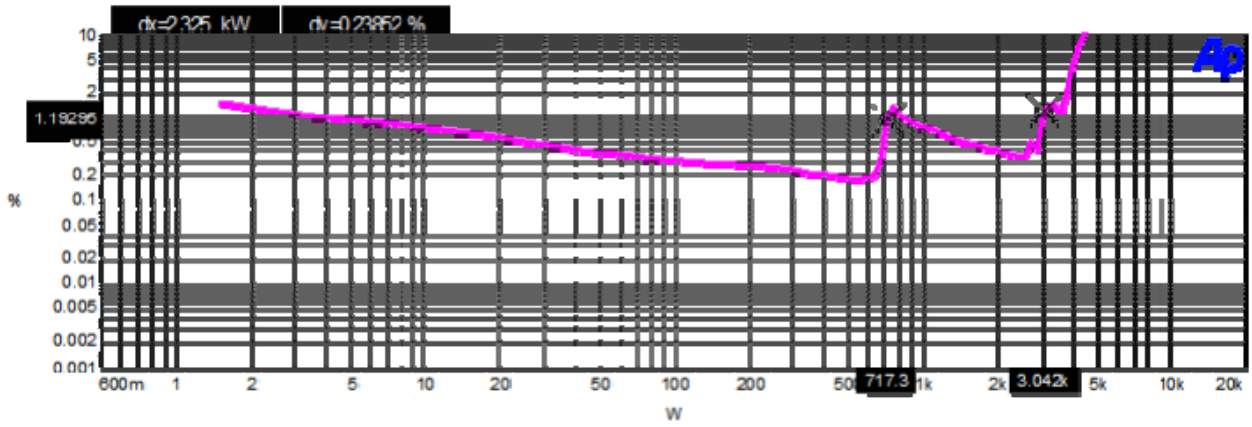
These tests, as you would expect, are designed to make sure that the amplifier will survive years upon years of hard use in the field. Our process is as follows:

1. We start with initial checks, which looks at all the critical internal components of the amplifier, and how they perform under load. One of the most important tests is the inspection of voltage spiking on the MOSFETs of both the power supply and the Class-D sections of the amplifier. The reason this is so important is that MOSFETs have a maximum voltage rating (VDS max) that the manufacturer guarantees them to be reliable at. As an amplifier designer, you want to choose the best MOSFETs you can that will fit within the costing and that meet the design requirements. It is common to see the use of MOSFETs with a max voltage rating that is within 10V or less of the voltage rails, so it is imperative to make sure that any spiking that occurs under load does not exceed the MOSFETs' maximum voltage rating. If it does, it will shorten the lifespan of the amplifier, or if the spiking is high enough, the amplifier can have a catastrophic failure when stressed over time.
2. **Turn-on-and-off times:** These are tested and verified to keep your system from having any unwanted turn on/off clicks and pops. We want to make sure that our amps turn off quickly and turn on after the source unit has been powered up and begins to pass audio.
3. **Short-circuit testing:** We test for shorts both across the speaker leads, and from the speaker leads to ground, ensuring that the amplifier's protection circuits will protect it in case of an installation failure.
4. **Over-voltage testing:** We test it to make sure that the amplifier protects itself if it sees too high of an input voltage, as this can damage internal amplifier parts.
5. **Under-voltage testing:** Because during an under-voltage condition (typically below 9V) some critical control chips may lose the ability to keep correct operation, potentially resulting in shorting of the MOSFETs, all KICKER amplifiers have a Low-Voltage Protection circuit. During this test, we make sure the amplifier will operate correctly down to its lowest rated voltage and safely turn off below this point.
6. **Time-To-Thermal testing:** This test is designed to make sure all KICKER amplifiers will perform well in the field and not overheat, ensuring that the end user gets uninterrupted enjoyment from his system.
7. **Music Testing:** In this test, we run our amplifiers in multiple install configurations to make sure that they perform as intended, without any turn-on-or-off pops with either 12V or DC offset turn-on modes.
8. **Life-Cycle Testing:** In this test, we run our amplifiers in a simulated vehicle environment for a minimum of 24 hours, making sure that they perform well in all vehicle environments and in multiple install options for an extended period.

Having KICKER amplifiers pass all the strict testing procedures described above is what makes them perform so well in the field, and as a result, being some of the most reliable and best-selling products in the industry. For the sake of comparison, let's look at a typical "Brazilian design" amplifier within these same parameters.

**Power:** Commonly called a "Brazilian design", this is a basic amp designed to make as much dynamic power as possible, but not necessarily RMS power. So, what does this mean? RMS power is industry-rated power at 1% of THD and is a steady state power delivery—which means that the amplifier *is required* to make this RMS power constantly, until it hits thermal protection. A "dynamic power only" amplifier design (such as the Brazilian amps) is inherently cheaper, as it is only making rated power for a few seconds at a time, and therefore doesn't need to be as robust as an amplifier that does both *Dynamic* AND *RMS* power.

Typically, Brazilian amplifiers rely on the impedance rise of the speakers, as well as the natural dynamics of music, to lessen a robust design. This allows the designer to use less MOSFETs and internal components, and obviously comes with downsides. The first drawback is, when you make full power, all parts inside the amplifier that handle high amounts of current and power will run at or more than 100% of their safe operating limit. That dramatically lowers the life expectancy of such parts. The second drawback is, by running more power through each MOSFET, all the heat being created is dissipated by fewer of these devices, further reducing their lifespan. We have tested multiple competitive samples of these amplifiers, and the "Power vs. THD" graph below is typical for them:

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|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | Magenta | Solid | 4 | Anlr.THD+N Ratio | Left | | *0.05443 % | *1.10205 % |

THD vs Power 50Hz.at2

As you can see, this amplifier does not have very good THD, as it starts out above the 1% limit and then it crosses this limit again it at 700W, and finally again around 2500W which is what the amplifiers is rated to output. As this sweep normally takes about 60 seconds, we have had many "Brazilian-style" amplifiers fail during this test. For this reason, we have updated the test to be faster by using less data points, in particular when testing these Brazilian designs. This allowed the sweep to take around 20 seconds, which hopefully will keep it from stressing them to a point of failure.

**The Reliability Test**: We have not yet found a Brazilian-designed amplifier that can survive the Full Power Test (60s at full power) without breaking.

**The AMP DYNO test:** Seems like these amps were designed around this test, as almost all of them can perform the quick bursts that the SMD Dyno uses, without failure. They all seem to make pretty decent power for the price in this test, even if they do not meet the advertised rated power.

**Signal-to-Noise:** All the Brazilian-designed amplifiers we have tested have performed very poorly in this test. We have investigated why this happens and have found the following:

1) A lot of them do not have a true input gain knob, but rather, a potentiometer in the signal path acting as a volume control. As a consequence, you will get the best "signal-to-noise" the amp can make with this potentiometer at the minimum setting. If you adjust the "gain" up, the SNR significantly gets worse;
2) Poor PCB layouts for shielding radiated noise;
3) Severe power supply spiking which radiates into the audio path;
4) Low-cost audio components;
5) Simplistic audio input pre-amplifier.

All these things together add up to the amplifiers having a 1W SNR between -35dB to -45dB.

**Noise Rejection:** Every Brazilian-style amplifier we have tested have inexpensive single-ended inputs that do not have any ability to reject external noise.

**Reliability Testing:** With the design limitations of these amplifiers, we have yet to test a Brazilian-style amplifier that successfully completes KICKER testing. This does not necessarily mean they may not work just fine for a consumer in the field, but surely it does mean they are not as robust as we require KICKER amps to be.

**Conclusion:**

These two amplifier-design practices, that being "Dynamic Power" and "RMS Power", have been around since the 1960s—with the Dynamic-style amplifiers losing popularity over the years. Until recently, with the Brazilian amps coming to market, it has once again brought up the debate as to which design practice is better.

There are so many factors to go into designing an amplifier that it can be difficult to say definitively which practice is best. We do believe that it is possible to create an amplifier that makes great dynamic power AND have the reliability of a good RMS power design; but it will always have the drawback of being significantly more expensive than the Brazilian designs.

Overall, to provide the best customer experience, we work to make sure that our amplifiers make good power reliably for many years—even past the warranty period. This means restraining ourselves sometimes from making concessions that would allow for higher dynamic power at a lower cost—unlike many of the Brazilian amplifier designs.

Blue = Suggestion