PS Audio Power Plant Premier

By Gary Galo

Traditional power line “conditioners” and “filters” do exactly what their descriptions imply—they take dirty AC from the power outlet and filter out high-frequency noise and garbage found on every AC power line.

Longtime readers of the predecessor to aX, The Audio Amateur (TAA), may recall three articles I wrote in the early 1990s covering Adcom’s ACE-515 power line filter, plus two generations of Audio Power Industries’ Power Wedge products.1,2,3 In TAA 3/93 I attempted measurements on several of these filters. The Adcom ACE-515 was one of the first widely available power line filters specifically intended for audio use, with a common-mode choke and three capacitors connected hot-to-ground, hot-to-neutral, and neutral-to-ground. Typical of this type of filter, the Adcom has a 22dB resonance peak at 60kHz, followed by a rolloff in the RF region. The -3dB point for the Adcom is 110kHz, the highest frequency I was able to measure.

The ACE-515’s attenuation begins lower in frequency than the “blackbox” power line filters sold by Corcom and others. A Corcom F2411 filter I tested peaked at 90kHz before rolling off, and a Hopkins F85089 was still rising at 110kHz. Despite the peaks below 100kHz, the Adcom and Corcom filters both yielded a notable sonic improvement, with the Adcom offering the best performance. That led me to conclude that the power line must be loaded with noise in the RF region, beyond my measurement capabilities.

Audio Power Industries’ Power Wedge products use a proprietary filter especially designed for audio applications. The Power Wedge 116 includes four high-current outlets connected directly to the output of this filter for power amplifiers, and six transformer-isolated outlets for low-level gear.

Unlike the Adcom, the Power Wedge 116 does not have any high-frequency peaks. The transformer-isolated outlets begin rolloff above 10kHz, with the power amplifier outlets rolling off above 30kHz. The Power Wedge 110, which has only the high-current outlets (no transformers), rolls off exactly like the high current outlets on the 116. Adding the PE-1 Power Enhancer (essentially a shunt filter) to either the 116 or 110 adds another 5-6dB of attenuation above 30kHz.

The Power Wedge products are measurably and audibly superior to the Adcom ACE-515, but I found the sequenced switching provided by the ACE-515 to be an extremely convenient way to turn my entire system on and off. So, I tried cascading my ACE-515s with the Power Wedge 110 and 116. Measurably and audibly, this com-
bination has worked well, with much steeper attenuation above 10kHz. Adding the PE-1 yields another 5-10dB of attenuation. So, for the past 16 years my system has been powered with a combination of Adcom ACE-515s and Power Wedge products. Each of my mono power amplifiers has been powered by an ACE-515 feeding a Power Wedge 110 and PE-1 (two of each—one set per amplifier).

My low-level gear has been powered by another ACE-515 feeding a modified Power Wedge 116. I paralleled the transformer secondaries in the 116 to get three higher-current outlets, rather than six lower-capacity ones as supplied by the factory. I also fed the high-current outlets on the 116 to a pair of Signal Corporation A41-175-230, 175VA, dual-bobbin, 1:1 isolation transformers which have powered my preamp and D/A converter. I have connected three other pieces of low-level equipment—my digital transports and sample rate converter to the three transformer-isolated outlets on the modified 116.

I switch the control cords on the three ACE-515s with a single Furman M-8, so one switch turns the entire system on and off. I use the Furman M-8 strictly as a master switch-box, and it plays no role in the power line filtering. This rather complicated arrangement has yielded excellent performance, and other passive line filters and conditioners I’ve tried failed to offer any significant improvement.

**AC REGENERATION**

The concept behind AC regeneration is simple. Rather than filtering the AC power line, simply make a new one. An AC regenerator consists of a low-distortion oscillator operating at the power line frequency (50 or 60Hz, depending on your country), and a power amplifier to step the oscillator’s output up to 120 or 240V AC.

I designed a low-current regenerator back in the mid-1980s to power my belt-drive turntable, which I’m still using. The turntable power supply has an oscillator based on an XR-2206 function generator chip, which produces a 60Hz sine wave at about 0.4% THD. The oscillator output is amplified and stepped up to 110V AC with an audio amplifier and a toroidal transformer. But, this power supply was designed to operate a low-current synchronous turntable motor, not preamps and power amplifiers.

PS Audio built their first AC regenerator—the P300—in 1998. At 300W, the P300 had relatively modest current capability. The line was expanded to include the P500, P600, P1000, and P1200, each offering progressively greater current capability. The P1200 could deliver 1200W of continuous power, enough to meet the demands of the high-current power amplifiers that had become increasingly popular. The P1200 had two disadvantages: they were large and heavy due to their relatively low efficiency. They generated extremely clean AC, but produced a lot of heat in the process.

The Power Plant Premier is PS Audio’s latest AC regenerator, and represents a breakthrough in efficiency (Photo 1). It’s still no lightweight, but it runs considerably cooler than its predecessors, and can supply 1500W continuous, with peak current delivery of over 50A (6000W). Output distortion is rated at 0.5% at 120V AC, regulated to within ±0.5V.

**IMPROVED EFFICIENCY**

PS Audio President Paul McGowan offered this overview of how the improved efficiency was achieved: “The original Power Plant, which has an efficiency of around 50% (on a good day), had two power amplifiers—one for each half of the sine wave. Each of these power amplifiers ran on very high power supply rails (200V in total for each amp). When you have such high voltage rails, the amplifier’s output signal is moving between the rails—and this means there is a lot of voltage dropped across the output transistors—dropping voltage while delivering power creates heat.

“The new Power Plant Premier has only one power amplifier that handles the entire output voltage of the Power Plant. If we were to try this with the old technology, we’d have to have voltage rails of 400V! This would be even less efficient. PS Audio’s Chief Engineer Bob Stadtherr figured out another way, and received a patent for his work. The new way has a variable power supply that tracks (moves) with the output signal. This means that the output power amplifier actually rides up and down with an exact copy of the AC waveform—thus keeping the voltage across the output power amplifier low—while allowing high output to the equipment.”

My aX colleague Chuck Hansen found Stadtherr’s complete patent online at www.google.com/
patents?vid=USPAT7259705. The patent includes schematic diagrams and a detailed description of its operation. According to the patent, a line synchronization circuit is used to convert the incoming AC into a 5V peak-to-peak square wave, precisely in-phase with the incoming signal. This square wave is then processed with a microprocessor to generate a digital representation of a sine wave which, in turn, is converted into a 2.5V peak-to-peak analog signal with a digital-to-analog converter. The sine wave is generated using DSS (Direct Digital Synthesis) techniques to produce a waveform with 16-bit precision, accurate to ±0.001Hz with harmonic distortion of less than 0.01%.

The analog sine wave from the DAC remains precisely in-phase with the incoming AC. The analog signal is capacitor-coupled to the next stage, a third-order, low-pass filter. The capacitor coupling removes a DC component from the waveform, and the low-pass filter removes the sampling by-products. The resulting low-distortion sine wave is then amplified to the desired output level using a unique topology.

The patent shows two dual-polarity power supplies in the schematic diagrams. ±15V DC rails are used for the post-DAC analog filter and the amplifier output stage (referred to as the “current amplifier”). The voltage amplifier stage is powered by ±30V DC rails.

Stadtherr describes four embodiments of the circuit—the last appears to be the one used in the Power Plant Premier, and is the key to the high efficiency he has achieved. From the patent, this method consists of “superimposing a dual direct current ("DC") supply voltage on a source of alternating current ("AC") power, and synchronizing the dual DC supply voltage with the AC power to produce a range of available tracking power supply voltages sufficient to feed a power amplifier producing a desired output voltage.” That source of AC power is the incoming AC line.

“The output signal can be adjusted (if desired) infinitely to any voltage, since the output waveform... is not simply a multiple of the input power... Also, since the output waveform is not dependent on the input waveform shape, distortion, noise and other anomalies can be eliminated. Further, since the DC voltages are superimposed on the incoming AC signal, the voltages seen by the power devices are much smaller than standard regenerators, thus improving efficiency and thus allowing high power systems to be achieved in a smaller, lighter package than traditional regenerators. Finally, since the active output stage drives the load directly, without the use of transformers, the source impedance is very low. The active output stage can have a source impedance that is actually lower than the original AC power source.”

A couple of things are apparent. Since the incoming AC is used to “modulate” the relatively low-voltage DC supply rails, it’s important that the regenerated AC be in-phase with the incoming AC power line, as noted in the patent. The supply rails for the Power Plant’s power amplifier must reach their peak level at the same moment as the regenerated AC. Otherwise, the Power Plant would be unable to output the required AC line voltage. The second half of the preceding paragraph is key to understanding how the improved efficiency has been achieved, and how the Power Plant Premier can actually deliver higher current than the power outlet it’s connected to for brief periods of time. The peak current capability also depends on Power Plant’s own internal power supply, particularly the power transformer and capacitor bank. PS Audio claims 85% efficiency for the Power Plant Premier, an impressive achievement.

Several other reviews have described the Power Plant Premier as having a Class-D amplifier. This is incorrect. In a Class-D amplifier the output transistors are operated as switches, which is clearly not the case with the Power Plant Premier. In his patent, Stadtherr actually mentions Class-D amplifier operation as an alternative to the method he describes.

CONSTRUCTION AND OPERATION

The Power Plant Premier is an attractive and robust unit, measuring 17” × 16.5” × 4” and weighing 35 pounds. It’s no surprise that it looks like a power amplifier, because it is! The front panel LCD display provides a variety of information. Mode buttons, accessible on the front panel or on the remote control, toggle between input voltage, output voltage, voltage difference, input THD, and output THD. You can dim the display or turn it off altogether with another button on the front panel, or with the remote.

In addition to a low-distortion sine wave, the Power Plant Premier also
includes a MultiWave output, designed for PS Audio by Northrop Grumman scientist Doug Goldberg. MultiWave adds 3rd harmonic to the sine wave, producing a waveform with rounder peaks, which increases the charging time on power supply capacitors. The result is lower supply ripple. The previous generation of Power Plants was supplied with a version of MultiWave called MultiWave II, which produced a frequency-modulated waveform along with the added 3rd harmonic. The Power Plant Premier has the added 3rd harmonic, but not the frequency modulation.

CleanWave is a modulated sine wave used for degaussing the power transformers in connected equipment. When CleanWave is activated, the front panel display counts down for five seconds, at which point the process is complete. CleanWave is not intended for listening. You must use the remote to activate the MultiWave and CleanWave functions.

**ISOLATED OUTPUTS**

The Power Plant Premier has five pairs of isolated, color-coded outlets, which PS Audio calls “IsoZones” (Photo 2). The outlets themselves are PS Audio Power Port types, which they also sell separately for those who wish to upgrade existing wall outlets. As noted, isolation transformers can add distortion of their own, and can also limit the current capability of any power supply. PS Audio has a different approach.

The regenerated AC line to each pair of outlets is fed through one of PS Audio’s Nano-Crystalline filters (Photo 3). These differential-mode filters use very short pieces of heavy gauge wire, wrapped around small high-permeability magnetics to achieve isolation between outlet pairs, preventing noise generated by one piece of equipment from degrading the performance of other connected equipment. This is especially important if you have digital and analog equipment connected to the same source, since all digital devices generate noise.

According to PS Audio, the Nano Crystalline material has approximately ten times the permeability of any other...
magnetic material. The high permeability means that an effective filter can be built with fewer turns of wire. The heavy, low-resistance wire used in these filters ensures that they will not limit the current capability of the Power Plant. PS Audio also uses ¼" thick, solid copper power bars internally, to avoid compromising the Power Plant’s current capability.

Power sequencing is often desirable and sometimes necessary in order to ensure silent system power-up and power-down. Normally, you should power up low-level gear (preamp, digital transport, D/A converter) first, turning on power amplifiers last. When powering down, turn power amps off first, followed by low-level equipment.

Some equipment, such as cable boxes and Tivos®, may require live AC all the time. Three rear-panel switches allow you to program the rear panel outlets for “always on” operation, switched operation, or a three-second power-on delay. Because there are five pairs of isolated outlets, switch A operates IsoZones 1 and 2, switch B operates IsoZones 3 and 4, and switch C operates IsoZone 5 (which is intended for power amplifiers, though it is electrically identical to the others).

The Power Plant Premier also contains no-loss telephone and CATV protection. Two in/out pairs of “F” connectors are included for users who have two television sources, such as cable TV, satellite, or a conventional antenna.

You can turn on the Power Plant Premier three ways—with the front panel power switch, the remote control, or with a DC trigger voltage between +5 and +15V DC. I prefer the trigger method. The rear panel has two 3.5mm phono jacks that you can connect to any equipment that produces the correct trigger voltage. Alternately, you can simply use a low-current 9 or 12V DC wall-wart fitted with a 3.5mm phono plug (tip must be positive!). I use a Radio Shack 9V/300mA adapter, #273-027, plugged into the Furman M-8 mentioned above, but you can also use a switched outlet on your preamp.

PS Audio supplies a 14-AWG IEC power cord with the Power Plant Pre-
mier, but this is only intended to get you started. PS Audio highly recommends upgrading the power cord—they make several that are suitable. I made my own with Wattgate connectors (#110-442 and #110-430 from www.partsexpress.com) and D.H. Labs Power Plus Studio Reference bulk power cable (www.silversonic.com).

Internal photos reveal much of the Power Plant Premier’s physical heft (Photos 4 and 5). The chassis houses a large toroidal power transformer and a pair of substantial heatsinks. Most of the circuitry is contained on the single main PC board. The Power Plant Premier has a plug-in power cartridge tailored to the specific line voltage in the country where it is sold. There are no internal fuses in the Power Plant Premier, just a single circuit breaker built into the power cartridge, accessible on the rear panel.

In addition to generating clean, laboratory-grade AC, the Power Plant Premier also protects your equipment from damage due to power line surges and lightning strikes. In the event of an electrical calamity, damage to the Power Plant is likely to be confined to the field-replaceable power cartridge, simplifying repairs.


Just click on “Video” on that page. If that link doesn’t work, go straight to www.youtube.com and search for “Paul mcgowan power plant.”

MEASUREMENTS

I measured my AC line and the Power Plant Premier using my Sound Technology 1700B distortion analyzer, Tenma 72-410A true RMS DMM, and Tenma 72-740 oscilloscope (Tenma is the house brand of MCM Electronics, www.mcmelectronics.com). I took the scope photos with my Nikon CoolPix 995 digital camera. Photo 6 shows the AC power line—the waveforms show visible flat-topping, which is typical of most AC power lines. I measured 1.21% THD on the Sound Technology analyzer, at a line voltage of 118.5V AC. The distortion analyzer on the Power Plant Premier read 1.1%.

I made these measurements in my office, which tends to have a cleaner power line than my house. In my home listening room, the Power Plant Premier’s analyzer usually reads between 2.2 and 2.5% THD on the incoming AC line.

Photo 7 shows the output of the Power Plant Premier in the normal (sine wave) mode. THD measured 0.31% on the Sound Technology, at 118.9V AC, with the Power Plant’s distortion analyzer reading 0.4%. Despite the fact that the incoming THD at home is twice what it is in my office, the output of the Power Plant Premier remains between 0.4 and 0.5%. The Power Plant Premier’s AC regulation maintains line voltage at 119V AC, within 0.1V, re-
PHOTO 8: AC output of the Power Plant Premier in the MultiWave mode. The rounded peaks are achieved by adding 3rd harmonic, which increases the measured THD to 5.0%.

PHOTO 9: AC output with CleanWave activated. This degaussing feature modulates the 60Hz waveform with a higher frequency signal centered around 2kHz.

gardless of the incoming line voltage.

Photo 8 shows the Power Plant’s output in the MultiWave mode. The waveform has been altered, producing rounder peaks than a conventional sine wave. The Sound Technology read 5.0% THD, with the distortion waveform dominated by the 3rd harmonic added to produce the modified waveform. The Power Plant Premier’s distortion analyzer read 0.2% at 118.9V AC, so I assume that the Power Plant’s distortion analyzer compensates for the added 3rd harmonic when reading THD in the MultiWave mode (under load the MultiWave THD rises to around 0.4%).

PHOTO 10: Raw DC preamp power supply, with the scope set at 0.1V per division. The preamp was powered with the Power Plant’s sine wave output.

PHOTO 11: Raw DC preamp power supply with the Power Plant in MultiWave mode. Peak-to-peak ripple is about 40mV less than in Photo 10.

PHOTO 9: AC output with CleanWave activated. This degaussing feature modulates the 60Hz waveform with a higher frequency signal centered around 2kHz.

PS Audio suggests connecting the Power Plant Premier to your current power line filter, and using its internal distortion analyzer to measure the AC coming out of other power line conditioners. The Adcom ACE-515 measures around 2.2%. The high-current outlets on the Power Wedge 116 mea-
sure 2.4%, and the transformer-isolated outlets measure 4.4% (transformers can cause a measurable increase in THD). Because my frequency response measurements clearly showed effective filtering above the audible spectrum, a good portion of these THD readings may be due to the clipping of the AC sine wave, something that no filter operating above 10 or 20kHz can correct. So, the Power Plant Premier is clearly superior to any of these power “conditioners.”

Photos 10 and 11 are oscilloscope photos of the raw supply ripple in a preamp I recently built. I connected the scope across the positive and negative unregulated rails, and set it to 0.1V per division. Photo 10 shows the supply fed from the Power Plant Premier’s normal sine wave AC, and Photo 11 shows the effect when you switch the Power Plant to the MultiWave mode. The MultiWave photo shows about a 40mV reduction in peak-to-peak supply ripple, a slightly rounder positive peak, with leading edges that are not quite as steep. This raw supply has HexFred high-speed, soft-recovery rectifiers and 4700µF filter capacitors. I would expect the differences between the two photos to be greater with less robust power supplies.

SONIC IMPROVEMENTS
Readers who have added power line filtering to their audio systems are well familiar with the improved sound resulting from powering audio equipment with cleaner AC. The PS Audio Power Plant Premier takes those improvements at least an order of magnitude further, and perhaps more.


The Power Plant Premier made as great an improvement in the sound of my system as virtually any change I’ve made. The entire soundstage appears to have been moved back, further away from the listener, primarily due to an increase in hall ambience. There is simply a greater sense of space between the performers and the listener.

Yet at the same time, this increased sense of space is accompanied by substantially improved inner detail and resolution. This is especially true of low-level detail, but it is significant across the dynamic spectrum. Inner lines in even the densest orchestral works are revealed with remarkable clarity. The soundstage is also wider and deeper, with more precise localization than ever before.

The bass is tighter and faster. This can sometimes give the impression that the bottom octave is thinner, but it’s not. What the bass now has is improved clarity and detail, and an absence of any overhang or ringing, which can sometimes produce a false sense of low-end weight. In fact, the entire sonic presentation is more articulate.

Tonally, the Power Plant Premier is neutral—it simply makes my system sound tonally “right.” It would be easy to say that my system has greater harmonic richness powered by the Power Plant, but the Power Plant simply allows my equipment to reveal the harmonic richness inherent on my best recordings. If there was any mid-range grunge and upper frequency edge left in my system, the Power Plant seems to have removed the last vestiges of it, leaving the mid-range amazingly liquid and the treble silky smooth.

In reality, my best recordings simply sound less like reproduced sound and more like a live orchestra in a fine concert hall. The Power Plant also makes problematic recordings easier on the ears, including some of the bright, glary, over-miked Deutsche Grammophon CDs in my collection.

The Power Plant Premier offers a new level of dynamic contrasts. I always knew that the isolation transformers in my old line filtering system probably caused current-limiting, but it was a compromise I was willing to live with because the transformers improved system performance in other respects (parallelizing the secondary windings in my Power Wedge 116, as I noted earlier, definitely improved this limiting factor). With the Power Plant Premier, the dynamic limitations caused by isolation transformers are a thing of the past. My system maintains a clarity, definition, and lack of strain, playing the most demanding orchestra material, that is superior to anything I’ve heard before. The Power Plant Premier has also lowered the subjective noise floor in my system, which further improves dynamic contrasts. Low-level
details emerge from an absolutely silent background.

The real noise floor in my listening room is also lower. The isolation transformers in my old power line filtering made a slight mechanical buzz, which could sometimes be audible during the very softest musical passages. The Power Plant Premier is silent in its operation. It does contain an internal fan that will turn on if the heatsink temperature warrants. But, powering my low-level gear, it runs slightly warm but never enough to turn on the fan (the fan does come on momentarily when you first turn on the unit, as a precaution, but turns off as soon as safe heatsink temperature is detected).

The MultiWave feature is an interesting and worthwhile enhancement. The most noticeable difference is in the low-end weight. On bass drums, it's more a matter of the portion of the spectrum that you feel rather than hear. MultiWave also opens up the soundstage a bit further. The magnitude of the difference will probably have a lot to do with how good the regulation is in your power supplies.

My preamplifier has Walt Jung's "Improved Positive/Negative Regulators" described in Audio Electronics 4/2000, which have superior line rejection and better dynamic performance than any regulator I've used. With my low-level equipment, MultiWave was more like icing on the cake than another dramatic improvement. I suspect that the poorer the supply regulation, the greater benefit that MultiWave will provide, with power amps probably benefiting the most (power amps generally have unregulated power supplies, at least for their output stages; if regulation is used, it's usually for the voltage-gain stages).

The effect of degaussing your connected components with CleanWave is subtle. If you run CleanWave on a daily basis, you may conclude that it's not doing anything at all. However, if you haven't run CleanWave for several weeks, you may find that it takes a slight edge off your system. Edginess is a characteristic I have associated with permeable metals in the signal path, especially resistors and capacitors with steel leads. If any residual magnetism has built up in your equipment's power supplies, degaussing it can only help, and certainly can't hurt.

After living with the Power Plant Premier operating only my low-level gear, I decided to connect my power amplifiers to the Power Plant (I am currently using a pair of Monarchy SM-70s, reviewed in Audio Electronics, Sept. 2000). Although I noted similar sonic improvements with the power amps fed by the Power Plant, the differences were not as dramatic as they were for my low-level equipment. I also noted one negative—the bass seemed thinner than before, lacking some of the weight and impact in the bottom octave.

I raised this issue with PS Audio's Vice President of Sales and Marketing, Dave Kakenmaster. With about 500W of current draw per amplifier, a pair of Monarchy pure Class-A power amps combined with my low-level gear is running the Power Plant Premier close to its constant-load limit. Dave notes that they normally recommend a maximum continuous draw of 1000W, with the Power Plant Premier's maximum of 1500W reserved for occasional peak requirements. This makes sense to me, so I reconnected my power amps to my old line conditioning equipment. But, I can't help wonder how the power amps would perform with their own, dedicated Power Plant Premier. I should note that even adding the Monarchy Class-A power amps never generated enough heat to activate the fan.

During my evaluations of the Power Plant Premier, I spent several evenings comparing the sound of my system using my old power conditioning scheme with that of the Power Plant Premier. This is a fairly simple thing to do. Simply listen to a reference recording with one source of AC power, temporarily power your system down, and plug your equipment into the other AC source. Power up and listen again.

One advantage of this type of comparison is that it doesn't change any of the MAAD parameters (Mothers of All Audible Differences—level, frequency response, and absolute polarity, which some claim are the only factors that have an audible effect on the sound). Everything remains the same except the power source.

I was repeatedly shocked and disappointed with the sound of the line filtering scheme that has served me so well for more than 15 years. Every time I went back to my old line filtering, the sound became unrefined and inarticulate. "Mushy" is a good word to describe the relative lack of clarity.
and definition with my old line filtering equipment. After a few evenings of back and forth comparisons, it was obvious that my old line filtering equipment had run its course.

CONCLUSIONS
The PS Audio Power Plant Premier will raise the performance of your audio system to a new level, and it should be equally well-suited to high-end home-theater applications. A clean AC power supply is an essential part of a reference-quality music system, and the Power Plant Premier is the finest source of AC power that I’ve used. At a list price of $2200, it’s not cheap, but the design is sophisticated and execution and quality of construction are first-rate. Once you’ve tried a Power Plant Premier, there’s no turning back. Highly recommended!

Manufacturer’s Response:
On behalf of everyone at PS Audio, I thank Mr. Galo for his very thorough and thoughtful review of the Power Plant Premier. We agree with his findings and it’s no wonder the PPP has become the reference AC product for so many audio- and video-philes.

There is one thing I’d like to add. Consider this item an “Easter egg” of sorts. There are actually two CleanWave modes, short (5 seconds) and long (60 seconds). The instruction manual describes the short mode only. To access the longer and more effective mode, start CleanWave and press the CleanWave button again within the 5 seconds that the short mode is running. We recommend you run this long mode 2 or 3 times at the beginning of any serious listening session and here and there throughout, with the 5 second mode for “touch up” between discs or album sides.

Dave Kakenmaster
VP Sales & Marketing
PS Audio International

REFERENCES
1. Galo, Gary. “Ask TAA.” Essay on power


TABLE 1: MANUFACTURER’S SPECIFICATIONS

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<tr>
<th>Description</th>
<th>Specification</th>
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