

## Designing VPI's Next Generation Direct Drive Motor Technology

Harry Weisfeld's 2012 CLASSIC DIRECT direct drive turntable was an outstanding technical achievement, earning Stereophile Magazine's Class A+ rating. This award-winning table was loosely based on the VPI Classic Series table technology and included a thick aluminum plinth and armboard and an inverted platter bearing riding on a PEEK thrust disc. Combined with a cutting-edge BLDC direct drive motor, the CLASSIC DIRECT was created. The Classic Direct provided a stable, solid foundation for the music, allowing the listener to hear deeply into the recorded grooves to the treasures buried with-in!

Designing a new turntable to celebrate VPI's 40th anniversary provided VPI an opportunity to update the direct drive motor technology to incorporate advances in motion control and materials technologies.

### The 40th Anniversary project:

As the starting point we re-evaluated the CLASSIC DIRECT's motor design. While still an awesome motor, our assessment found it to be overly complicated, difficult and expensive to manufacture, requiring custom written motor control software and no ability to fine tune or scale the technology into other models.

Surveying current available motion control technology, it was apparent that advances had been made in not only the available drive electronics, but also in materials and software control. The demands of mainstream industries involved in robotics, manufacturing, machining, inspection, etc. had been driving the motion control industry for higher precision, speed, reliability and affordability, providing a wide range of technologies to evaluate.

### Starting with the Motor Components

The first decision made was to retain the 2012 motor components and re-engineer the motor housing and platter. The rotor and Stator components being still available from our American vendor. These component parts are one of their most popular models due to its size, high torque and smooth cog-less motion.

CLASSIC DIRECT/HW-40 motor stator coils are constructed of solid copper, square cross section wire embedded in a hi-temperature composite material for increased vibration damping. The stator's tubular construction also resists the flexing under load that affects substrate base coil designs. This construction also provides excellent cooling and near-optimal interaction of the electromagnetic conductors within the magnetic circuit. The unique iron-less coil assembly avoids the use of magnetic materials in its construction. The stator coils also feature a overlapping V-shaped coil construction, these features smooth the rotational transition from pole to pole, eliminating the cogging

that accompanies simpler direct-drive motor designs.

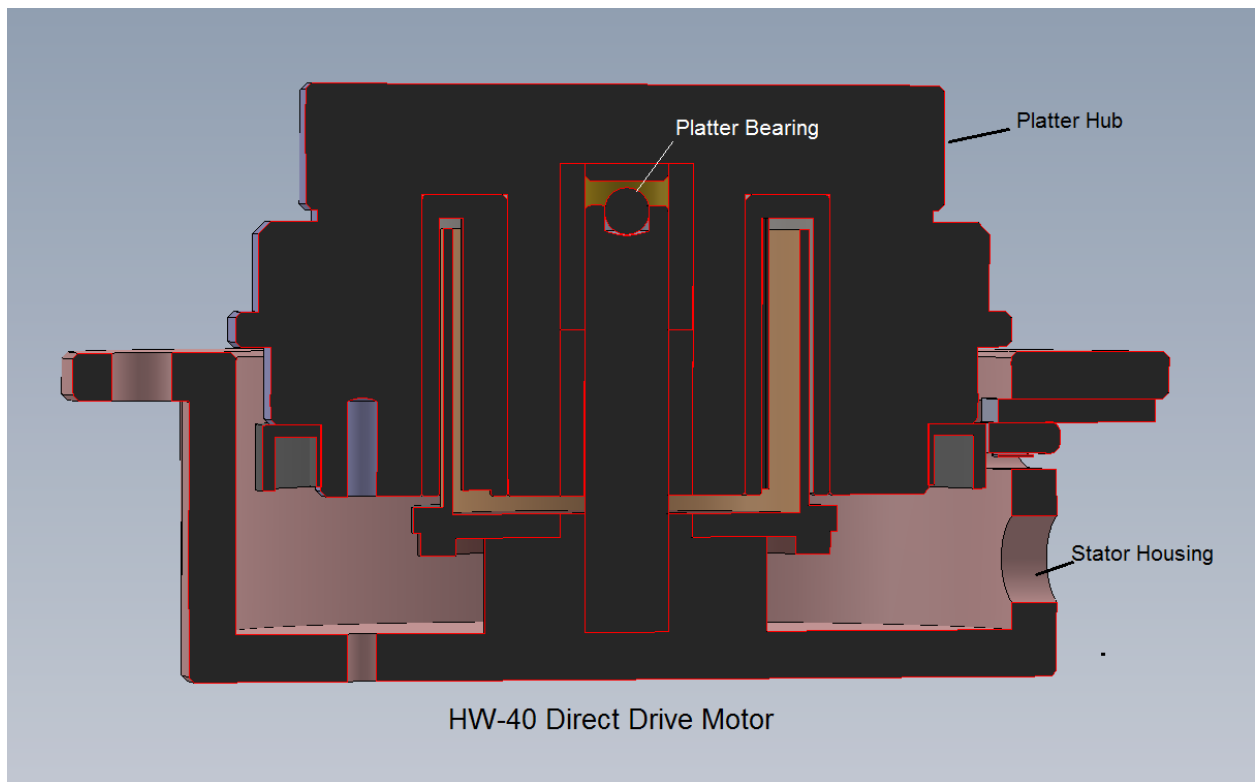


Additionally, the rotor magnets are shaped to smooth the Back EMF (electromotive force) from the stator as they transition from pole to pole. This feature eases the demands on the motor drive circuitry and power supplies. Combined, these elements of the thin-gap motor components produce an unprecedented rotational smoothness and virtually unmeasurable wow-and-flutter.

### Motor Design Improvements

Because we were retaining the original BLDC motor components discussed above, we next focused on the mechanical design of the new motor. Working with engineers at our long-term machine shops and learning from Harry's experiences with the 2012 design, the first step was to design the massive can-style housing to support the stator assembly and machine it from a solid billet of T6061 aluminum. Its design was optimized to create a solid platform to support the stator and act as a vibration sink, effectively absorbing motor vibrations into the 1/2" thick MDF-damped aluminum plinth through a solid 5-point mounting.

The rotor/magnet assembly is pressed into the aluminum platter support hub; this, too, is milled from a solid billet. The hub housing provides mass damping, absorbing and dissipating drive vibrations into its mass. The platter was engineered to securely mate to the hub, improving its damping while still allowing its easy removal for shipping.



The rotor hub is precision machined to hold the 100mm rotary encoder system that provides '2500 timing counts per revolution of position' feedback to the servo amplifier. At 33RPM, this provides 1423 counts/sec of extrapolated resolution contributing to the tables' extremely low wow and flutter and exceptional speed accuracy.

### **Servo Drive Electronics and Motor Control Software.**

The need to precisely control mechanical movements in smooth precise motions has helped the motion control industry create hardware and software far advanced from their 2012 equivalent.

The 2012 version of the direct drive motor was a bit under-driven, with low torque and a very slow ramp-up to speed. Driving it harder resulted in an objectional rise in servo noise.

The motor drive electronics for the 2019 HW-40 are being sourced from one of the leading companies in the industry. Established in 1990, they now have locations and manufacturing plants worldwide.

Historically, VPI tables have shown increasing improvement in the foundation and purity of music as the torque has increased. This evolution has involved utilizing massive platters, multiple

belts, flywheels, dual flywheels, dual motors through rim drive models.

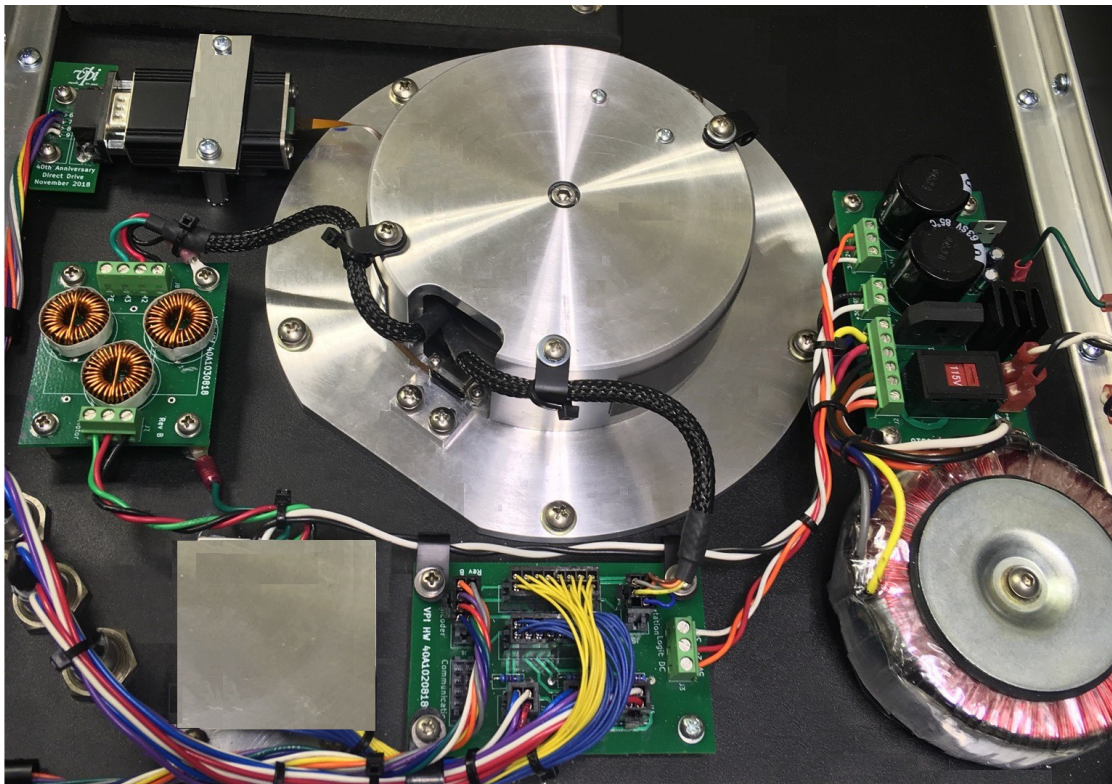
The focus for the evolution of the HW-40 motor was to increase the running torque and improve speed stability without affecting the silent noise floor that VPI turntables are renowned for.

A design challenge stemmed from using a motor that is more powerful and efficient running at 2-3K RPMs and running it at 33 RPM. Adding the mass and inertia of a 27lb platter, it became a challenging feat to manage the drive signal to obtain our torque and speed stability goals while maintaining low drive noise.

Working closely with motor control engineers while monitoring/listening to the motor noise using an unmodulated disc, we were able to fine tune the motor drive for high torque and silent operation. Listening to the HW-40 allows the listener to hear the success of our efforts.

### **Electronics Layout and Construction.**

Considerable effort was put into the physical layout of the HW-40. Stable operation, low electrical noise, ease of assembly and servicing as well as long-term reliability were the goals.



## HW-40 Isolation

Very high on our design checklist list for the HW-40 was the physical isolation the table, with two specific priorities to address. First, obviously, was to provide a high level of isolation to structural borne and airborne vibration. Second was to cleanly integrate the isolation into the look of the table.

Towards this end VPI performed a lot of development work evaluating the technology and materials available. After evaluating dozens of prototypes and an endless supply of damping materials, the table isolation was finalized. The HW-40 is the first VPI table to benefit from these efforts.

Through a combination of reinforced composite absorption pads coupled with low durometer horizontal isolators and their mounting assemblies, the HW 40 suspension interacts with the mass of the table to provide excellent broadband isolation in both the vertical and horizontal axes.

The Elastomeric composite pads provide high energy absorption with less than 10% compression set. There are no plasticizers to interact with cabinet surfaces. The combination and execution of the design elements guarantee consistent long-term performance of the isolation system.

The sonic results are heard as an improved sense of focus and articulation in the bass that extends well into the lower midrange.

Check out this Facebook link to see the isolation in action.

The Bottle Challenge on Facebook:

<https://www.facebook.com/vpiindustries/videos/vb.313369810917/335742833641928/?type=2&theater>

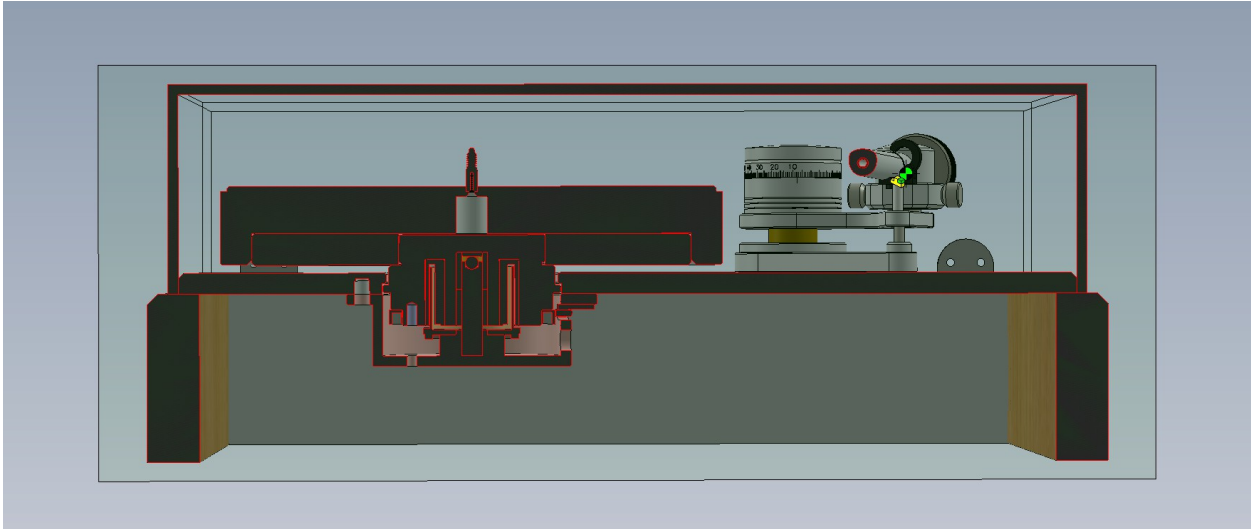
### **In summary,**

VPI's efforts to create the next generation direct drive table have been well worth the time, effort and money invested in this project. We have created an extra powerful, yet ultra-quiet direct-drive motor, resulting in unprecedented rotational smoothness and relatively unmeasurable wow-and-flutter.

The isolation system that grew out of our research is also first class and provides cutting edge isolation performance.

With the combination of 40 years of global award-winning table design, the inclusion of the new 3D Gimbal Fat-Boy tonearm, our

new state of the art direct drive technology, and an isolation system that lowers all noise levels, VPI has created a turntable that truly demonstrates what is possible from vinyl playback technology in 2019: the [VPI 40<sup>th</sup> Anniversary HW-40!](#)



Michael Bettinger, February 2019