**Report Title:**

Comparison test of original Precision Acoustics LabVIEW software to new 8Fold Manufacturing python software on existing wet test fixture hardware.

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**Client:**

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**Executive Summary:**

Todo

In February 2022 8fold Manufacturing was contracted by Profound Medical to create a new graphical user interface for their existing and future Wet Test Fixture (WTF) systems. The goal was to transition from a closed-source LabView interface to a modular, easy-to-maintain, and well documented Python application that can be improved and kept up to date by either 8fold or Profound in the future.

Several months after the project was contracted it was expanded to include the construction of an additional WTF system, using a combination of parts provided by Profound and parts purchased by 8Fold. The system includes a new motor controller assembly, featuring a Galil 4123 controller. This decision was made because the Parker VIX 250 IM Drive controllers are end of life and use obsolete software. In addition, testing with them showed that communication with them is slow and unreliable by comparison. The new motor controller assembly is fully backwards compatible with the existing systems. Pending complete validation of the new software and new motion controller system, existing WTF systems will be able to be seamlessly upgraded at Profound’s discretion, making them more futureproof, reliable, and easy to maintain.

Prior to this report’s preparation the software was tested on the new WTF system in Dallas. The goal of this report are as follows:

* Compare the results of the Python software to results from the Existing LabView software and determine if the differences are within repeatability limits.
* Investigate to what degree the differences observed in the previous report were due to hardware differences, changes to the UAs as a result of shipping, and changes to the UAs as a result of years of storage.

**Methods**

A total of 8 UAs were tested using Wet Test Fixture 2 with the original LabVIEW software using the Standard Test Script Version 1.2. According to these tests, 3 of the UAs passed and 4 failed. Approximately a week later, these UAs were tested using the same script with the new Python-based software developed by 8Fold Manufacturing.

**Results Summary**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Measurement** | **Mean (LabVIEW)** | **Mean (Python)** | **STDev (LabVIEW)** | **STDev (Python)** | **Systematic error** | **Average error** |
| Beam Angle (deg) | -90.47 | -90.49 | 2.13 | 1.91 | 0.03 | 1.09 |
| LF.Eff (%) | 64.40 | 64.83 | 11.54 | 8.83 | 0.43 | 4.48 |
| LF.Rfl (%) | 9.37 | 10.61 | 6.88 | 6.85 | 1.23 | 3.38 |
| LF.Pf (max) (W) | 7.30 | 7.20 | 2.56 | 2.17 | 0.10 | 0.67 |
| HF.Eff (%) | 39.89 | 38.94 | 7.47 | 7.02 | 0.95 | 2.18 |
| HF.Rfl (%) | 3.57 | 3.33 | 2.70 | 2.60 | 0.24 | 0.60 |
| HF.Pf (max) (W) | 5.50 | 5.39 | 1.52 | 1.51 | 0.11 | 0.36 |

**Element Case Studies**

Element 1 of GM0912 failed its LabVIEW test due to the LF.Pf (max) (W) exceeding the limit (13.4W > 12W). With the Python software, this quantity (10.7 W) did not exceed the limit, despite being close. Upon retesting, the result was closer to failing, but still passed by a narrow margin (11.3 W). The difference between this result and the initial result (2.1 W) is greater than the average error for LF.Pf (max) (0.67 W), but is not the greatest error observed. This element is borderline according to this pass/fail criterion and as such may have tested one way or the other regardless of the software used.

Element 6 of HB0398 failed its LabVIEW test and also failed its Python test, though despite the initial test showing 40% LF efficiency, the Python test showed no power from this element whatsoever. Presumably this element went from underperforming to completely dead, or it has an intermittent connection. It was excluded from the analysis because it did not have a valid Pf (max) and the lack of any acoustic power delivered by the element cannot be attributed to the software.

**Discussion**

The first question worth asking when comparing the results from the existing LabVIEW application to the newly developed Python application is whether there is a systematic difference between them, or in other words, if the average results with the new software tend to be greater or less than the current software. If there was any meaningful difference in the calculations performed, the accuracy of locating the elements, or the ability to isolate the intervals of stable data where the UA is on/off, one would expect that there would be a tendency for the results from the new software to be different on average. As it turns out, they are remarkably close. The average beam angle is virtually identical, with both applications agreeing within a tenth of a degree. The LF eff (%) and HF eff (%) are also very similar, with systematic errors of less than .5% and 1% respectively. The Pf (max) for both frequency ranges agrees within about 0.1 Watts. The greatest systematic error observed was the Lf.Rfl (%), which still only differed by 1.25%. This clearly shows that the Python software does not tend to provide significantly higher or lower results on average. Furthermore, the standard deviations of each measurement across all elements are very comparable and in fact they are slightly less than the current software in every case, indicating that there is not a greater propensity towards random error.

The differences observed between the results of the new software and the current software are overwhelmingly random error, with little if any tendency towards producing higher or lower measurements. The magnitude of this random error depends on the measurement, with the greatest being LF efficiency percent. Still, the random error is less than 4.5% on average, with a standard deviation of 3.9. This means that differences in LF efficiency between 0.6% and 8.4% are typical between the two trials in either direction. This difference may seem substantial and, in some cases, can be the difference between a UA passing and failing. However, it is not certain that the day-to-day repeatability of the tests would have been any better using the existing software only. Further testing could be done to determine the repeatability of the existing software and hardware as a control.

These tests suggest that there is extremely little, if any, systematic difference in the results of the new Python Wet Test Fixture interface and the existing LabVIEW application. This bodes well for the new software’s ability to locate elements, read forward and reflected electrical power, obtain accurate balance readings and isolate the stable on and off intervals, and finally to calculate acoustic power. If any of these key components were not functioning as well as the original system, there would be a tendency for the results to be meaningfully greater or less than the original system on average, which is not the case.

The random variability observed between the results with the original LabVIEW software and the results with the new Python software was less than 5% on average for every quantity tested, which is presumed to be comparable to the day-to-day variability on the same system and the same software. One element narrowly failed with the current software and narrowly passed on the new software. However, this should be expected to occur occasionally, even when testing with the same software and hardware, due to the day-to-day variability of the UAs.

This report recommends that these results be compared to a repeatability test on an existing WTF system with original LabVIEW software, and if the random error observed in this report is not significantly greater than the variation observed on the same system

can be concluded that this software is fit for use alongside the existing LabVIEW software and can be considered as a future replacement for the LabVIEW software.

The Dallas wet test fixture with python GUI has high frequency efficiency results that are repeatable within a tolerance of +/- 0.41 percent, low frequency efficiency results that are repeatable within a tolerance of +/- 0.71 percent, element X position measurements that are fully repeatable at a 0.4 mm resolution, and element Theta position measurements that are fully repeatable at a 0.4 mm resolution. The system also can be calibrated based on a reference power meter by changing its config file. After calibration, the system passes and fails elements in accordance with their initial WTF calibration.

Prior to calibration, the comparison between this system and the initial calibrations done on existing systems showed a difference of 5.6 percentage points at low frequencies and 6.3 percentage points at high frequencies. Both of these are well within the acceptance criteria of 20%. The latter was a systematic difference and was addressed by recalibrating the system. This also addressed the issue of elements passing their high frequency efficiency test when they should have failed.

An additional test was done to compare the high and low frequency efficiency results of a UA at two different forward power levels, about 1 Watt and about 5.35 Watts. The resulting differences were small (typically under 2%), supporting the assumption that efficiency is not highly dependent on forward power.

The remaining factors cannot be readily narrowed down without further on-site testing. The first phase of this will involve testing the same UA using existing software and using the new software on the same Wet Test Fixture equipment, to investigate if the difference is entirely on the hardware side.

When the new Wet Test fixture is brought to profound, any remaining differences due to different hardware can be investigated and resolved if they are found to be significant.