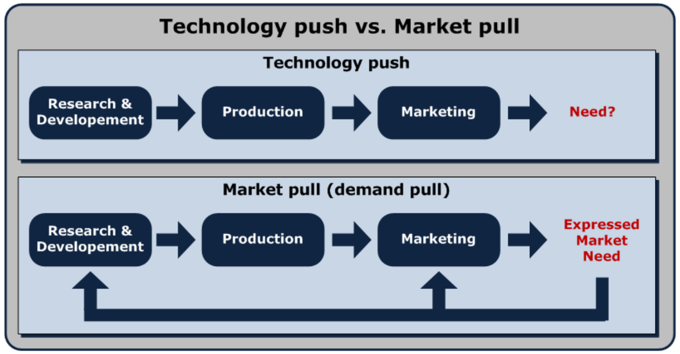
The Evolution of IADS Analysis

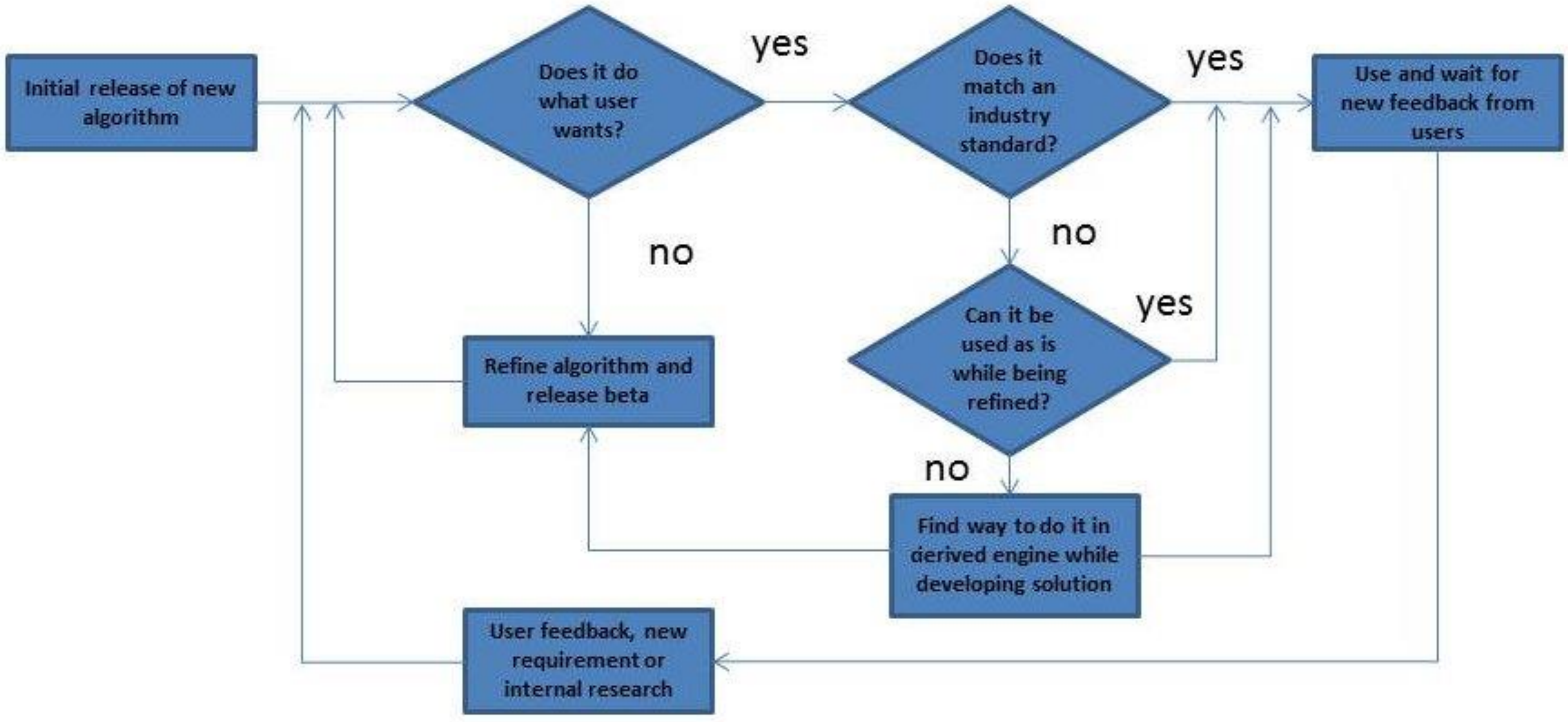
Introduction

- Development of new IADS analysis algorithms is influenced by forces analogous to the Technology Push/Market Pull model.
- Internal and external technological advancements spur internal research which is presented to users for evaluation of usefulness (Push).
- User requirements drive development of a specific capability (Pull).



- Once a basic capability is in place, it is refined to suit users and match capabilities of standard tools in the industry.

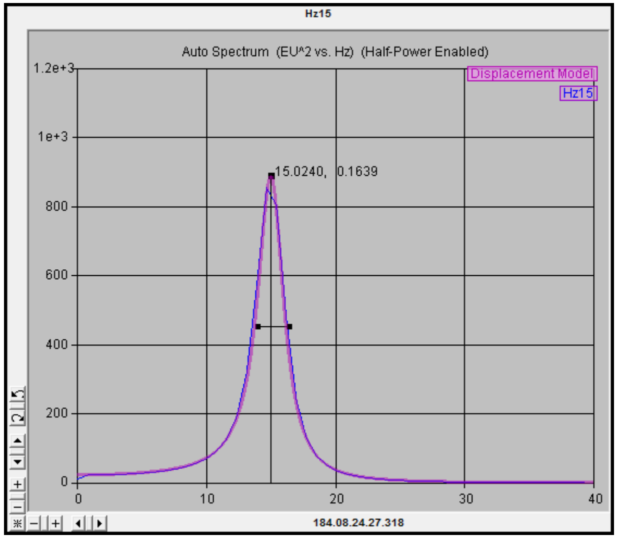
Typical Algorithm Refinement Flow



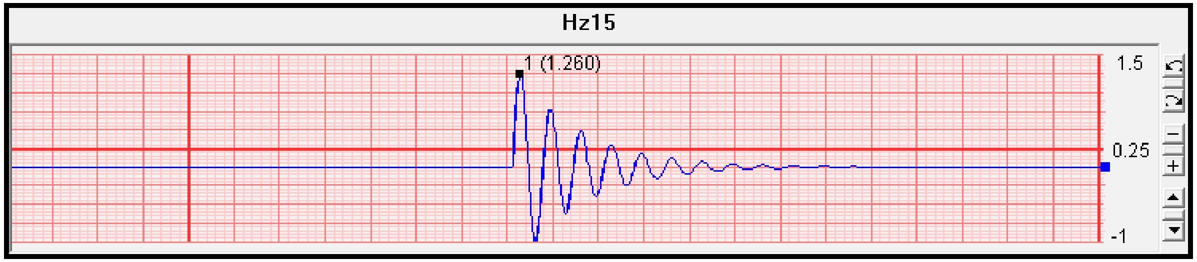
Once in a release, algorithms evolve and are continually evaluated.

Frequency Plot – PSD/Autospectrum

- First Frequency Plot yielded accurate Half Power Damping estimates.
- Credibility suffered due to amplitude of data waveform. Rescaling is easy…
- The Frequency Plot was used this way for a long time because it produced the correct HPD result.



FP Input Data →



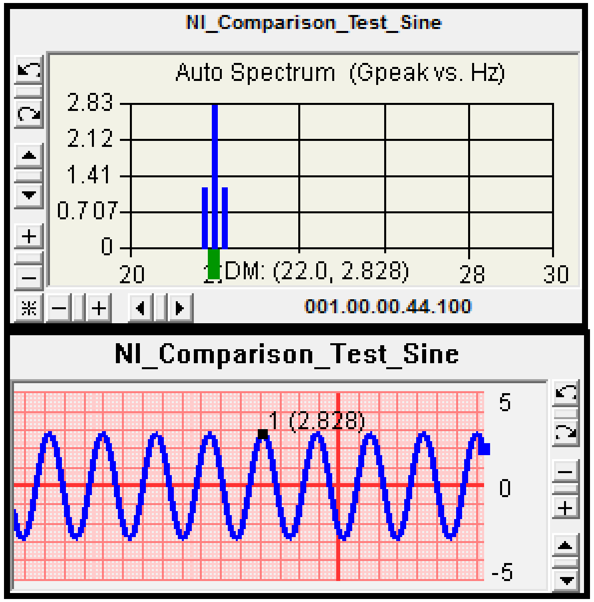
Frequency Plot – First Attempt at Scaling

- Amplitude needed proper scaling factor to be a standard PSD.
- First "PSD" really a Power Spectrum.
- A user helped us correct PSD scaling.
- Autospectrum Plot now a Power Spectrum.
- Bin summing required to estimate levels.
- The PSD finally matched amplitudes with Labview for all windows - credibility attained.

Nice, but you can't call that a **PSD**!

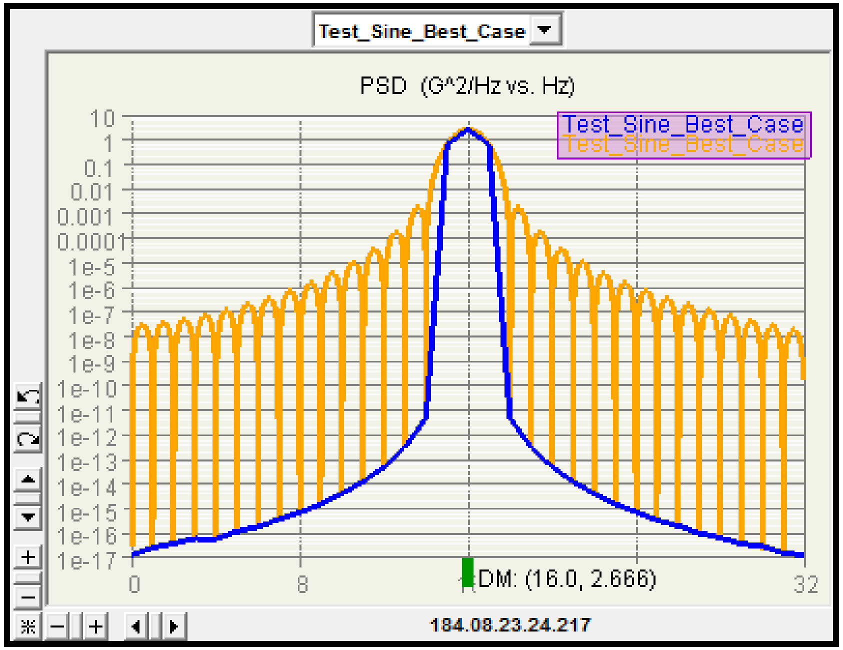
Frequency Plot – Further Refinements

- Window Equivalent Noise Bandwidth correction factors discovered and implemented for Autospectrum.
- Autospectrum credibility attained by amplitude match with Labview for all windows.
- Bin Summing technique no longer needed, but is still available. (Automatic/SARMS)
- Square Root scaling for Autospectrum allowed direct RMS amplitude from Power Spectrum.
- Peak value scaling for Autospectrum allowed direct peak amplitude levels.

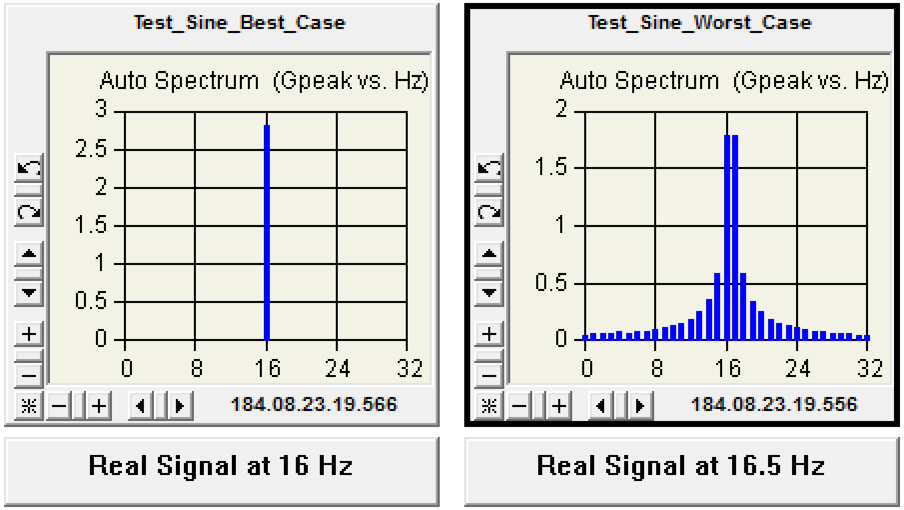


Frequency Plot – Chirp Zoom Transform

- FFT typically had poor resolution around peaks, making frequency estimates tough.
- Internal research found that the CZT concentrated resolution in a defined frequency band rather than 0 to Nyquist Freq.
- Please notice the sidelobes that would go undetected using the FFT in this example. They can give the illusion of damping where none exists.



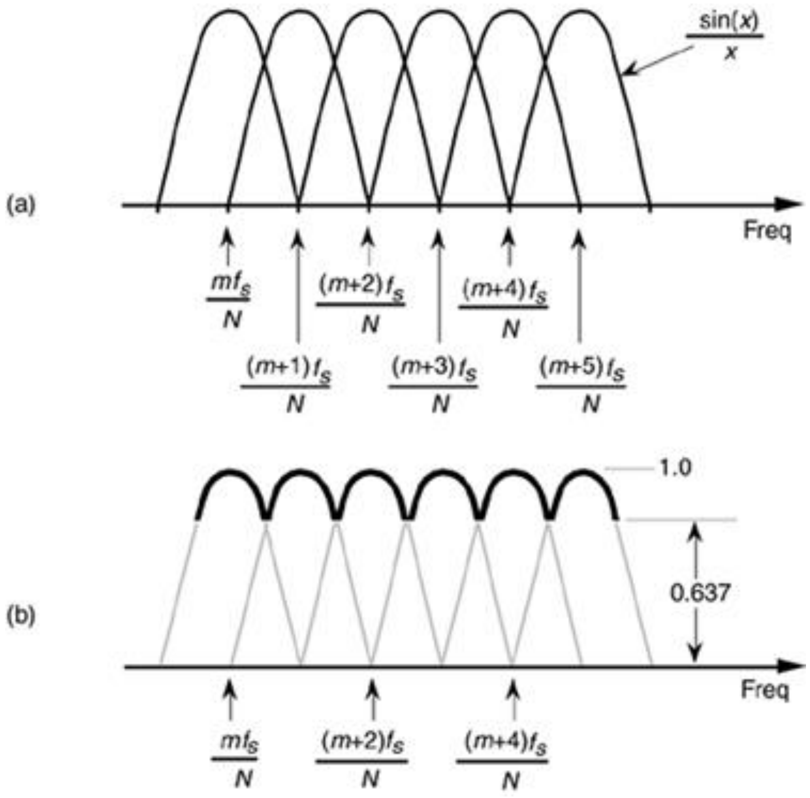
Frequency Plot – Scalloping Losses



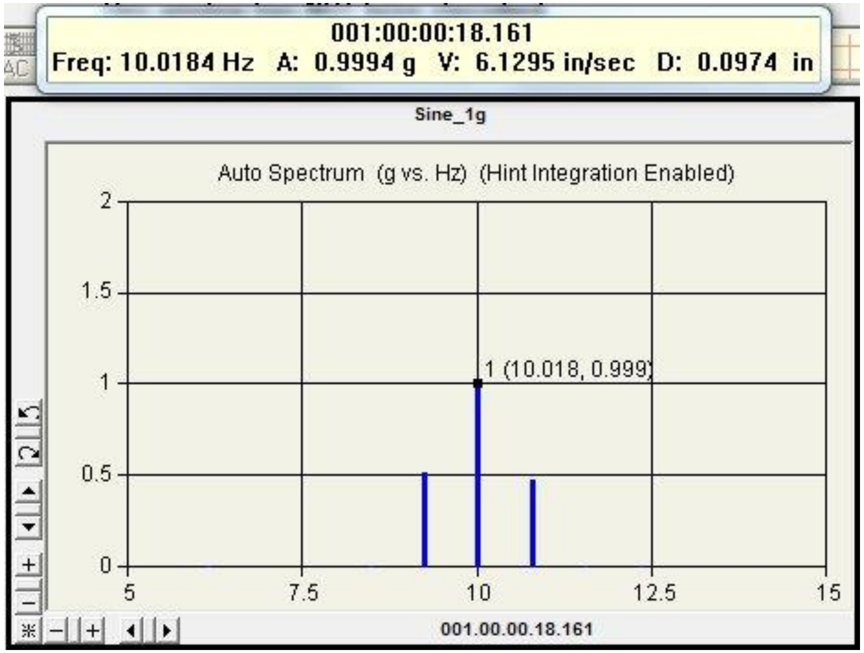
- After the amplitudes were correct, Scalloping Losses became an issue because we could see them.
- In between frequency bins, displayed amplitudes could be more than 3 dB lower than they should.

Frequency Plot – Flat Top Window

- A user suggested that we offer a Flat Top Window for accurate amplitude estimates.
- Using the wider center lobe of the Flat Top Window, amplitude estimates were greatly improved, even at the halfway point between frequency bins.



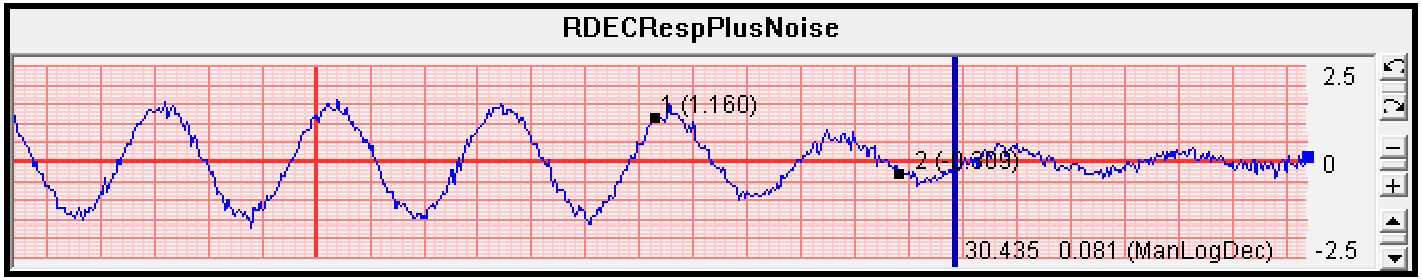
Frequency Plot – Frequency Domain Integration



- Many users have requested integration, which is difficult in the time domain with a broadband signal.
- Integration is rather simple in the Frequency Domain.
- New Feature – Credibility will be built as users check these results against their own methods and widely available Velocity/Displacement apps.

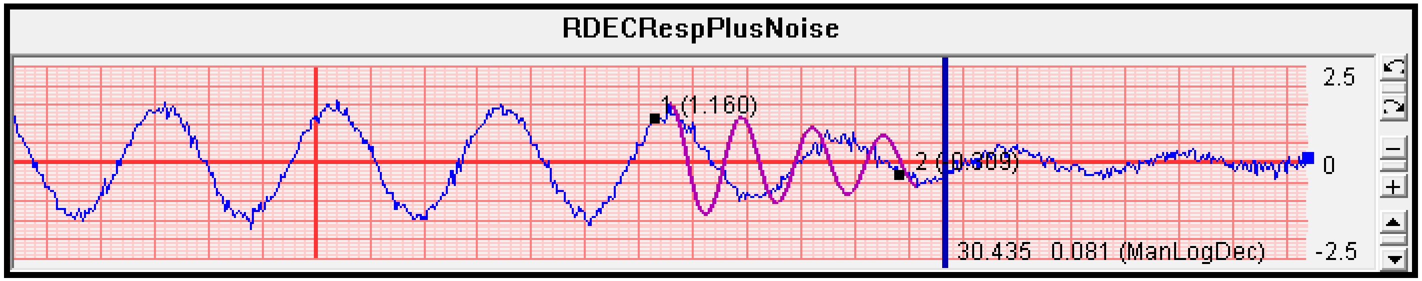
Logarithmic Decrement

- The original Logarithmic Decrement algorithm actually produced correct numbers for one kind of damping if it wasn't fooled by something.
- A user requested some sort of visual indication of the accuracy of the 1DOF fit because of a case like the one shown in the picture.
- We put in an overlay to increase confidence in the displayed result and added the ability to drag a selection and recalculate if the curves didn't match well.

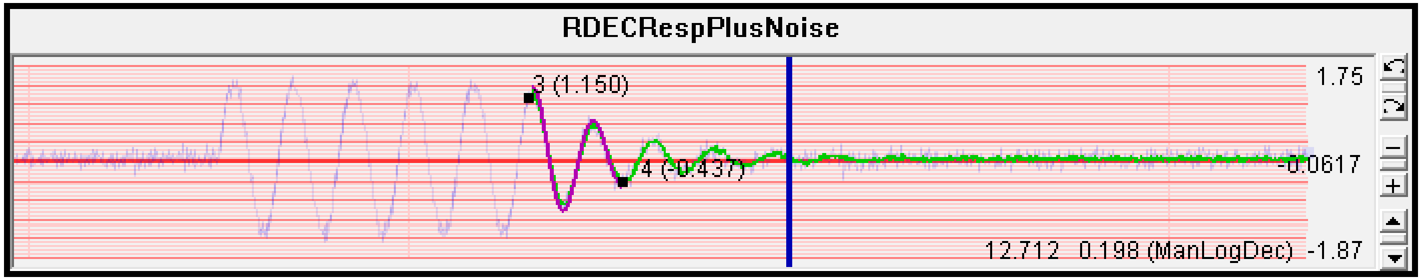


Logarithmic Decrement – Visual Aid

- With the requested overlay present, it is immediately obvious that the results are off.



- After being alerted to the inaccuracy, a user can employ more sophisticated algorithms to obtain better results.



Logarithmic Decrement – Damping Ratio

- With only one type of damping calculation, LogDec type algorithms were only useful for structural damping.
- A user requested that we add a calculation called "Damping Ratio" to our toolset so that he could calculate damping in a Flying Qualities context.
- "Damping Ratio" is used much more widely in Engineering disciplines, so we put it in.
- Undamped Natural Frequency was also included in this upgrade.

$$\zeta = \frac{\delta}{\sqrt{(2\pi)^2 + \delta^2}} \quad \text{where} \quad \delta \triangleq \ln \frac{x_1}{x_2} \qquad \omega_n = \frac{\omega_d}{\sqrt{1 - \zeta^2}}$$

Logarithmic Decrement – New Method

- Existing Logarithmic Decrement calculations fail if decay is not centered about 0.0.
- Analysts forced to use filtering to center their decays about 0.0, introducing additional transient response from the filter.
- Filter's impulse response can look just like a structural natural decay, so meaningful analysis could be difficult.
- Upon hearing of our problem, a user shared a formula for the Transient Peak Ratio Method. It will be added to IADS as soon as possible.

$$\zeta = \frac{1}{\sqrt{1 + \left(\frac{\pi}{ln(TPR)}\right)^2}}$$

Conclusions

- Most algorithms in IADS evolved in a manner similar to the two algorithms discussed above.
- User feedback should be encouraged and used as a tool to refine algorithms. Credibility is the goal, and users help build it.
- Credibility can also be obtained by matching performance or output with industry standard tools in parallel with user feedback.
- Suggestions concerning the modification of existing algorithms to make them useful in new applications can come from open discussion at Conferences like the ITEA Workshop. This is why we are here...
- We appreciate your input!

Contact Information

For further information regarding IADS contact:

Patrick Mattingly
Vice President
SYMVIONICS, Inc.
(661) 273-7003 x206
E-mail: pmattingly@symvionics.com

Commercially available product. Numerous contracting options are available to procure IADS, including GSA contracting vehicles.

For more information about SYMVIONICS, see our web site www.symvionics.com, or contact:

Richard A. Weeks
Executive Vice President
SYMVIONICS, Inc.
(626) 585-0115
E-mail: rweeks@symvionics.com

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