Datod Comments on NTIA

Notice of Inquiry

Spectrum Monitoring Pilot Program

October 3rd, 2013

1) Introduction:

This submission has been prepared in response to the US NTIA Federal Register invitation of August 14th , 2013 (placed August 19th) to comment on the Spectrum Monitoring Pilot Program.

This program derives from The Presidemtial Memorandum – Expanding America's Leadership in Wireless Innovation.

Specificately this iniative relates to the following memorandum section:

3(c) The NTIA shall design and conduct a pilot program to monitor spectrum usage in real time in selected communities throughout the country to determine whether a comprehensive monitoring program in major metropolitan areas could disclose opportunities for more efficient spectrum access, including via sharing. The NTIA shall work with agencies to ensure the program will not reveal sensitive or classified information. The NTIA shall consult with each agency to determine the correct technical parameters to monitor usage.

2) Background:

In order to comment on all aspects of this iniative it is first necessary to establish the wider context from both a regulatory, technical and commercial perspective.

2.1 Related Presidential iniatives:

On the 9th of August, the US President also directed his Administration to work with the US Congress to pursue appropriate reforms to America's surveillance programs and the court that oversees them.

Specifically, the President laid out four steps his Administration will take, with Direction (4) being the section relevant to the issue of Spectrum Monitoring which I call attention too:

(4) The President called for a high-level group of outside experts to review our intelligence and communications technologies. The President is tasking this group to step back and review our capabilities – particularly our surveillance technologies. They will consider how we can maintain the public's trust, and how this surveillance impacts our foreign policy – particularly in an age when more and more information is becoming public. They will provide an interim report in 60 days and a final report by the end of this year, so that we can move forward with a better understanding of how these programs impact our security, our privacy, and our foreign policy.

This submission notes this reform context relating to Spectrum Monitoring and Analysis for NTIA personnel but does make any specific recommendations.

2.2 Synthetic Biology, Grid Cells and Modulation Theory

What has Synthetic Biology to do with Communication Technologies? After all Synthetic Biology relates to multi-signal integration and processing in living cells for diagnostic, therapeutic and biotechnology applications, right?

Well, actually, it also has a place to play in overcoming the binary digital paradigm which Western Technology has got muddled into over the last 60 years and it is closely related to the work underway regarding the fusion of Quantum Computing and Biological Computers within the forth coming era.

Consequently, I would draw too your attention the recent paper in Nature: Synthetic analogue computation in living cells; Nature Vol 497 30th May 2013 from researchers at MIT and the Lincoln Lab (one of the top US National Security Research Institutions). One other aspect of this nascent Synthetic Biology technology, which should be of interest, is how it can be aimed at replacing current generation signal detection technologies. But first it shall be applied to establishing the way forward in the perennial debate regarding the continuous verse discrete mathematical modelling divide and settling a few arguments, especially regarding superposition and the so-called mathematical laws allegedly prevalent in physical reality.

The other technical paper which delves into this context is also from Nature: Membrane potential dynamics of grid cells: Vol 495 14th March 2013. All researchers are at Princeton. They are engaged in the neuroscience field, attempting to understand how the communication and signalling pathways in the human body operate.

This paper critiques the State of the Art of various Mathematical Models that relate to the body of work which comprises standard Modulation Theory.

It is important to recognise and appreciate that their approach to the investigation of Oscillatory Interference Models that because of this biological aspect they have the advantage over telecommunication system engineers in respect of the fact that the Boundary Condition aspects of the physical representations are well defined and quantifiable.

As such they can permit the Oscillatory Mathematical Models to be explored and developed further and then adapted for overcoming the effect of propagation.

Whereas the Signal Processing Techniques discussed therein relate to Spike formation in AM systems there is still unanswered related to FM Spike formation processes to be addressed from the historical perspective of the work of Corrington, Hamkins and Datod.

As usual these Princeton researchers fall into the trap of applying standard complementary filters with non-overlapping passbands for spike removal, instead of recovering and analysing the propagation information presented through the spike formation process itself.

See -

a) Murlan S. Corrington (1945) "Frequency-modulation distortion caused by multi-path transmission", Proceedings I.R.E, p878-891.
b) Murlan S. Corrington "Frequency modulation distortion caused by common- and adjacent- channel interference". RCA Review, 522-560.
c) Jon Hamkins : An Analytic Technique to Separate Cochannel FM Signals : IEEE Trans. On Comms Vol 48 No 4 April 2000
d) Barry McKeown (2010) " The Spectrum Anomaly" : Electronic World Magazine August 2010

2.3 Related Agilent Market Call.

When the CEO of IBM was asked why he disposed of their PC operation to Lenovo he replied with just one word : smartphones. He was prescient and saw them coming and made a Market Call.

On September 19th Bill Sullivan, Agilent president and CEO made a similar Market Call, announcing plans to separate into two publicly traded companies: one in life sciences, diagnostics and applied markets (LDA) that will retain the Agilent name, and the other that will be comprised of Agilent's current portfolio of electronic measurement (EM) products. The separation is expected to occur through a tax-free pro rata spinoff of the EM company to Agilent shareholders. He stated "Agilent has evolved into two distinct investment and business opportunities, and we are creating two separate and strategically focused enterprises to allow each to maximize its growth and success"

Agilent believes that the separation will result in material benefits to the standalone companies through

a) Greater management focus on the distinct businesses of LDA and EM

b) Ability for the LDA company to devote resources to the higher-growth LDA business, while reducing exposure to the more cyclical EM industry

c) Ability for the EM company to devote resources to its own growth that were previously used to capitalize LDA

Consequently why he made this Market Call judgement can be similarly summed up in one word: mHealth.

As Julius Genachowski, the former chairman of the FCC, stated in an interview with the Financial Times, (30th September 2013): "The next generation of workers will be "more and more digitally literate and digitally demanding" and that will force companies and governments to change how they operate. In sectors such as healthcare and education, for instance, "the decision makers will by 40-somethings who can't live without their iPhone or iPad and simply won't accept from their vendors that they can't have the products that they know are buildable".

Accordingly in one one word why this Spectrum Monitoring Pilot Program and a Full Spectrum Monitoring System is required by 2020 is : mHealth.

What this market call is also prescient off is the forthing market change from standardised rack and stack (R&S) measurement instrumentation to Synthetic Instrumentation; whereby the Internet enabled Cloud Computing shall take up the measurement burden for real-time signal processing on High Performance Computing. Thereby changing the busness model from selling expensive instrumentation boxes to selling the analysis of individual data sets at an afordable cost. Datod anticipates that the EM R&S marketplace shall be decimated by 2020 along similar lines to the PC/Smartphone fracture and that Agilent recognises this.

The Pilot Program needs to be constructed to accomidate this forthcoming market change inorder to be commercially viable for a new global industry.

The NTIA NOI states that " standardised data sets would be accumulated and analysed withing the unit and uploaded to centralised data base". This approach mitigates against adopting a commercially affordable Synthetic Instrumentation HPC Cloud based system thus it should take into conderation of current and future market changes. It should be recognised that any R&S based development system suitable for a Pilot Program shall be obsolete for deployment come this market change beyond the anticipated two-year time frame.

It is unclear as to how the NTIA budgetary submission relates to this eventuality.

2.4 Related NTIA Test Bed Activity

The US NTIA Test Bed is seeking to advance the state of the art in Real Time Spectrum Monitoring technologies in order to implement Spectrum Sharing strategies for enabling coexisting communication system topologies.

In this respect it is also seeking to advance the state of the art of Spectrum Sensing measurement techniques.

I call into question the technical capability and consequences of applying the Discrete Fourier Transform as a basis for obtaining accurate frequency, amplitude and phase information in order to advance the state of the art for spectral component estimation for both devices and for stand alone measurement instrumentation, such as the Vector Signal Analysers called out in the Draft Phase II/IIITest Plan.

In this submission I also pose a further series of technical questions on Spectrum Sensing Measurements

2.5 US ITAR Laws

Currently the US ITAR laws, which contributed to the surrender of the US commercial leadership in satellite technologies, shall need to be reformed inorder for a global Spectrum Monitoring industry to be established through US technological leadership.

Datod can release paired down algorithms to the US but not the full Datod capabality and potential capability until this issue is addressed and resolved.

3) NTIA Assessment of the State of the Art in Spectral Measurement:

The NTIA assessment of Spectrum Sensing analysis measurement technology is outlined in the published report by Rodger Dalkie's work from NTIA Technical Report TR-10-470: **Radio Spectrum Estimates Using Windowed Data and the Discrete Fourier Transform,** published September 2010.

This report, as with Rodger Dalkie's other published body of work by the NTIA, is primarily aimed at establishing a firm appreciation of the State of the Art associated with the technical measurement requirements for future Dynamic Spectrum Access technology and especially the crucial initial signal acquision Spectrum Sensing element stage required when a wireless communication device is activated.

Dalkie states in his introduction *"Digital signal processing algorithms are commonly used to obtain radio spectrum estimates based on measurements. Such algorithms allow the user to apply a variety of time-domain windows and the discrete Fourier transform to RF signals and noise. The purpose of this report is to provide a description of how signal processing options such as window type, duration, and sampling rate affect power spectrum estimates. Power spectrum estimates for periodic RF signals and random processes (stationary and cyclostationary) are analyzed. The results presented can be used to select signal processing parameters and window types that minimize errors and uncertainties."*

Dalkie also states his conclusions as follows *"In this report, we have described how the application of a window in conjunction with the DFT to periodic radio signals and radio noise affect power spectrum estimates. The results are used to describe how window characteristics and related signal processing parameters affect measurement errors and uncertainties.*

In the case of periodic radio signals, we show that there are errors due to spectral leakage and window scalloping. These errors depend on the window type and related signal processing parameters. In particular, error bounds for various windows are presented. In all cases, the leakage error can be reduced by increasing the number of signal periods in the window (i.e., the window duration). By far, the leakage error decreases most rapidly (as a function of the window duration) for the Gaussian window. The scalloping error is independent of window duration and is smallest for the flat top window.

In the case of stationary noise, we describe how the window and related signal processing parameters affect both the estimated power spectral density and the total power in the measurement bandwidth. It is shown that the window should be selected so that the noise power spectral density is essentially constant over the bandwidth of the window. Also, the window duration should be long enough so that the noise power spectrum is adequately sampled.

Cyclostationary random processes were also considered. In this case, we examined estimates of the time average of the power spectrum. It was found that in addition to the considerations described for stationary processes, the window bandwidth should be less than (one-half) the repetition rate of the covariance function."

Taking note of all the above, then consequently in real engineered systems, at the initial signal acquisition stage, especially as we journey towards deploying DSA Spectrum Sensing technology for sharing and monitoring spectrum, the technical measurement problems posed by Dalkie's window technique solution become apparent for both devices and standard spectrum analysis instruments.

Note: any (implied) assumptions about clock recovery and synchronisation techniques made at this initial signal identification stage are irrelevant, especially for a coexistence environment, where there are multiple independent emitters present in a Radio Frequency environment.

Fundamentally, Dalkie's work neglects the fractional signal aspect as described in published Datod articles in Electronics World Magazine (see Section 4) but Dalkie correctly concludes that for the application he is seeking to address for DSA Spectrum Sensing that the Flat Top Window is currently the State of the Art for Spectrum Estimation open to the NTIA.

The other fundamental omission from Dalkie's assessment of the DFT is the provision for any account of the attenuation of the signal introduced and the roll-off assessment, especially establishing inverse-squared relationships from isotropic radiators whereby the propagation effects are subtle but discernable by a multi-sensor spectrum geo-location monitoring system.

Standard Rack and Stack Spectrum Analysis instrumentation adopted in isolation cannot undertake these parametric measurements.

This omission is akin to the evaluation of the more onerous technical measurement challenge of the Finite Inductive Decay analysis required for Spectroscopy and Magnetic Resonance Spectroscopy (MRS) in particular which is discussed in the following section.

4) Datod Benchmark Test Signals and Algorithms :

In the following two published articles I critique the issues related to Spectrum Sensing and Monitoring and introduce the standard Datod Benchmark Test Signals for both Communication and MRS Systems.

a) Barry McKeown (2011) "Spectrum Analysis: Opening Another Can of Worms" Electronics World Magazine September 2011
b) Barry McKeown (2013) "Spectrum Analysis : The State of The Art of US Spectrum Sensing Capability" Electronics World Magazine January 2013

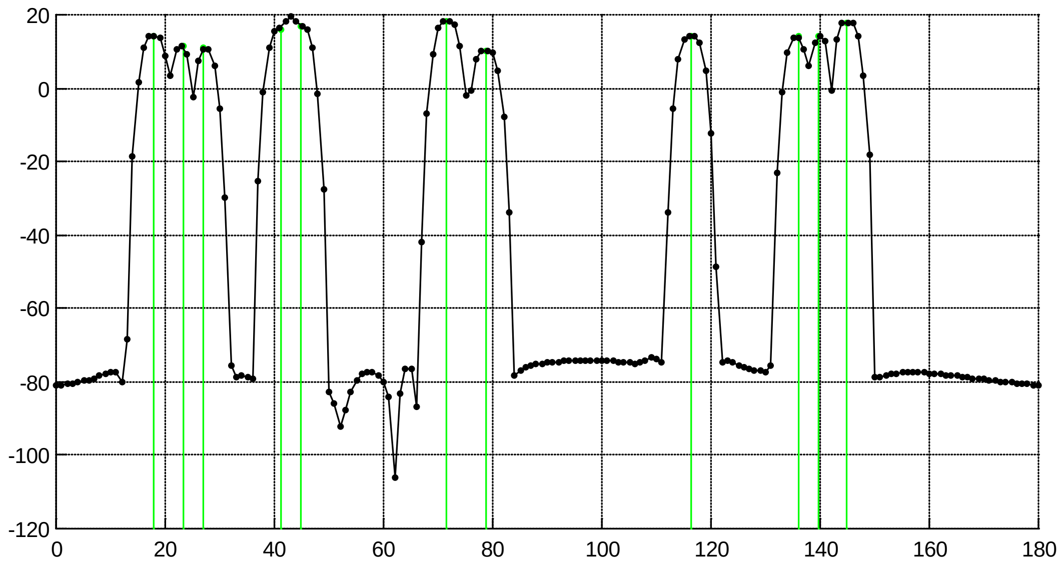
The first article seeks to critique the pitfalls in applying window techniques and zero padding and introduces a Datod Algorithm for obtaining Fractional Frequency Resolution from the identical samples fed into a DFT/FFT.

The second article introduces an additional Datod Algorithm for attaining the information introduced by a decay parameter. This is particularly aimed at addressing Spectroscopy issues.

The technical limitations and capabilities of these algorithms beyond these data sets are not disclosed. However I note that no commercial Spectrum Analyser instrument manufacturer (Agilent, Tektronix or National Instruments etc) is capable of attaining the level of accuracy discussed. Defence system manufacturers (e.g. Boeing) are a separate consideration.

In Figure 1 we apply Dalkie's Flat Top Window and the FFT to a standard Datod Benchmark Test Signal, cited in the article, composed of eleven fractional frequency parameters specified to two decimal places.

Figure 1 : Datod Test Signal with Flat Top Window Applied



This figure is derived from 1000 half-interval samples of the Datod Test Signal. The green lines indicate the location of the actual underlying signal frequencies.

An appreciation of the difficulty of attaining accurate parameter estimates via the DFT/FFT and Windowing approach becomes apparent from a study of this Datod Benchmark Test Signal.

An alternative analysis with the Gaussian window exhibits similar Spectrum Estimation limitations.

Observe that only the eighth spectral component at 116.35 Cycles per Observation Interval is clearly individually discernable.

Note that the application of Dalkie's Flat Top window has infact broadened this recovered spectral component.

Observe also in Figure 1 that when the fourth and fifth spectral components run into each other they give a single erroneous central positioned spectral peak which is above the actual amplitudes of these two spectral components.

The really serious point to address here is the waste of a precious asset called Spectrum and recognising and accepting that windowing is a work-a-round procedure developed by engineers to overcome a specific problem with the Applied Mathematics that has still to be fundamentally addressed in the Art of Signal Processing for Fourier Analysis.

Now give consideration to what happens when interfering signals are present and how you identify wanted from unwanted spectral components, dominant, sub-dominant or otherwise dynamic range constraints at this initial Spectrum Sensing analysis stage. This problem is at the heart of what DSA technology seeks to both address and overcome and thus of foundational relevance to the Spectrum Monitoring Pilot Program.

The Datod Algorithm cited in the Electronics World article can accurately identify each of these eleven spectral components, to two decimal places in respect of frequency, amplitude and phase without recourse to windowing or filtering by the application of differencing techniques for evaluating a Radio Frequency environment and especially for determining which frequencies are available for use on a non-interference basis. The penalty to be paid is the additional processing which is a factor of frequency resolution required.

As for current legacy and 3G and 4G technologies open questions arise as to how have they been engineered to address spectral efficiency and operation in this type of spectrum environment for tackling the coexistence problem and Spectrum Sharing?

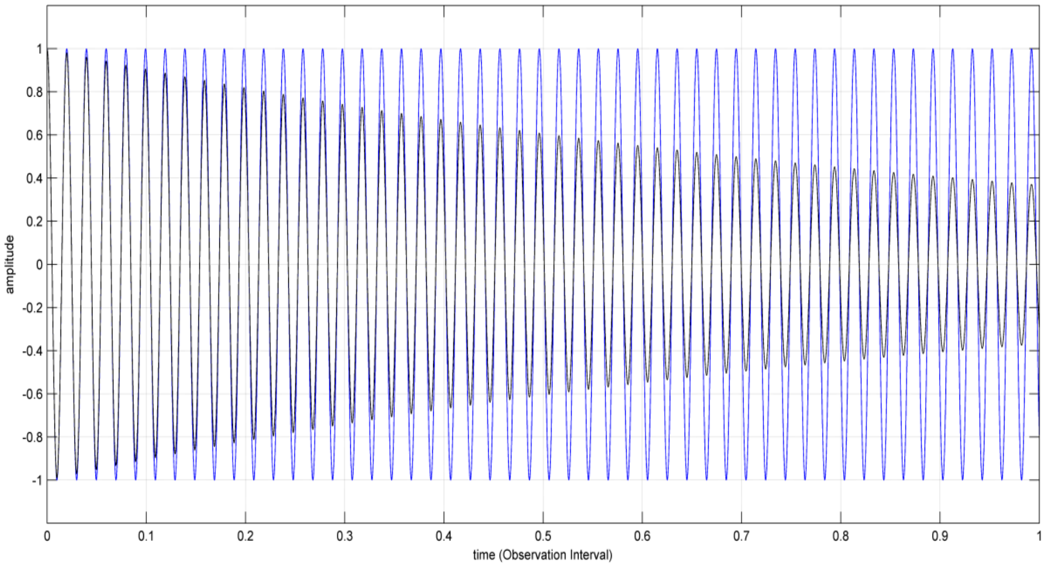
Signal Decays in Communication Systems and in Magnetic Resonance Spectroscopy.

When Fourier Analysis, augmenting a second order differential equation model, is adopted by Magnetic Resonance Spectroscopy the resulting observable time domain response exhibits a damped sinusoid response due to an applied Forced Vibration. This response characteristic is known as a Free Inductive Decay (FID) in the literature. The where-with-all of the theoretical analysis should not concern us within this submission.

Instead, it is the usual induced spectral artefacts that arise in the DFT/FFT and the work-a-round introduced that I wish to bring to the NTIA's attention as the MRS problem is an order of magnitude above the propagation attenuation decay inherent in Communication Systems.

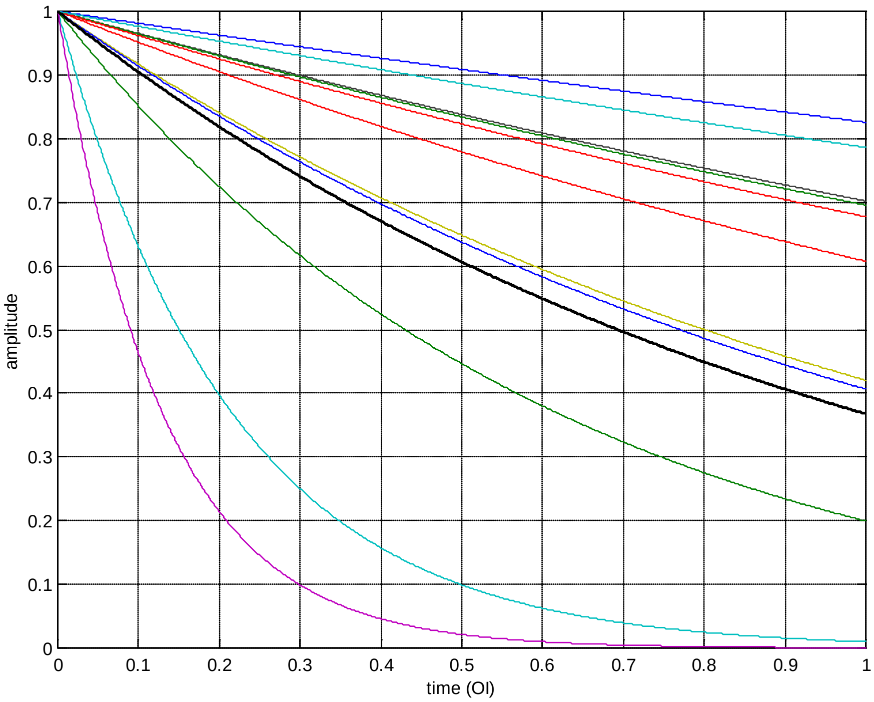
In Figure 2 we present a time domain signal comprised of a fractional 50.4 Cycles per OI signal which is overlaid with a damped exponential response due to the Forced Vibration model familiar to engineers.

Figure 2 : Free Inductive Decay Response Overlaid on Sinusoid 50.4 Cycles/OI



In Figure 3 we introduce a range of exponential roll-off time domain envelope responses that we shall apply to the individual eleven spectral components of the Datod Test Signal. In addition we introduce for reference the black line which represents the response for the unitary e^{-1} roll-off factor. Note that three of the roll-off decays are below this unitary value whereas the other eight are above this unitary roll-off response.

Figure 3 : Exponential Amplitude Decay Responses to be Applied to Datod Test Signal

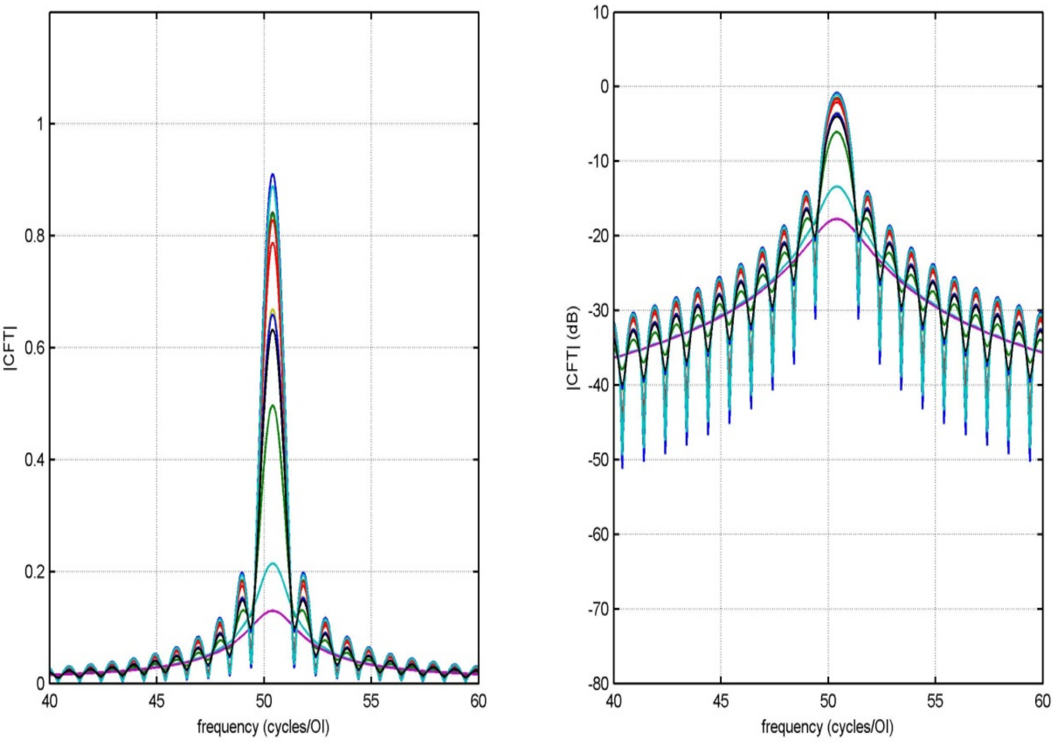


Instead of rushing to the FFT we shall now compute the individual Continuous Fourier Transform (CFT) of the theoretical response and overlay these individual frequency responses in the Normalised Magnitude scale.

For a deeper insight into the resulting frequency response profiles we shall apply all of these amplitude decays individually to a signal at 50.4Cycles per OI in Figure 4 for reference. Note that with no decay applied the theoretical response would attain unity. Observe now the shape of the frequency response of the three decayed components that are below the unitary e^{-1} roll-off factor.

One issue that shall be familiar to engineers is the establishment of Q-factor analysis and how this relates to resonance. But what familiarity, especially among communication engineers, is there with a decayed resonance being damped out over time and the importance of this aspect to physicists and chemists?

Figure 4 : Computed Continuous Fourier Transform Frequency Domain FID Responses

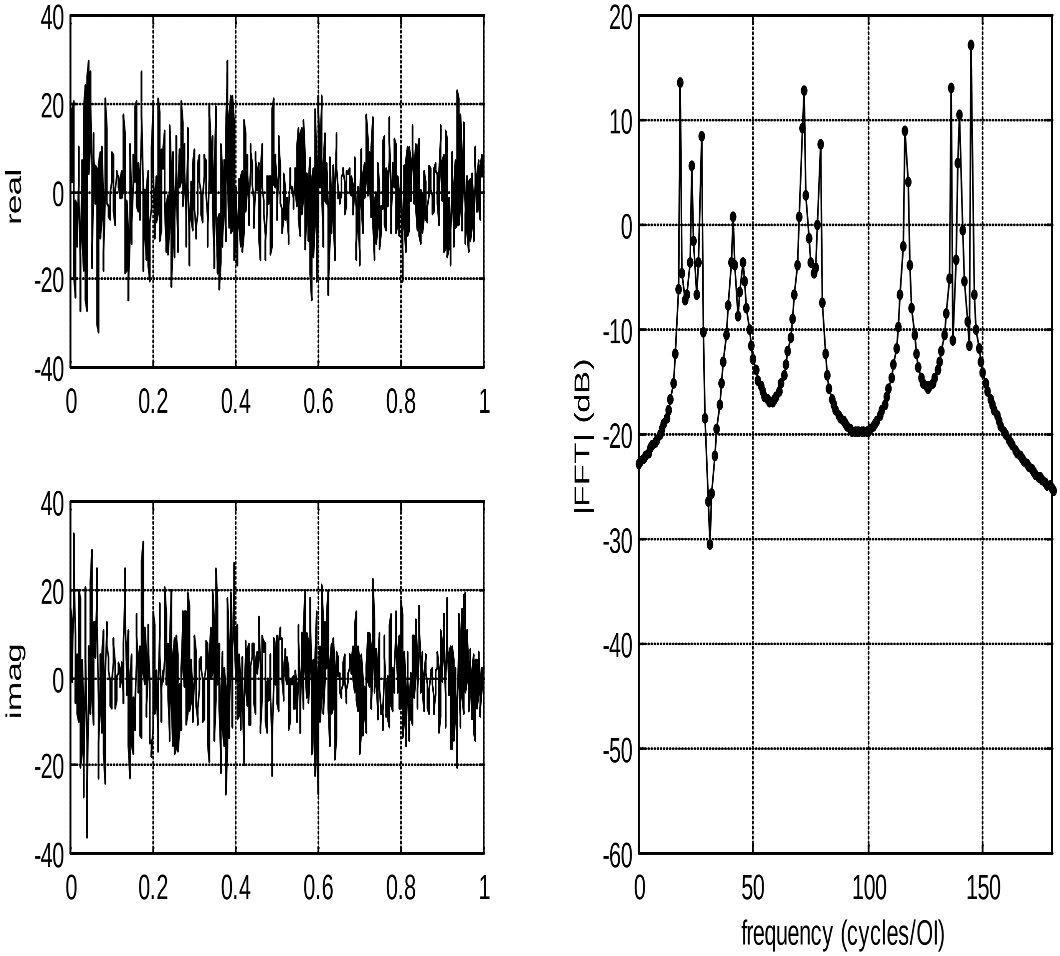


We now apply these eleven exponentially decayed responses to the original Datod Test Signal components. In Figure 5 we plot both the Time Domain and the normalised FFT magnitude response of the composite FID signal.

These diagrams should be compared with the diagrams in the first Datod article in order to gain a full appreciation of the further difficulties introduced by the decay parameters and the enhanced Datod Algorithm that was introduced to overcome the inadequacies of the FFT.

Now, if you were unaware that this FFT in Figure 5 incorporated a decay element could you tell this aspect by visual inspection?

Figure 5 : The Datod FID Test Signal with FFT



In Figure 6 we plot overlaid the eleven theoretical individual normalised magnitude CFT spectral components and in Figure 7 we plot the composite normalised magnitude FFT frequency response. Comparing both of these figures we observe the difficulty of superposition when viewed in the frequency domain and what the MRS community are up against.

Figure 6 : The CFT of the Individual Datod FID Test Signals Components Overlaid

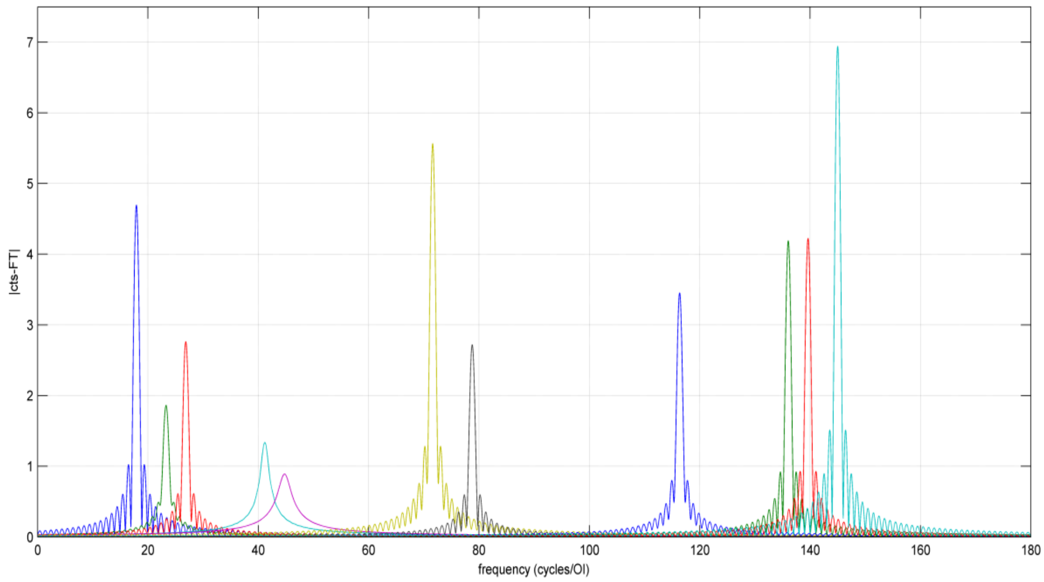
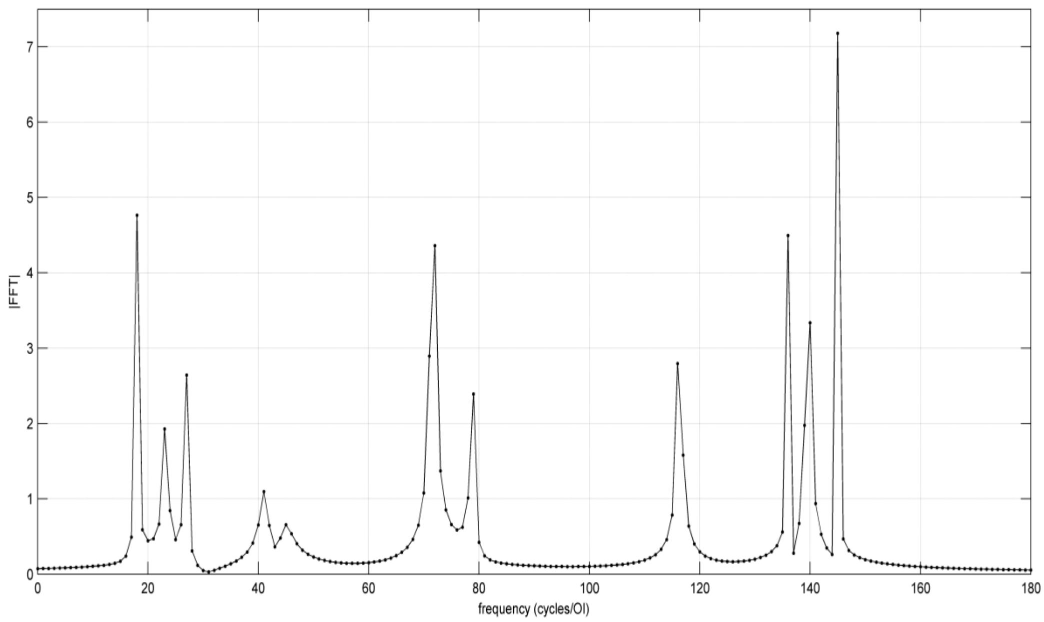
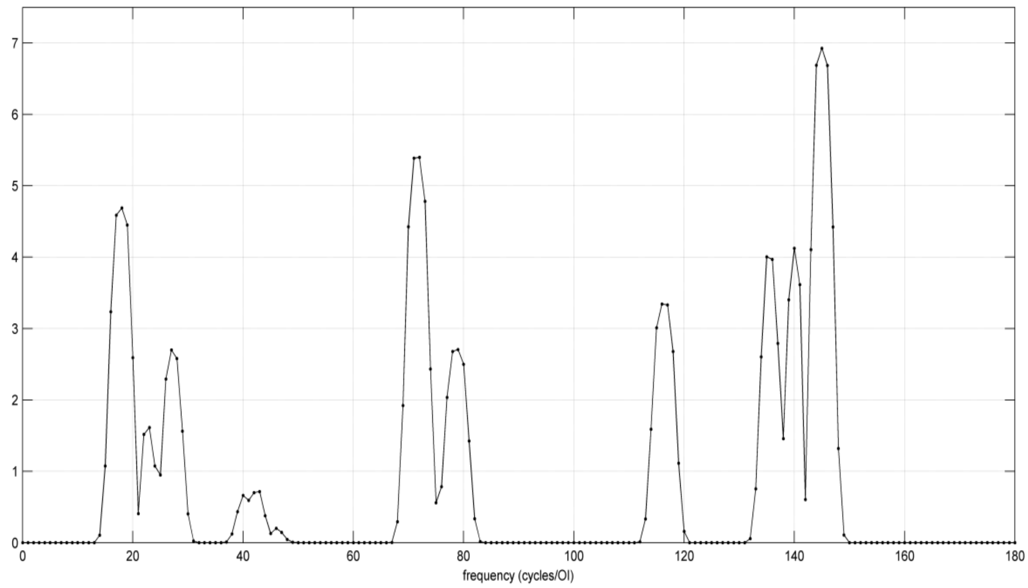


Figure 7 : The FFT of the Composite Datod FID Test Signal



For good measure we now apply Dalkie's Flat Top Window to this Datod FID Test Signal in Figure 8.

Figure 8 : The FFT of the Datod FTD Test Signal with the Dalkie Flat Top Window



Observe the effect of line broadening introduced here by the window.

Recall that Dalkie states this to be the Window reputed to give the most accurate amplitude peak information.

Unfortunately Dalkie does not consider the effect introduced by the exponential decay due to a Forced Vibration case. How do these amplitudes compare with the individually plotted theoretical responses from Figure 6?

One traditional example of the application of this Datod Algorithm is that it is still possible not only to accurately identify the time domain parameters but by a careful synthesis of each spectral component they can be differenced from an “Actual Frequency Spectrum” (not the FFT spectrum) measurement for analysis of the residual signals by a careful application of the true Analysing Function properties.

The objective of this approach is to apply differencing techniques in the frequency domain to complement the adoption of the Superposition Theorem with applies to Time Domain Samples. Differencing is the true complementary technique: not filtering.

Technical issues related to Convolution and Correlation are not discussed in these published articles

Now we delve into the work-a-round introduced by the MRSpectroscopy community. In the recent survey paper ^{1}H MR Spectroscopy of the Brain: Absolute Quantification of Metabolites: Jansen, Backes, Nicolay & Kooi: Radiology : Vol 240 : No 2 : Aug 2006 outline the State of the Art of the FFT applied to essentially “count molecules”. With the FFT this task is a big ask. What this MRSpectroscopy community does is essentially “peak” the FFT spectrum, component by component, applying first a Quadrature Phase Cycling rotation operation and then apply a line fitting algorithm such as the Lorentzian, Gaussian or Voigt model response profile between the “peak” and the “half-height” of the FID frequency response. Compare the signal response at 116.35 Cycles per OI in Figures 6,7 and 8. What dose the NTIA consider to be an acceptable margin for error in this line fitting approach? Note: without the decay parameter a quadratic would suffice for line fitting although this step is unnecessary in communication systems.

The Datod Test Signal applied in this submission is of the composite form:

Signal is of the form $$s(t) = \sum_{k=1}^{11} A_k e^{-M_k t} e^{2\pi i (f_k t - \theta_k)}$$

Listed in Table 1 are both the calculated parameters and estimated results from application of the Datod FID Algorithm.

Table 1 : Datod Exponentially Damped Frequency Response FID Estimation Algorithm Results

Identified Signal Parameters

	Frequency f_k (cycles/OI)		Decay parameter M_k		Amplitude A_k		Phase θ_k (cycles)	
	Actual	Estimated	Actual	Estimated	Actual	Estimated	Actual	Estimated
Sig 1	17.90	17.9000	0.1915	0.1915	5.16	5.1605	0.87	0.8700
Sig 2	23.27	23.2698	1.6120	1.6117	3.75	3.7506	0.93	0.9299
Sig 3	26.85	26.8500	0.4987	0.4998	3.51	3.5119	0.26	0.2600
Sig 4	41.17	41.1702	4.6210	4.6202	6.24	6.2423	0.16	0.1601
Sig 5	44.75	44.7501	7.7016	7.7093	6.85	6.8559	0.87	0.8701
Sig 6	71.60	71.6000	0.8664	0.8664	8.32	8.3199	0.24	0.2400
Sig 7	78.76	78.7600	0.3536	0.3536	3.23	3.2300	0.65	0.6500
Sig 8	116.35	116.3500	0.9002	0.9002	5.24	5.2399	0.97	0.9700
Sig 9	136.04	136.0400	0.3629	0.3629	5.00	4.9999	0.66	0.6600
Sig 10	139.62	139.6200	0.3894	0.3895	5.10	5.1001	0.87	0.8700
Sig 11	144.99	144.9900	0.2407	0.2408	7.81	7.8105	0.01	0.0100

Note: N=1000 half-interval samples over the OI.
Initial frequency range 0-180 cycles/OI in steps of 0.1.
50 Iterations examined here.

4) Federal Register Open Questions

As well as requesting submissions on all aspects of the proposed pilot program (discussed above) the NTIA specifically invited comment on the following questions placed in the Federal Register for this Spectrum Monitoring Pilot Program:

1. How should a measurement system be designed to measure a variety of emissions, including weak or intermittent signals, airborne platforms, and radar systems, while keeping incremental costs in check? With the eventual goal of adopting a distributive Synthetic Instrumentation Architecture solution operating via the Internet and the Cloud.
2. What types of measurement/ monitoring techniques should be used for the different types of radio services? No Comment.
3. What frequency bands should initially be measured during the pilot phase of the program? The NTIA should consider as a minimum the Test Bed bands, the FCC mHealth band, WhiteSpace bands together with the GPS bands. Note: possibility to revisit LightSquared/GPS interference issue with a view to providing a workable solution as a Test Case or another Test Case needs to be sought for a technical demonstration of the system.
4. How should measurement and monitoring parameters (e.g., resolution and video bandwidths, sampling rate, dwell time, detector selection, antennas, pre-selector filtering, dynamic range) be specified? No comment.
5. Which geographic locations within major metropolitan areas or other communities throughout the country would provide the greatest value for the pilot? No comment.
6. How should individual measurement units be deployed in each community? No comment.
7. How could the long- or short-term placement of multiple fixed units within the same general geographic area improve the accuracy and reliability of the data collected in each community and at what incremental cost? No comment.
8. How could mobile or portable units be utilized to supplement data collected at fixed sites within a community and at what incremental cost? No comment.
9. How long should measurement data be collected to provide statistically relevant results, particularly for intermittent operations, at each geographic location? No comment.
10. How should the measurement system design take into account variations in population densities, buildings, terrain and other factors within or surrounding selected measurement locations (i.e., in urban, suburban, and rural parts of a metropolitan area)? No comment.
11. What steps can be taken to eliminate or minimize the possibility of hidden nodes when conducting measurements? Airborne spectrum sensing and monitoring elements required to be incorporated into system.
12. What kind of spectrum utilization and occupancy information (e.g., precise received field strength levels, time-of day occupancy percentages, times that signals are measured above specified thresholds) would be most useful to spectrum stakeholders? No comment.
13. What detection thresholds should be used to measure and characterize the usage patterns of incumbent systems? No comment
14. What data and information would be useful in evaluating potential sharing compatibility with wireless broadband devices? No comment.
15. How can the gathered data and analysis better inform spectrum policy decisions, enhance research and development of advanced wireless technologies and services? No comment.
16. What data formats and evaluation tools should be employed? No comment
17. How can the large amounts of measurement data be effectively managed, stored, and distributed? Through the creation of new companies specifically dedicated to this task.
18. What steps can be taken to ensure that sensitive or classified information will not be revealed to unauthorized parties? Only solution is for gathered signals to be processed on a minimum number of HPC centres in secure environments fed by unprocessed Time Domain Sample Data prior to distributing processed spectrum information.

Concluding Remarks:

Whereas the NTIA in its Test Bed should be seeking to explore DSA Technology, which is still in its infancy, to a higher measurement standard than that which is commercially available with the current generation of Vector Signal Analysers and Spectrum Analysers and especially their Joint Time Frequency Spectrogram estimation techniques for accurate signal crossover tracking, alignment, detection and recovery in order to gain a fuller appreciation of the technical limitations and true potential of DSA technology for Spectrum Sharing.

Consequently for a national roll out of a Full Spectrum Monitoring System, circa 2020, required to mitigate interference, especially for life-critical mHealth systems, and to permit Spectrum Sharing it shall need to address the historical problematic issues related to Fourier Analysis and the DFT/FFT discussed in this submission and published Datod articles.

The NTIA Pilot Program should therefore seek to begin to tackle these issues with a view to a standardised globalised monitoring system promulgated through a forthcoming ITU-WRC in a transparent manor.

All Datod Algorithms discussed in this document are intended to be applied in future Synthetic Instruments operating on Real Time High Performance Computers within the Cloud via the Internet. Consequently they can be held securely without disclosure and only need to be fed with Real-Time Time-Domain Samples.

It is unclear as to how the NTIA budgetary submission relates to this eventuality.

Datod believes that an eventual commercially affordable and deployable global Spectrum Monitoring System shall have to adopt this format strategy and architecture.

The issues at stake are the US and the NTIA's technical excellence and technical leadership in this field.

Prepared and submitted by:

Barry McKeown