LabVIEW Powers Next Generation Phase Noise Analyser

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Category:
Communications

Products Used:
NI LabVIEW Full Development System V6.0.2
LabVIEW Signal Processing Toolkit

The Challenge: To create a compact, integrated instrument that simplifies the process of phase noise analysis.

The Solution: A custom hardware platform capable of accepting a variety of instrumentation modules, all integrated using LabVIEW and LabVIEW Toolkits.

Abstract
This paper describes an innovative new phase noise analyser for measuring the properties of radio and microwave signals. This instrument has been developed for the worldwide market by Australian company Poseidon Scientific Instruments, manufacturers of the world's lowest noise microwave signal generators. The high-level operating software for this industry-leading instrument is entirely written in LabVIEW, although it looks nothing like a conventional LabVIEW front panel. The interface is designed to be familiar to users of other high-end analysers on the market, with a custom push button panel, and no mouse, keyboard, or PC "look-and-feel". Commercially this application represents another significant example of LabVIEW competing directly, and very successfully, as a general purpose technical programming language with the likes of C, C++ etc. It also illustrates LabVIEW's particular strength as an environment for integrating different kinds of hardware and sub-systems.

Why Build a Phase Noise Analyser?
Phase noise is the deviation from ideal phase of a signal. It is commonly observed as the timing jitter of a periodic signal. Phase noise sets a fundamental limit to the throughput, resolution, and quality that can be achieved in any transmission system, whether it is optical, radio, cable, or satellite communications. Phase noise also sets fundamental limits to the sensitivity and resolution of radar systems.

Phase noise in the output of a system is determined by the phase noise in all its sub-systems and components. So understanding how phase noise in a component contributes to the overall phase noise of a system is critical to the process of improving signal quality and increasing system throughput or sensitivity. Measuring phase noise in signal generators or measuring the additive noise of signal processing components has traditionally been a cumbersome, expensive and somewhat mystifying process, to the point that it has a reputation of being a "black art".

Historically engineers have been able purchase "Phase Noise Test Sets" off the shelf from major instrument suppliers such as Agilent, or they have had to resort to building their own custom measurement systems. Either of these approaches results in a large integrated rack of instruments, which often could be the size of a household refrigerator. A major objective of the ODIN instrument was to overcome the large size, difficult configuration and slow acquisition speeds of these traditional approaches.

Advanced workers in the area of phase noise analysis have sought to use the Cross-Spectrum Technique to simultaneously correlate the noise detected in their measurement systems using a dual-channel signal analyser. The process of integrating the different instruments, and optimising and carrying out the various measurements that make up Cross-Spectrum phase noise analysis is not for the faint hearted!

The cost and associated "mystique" has kept phase noise analysis out of the reach of all but the largest or most specialised of electronics manufacturers. A compact, fully-integrated instrument that made phase noise analysis simple and cost-effective would have the potential to vastly expand the range of applications, resulting in across-the-board improvements in the quality and throughput of components and signal transmission systems.

Introducing ODIN

Poseidon Scientific Instruments (PSI) is an Australian company best known in the electronics industry as the manufacturer of the world's lowest noise microwave signal generators. Their experience with RF sources and RF signal processing led them to develop a concept for a fully integrated, two-channel Phase Noise Analyser. The concept relies on combining a proprietary analog signal handling front-end from PSI, with a digital signal processing back-end that refines and automates the sequence of industry-standard procedures that are required to make standard single channel or advanced correlated phase noise measurements. The new instrument was released to beta customers in March 2003 as the ODIN Phase Noise Analyser. The initial release operates on signals in the frequency range 6 -12 GHz, and targets PSI's traditional customer base in the high end performance Radar, RF, and microwave markets.

Figure 1 shows a schematic of ODIN's major sub-systems, including a fully integrated Phase Lock Loop and Signal Generator. All operations of ODIN are under the control of a LabVIEW software application. The LabVIEW application handles data acquisition, internal communications between the various instrument modules, signal processing, and all operator interface functions.

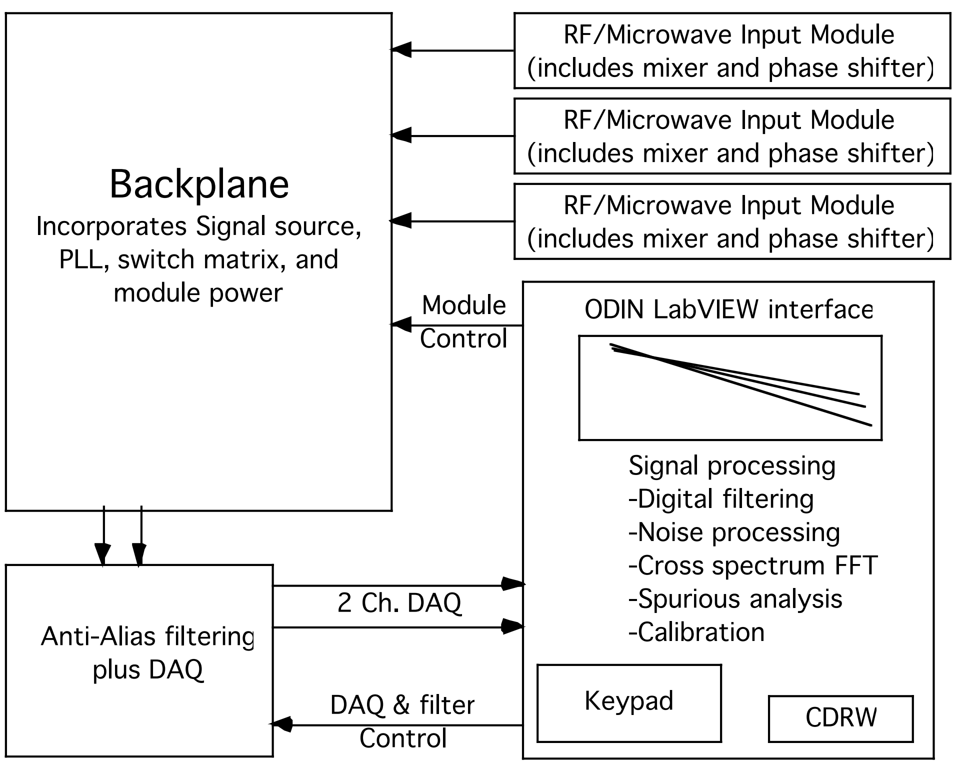

Fig. 1 – ODIN Phase Noise Analyser schematic. There is provision for three input modules, any two of which can be switched to the 2-channel DAQ analyser.

ODIN was designed from the ground up as a PC-based instrument, to maximise its ability to be reconfigured with different instrument sub-systems, and to allow its signal processing functions to be readily upgraded and extended. After reviewing several alternatives LabVIEW was chosen as the software development environment because of its strengths in integrating different hardware and sub-systems, and its strong credentials as a real-time signal processing environment.

Although PSI clearly embraced the concept of ODIN as a PC-based instrument, for marketing reasons they were adamant that the final product not look like a PC. It was designed to be familiar to users of other high-end signal analysers on the market, with a custom push button panel, no mouse, no keyboard, nor a PC “look or feel”. The LabVIEW application interface looks nothing like a conventional LabVIEW front panel. Figure 2 shows the ODIN instrument, and Figure 3 shows the LabVIEW operator interface. Figure 2 clearly demonstrates the compact nature of ODIN compared with the alternative of a complete rack of instruments needed for some systems.

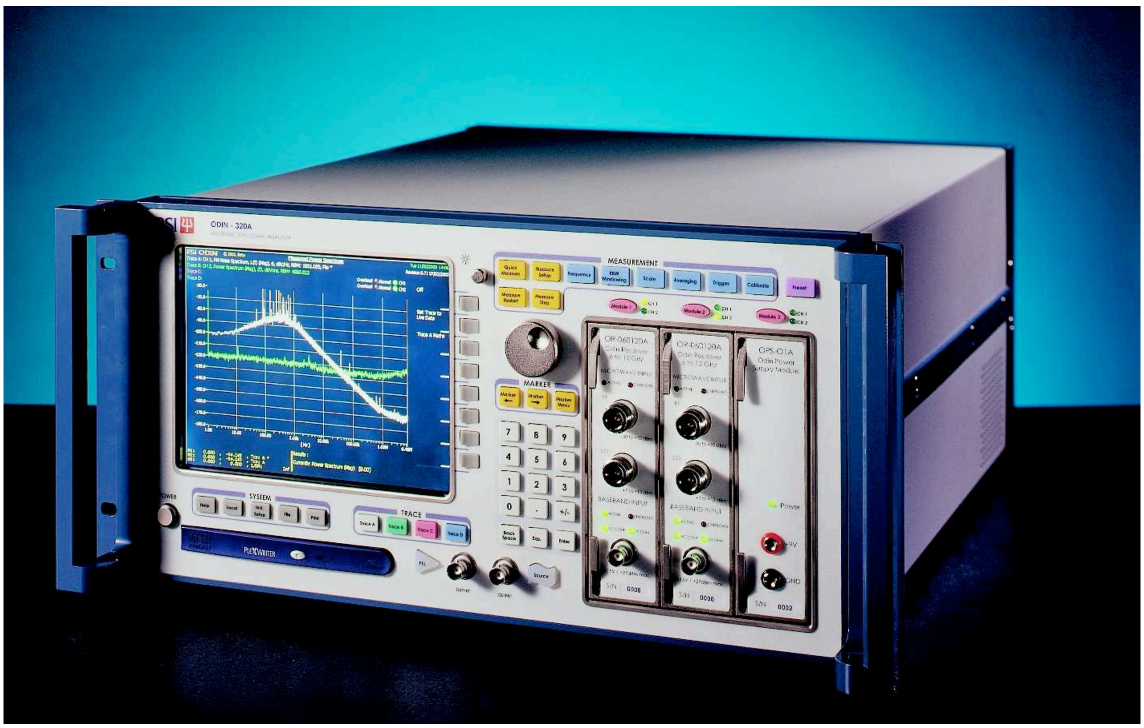

Fig. 2 – The ODIN Phase Noise Analyser.

As a fully integrated two-channel instrument ODIN can take two simultaneous measurements and automatically calculate the spectrum, transfer function or cross-spectral density of the two input signals. In the two channel cross-spectrum mode it passes correlated noise only, automatically rejecting the contribution to phase noise of its own mixers, amplifiers, filters etc allowing measurements to be made which are only limited by the Nyquist thermal noise of the input signals. As well as being as the world’s first fully integrated and automated Phase Noise Analyser, it also functions as broadly capable two-channel signal analyser making it a versatile and useful instrument in research, development laboratories, and production environments.

“The Software Is The Instrument”

It is difficult to make precise estimates of the cost and time savings that ODIN offers over the traditional approaches to phase noise analysis, because this is the first time this class of measurements has been available on a single instrument. However, ODIN is priced competitively with more traditional instruments yet offers far greater measurement flexibility, capacity, and expansion than conventional instruments. Ultimately its greatest value is likely to be the extension of phase noise analysis as a standard technique into a much broader range of end-user customers, through its ability to “de-mystify” what has previously been a tedious and sometimes daunting measurement for the operator.

ODIN’s most immediate application will be in areas linked directly to the telecommunications industry such as telephony, wireless, digital radio, radar etc, that operate in the 6 -12 GHz band. However its modular design means that in principle it could be tuned to other commercially relevant spectral bands, to bring the benefits of phase noise analysis to other industry sectors such as photonics.

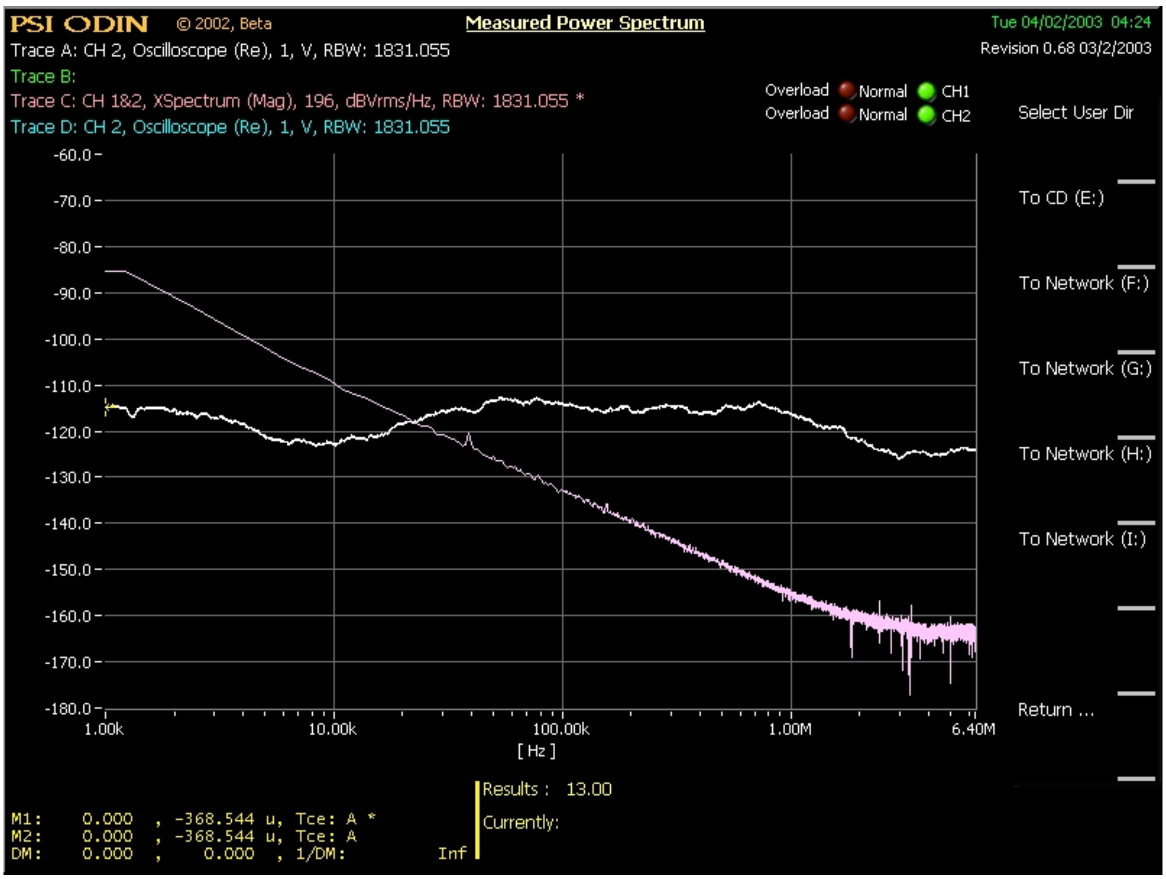

Fig. 3 – An ODIN screen shot – not your average LabVIEW “look and feel”! The traces show the phase noise from two DRO oscillators, as a spectrum (pink trace), and as a real-time voltage display as it would normally be viewed on an oscilloscope (white trace).

It is difficult to imagine that ODIN could have been brought to market as successfully without taking advantage of PC-based virtual instrumentation technology. The flexibility of the PC platform running LabVIEW software to integrate different instrument sub-systems, and to implement and sequence complex signal processing techniques, were critical aspects of the successful development. The ability to extend and re-sequence the signal processing functions has already opened up opportunities to enhance the base instrument by adding new functionality and automating complex tasks. In every sense ODIN is a classic example of the catch cry “the software is the instrument”.

In particular, ODIN represents another significant example of LabVIEW competing directly, and very successfully, as a general purpose technical programming language with the likes of C, C++ etc. Although the conventional LabVIEW “look and feel” was hidden, the initial feedback from customers was very positive when they discovered LabVIEW was the ODIN powerplant. As high-end players in electronics design and test, they were already very familiar with the power of LabVIEW. They saw this as a very logical extension of their software experience, and gave them confidence in the reliability, maintainability, and flexibility of ODIN’s software engine.