Application Note

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Re-configurable test solution for advanced wireless test

Much has been written about the future of mobile radio design. A popular view is that in the future radios will be software defined. Could this view be extended to radio test equipment too?

Abstract

This article looks at the potential for re-configurable and software defined test equipment for use in radio system design and manufacturing. An example is given of a new approach to test being introduced by Aeroflex for RF signal analysis along with a review of the various software environments available in the market today that could be the key to truly re-configurable and software defined radio test equipment.

Introduction

The pace of change in today's new era of digital communications demands rapid product development cycles. This poses challenges for both radio system designers and test equipment suppliers alike. The question being asked by many is how do we break the cycle whereby test solutions are always lagging behind the curve. The usual scenario is one where test equipment vendors are reluctant to commit to system specific equipment too early for fear of making design decisions that are difficult to reverse later when standards or market conditions change, and for very good reason. So to manage the risks, test equipment vendors do their best to ensure that their equipment is 'flexible.' Whatever the definition, this flexibility usually means the vendor will do its best to keep up with changes in the market just as long as it suits them. This is determined either by their view of the market potential or by the technical constraints of the underlying platform. So what happens when, having made an investment decision, the customers' and vendors' timescales and product route maps become unaligned? Every day test equipment suppliers are bombarded by requests from customers who want features and improvements added to existing equipment as their needs change. The dilemma for test equipment vendors is which customers' needs to cater for and which to let fall by the wayside.

It's no wonder that so many laboratories around the world are filled with test systems comprised of a mixture of purchased and self-developed components. The instrumentation RF designers are forced to develop for themselves is rarely well supported, has a limited life and is expensive to repair. Furthermore, the activity is rarely costed properly.

Figure 1 - 2319E Simple PC Applications

Hardware for data capture

This all begs the question, is there a better way? How can equipment vendors maintain the pace and satisfy all their customer needs? A clue to a possible solution can be found by taking a lesson from history and then re-applying it. The PC is made up of hardware and software. Both are mutually dependent upon the other yet the domains are kept very independent of one another. PC manufacturers and software houses each drink harmoniously from the same pool but each sticks rigidly to their own side.

A test instrument is made up of a system for capturing the signal of interest and a system for processing and presenting the results of analysis. Historically, both systems have been integrated within a single instrument. This results in two side effects. First, the design is largely "frozen in time." The processing power is finite and very soon becomes the limitation on future expansion. Second, a user's application lies outside of the box and cannot be integrated without the cooperation of the test equipment vendor. Test equipment vendors have therefore created a barrier to application development outside of their own laboratories. Much has been made of the benefits of integrating PC architecture into instruments but very little has been done to welcome in suppliers of application software. There are various reasons why this is so, such as protecting valuable IPR, an inherent entwined relationship between applications software and instrument hardware control or a deliberate oversight to safeguard a captive market.

Many RF Test equipment suppliers have hurried to integrate standard PC capability to their instrumentation. This very integration may be their Achilles heel. PC and DSP technology evolve much faster than RF and microwave technologies. A decision made in the early design phase of a test instrument to use embedded PCs immediately condemns the product to an early grave. A test instrument can spend at least 2 to 3 years in development, and then expect to spend 5 years in the market. How many people would be content working with a 7-year-old desktop PC? The very fact that PC technology is more volatile means that finding a reliable long-term source of embedded PC technology can be difficult. As a rule, test equipment vendors endeavour to support their products for 7 years after withdrawal from sale. To do so with embedded PCs can force vendors into last-time-buy decisions very early in a product's life committing themselves to large component inventories whose cost is passed on to their customers in one way or another.

So to the punch line…breaking the eternal cycle is simple. Do everything to capitalize on the power of the PC, but avoid integrating it inside an instrument. That is unless you plan to re-design the product every year like a 1960s Cadillac. However, if the PC and the instrument are separated, a new challenge is created. Careful consideration must be given to how they interface. The instrument is now collecting RF signals, (a hostile environment) and communicating them to the PC as digital information (a friendly environment). The digital information must be a faithful representation of the RF signal. The instrument is therefore an RF Digitizer, devoid of any knowledge or concern about the nature of the measurement being made, but designed to provide a conduit between RF and digital domains without adding or subtracting anything from the original signal and retaining both the phase and amplitude information contained in the signal. The digitizer must also present the PC with data samples conveniently configured to suitable interfaces that meet the needs of the application. Some applications will demand high volumes of data to represent the signal of interest and others will need only low rate data. By matching the interface with the needs of the applications the best economies can be achieved.

This is in summary the philosophy behind the new IFR 2319E 500 MHz to 2.5 GHz RF Digitizer. This instrument re-defines the boundary between signal capture and signal analysis, and in doing so opens up the possibility for engineers to get ahead of the game and develop test solutions which match specific test needs.

Software Environments

The serving application can now be defined entirely by software residing outside the instrument. The application that will extract the required information from the digitized data samples can be trivial or highly complex. It can be customer specific or general purpose. The available options open to the customer are three-fold. Use commercial off-the-shelf software from a third party, develop or commission their own application code or use that supplied by the manufacturer of the digitizer.

Looking around at the software engineering tools available today there are numerous packages widely in use with engineers that can accept digital IF or digital IQ data samples as their input. These tools include household names such as LabWindows CVI™, LabView™, Matlab™, Mathcad™, System View™, ComponentWorks™ and so on. Each has some merit, and will be a favorite of somebody somewhere. Some of these packages provide very useful features to reduce application development times for instance, higher level API, built in interfacing and data manipulation functions. Another potential benefit of these application development tools is the ease by which code written for one can be re-used in another. Much is owed to the work being carried out by groups such as the IVI foundation in this respect.

Visual C++ gives advantages in terms of flexibility and execution speed. Visual BASIC would usually allow more rapid application development, particularly for the software developer with little C or C++ experience. LabWindows CVI™ is a development environment provided by National Instruments which comprises an ANSI standard C compiler. It incorporates a Data Acquisition Library for interfacing with the DAQ hardware. Another development tool is LabView 6i™. This is a complete development environment that can be used to produce applications. LabView™ is a graphical integrated development environment, so it might be more suited to the non-C/C++ developer who would like to produce powerful applications without getting into the detail and complexity of text-based coding.

Aeroflex has chosen to develop applications using Visual C++ 6 with ComponentWorks++™, along with NI-DAQ libraries. National Instruments ComponentWorks ++ provides class libraries for analysis and acquisition of data along with components for displaying the data. This choice is based upon Aeroflex's experience working in C/C++, and the low-level flexibility and power of the language. To develop in C or C++ provides the ability to code in detail down to the lowest level and it also provides fast execution times. Aeroflex applications under development are a mixture of general-purpose tools and customer specific test cases focussed primarily on the 2G, 2.5G and 3G advanced digital wireless marketplace.

Figure 2 -NI Data I/O interface to 2319E

Interfacing alternatives

To cater to the widest variety of application needs, the interface between the digitizer and the PC needs to accommodate low, medium and high rate data transfer. The data must also be open to manipulation. Data should be IF or IQ samples with definable sample rates.

A variety of interface choices exist which are appropriate to the PC environment. Some require protocol like GPIB, USB, Firewire, Ethernet or MXI-3. Others do not, such as those supported by commercial DAQ I/O plug-ins and LVDS (low voltage differential signalling) which provides a very fast interface for digital IF or IQ samples. The IFR 2319E RF Digitizer incorporates three interfaces for data transfer. For low speed transfer combined with instrument control GPIB can be used. Higher speed transfer is supported through a custom parallel interface compatible with National Instruments DAQ products such as the DIO-32HS from the DIO 6533 device family. This can be used to interface directly with TTL IQ or IF data samples. The PCI-DIO-32HS card is driven using the NI-DAQ software from National Instruments who provide functions for use in C/C++, BASIC or Pascal. These functions provide the means of configuring and controlling the card and transferring captured data from the card into the PC memory. This mode of interface can be expected to accommodate transfer rates of up to a few 10s Ms/s.

Figure 3 - Sundance PCI DSP/FPGA card

Alternatively, a plug-in DSP card such as can be found from Sundance Technologies Ltd., can accept data transfer rates of several 100's Ms/s using an LVDS (low voltage differential signalling) interface. Sundance Technologies range of products is based upon the Texas Instruments Mezzanine (TIM) standard making them highly configurable. A range of plug-in modules provides DSP and FPGA resources. The host card can be PCI, cPCI or VME based. Using this power, real-time applications are possible such as system emulation, i.e. demodulation of UMTS mobile transmissions. By using a dedicated DSP card, the host PC CPU background processing activity does not interfere with critical high speed applications.

Conclusion

If maximizing the effectiveness of capital investment is your concern or you have a desire to develop test system solutions based on inherently flexible tools; then re-defining the boundary between signal capture and signal processing through the use of an RF digitizer coupled to commercial high power PCs and software tools may be the answer. This approach can not only deliver highly flexible measurement capabilities, but can also be used within system simulators. The ability to stream real-time data samples to programmable DSP cards provides a very open architecture for system simulator designs.

Aeroflex's latest developments in this area are purposely designed to maximize flexibility. The 2319E RF Digitizer will convert RF signals between 500 MHz to 2.5 GHz and with powers up to 50 W into digitized IQ or RF data with a bandwidth of up to 20 MHz, a resolution of 12 bits and sampled at up to 65M s/s. Its RF performance is designed to meet the toughest requirements for communications systems measurement including those of real-time applications. In doing so Aeroflex has shown that software re-configurable RF test equipment is a reality and demonstrates several advantages over the standard integrated test instrument approach.

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Our passion for performance is defined by three attributes represented by these three icons: solution-minded, performance-driven and customer-focused.

Part No. 46891/897, Issue 2, 07/05