

A COMMON CORE APPROACH TO RF INTERFACE DESIGNS

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Abstract – Designing test systems based on commercial-off-the-shelf (COTS) instrumentation can reduce non-recurring engineering costs and time to production by providing a reusable infrastructure that is usually based on industry standards. Custom designs can result in high maintenance costs due to premature obsolescence; these implementations often lack adequate documentation required for sustained support activities. The high frequency signal components resident in RF/Microwave subsystem designs often prohibit the use of more generic COTS-based solutions that are developed to address a broader range of applications, thus driving the need for a custom solution. This paper will discuss a unique approach to RF interface and signal routing development that combines COTS hardware with innovative embedded web design tools.

INTRODUCTION

[RF/Microwave interface units](#) (RFIU's) typically route high frequency signals between test instruments such as spectrum analyzers and synthesizers, and devices under test for a variety of application spaces and needs. Incorporating common core scalable, reconfigurable COTS hardware in the design helps manage costs by reducing non-recurring engineering hours, minimizing lead times, and providing a standard platform that can be reused to meet changing requirements. Additionally, COTS solutions are well-tested and documented and enable a repeatable manufacturing process that can be supported for long periods of time.

There will always be instances that necessitate custom solutions and these can also benefit from a COTS design approach because of significantly reduced development times and lower non-recurring costs. The benefits of LXI Class A instruments have provided the basis for a COTS core interface that VTI has leveraged across all of its RFIU designs. The communications interface integrates the versatility of industry standard Ethernet with additional features that ensure a high degree of synchronization as well as

compatibility with a broad range of complementary products.

A patented web-based graphical design wizard is incorporated to streamline the specification and development process that leverages a comprehensive online database of preferred components. The process continues with an embedded design wizard that 'personalizes' the RFIU and lays the foundation for path-level programming. This tool automatically generates support documentation and web-based graphical user interfaces to allow system engineers to focus their time on the design and routing of the internal component layout specific to the application, greatly reducing development costs and time to production.

SELECTING THE DESIGN APPROACH

A fundamental question that arises during the design process is whether to pursue a modular architecture utilizing COTS components or one that is fully integrated. A modular approach makes use of building blocks, or 'slices' that directly expose component I/O to the user (see figure 1). [Modular designs](#) are generally quite flexible and can be quickly reconfigured through external cabling to assume a variety of topologies.

Using the building blocks shown in Figure 1 (14 SP6T relays) external cables can define a number of different configurations such as dual 1 x 36 multiplexers, or a 6 x 6 matrix. This approach can provide significant cost savings as it reuses common assets to address multiple requirements. However, the additional cables and connections may add insertion losses and degrade the overall integrity of the signals passing through the interface. Test requirements will dictate whether this approach can yield acceptable results.



Figure 1: Modular RF Switch Building Block

An alternative approach involves configuring a completely [integrated design](#). Integrated designs are customized to meet specific application requirements, and embed the entire solution within a subsystem chassis (see Figure 2). This approach will ultimately result in the best performance and deliver the highest level of signal integrity; additionally, advances in embedded core development tools make it possible to reconfigure and reuse components to meet future needs.

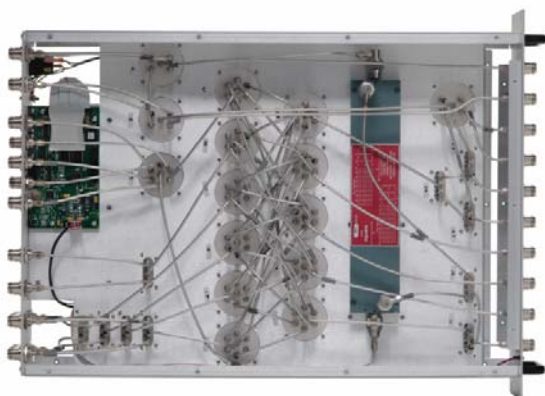


Figure 2; Integrated Box RFIU

Different application requirements will dictate which approach is to be used. Systems that must test a variety of devices will generally use a modular solution because it can be adapted to test different DUTs with minimal time and effort. Other systems may have more complex design requirements which require an integrated subsystem, and both of these instances can benefit from a core COTS-base methodology.

COMMON CORE METHODOLOGY

Even custom subsystems incorporate a number of common operations that are repeated during the design and build phases; a number of these phases are identified below:

- Communications and control selection
- Component selection and qualification
- Software driver development
- User test program set code development
- Bill of Material generation
- Wire lists and signal routing tables
- Assembly instruction generation

An innovative COTS common core development kernel can be seen in [VTI's RFIU LXI-based Class A communications and control interface](#). The three main components of the kernel are the patented embedded web interface, a digital communications board which is the main interface to the host controller, and an open-collector component driver board to generate the control signals for the microwave relays.

Flexibility, scalability and reusability are the primary objectives behind this design are. The embedded web interface simplifies setup and implementation with intuitive built-in configuration tools and path-level programming functionality. Complicated signal paths involving multiple relays and settings can be combined into one path-level command greatly simplifying top level programming tasks. Furthermore, as requirements change the web interface can quickly modify the configuration and generate new path-level command, wire lists and BOM.

The [common core](#) can be scaled to provide drive control in 72 channel increments, and expanded to a 576 channels. Additionally, the digital control board also contains non-volatile memory to store system documentation and a device configuration file. This information is used to automatically generate a custom web-based graphical user interface and is the basis for IVI path level switch programming. These features significantly reduce development and debug time for systems engineers.

This approach also allows modular and custom designs to benefit from open industry standards. For example the IEEE-1588 protocol enables very precise synchronization and deterministic over-

the-wire triggering as part of LXI Class A standard operation.

DEVELOPMENT PROCESS

VTI's [Broadband Integrated Design Wizard](#) greatly simplifies the entire development process through a number of automated tools. RFIU design typically includes research and selection of components that meet the application requirements. Preferred vendor lists are commonly used in the industry to maintain a manageable pool of sourced components. The flexibility of the internet was leveraged to develop a searchable online components database that is automatically integrated within the development process. The interface has been developed to include key specifications that can be entered via pull down lists, to quickly display a subset of parts that meet design criteria (see Figure 3).

COMPONENTS : ATTENUATORS

MAX FREQUENCY (GHZ)	4
STYLE	Variable
CONNECTOR TYPE	N
POWER LEVEL (WATTS)	2 or less

TOTAL NUMBER OF ITEMS: 6 [LIST](#) [Add Component to Database](#)

Attenuators, also known as pads, are a lot simpler than they may seem. Though attenuator can mean a variety of things, when referred to in an RF or Microwave system it is a broadband resistive device that drops the amplitude of the signal going in by the designated amount, generally given in dB. Attenuators are most commonly designed for 50 ohm systems since the vast majority of RF and

Fig. 3: Online Utility for Component Selection

The database also provides direct links to data sheets, numerous technical notes intended to educate new engineers, current pricing and lead time information. Once selected, components are added to a configuration list and the details are stored online. All the pertinent information relative to the RFIU design (i.e., component model numbers and quantities) is included. Saved configurations can be easily accessed and made available to all team members. This online component selection utility not only reduces design hours, but also provides the framework for expediting subsequent processes in the development cycle.

Since the LXI digital interface is 'Ethernet-enabled', the system configuration information is uploaded directly through an automated process that is part of the online configuration utility. The configuration data from an SQL database is converted to Extensible Markup Language (XML) data which is uploaded directly to the interface.

XML is not necessarily intuitive for a software engineer who is looking to develop test program application code. Therefore, a Java-based applet has been embedded on the interface control board and allows further customization of the assembly in a point-and-click environment. An XML file is then automatically generated that will be targeted by the application software.

SCHEMATIC REPRESENTATION

Once the component list has been uploaded in XML format to the digital board, the wiring process can begin using the embedded configuration utility resident on the control board. Path level definitions and connections can be easily assigned and modified with this intuitive interface. Figure 4 shows a 2 x 6 matrix schematic that uses 8 relays and 20 wires. The goal is to translate the schematic into an XML file that will virtually define the assembly's wiring.

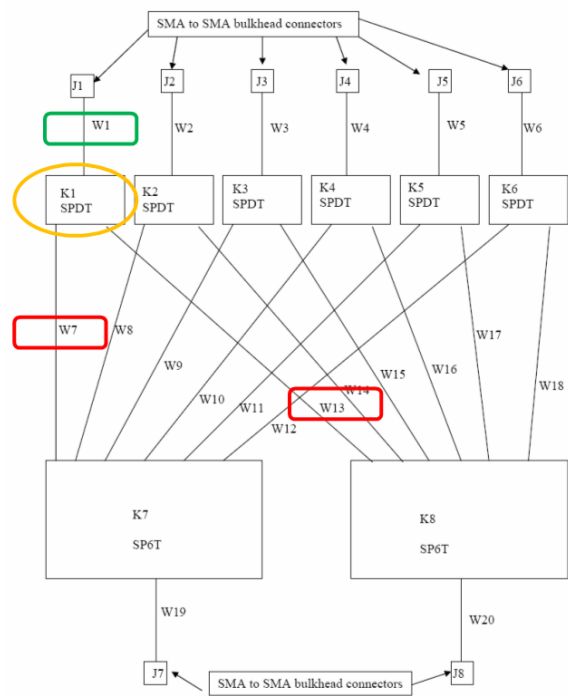


Fig. 4: Top-level Schematic of 2 x 6

Each component in the configuration can be quickly assigned a logical name and virtually connected to other components using the embedded interface. Figure 5 illustrates a panel within the embedded web interface that details component K1. This intuitive process allows

users to specify connections between pins on individual components; each pin is assigned the same wire name for simplified identification.

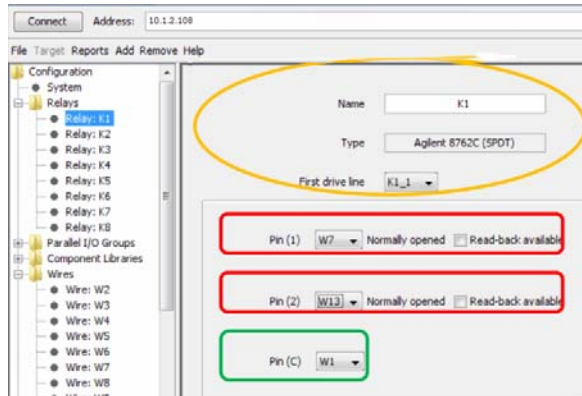


Fig. 5: GUI for Schematic Generation

For example, K1 port 2 and K8 port 1 are connected in the schematic, and are both assigned the label 'W13' by the web interface, while K1 port 1 and K7 port 1 are assigned the label 'W7'. Once the schematic has been translated using this tool, the XML file can be loaded on the digital board; this effectively stores the unique personality of the subsystem in memory on the unit. This methodology is analogous to downloading music files onto a player, effectively personalizing the device to meet specific requirements.

SOFTWARE DEVELOPMENT

Conformance to the LXI standard mandates industry-standard IVI drivers as a minimum requirement for an application programming interface (API)². The IVISwitch driver is used to program the RFUI and provides an API that connects functional paths, as opposed to closing individual coils on relays.

The XML file (schematic) that was generated by the design wizard maintains a database of all the system interconnects, including the logical names of end points. Software engineers are not required to delve into the internal details of the RFUI and architect software based on individual components nor do they need to generate a list of possible paths. The virtual schematic provides this information and the end-to-end connection statements can now be made to establish desired (see statement below).

driver->Path->Connect ("J8", "J1")

This command activates coils on two different relays (K1 and K8) with a single function call using an industry standard API. Software development time is greatly reduced because the IVI driver is common to all system designs. Further, the digital interface can be reconfigured on-the-fly to adapt to new system layouts by uploading a new XML file. This is particularly useful for applications that utilize modular building blocks and test adapters as part of the system architecture.

DESIGN DOCUMENTATION

Aggressive schedules, combined with custom or application specific requirements, typically mean delivering subsystems to the field as quickly as possible, and documentation is often an afterthought. However, comprehensive documentation is critical for long term support and maintenance, as well as ensuring a repeatable build process for future requirements.

VTI leverages an open standard COTS communications interface, so documentation generation can be leveraged across multiple subsystem designs. Furthermore, because the IVISwitch driver is common to all modular and integrated subsystems, the documentation is readily available as part of an html file, and through the IVI Foundation³. The LXI Class A compliant digital interface simplifies synchronization with other LXI-based instruments with the LXIsync API used to invoke LAN events and triggers for.

The XML file also contains all of the individual component information, including OEM part numbers that can generate a comma delimited value-based (.csv) bill of materials through the design wizard. Wire lists also play an important role in providing the tools needed to maintain fielded subsystems. All interconnects have been captured, including those to passive components, as well as wire lengths, and types. The design wizard can also create a .csv based wire-list for manufacturing activities. Both .csv files can be easily edited and customized to meet changing requirements.

Finally, the XML file provides the information to generate a customized soft front panel accessible through a standard web browser. Simply enter the IP address in the address toolbar; no additional coding is necessary. Figure 6 shows an example of a soft front panel which allows immediate point

and click monitor and control capability of the RFIU. The interface also includes detailed component information including model numbers, specifications and cycle counts.

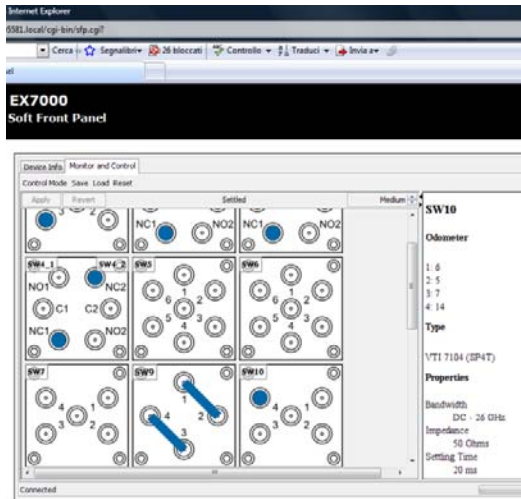


Figure 6: Monitor and Control GUI

These displays can be accessed from anywhere in the world through the LXI interface, turning a custom-designed solution into a product that is designed for supportability.

SUMMARY

Custom RF interface designs present many challenges that can result in excessive non-recurring engineering time, driving system cost and extending production cycles. However, it is now possible to extract common core elements that are scalable and reconfigurable for use in all designs. A standard infrastructure, based on a COTS toolset, can be reused in many different applications to minimize non-recurring engineering (NRE) costs, reduce risk, and speed time to test.

Scalable open-architecture hardware and software designs also ensure that the common core implementation can evolve to meet changing needs from product development, to production, and through support in the field. Additionally, long product support cycles can be addressed with minimal exposure to product obsolescence while providing a viable upgrade and expansion path.

REFERENCES:

¹ W3C Website, www.w3c.org

² LXI Standard Revision 1.1

³ IVI Foundation Website, www.ivifoundation.org

VTI INSTRUMENTS

VTI delivers precision instrumentation for electronic signal distribution, acquisition, and monitoring, which is used in the world's most demanding test applications. Our solutions provide reliable data first time, every time. Serving the aerospace and defense, power generation, energy, automotive and commercial electronics industries, VTI's solutions allow our customers to optimize their capital investment through product longevity while ensuring unmatched measurement integrity and data reliability. ISO 9001 certified, with plants in the U.S., Europe and Asia, worldwide product support is provided through a network of VTI certified engineering representatives. VTI is a sponsor member of the VXI Consortium, a founding member of the LXI Consortium and an active member of the VITA open standards organization. For additional information, please visit <http://www.vtiinstruments.com>