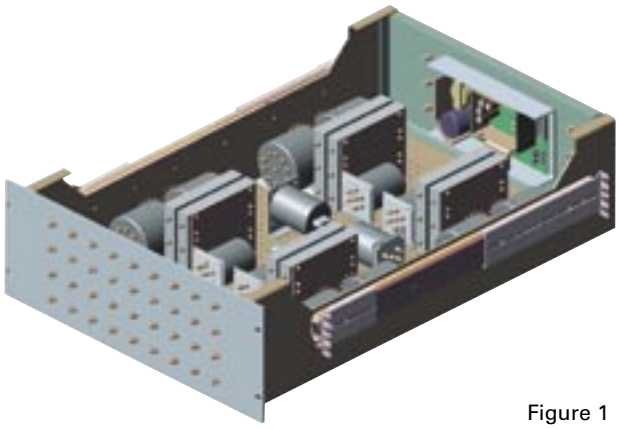


Figure 1

Technical Note

Microwave Switching

Introduction

Historically, the design and implementation of microwave switch systems has been a highly specialized process that necessitated the acceptance of custom designs and interfaces by the customer. Each manufacturer would adopt their own unique flavor of interface, and effectively restrict competitive entry based upon proprietary hardware and software driver designs. Furthermore, many designs were based upon the collective knowledge of a few select individuals, rather than on solid quantitative engineering practices that could be consistently reproduced.

Additionally, most microwave subsystems were designed with one unique function in mind, and the concept of re-usability was seldom considered. If system requirements changed throughout the years these rigid designs were difficult to modify, and often resulted in new systems being procured thus greatly reducing the overall benefit derived from ones initial investment. New advances in computer aided design, manufacturing processes, and test hardware are revolutionizing this industry, and providing the end user with new founded options and flexibility commonly expected in most other areas of test system design.

The Slice

Typically, most traditional microwave switch systems have been configured as a single integrated unit, intended for a single unique use with little or no consideration for reusability. The migration of military and aerospace markets towards commercial-off-the-shelf (COTS) hardware solutions has influenced the microwave switch subsystem arena as well. Systems can now be configured in reusable slices that can be mixed and matched with other devices and subsystems. The VXI platform is ideal for this transition primarily due to several inherent advantages in the VXI specification.

VXI Technology, Inc. pioneered the microwave slice which can incorporate a variety of switches that can be connected to other modules containing additional switches, splitters, amplifiers or attenuators. Clearly, if expansion is required a completely new proprietary switch system is not required, because you can simply order a new slice that performs the function that is required. Several slices can be seen in Figures 1 and 2.

This approach not only provides the end user with a tremendous amount of flexibility when initially configuring the system, but it also permits the ability to modify the system at a later date without being faced with non-recurring engineering and design costs common throughout the industry.

Design Revolution

One of the key developments that have lead to this evolution in microwave switch design has been the explosion of low cost desktop computing power. Even a decade ago, most 3-D modeling applications were limited to dedicated Unix-based systems that were neither user friendly, or attractive from a cost standpoint. Therefore, these systems were not widely adopted throughout the industry. The desktop PC explosion has resulted in the availability of relatively inexpensive computers with capacity and computational power only dreamed of in the recent past.

VXI Technology incorporates dedicated state-of-the-art 3-D design and assembly tools, specifically SolidWorks™, to ensure that component layout and critical interconnect cable routing is performed consistently every time (See Figure 3). This approach ultimately results in reduced cable paths, guaranteed phase matching, improved signal integrity, and high density compact system solutions. Overall system and engineering costs are also reduced using these techniques because extensive microwave component libraries can be compiled and reused in subsequent designs. Additionally, time to market is also reduced because processes are not reinvented with each design.

The evolution of these tools is one of the primary reasons that custom microwave assemblies can be

Figure 2

designed and implemented in a manner that moves them from the realm of a "black art" into that of modern engineering. Additionally, it is essential that once a design is complete that the manufacturing process be implemented in a controlled and repeatable fashion. Some of the most critical performance specifications that systems designers are concerned with when dealing with microwave signals are voltage standing wave ratio (VSWR), insertion loss, phase matching and isolation. Therefore it is not a coincidence that these are also some of the most difficult parameters to control during the assembly process.

Selecting microwave subsystem components with world class specifications will not necessarily result in a world class final product, especially if the manufacturer does not have the tools and processes in place to assemble and test the completed subsystem in a reliable, repeatable fashion. A typical microwave assembly will contain a variety of components such as single and multiple pole switches, transfer switches, amplifiers, attenuators, mixers, and splitters. Furthermore, defining these various components is in many respects the lowest risk aspect of the process. Detailed component specifications are available from a number of reputable microwave manufacturers, but assembling these parts in a cost effective manner that will result in acceptable system performance is the real challenge.

Determining the optimum system layout and component location is a major concern to the manufacturer. Design considerations that are inconsequential at low frequencies become critical at higher frequencies, and these include:

- Minimizing signal path lengths
- Standardizing path lengths
- Standardizing rigid and semi-flex cable bend radius
- Component placement

Therefore, the end user should be aware of the process that will result in the best performance, and ensure that these processes incorporate tools such as SolidWorks™ modeling and simulation.

Manufacturing Repeatability

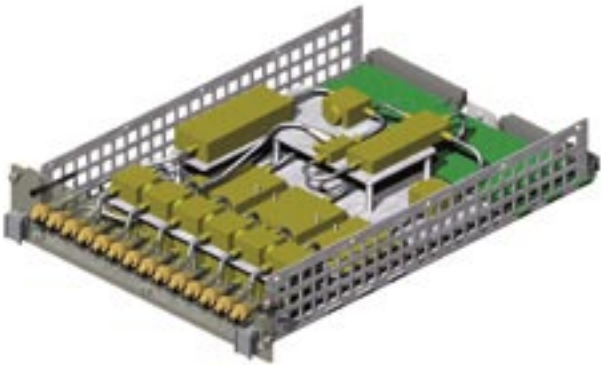
Another critical aspect of any microwave manufacturing process is the repeatability of the manufacturing process. As discussed previously, knowing the specifications of individual components is not sufficient when specifying the performance of a microwave slice. The performance of the integrated slice, therefore, cannot be completely defined by reviewing the sum of the components. Other items must be considered such as device interconnections, the bend radius of rigid and semi-flex cables, component placement, and manufacturing variances between like components.

Simply penciling out a rough layout, and hoping that manufacturing personnel will perform fine adjustments and route interconnect cabling correctly is not an acceptable approach in todayís marketplace. Furthermore, when multiple systems are manufactured over some finite period of time, it is nearly impossible to maintain consistent manufacturing processes and system performance using this outdated approach. It is entirely feasible to have two systems, manufactured at six month intervals, which look and perform significantly different.

Developing assembly aids is therefore a critical aspect of assuring an end product that can be reproduced in a repeatable, high quality fashion. These aids are generated directly from the automated design systems, and include cable routing diagrams and bend radius requirements. Furthermore, assembly fixtures are incorporated into the process to remove the uncertainty and variability which is possible when different operators and assemblies are involved.

Test

The unique challenges faced by design and manufacturing engineers when frequencies reach 18 GHz, 26.5 GHz, 40 GHz, and beyond, are also experienced by the test engineering community. To accurately perform manufacturing test and characterization at these high frequencies, sophisticated test equipment and techniques must be utilized. The overall performance of the slice must be characterized and documented, which requires test equipment that can sweep through the entire operational range.



Microwave Switching

Characterizing an integrated slice in this manner will provide the user with detailed system level performance of key design parameters such as VSWR, isolation, and insertion loss. VXI Technology utilizes high performance Vector Network Analyzers (VNA) for this function because of the instruments ability to generate a known test signal that is swept through the entire operational range. The results of this swept test will provide detailed performance data that will be critical to the end user once the slice is integrated into the test station. Failure to provide such test data will place the end user at a distinct disadvantage once their system is completely integrated.

The performance characteristics of microwave components, and therefore the completed slice, will vary with frequency. Subsequently, without these test details it will be difficult to determine how well the actual unit under test is performing.

Summary

The evolution of technology has raised expectations on many levels; therefore, microwave system and test designers should be no exception. Accepting design and manufacturing practices pioneered in the sixties and seventies, while perfectly acceptable at the time, are outdated and not competitive today.

Our Microwave Configurator is yet another example of our desire to decrease the efforts and uncertaintity associated with configuring a microwave subsystem. This tool allows the end user to build their microwave slice utilizing a web based, intuitive pull-down menu aimed at simplifying the component selection process (See Figure 4). The configurator provides access to online data sheets, pricing, specifications, and also generates an Excel compatible reference file.

Figure 4