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Technology Focus: Test & Measurement

Ka-Band TWT High-Efficiency Power Combiner for High-Rate Data Transmission

Two-way combiner waveguide circuit can be concatenated for 2^n-way combining.

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A four-port magic-T hybrid waveguide junction serves as the central component of a high-efficiency two-way power combiner circuit for transmitting a high-rate phase-modulated digital signal at a carrier frequency in the Ka-band (between 27 and 40 GHz). This power combiner was developed to satisfy a specific requirement to efficiently combine the coherent outputs of two traveling-wave-tube (TWT) amplifiers that are typically characterized by power levels on the order of 100 W or more. In this application, the use of a waveguide-based power combiner (instead of a coaxial-cable- or microstrip-based power combiner, for example) is dictated by requirements for low loss, high power-handling capability, and broadband response. Combiner efficiencies were typically 90 percent or more over both the linear and saturated output power regions of operation of the TWTs .

Figure 1 depicts the basic configuration of the magic-T hybrid junction. The coherent outputs of the two TWTs enter through ports 1 and 4. As a result of the orientations of the electromagnetic fields, which also provides a needed high port-to-port isolation, of these two input signals and the interior design of the magic-T junction, the input powers are divided so as to add in phase at one output port (port 2), and to be opposite in phase and hence cancel each other at the opposite coplanar output port (port 3). The net result is that the output power at port 2 is essentially double that of the output of one TWT, minus the power lost in the magic-T hybrid junction. Optimum performance as a high-efficiency power combiner thus requires a balance of both power and phase at the input ports of the magic-T.

Replicas of this two-way combiner can be arranged in a binary configuration to obtain a 2^n-way (where n is an integer) combiner. For example, Figure 2 illustrates the use of three two-way combiners to combine the outputs of four TWTs.

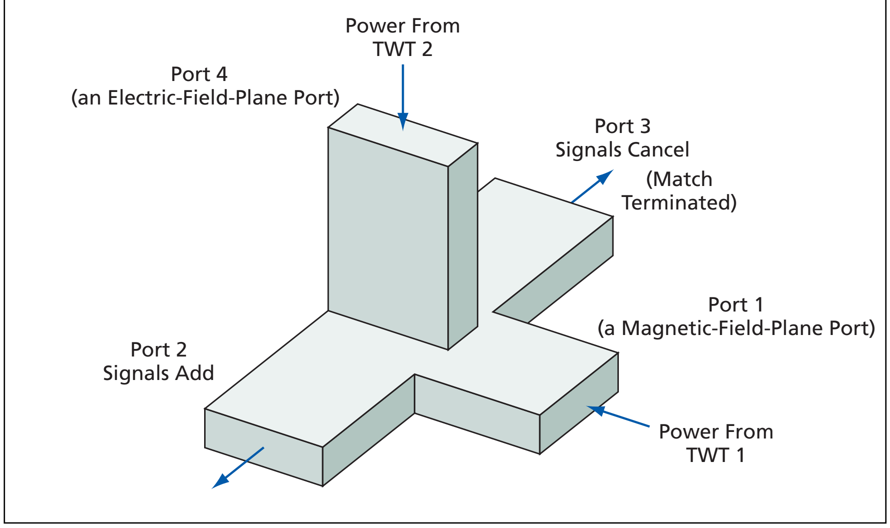


Figure 1. Basic configuration of a four-port **Magic-T Hybrid Waveguide Junction**. In the present application, coherent signals entering via input ports 1 and 4 add at output port 2 and cancel each other at output port 3.

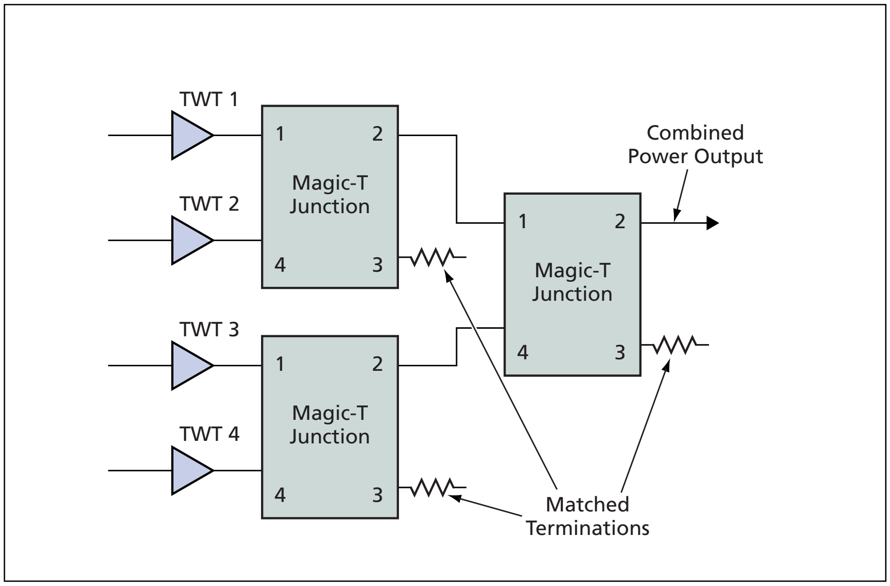


Figure 2. This **Four-Way Power Combiner** consists mainly of three magic-T junctions like that of Figure 1 in a binary configuration.

In data transmission tests at the Deep Space Network carrier frequency of 32.05 GHz, it was found that, because of the broad maximum in peak output power at the sum port, a phase-modulated narrow bandwidth data signal could be transmitted at a rate of 8 Mb/s via this power combiner with no observable error. However, a 622-Mb/s data signal (for which a minimum bandwidth of 311 MHz was required) initially could not be transmitted because of a large drop in signal power at the band edges. The large drop was the result of significant phase imbalance at the input ports of the magic-T hybrid junction resulting from a large difference between the rates of change of phase with frequency, which in turn was caused by a large difference between the electrical lengths of the two TWT signal paths. To correct for this disparity in electrical lengths, it was necessary to add a dispersive circuit element to one of the paths, thereby reducing the difference between the rates of change of phase by more than an order of magnitude. This correction made it possible to transmit the 622-Mb/s signal at a very low bit error rate (10^{-8}).

The helical TWTs used in the above demonstration have bandwidths of at least 9 GHz. By maintaining a balance of phase with changes in frequency at the input ports, it is thus possible to extend the operational bandwidth of the magic-T hybrid junction, which was observed to be at least 3 GHz, to that offered by the inherently wide band individual TWTs.

This work was done by Edwin G. Wintucky, Rainee Simons, and Karl R. Vaden of Glenn Research Center; Gary G. Lesny of Alphaport Inc.; and Jeffrey L. Glass of ZIN. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18092-1.

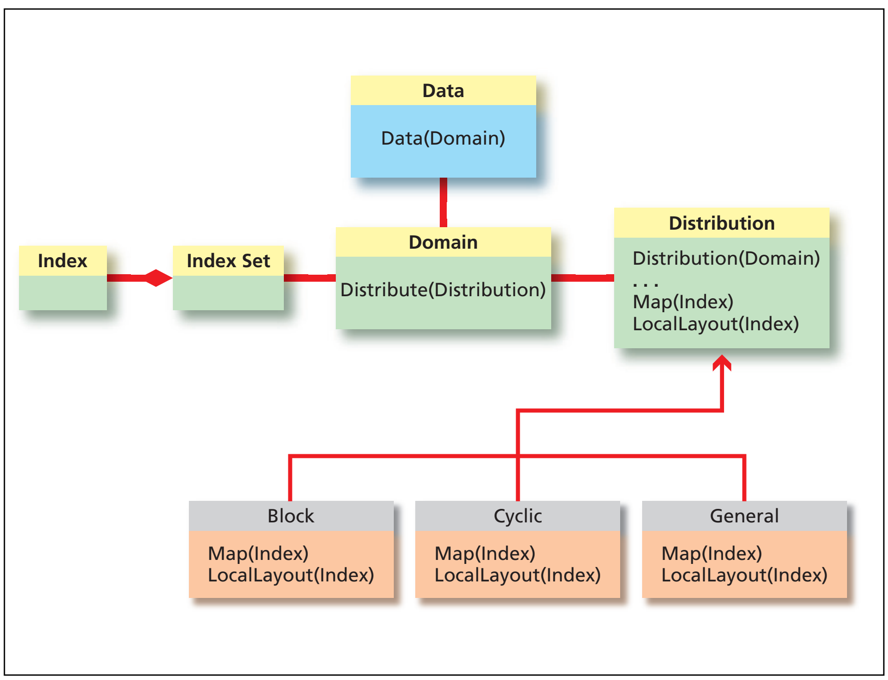
Reusable, Extensible High-Level Data-Distribution Concept

Users can optimize distributions for parallel computing, without concern for tedious details.

NASA's Jet Propulsion Laboratory, Pasadena, California

A framework for high-level specification of data distributions in data-parallel application programs has been conceived. [As used here, "distributions" signifies means to express locality (more specifically, locations of specified pieces of data) in a computing system composed of many processor and memory components connected by a network.] Inasmuch as distributions exert a great effect on the performances of application programs, it is important that a distribution strategy be flexible, so that distributions can be adapted to the requirements of those programs. At the same time, for the sake of productivity in programming and execution, it is desirable that users be shielded from such error-prone, tedious details as those of communication and synchronization.

As desired, the present framework enables a user to refine a distribution type and adjust it to optimize the performance of an application program and conceals, from the user, the low-level details of communication and synchronization. The framework provides for a reusable, extensible, data-distribution design, denoted the design pattern, that is independent of a concrete implementation. The design pattern abstracts over coding patterns that have been found to be commonly encountered in both manually and automatically generated distributed parallel programs.



The **Items Named in the Boxes** are the elements involved in defining a distribution.

The following description of the present framework is necessarily oversimplified to fit within the space available for this article. Distributions are among the elements of a conceptual data-distribution machinery, some of the other elements being denoted domains, index sets, and data collections (see figure). Associated with each domain is one index set and one distribution. A distribution class interface (where "class" is used in the object-oriented-programming sense) includes operations that enable specification of the mapping of an index to a unit of locality. Thus, "Map(Index)" specifies a unit, while "LocalLayout(Index)" specifies the local address within that unit. The distribution class can be extended to enable specification of commonly used distributions or novel user-defined distributions.

A data collection can be defined over a domain. The term "data collection" in this context signifies, more specifically, an abstraction of mappings from index sets to variables. Since the index set is distributed, the addresses of the variables are also distributed.

This work was done by Mark James, Hans Zima, and Roxana Diaconescua of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

The software used in this innovation is available for commercial licensing. Please contact Karina Edmonds of the California Institute of Technology at (626) 395-2322. Refer to NPO-42538.