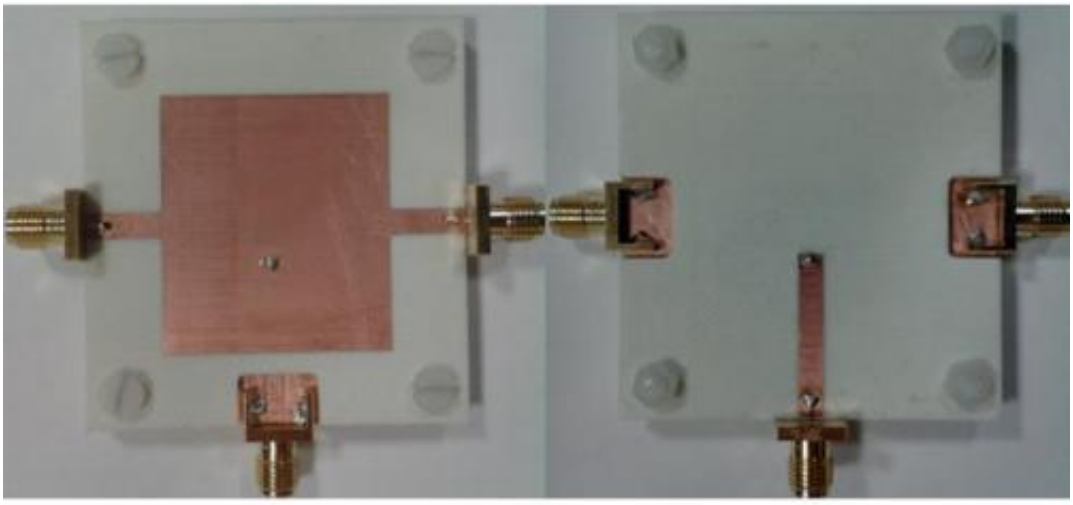
Microwave multi-tool

August 19 2014



The prototype device operates as a filter and an antenna simultaneously.

A resonator element that can simultaneously act as both a filter and antenna has been developed as a step towards creating PROMFAs - the microwave circuit equivalent of an FPGA.

Flexibly functional

A programmable microwave function array (PROMFA) is a network of microwave hardware that can be reconfigured to assume different circuit

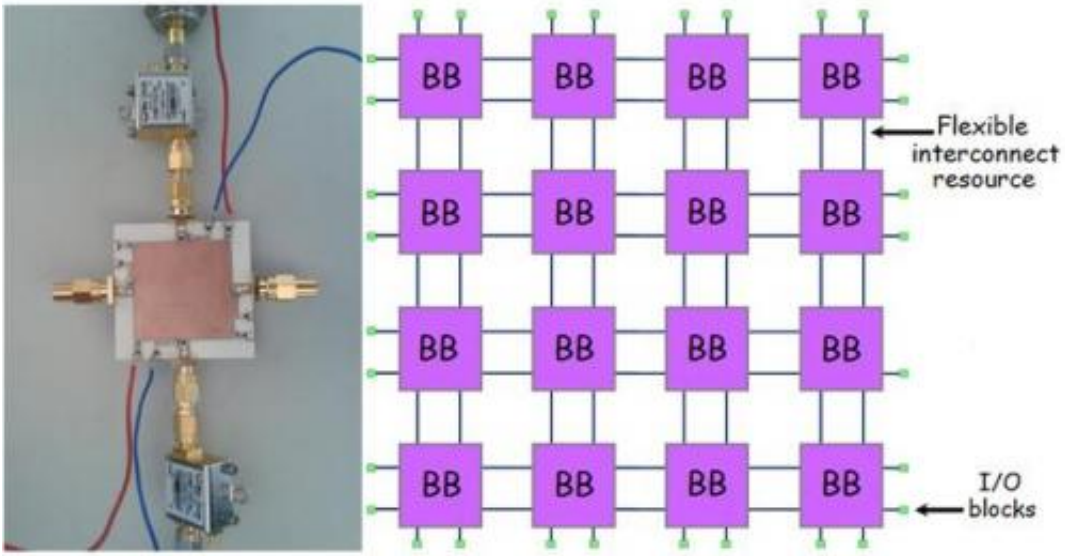
functions. "It has the potential to revolutionise the microwave industry; reducing the development time and weight of systems while increasing their flexibility" explained Dr James Kelly, one of the authors of the paper reporting the advance, published in this issue of *Electronics Letters*.

The vast majority of microwave hardware functionality is fixed at the time of manufacture, whereas a PROMFA could be reconfigured in operation; enabling the system to respond to changes in operational requirements. Such an array would consist of 'building block' elements analogous to the logic blocks in an FPGA, with each element able to assume different circuit functions, on demand, giving a lot of functionality in a compact volume.

Not only would this allow valuable volume and weight savings, it is possible that such PROMFAs could be made capable of altering their internal wiring to bypass faulty components, extending their operating lifetime. "This would be particularly valuable in applications where the hardware is difficult or impossible to access for maintenance and upgrades, such as space satellites," said Kelly. "The technology will also reduce the cost and time associated with the hardware development cycle, because components will become off-the-shelf items that no longer require customisation."

The PROMFA concept has been around since at least 1990, but its development has been hard to track, as Kelly explained: "The majority of PROMFA work has been confined to the military domain. We assume only a small proportion of the results achieved have been openly published. However, it is likely that cost and complexity have been a major drawback. It is also challenging to devise a hardware block with a simple structure that can be reconfigured to assume a wide range of different circuit functions." Reconfigurability has often meant a trade-off in performance, so that the reconfigurable device did not match the function specific performance of its single function equivalent.

Double duty



L: The authors are working on elements including microwave switches. R: Multi-function building block elements are key

In their paper Dr Kelly of the University of Surrey, UK, and Dr Alejandro Borja of Universidad de Castilla La Mancha, Spain, present a step towards creating the kind of building block element required for a true 'microwave FPGA', a hardware element that can operate simultaneously as a filter and antenna.

Consisting of a microstrip square patch resonator connected to three external ports, the device provides the different circuit functions on different ports. Designed to operate within the industrial scientific and medical (ISM) band, Kelly and Borja describe it as a proof-of-concept. "It is significant because it demonstrates that one can achieve two circuit

functions at the same time, with little or no performance trade-off," said Kelly.

"The greatest challenge was to find a way to make a single resonator perform two functions without suffering a high degree of energy coupling between the two. We achieved this by employing orthogonal eigenmodes within the resonator. Additional isolation is achieved by displacing the operating frequencies associated with the filter and antenna mode of operation."

In the short term, the volume reduction offered by their approach could be used to reduce microwave circuit sizes by combining functions within a single resonator. This could be of particular use for system-on-chip designs and they believe the same concept could be extended to other technologies like waveguides.

Flexible future

The authors believe the main factors preventing widespread uptake of PROMFAs to be the number of circuit functions that a building block can incorporate, cost and the performance trade-off. They have recently developed elements that can assume more than two circuit functions, as well as elements that provide dual-band filter performance and some that incorporate microwave switches.

They are confident that the limitations can be overcome and expect that the first microwave IC analogous to an FPGA will be realised in around 4 years, followed by ongoing research to improve the flexibility of the building blocks in terms of function and varying their operating parameters.

The authors have high hopes for the PROMFA concept: "We believe PROMFAs have great potential. Their cost, size and complexity will

gradually reduce as the technology matures. This will enable more widespread use in areas such as next generation mobile technology and satellites. We hope to see entire microwave systems implemented on a single low cost PROMFA chip. These systems would be analogous to single board computers like Raspberry Pi, which have helped to democratise access to computing technology. We hope that PROMFAs will have a similar effect in the domain of microwave engineering."

More information: "Hardware block for use in programmable microwave function arrays." J.R. Kelly and A.L. Borja. *Electronics Letters*, Volume 50, Issue 15, 17 July 2014, p. 1076 – 1077. DOI: 10.1049/el.2014.0970 , Print ISSN 0013-5194, Online ISSN 1350-911X

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