Integrated Magnetics in mmWave Systems

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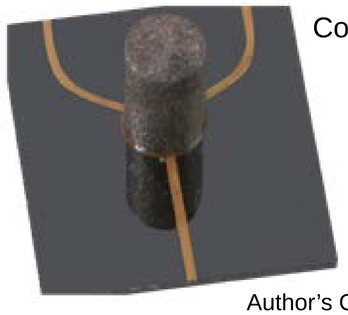
M3IC: Magnetic Miniaturized and Monolithically Integrated Components — *5G and Future RF*

Background

Program Objective: Improve the capability of electromagnetic (EM) systems for communications, radar, and electronic warfare (EW), by integrating magnetic components onto semiconductor materials.

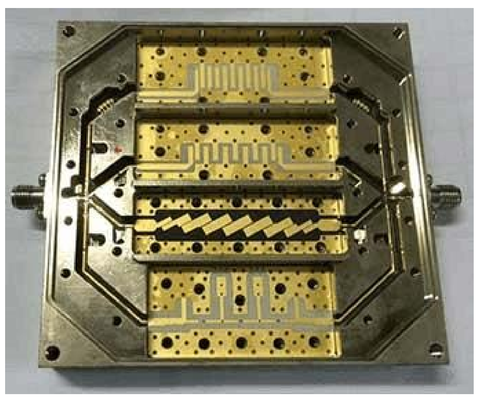
Motivation: Existing EM systems use standalone bulky magnetic components (circulators, inductors, isolators). This limits their utility in overall system performance and restricts Size, Weight, and Power (SWaP) optimization.

Solution: Reduce SWaP of the magnetic components and integrate them onto microwave monolithic integrated circuits (MMICs). This enables broader exploitation of magnetic materials and provide new mechanisms for the control and manipulation of EM signals.



Conventional Circulator

Author's Own



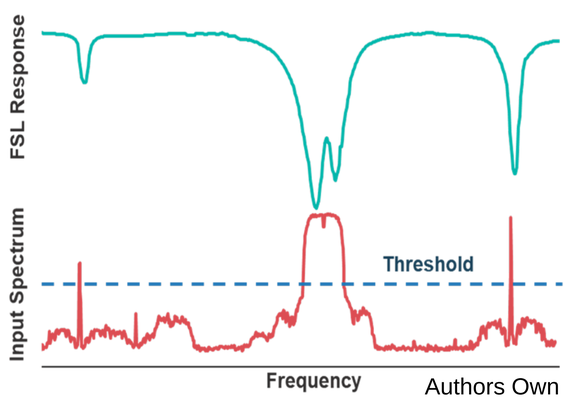
Conventional Switched Filter Bank

https://www.digitalbroadcasting.com/doc/rf-switched-filter-banks-0001

Approach

Frequency Selective Limiters: FSLs are passive devices based on crystalline magnetic films that provide automatic, adaptive, power-driven filtering. Previous FSLs have been expensive, bulky, limited in performance and difficult to integrate with modern technology.

As part of the M3IC program, Metamagnetics has worked with system integrators to develop FSLs for use in existing and future communications, radar, and electronic warfare systems. Modeling toolsets that shorten FSL design cycle, predict the FSL's system-level impact and aid in the integration of the devices were developed and validated.



Authors Own

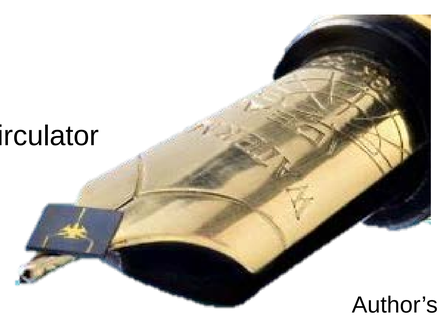
Frequency Selective Limiter

Authors Own

Integrated Self-Biased Circulators: Metamagnetics has developed a novel magnetic material that enables the integration of miniature Circulators and Isolators into semiconductor chips, at mmWave frequencies.

The breakthrough came when Metamagnetics material scientist and engineers figured out how to control the crystal structure of Barium Hexaferrite to improve all the critical material electrical properties simultaneously, while using processes and tools compatible with the semiconductor fabrication process

Self-Biased Circulator



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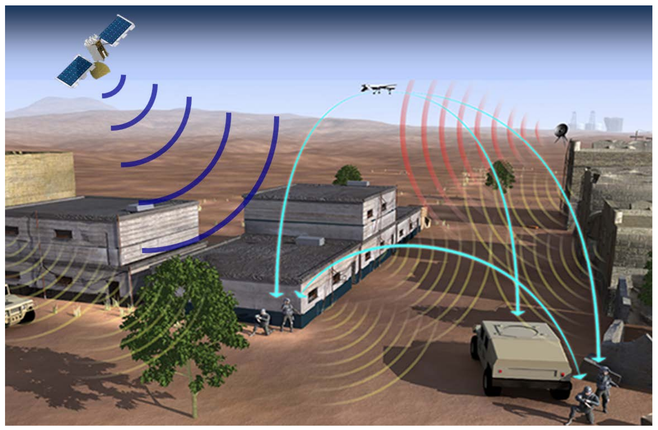
Results and Impact

FSL technology is ready for insertion into a wide variety of systems and platforms

FSL design cycle is faster and no longer empirically-driven

Systems designers can quickly evaluate FSL technology in their architectures



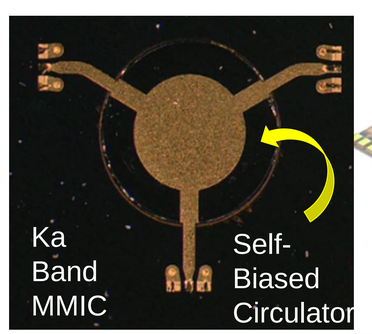
Adapted from www.shadowspear.com

Low-loss integrated Circulators demonstrated from 18-100 GHz

First ever active circuit with integrated circulator

Metamagnetics teamed with leading foundries to develop novel magnetic-semiconductor integration approaches

Future semiconductor devices can be designed with improved SWaP and EM capabilities, enabled by integrated magnetics



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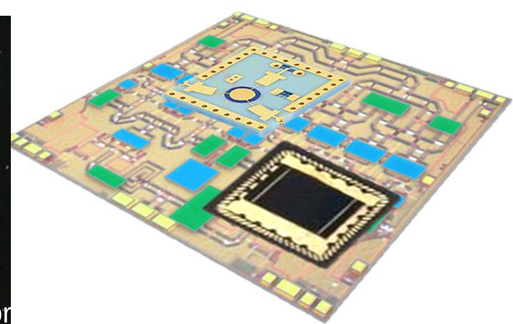

https://www.darpa.mil/program/magnetic-miniaturized-and-monolithically-integrated-components

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