METAMAGNETICS
ADVANCED FERRITE-BASED SOLUTIONS

REDUCE VOLUME, WEIGHT AND COST WITH ADVANCED SELF-BIASED CIRCULATOR TECHNOLOGY

A long-standing problem with conventional circulators is the excessive weight and bulk attributed to the permanent magnets used in their construction. This issue is particularly acute in radar systems that require thousands, or even tens of thousands, of circulators (Figure 1). For years, researchers have been trying to develop alternative technologies that do not rely upon the magnet as a key component of radar systems. While a few breakthroughs in the structure and materials used to make circulators have been achieved, finding the right balance of materials and properties has eluded researchers, who, until now, have been unable to develop a viable solution.

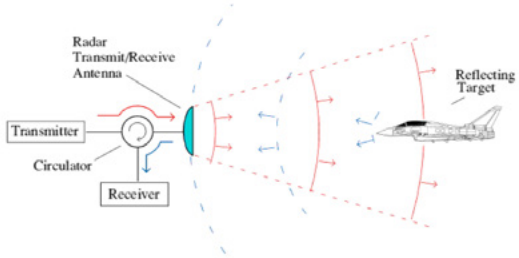

Figure 1 Ferrite circulator used to disribute signals in a radar system

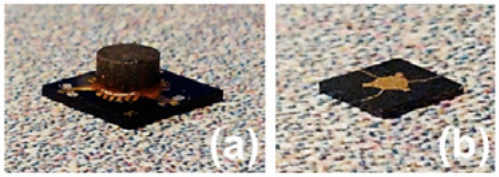

Figure 2 (a) Conventional ferrite circulator; (b) self-biased ferrite circulator

Ferrite self-biased circulators are passive components used to distribute signals in a three-port radar or wireless communication system. The magnetic material used to make this device gives it non-reciprocal properties, i.e., signals entering at a certain port can only propagate clockwise, but not counterclockwise. This property is very useful in designing radar systems, because it allows signals generated by the transmitter to be sent to the antenna, (shown in red, Figure 1), and signals coming back from a relective target to the antenna to be simultaneously routed to the receiver, (shown in blue, Figure 1). Conventional circulators typically consist of a substrate onto which a conducting circuit is patterned. A permanent magnet is placed on top to properly bias the device to operate over the desired frequency range (Figure 2a). This assembly process is delicate because the position and the amount of adhesive and pressure with which the permanent magnet is attached affect the performance of the device. Permanent magnets significantly increase size, weight and cost in a typical radar system, which may contain thousands of circulators. Rare-earth metals are used in the production of magnets, which exposes OEM manufacturers and systems integrators to supply chain risks. Due to their relatively large weight, permanent magnets tend to detach in high shock or vibration environments causing system failures. The elimination of these magnets has long been the goal of device manufacturers.

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Metamagnetics has developed an exciting new substrate that enables device manufacturers to produce radar systems that do not require permanent magnets. The material is created by aligning the magnetic grains and then processing the material at high temperatures to create a dense compact that is free of defects and voids—and which acts as a magnet itself. Manufactured in the U.S., this advanced magnetic material allows for the simplification of the circulator (Figure 2b). Using the material as the basis for self-biased circulators, Metamagnetics has been able to demonstrate 90% reduction in size and weight of the devices. Self-biased circulators withstand high levels of shock and vibration—eliminating the issues related to magnet detachment and resulting system failures—because of their monolithic construction and extremely low weight. Additionally they offer high ionizing radiation tolerance. Because the components are domestically produced—using readily available raw materials, rather than rare-earth metals—supply chain risks are greatly reduced.

Metamagnetics's self-biased circulators have a high frequency range and can be useful in a wide variety of commercial and military applications, including radar, wireless, and satellite communications. Examples of these applications include military target tracking, automotive intelligent cruise control and collision avoidance, 4G and 5G high capacity and gigabit wireless solutions, and satellite-based surface water and ocean topography.

Prototypes from low rate initial production runs are currently available at frequencies above 20GHz. For additional information please contact Michael Hunnewell at mhunnewell@mtmgx.com or (617) 833-2950.

**Figure 1 image courtesty of University of St. Andrews, Scotland*
www.st-andrews.ac.uk/~www_pa/Scots_Guide/RadCom/part15/page1.html