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Active RCS Reduction of an Object for an Arbitrarily-Polarized Signal Using a Microstrip Antenna

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Reducing the radar cross section (RCS) of an object or platform may be beneficial for various reasons. One reason is to reduce undesirable electromagnetic interference (EMI) with sensitive systems caused by scattering form the object. Reducing the RCS of an object is often done by using radar absorbing materials (RAM) and/or by selective shaping of the object. Another approach that can be used is e active cancellation, in which an active radiating source is placed on the object and used to radiate a countering signal that destructively interferes with the signal that is naturally scattered by the object, and thus partially cancels the signal (e.g., a radar signal) that is scattered by the object.

This approach has been used in [1] to reduce the scattering from a simple metal plate, roughly one wavelength in size, by incorporating a radiating microstrip patch antenna on the plate. The active RCS reduction system consisted of a sensor located near the patch antenna, connected to the patch via an amplifier and phase shifter (which may be in the form of a delay line). The sensor picks up the signal due to the incoming plane wave impinging on the object (plate), as well as the signal directly radiated by the patch due to unavoidable mutual coupling between the patch and the sensor. The use of a sensor called a "supersensor" (consisting of a pair of regular sensors with an appropriate phase delay between them) can reduce the mutual coupling, allowing the sensor to mainly pickup the signal due to the incident plane wave. This allows the sensor to be placed closer to the patch, while still keeping mutual coupling small. The system feeds the patch antenna after the system amplifies and phase shifts the signal picked up by the sensor. The amplifier and phase shifter are calibrated so that the signal radiated by the patch in a particular fixed direction cancels the signal scattered by the object at a single frequency, which is chosen here to be the carrier frequency of a incident time-varying radar signal. The RCS of the object in this previous scheme is thus reduced for a time-varying incident signal arriving from a single known direction with a given known polarization.

This previous approach is extended here to examine RCS reduction for an arbitrary-polarized plane wave impinging on the object. In this scheme two sensors are used, together with two feed ports on a square patch antenna. The feed ports are connected to the sensors by using amplifiers and phase shifters. By properly calibrating the amplifiers and phase shifters, it is possible to eliminate the RCS in a given direction for both possible polarizations of the incident plane wave (θ and ϕ), and hence for an arbitrary polarization of incident plane wave, at one frequency. Once again, the frequency is chosen to be the center frequency of a time-varying incoming plane-wave signal.

Results are given to show how effective the scheme is for time-varying incident signals such as a chirped radar signal. A figure of merit (FoM) is defined to help characterize the amount of RCS reduction that is achievable, defined as the energy in the scattered signal with the active RCS reduction scheme present relative to that without the system. It is seen that the energy in the scattered signal can be reduced significantly with the active system, provided the bandwidth of the patch antenna is larger than the bandwidth of the incident signal and the amount of time delay in the system (due to the amplification and phase shifting) is not too large.

1. S. Sengupta, H. Council, D. R. Jackson, and D. Onofrei, "Active Radar Cross Section Reduction of an Object using Microstrip Antennas," *Radio Science*, **55**, 2, February 2020, doi: 10.1029/2019RS006939.