preface

Special Issue on Active and Adaptive Antennas

R. C. HANSEN, FELLOW, IEEE
Guest Editor

RECENT YEARS have seen advances in antenna systems wherein antenna elements operate in such an integrated fashion with circuit elements that it is often difficult to say where the antenna portion stops. We are all familiar by now with such integrated antenna systems as multiple beam arrays, synthetic apertures, time modulated radiators, and correlation arrays, to cite several examples. The latest area of advance in these integrated systems seems to embrace two new capabilities: retrodirective systems, *i.e.*, which radiate a wave in the direction of a received wave, and self-steering or self-focusing arrays; these both are called "adaptive arrays." These two new techniques are the subject of this special issue. In addition, the issue treats dipole type elements where the dipole structure serves also as part of the microwave circuitry for a parametric amplifier, down converter or amplifier. Thus the radiating element and a portion of the receiver front end are physically combined; such "active elements" are directly applicable to the adaptive arrays.

The simplest retrodirective array is the Van Atta array consisting of elements properly connected to each other by transmission lines. It is the discrete analog of the corner reflector, and has similar interference lobes due to interaction of reradiated and scattered fields. In the patent (applied June 1955, granted October 1959) Van Atta also discusses use of active elements in each transmission line. Modulation of the array was then proposed by Bauer. In theme antime, the development of phase-lock loop theory and practice made possible the self-steering type of adaptive array. Altman and Sichak[1] proposed use of phase-lock loops for diversity combining; the phase-lock loops were used to phase lock each signal, *i.e.*, antenna and receiver, to a stable oscillator. Lehan and Hughes in their patent (applied November 1959, granted May 1962) show how this same principle can be used to phase coherently add signals from different antenna elements in an array. A further advance allowed the phase-lock loop scheme to produce retrodirectivity; the conjugate phase front required for retrodirectivity is contained in the lower coherent sidebands, and these are remodulated onto the transmitter output to produce a wave radiated in the proper direction.

Applications of these adaptive antenna systems seem to be plentiful, and system tradeoff studies are just starting to appear. The self-steering antenna system allows a large receiving aperture to be comprised of smaller apertures, each of which has only to be pointed with its usual accuracy. In this way, apertures greater than the current single steerable aperture limit of

The author is with the Satellite Control Office, Aerospace Corporation, Los Angeles, Calif.

[1] F. J. Altman and W. Sichak, "A simplified diversity communication system for beyond-the-horizon links," IRE TRANS. ON COMMUNICATIONS SYSTEMS, vol. CS-4, pp. 50–55; March, 1956.

around 300-ft diameter can be realized. Furthermore, directivity limitations due to manufacturing tolerance or due to tropospheric scintillations can be overcome at least in principle. Self-focusing, for targets within the radiating near field region, would allow optimum radar return. Beam tagging would also allow phase front errors in the transmitted wave to be corrected. Applications in diversity combining are obvious. Retrodirective systems have attractive features for satellite telemetry or communications. For example, an active Van Atta system on a deep space probe could send back data to earth with high directivity (realized twice) but with very modest IF type amplification in the bird. Or satellite telemetry could be read out from a ground station by transmitting cw pilot (up) signal[2] which would be modulated by the array. High directivity could be realized since the usual beamwidth limitations do not apply. The modulating signal could be received at the bird from another station, thereby providing point-to-point communications with modest vehicle power. Adaptive arrays of many elements, *e.g.*, the retrodirective arrays, fail gracefully; the enhanced reliability more than offsets the complexity.

As in any new field, there are some unsolved or insufficiently studied problems: mutual impedance effects, performance with multiple signals or targets, acquisition at low SNR, retrodirectivity or self-steering over large solid angles, effects of wide band signals—these are a few. However, the papers in this issue, and the references quoted therein, represent a major advance in a new facet of antennas. The next years will be equally exciting, and we should see hardware and system investigations culminating in a few practical satellite and ground installations.

[2] This reference was missed by the authors: D. E. N. Davies, "Some properties of Van Atta arrays and the use of 2-Way amplification in the delay paths," *Proc. I.E.E.*, vol. 110, pp. 507–512; March, 1963.