Comment on ‘Comment on ‘Enhancing the security of communication via directly modulated antenna arrays’’

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Abstract

A comment provided by Tao Hong concluded that ‘the directional modulation (DM) signal synthesised using a phased array needs at least three elements’. This loose conclusion is challenged here by clarifying some DM concepts that are foundations of the DM framework.

1. Comment

In [1] it was stated in the Summary Section that ‘The most important characteristic of directional modulation (DM) signal is that the relative phase information is scrambled with the direction information of the receiver’. However, the author argues that this statement is somewhat misleading. No similar statements were claimed or indicated in any DM related work, especially in some original DM literature [2], [3]. In fact the ‘DM’ means that signal waveform signatures, not only the phase information, are direction-dependent in free space. For some extensively used modern digital modulation schemes, it is signal constellation patterns (or diagrams) in In-phase and Quadrature (IQ) space that are direction-dependent [4]. Most reported work chose phase shift keying (PSK) for DM synthesis mainly because the associated bit error rates (BERs) are calculation-friendly. There are also DM work adopting higher order quadrature amplitude modulation (QAM), e.g., 16-QAM in [5], and even analogue modulation [6], [7]. In this sense DM signals can be synthesised using a two-element phased array as numerically proved in Section 2 in [1]. In fact a more general conclusion has been drawn in [8] that an N-element linear antenna array can be used to synthesise DM transmitters that are capable of projecting N-1 independent information beams securely into N-1 different spatial directions simultaneously.

What was actually proven in Section 1 in [1] is that phase relationships of a PSK modulated signal constellation points cannot be distorted along undesired spatial communication direction in a two-element phased
DM array. However, when excitation amplitudes for two array elements are not identical, even the above conclusion does not hold.

2. Reference


