Enhancing the phase shift of tunable phase shifters based on graphene nanoplatelets

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Graphene exhibits tunable conductivity in a wide frequency band ranging from DC to microwaves [1]. The tunable conductivity of graphene opens a new paradigm of innovative microwave components that can be dynamically tuned by a DC voltage. The tunable conductive behavior of graphene exists not only in monolayer graphene but also in few layer graphene nanoplatelets [2]. Few layer graphene nanoplatelets are easier to fabricate and deposit as compared to monolayer graphene. The availability of commercial graphene nanoplatelets paves the way for mass scale usage.
Graphene nanoplatelets were used in designing tunable attenuators [3] and phase shifters. By applying a DC bias voltage across graphene nanoplatelets, their sheet resistance drastically reduces. This variation of resistance can be converted to a variation of reactance by the help of stubs and tapered transmission line sections. The introduction of a variable reactance in the middle of a two-port transmission line causes a shift in the phase of the signal passing through the line. The lengths of the tapered lines are optimized to maximize the phase shift variation and minimize the additional insertion loss caused by the variation of the resistance of graphene. By adopting such structure, a phase shift of 40 degrees was demonstrated with an additional insertion loss of 3 dB [4].
The concept of causing a phase shift by introducing a tapered line and stub next to a transmission line can be extended by increasing the number of stubs as demonstrated in other similar structures [5]. This results in an increase of the total phase shift and the variation of the insertion loss. A further optimization of the structure can limit the variation of the insertion loss while keeping the phase shift high. An enhanced version of the phase shifter consisting of three stubs provide a phase shift of 60 degree with an additional insertion loss of 2 dB at 5 GHz.

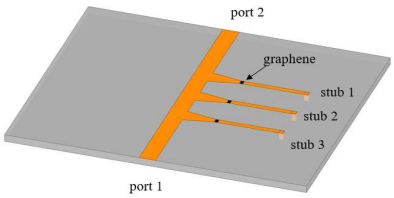

Figure 1. Graphene based enhanced phase shifter topology.

References

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