CLAIMS

What is claimed is:

1. A beam steerable antenna system comprising:

an antenna array comprising a plurality of first radiating elements;

a first phase control section coupled to the plurality of first radiating elements, the first phase control section being configured to control a phase of signals from the plurality of first radiating elements to output first phase controlled signals;

a first combiner coupled to the first phase control section, the first combiner being configured to combine the first phase controlled signals to output a first combined signal;

a first frequency converter coupled to the first combiner, the first frequency converter being configured to downconvert a frequency of the first combined signal to output a first downconverted signal; and

a second phase control section coupled to the first frequency converter, the second phase control section being configured to control a phase of the first downconverted signal to output a second phase controlled signal, wherein

the second phase control section comprises a second phase shifter and is arranged at an intermediate frequency (IF) domain of the beam steerable antenna system,

the second phase shifter is coupled to the first frequency converter at an input portion thereof,

the second phase shifter is a broadband phase shifter configured to generate a variable phase shift, and

the broadband phase shifter comprises a first branch and a second branch connected at input ends thereof and at output ends thereof, the first branch comprises a first component configured to generate a first phase shift with a first slope profile and the second branch comprises a second component configured to generate a second phase shift with a second slope profile, wherein the first slope profile and the second slope profile are different.

2. The beam steerable antenna system according to claim 1, wherein the first phase control section comprises a plurality of first phase shifters and is arranged at a radio frequency (RF) domain of the beam steerable antenna system.

3. The beam steerable antenna system according to claim 2, wherein each of the plurality of first phase shifters is coupled to a respective radiating element of the plurality of first radiating elements at an input portion thereof and is coupled to the first combiner at an output portion thereof.

4. The beam steerable antenna system according to claim 1, wherein

the antenna array is configured into a plurality of antenna subarrays,

a first antenna subarray of the plurality of antenna subarrays comprises the plurality of first radiating elements, and each remaining antenna subarray of the plurality of antenna subarrays comprises a plurality of second radiating elements, and

the beam steerable antenna system further comprises, for said each remaining antenna subarray:

a third phase control section coupled to the remaining antenna subarray, the third phase control section being configured to control a phase of signals from the plurality of second radiating elements of the remaining antenna subarray to output third phase controlled signals;

a second combiner coupled to the third phase control section, the second combiner being configured to combine the third phase controlled signals to output a second combined signal;

a second frequency converter coupled to the second combiner, the second frequency converter being configured to downconvert a frequency of the second combined signal to output a second downconverted signal; and

a fourth phase control section coupled to the second frequency converter, the fourth phase control section being configured to control a phase of the second downconverted signal to output a fourth phase controlled signal.

5. The beam steerable antenna system according to claim 4, further comprising a third combiner and a third frequency converter, wherein

the third combiner is coupled to the second phase control section associated with the first antenna subarray and the fourth phase control section associated with said each remaining antenna subarray, the third combiner being configured to combine the second phase controlled signal output from the second phase control section associated with the first antenna subarray and the fourth phase controlled signal output from the fourth phase control section associated with said each remaining antenna subarray to output a third combined signal, and

the third frequency converter is coupled to the third combiner, the third frequency converter being configured to downconvert a frequency of the third combined signal to output a third downconverted signal.

6. The beam steerable antenna system according to claim 5, further comprising an analog/digital converter and a controller, wherein

the analog/digital converter is coupled to the third frequency converter, the analog/digital converter being configured to convert the third downconverted signal to output a digital signal and is arranged at a baseband domain of the beam steerable antenna system, and

the controller is coupled to the first phase control section and the second phase control section associated with the first antenna subarray and the third phase control section and the fourth phase control section associated with said each remaining antenna subarray, the controller being configured to control the first phase control section and the second phase control section associated with the first antenna subarray and the third phase control section and the fourth phase control section associated with said each remaining antenna subarray based on the digital signal.

7. A method of manufacturing a beam steerable antenna system, the method comprising:

forming an antenna array comprising a plurality of first radiating elements;

coupling a first phase control section to the plurality of first radiating elements, the first phase control section being configured to control a phase of signals from the plurality of first radiating elements to output first phase controlled signals;

coupling a first combiner to the first phase control section, the first combiner being configured to combine the first phase controlled signals to output a first combined signal;

coupling a first frequency converter to the first combiner, the first frequency converter being configured to downconvert a frequency of the first combined signal to output a first downconverted signal; and

coupling a second phase control section to the first frequency converter, the second phase control section being configured to control a phase of the first downconverted signal to output a second phase controlled signal, wherein

the second phase control section comprises a second phase shifter and is arranged at an intermediate frequency (IF) domain of the beam steerable antenna system,

the second phase shifter is coupled to the first frequency converter at an input portion thereof,

the second phase shifter is a broadband phase shifter configured to generate a variable phase shift, and

the broadband phase shifter comprises a first branch and a second branch connected at input ends thereof and at output ends thereof, the first branch comprises a first component configured to generate a first phase shift with a first slope profile and the second branch comprises a second component configured to generate a second phase shift with a second slope profile, wherein the first slope profile and the second slope profile are different.

8. The method according to claim 7, wherein the first phase control section comprises a plurality of first phase shifters and is arranged at a radio frequency (RF) domain of the beam steerable antenna system.

9. The method according to claim 8, wherein each of the plurality of first phase shifters is coupled to a respective radiating element of the plurality of first radiating

elements at an input portion thereof and is coupled to the first combiner at an output portion thereof.

10. The method according to claim 7, wherein

the antenna array is configured into a plurality of antenna subarrays,

a first antenna subarray of the plurality of antenna subarrays comprises the plurality of first radiating elements, and each remaining antenna subarray of the plurality of antenna subarrays comprises a plurality of second radiating elements, and

the method further comprises, for said each remaining antenna subarray:

coupling a third phase control section to the remaining antenna subarray, the third phase control section being configured to control a phase of signals from the plurality of second radiating elements of the remaining antenna subarray to output third phase controlled signals;

coupling a second combiner to the third phase control section, the second combiner being configured to combine the third phase controlled signals to output a second combined signal;

coupling a second frequency converter to the second combiner, the second frequency converter being configured to downconvert a frequency of the second combined signal to output a second downconverted signal; and

coupling a fourth phase control section to the second frequency converter, the fourth phase control section being configured to control a phase of the second downconverted signal to output a fourth phase controlled signal.

11. The method according to claim 10, further comprising:

coupling a third combiner to the second phase control section associated with the first antenna subarray and the fourth phase control section associated with said each remaining antenna subarray, the third combiner being configured to combine the second phase controlled signal output from the second phase control section associated with the first antenna subarray and the fourth phase controlled signal output from the fourth phase control section associated with said each remaining antenna subarray to output a third combined signal, and

coupling a third frequency converter to the third combiner, the third frequency converter being configured to downconvert a frequency of the third combined signal to output a third downconverted signal.

12. The method according to claim 11, further comprising:

coupling an analog/digital converter to the third frequency converter, the analog/digital converter being configured to convert the third downconverted signal to output a digital signal and is arranged at a baseband domain of the beam steerable antenna system, and

coupling a controller to the first phase control section and the second phase control section associated with the first antenna subarray and the third phase control section and the fourth phase control section associated with said each remaining antenna subarray, the controller being configured to control the first phase control section and the second phase control section associated with the first antenna subarray and the third phase control section and the fourth phase control section associated with said each remaining antenna subarray based on the digital signal.

13. A method of beam steering an antenna array comprising a plurality of first radiating elements, the method comprising:

controlling, at a first phase control section coupled to the plurality of first radiating elements, a phase of signals from the plurality of first radiating elements to output first phase controlled signals;

combining, at a first combiner coupled to the first phase control section, the first phase controlled signals to output a first combined signal;

downconverting, at a first frequency converter coupled to the first combiner, a frequency of the first combined signal to output a first downconverted signal; and

controlling, at a second phase control section coupled to the first frequency converter, a phase of the first downconverted signal to output a second phase controlled signal, wherein

the second phase control section comprises a second phase shifter and is arranged at an intermediate frequency (IF) domain of the beam steerable antenna system,

the second phase shifter is coupled to the first frequency converter at an input portion thereof,

the second phase shifter is a broadband phase shifter configured to generate a variable phase shift, and

the broadband phase shifter comprises a first branch and a second branch connected at input ends thereof and at output ends thereof, the first branch comprises a first component configured to generate a first phase shift with a first slope profile and the second branch comprises a second component configured to generate a second phase shift with a second slope profile, wherein the first slope profile and the second slope profile are different.

14. The method according to claim 13, wherein

the first phase control section comprises a plurality of first phase shifters and is arranged at a radio frequency (RF) domain of the beam steerable antenna system,

the second phase control section comprises a second phase shifter and is arranged at an intermediate frequency (IF) domain of the beam steerable antenna system, and

the second phase shifter is coupled to the first frequency converter at an input portion thereof.