SUMMARY

According to at least one aspect is provided a front-end module comprising a power amplifier configured to amplify a radio frequency signal, the power amplifier having an input configured to receive the radio frequency signal and an output configured to provide an amplified radio frequency signal, a first coupler having an input port, an output port, a coupled port and an isolated port, the input port being coupled to the output of the power amplifier, an antenna switch module having an input coupled to the output port of the first coupler and an output, a second coupler having an input port, an output port, a coupled port and an isolated port, the input port of the second coupler being coupled to the output of the antenna switch module, an antenna port configured to be coupled to an antenna, the antenna port being coupled to the output port of the second coupler, and a first switch sub assembly to switchably connect one of the coupled port and the isolated port of the second coupler to an output of the first switch assembly and the other one of the coupled port and the isolated port of the second coupler to a first termination impedance.

In one example, the isolated port of the first coupler is connected to a second termination impedance.

In another example, the front-end module further comprises a second switch sub assembly to switchably connect one of the coupled port and the isolated port of the first coupler to an output of the second switch assembly and the other one of the coupled port and the isolated port of the first coupler to a second termination impedance.

In one example, the front-end module further comprises a filter connected between the output port of the first coupler and the input of the antenna switch module.

In another example, the front-end module, further comprises a controller coupled to the first switch sub assembly and the second switch sub assembly and configured to connect the coupled port of the first coupler to the output of the second switch assembly and to connect the isolated port of the first coupler to the second termination impedance to obtain a first measurement from the output of the second switch assembly, the first measurement providing an indication of forward power provided by the power amplifier.

In one example, the controller is further configured to connect the coupled port of the second coupler to the output of the first switch assembly and to connect the isolated port of the

output of the second power amplifier and the output port of the third coupler being coupled to a second input of the antenna switch module, a fourth coupler having an input port, an output port, a coupled port and an isolated port, the input port of the fourth coupler being coupled to a second output of the antenna switch module and a second antenna port configured to be coupled to a second antenna, the second antenna port being coupled to the second output of the second coupler.

In one example, the power amplifier, the first coupler, the second coupler, and the antenna port form a first chain, the second power amplifier, the third coupler, the fourth coupler, and the second antenna port form a second chain, and the amplified radio frequency signal of the first chain is in a different frequency band than the second amplified radio frequency signal of the second chain.

In another example, the amplified radio frequency signal and the second amplified radio frequency signal are transmitted at the same time.

In one example, the radio frequency signal received by the input of the power amplifier has a frequency in one of a range of about 600 MHz to about 2.5 GHz , a range of about 450 MHz to about 6 GHz, and a range of about 24 GHz to 52 GHz.

In another example, the first coupler is a unidirectional coupler and the second coupler is a bidirectional coupler.

According to at least one aspect there is provided a front-end module comprising a power amplifier configured to amplify a radio frequency signal, the power amplifier having an input configured to receive the radio frequency signal and an output configured to provide an amplified radio frequency signal, a first coupler having an input port, an output port, a coupled port and an isolated port, the input port being coupled to the output of the power amplifier, an antenna switch module having an input coupled to the output port of the first coupler and an output, a second coupler having an input port, an output port, a coupled port and an isolated port, the input port of the second coupler being coupled to the output of the antenna switch module, an antenna port configured to be coupled to an antenna, the antenna port being coupled to the output port of the second coupler, and a first switch sub assembly to switchably connect one of the coupled port and the isolated port of the second coupler to an output of the second switch assembly and the other one of the coupled port and the isolated port of the second coupler to a