

NO SPUR FAST HOT SWITCHING COUPLER ARCHITECTURE

BACKGROUND

Field

5 Embodiments of the present disclosure relate to electronic systems, and in particular, to radio frequency (RF) circuits.

Description of the Related Technology

10 RF systems can include a plurality of RF couplers and a number of power detectors. Such RF systems can include RF circuitry configured to receive an output of an RF coupler and to provide a coupler signal to a power detector.

15 An RF coupler can extract a portion of power of an RF signal propagating between ports of an RF path. A power detector in communication with the RF coupler can detect a power level of the RF signal and provide an output indicative of the power level of the RF signal, thereby providing a means for controlling RF systems. Dynamic power adjustment based on a distance from a base station may be mentioned as an example.

20 With the advance of the 5G standard, fast hot switching between different coupler modes is required to do closed loop power amplifier power control or antenna matching tuning. However, fast transitions of different coupler modes incur serious receiver de-sense issues, which may lead to a high bit error rate (BER) or the like.

25 Early solutions add a resistor to smooth transient impedance spurs due to coupler switching at the cost of slowed down mode to mode transitions. There have also been attempts to shape a coupler switching waveform, but wave shaping variations due to process variations, temperature variations and supply voltage variations make waveform shaping problematic.

SUMMARY

 The systems, methods and devices of this disclosure each have several aspects, no single one of which is solely responsible for the desirable attributes disclosed herein.

30 To address the above-mentioned problems, the present disclosure adds an isolation component between the coupler and a coupler circuit (e.g., a coupler multiplexer) so that a switching transient impedance or a charge spur is isolated from the main RF path.

Two variants are presented. In a passive solution a traditional isolator is inserted between the coupler and coupler multiplexer switches. In an active solution a unity gain buffer with a dummy resistance of *e.g.*, 50Ω is inserted as coupler termination. The unity gain buffer serves as an active isolator to isolate the transient spur.

5 In accordance with an aspect of the present disclosure, a radio frequency front end (RFFE) system is provided. The RFFE system comprises an RF path configured to propagate an RF signal between ports of the RF path, an RF coupler configured to extract a portion of a power of the RF signal propagating between the ports of the RF path, and a first RF coupler circuit. The first RF coupler circuit is coupled to the RF coupler and includes a first isolator
10 configured to isolate at least one of a switching transient impedance and a charge spur within a frequency range of the RF signal from the RF path.

According to one example, the first isolator includes at least one of a first passive isolator and a first active isolator. In one example, the first isolator is a first active isolator that includes a first attenuator. In another example, the first active isolator further includes a first
15 low noise amplifier LNA.

In another example, the RF path is coupled to a first RF module and the first RF coupler circuit is coupled to a second RF module. In a further example, the system further comprises a first termination impedance and a first termination switch configured to couple the first termination impedance to a first termination port.

20 In another aspect of the present disclosure, a radio frequency front end (RFFE) system is provided. The RFFE system comprises an RF path configured to propagate an RF signal between ports of the RF path, an RF coupler configured to extract a portion of a power of the RF signal propagating between the ports of the RF path, a first RF coupler circuit coupled to the RF coupler and including a first isolator configured to isolate at least one of a switching
25 transient impedance and a charge spur from the RF path, and a second RF coupler circuit coupled to the RF coupler and including a second isolator configured to isolate at least one of a switching transient impedance and a charge spur from the RF path. In one example, the second isolator includes at least one of a second passive isolator and a second active isolator. In a further example, the second isolator is a second active isolator that includes a second
30 attenuator and a second low noise amplifier LNA.

In yet a further example, the RF path is coupled to a first RF module and the second RF coupler circuit is coupled to a second RF module. In accordance with this example, the system may further comprise a second termination impedance and a second termination switch configured to couple the second termination impedance to a second termination port.

5 In accordance with another aspect of the present disclosure, a radio frequency device is provided. The radio frequency device comprises a transceiver and a radio frequency front

end (RFFE) system coupled to the transceiver. The RFFE system comprises an RF path configured to propagate an RF signal between ports of the RF path, an RF coupler configured to extract a portion of a power of the RF signal propagating between the ports of the RF path, and a first RF coupler circuit coupled to the RF coupler and including a first isolator configured to isolate at least one of a switching transient impedance and a charge spur within a frequency range of the RF signal from the RF path.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram of a coupler circuit according to an example.

FIG. 2 is a schematic diagram of coupler circuits arranged in a daisy chain according to an example.

FIG. 3 is a schematic diagram of a coupler circuit according to an example.

FIG. 4 is a schematic diagram of an RF system with coupler circuits arranged in a daisy chain according to an example.

FIG. 5 is a schematic diagram of an RF system with coupler circuits arranged in a daisy chain according to another example.

FIG. 6 is a schematic diagram of an RF system with coupler circuits arranged in a daisy chain according to another example.

FIG. 7A is a schematic diagram of an RF system with a coupler circuit according to an example.

FIG. 7B is a schematic diagram of an RF system with a coupler circuit according to another example.

FIG. 7C is a schematic diagram of an RF system with a coupler circuit according to another example.

FIG. 7D is a schematic diagram of an RF system with a coupler circuit according to another example.

FIG. 7E is a schematic diagram of an RF system with a coupler circuit according to another example.

FIG. 7F is a schematic diagram of an RF system with a coupler circuit according to another example.

FIG. 7G is a schematic diagram of an RF system with a coupler circuit according to an embodiment of the present disclosure.

CLAIMS

1. A radio frequency front end system comprising:
 - an RF path configured to propagate an RF signal between ports of the RF path;
 - 5 an RF coupler configured to extract a portion of a power of the RF signal propagating between the ports of the RF path; and
 - a first RF coupler circuit coupled to the RF coupler and including a first isolator configured to isolate at least one of a switching transient impedance and a charge spur within a frequency range of the RF signal from the RF path.
- 10 2. The radio frequency front end system of claim 1 wherein the first isolator includes at least one of a first passive isolator and a first active isolator.
3. The radio frequency front end system of claim 2 wherein the first isolator is a first
15 active isolator that includes a first attenuator.
4. The radio frequency front end system of claim 3 wherein the first active isolator further includes a first low noise amplifier LNA.
- 20 5. The radio frequency front end system of claim 1 wherein the RF path is coupled to a first RF module and the first RF coupler circuit is coupled to a second RF module.
6. The radio frequency front end system of claim 1 further comprising a first termination
25 impedance.
7. The radio frequency front end system of claim 6 further comprising a first termination switch configured to couple the first termination impedance to a first termination port.
8. A radio frequency front end system comprising:
 - 30 an RF path configured to propagate an RF signal between ports of the RF path;

an RF coupler configured to extract a portion of a power of the RF signal propagating between the ports of the RF path;

a first RF coupler circuit coupled to the RF coupler and including a first isolator configured to isolate at least one of a switching transient impedance and a charge spur from the RF path; and

a second RF coupler circuit coupled to the RF coupler and including a second isolator configured to isolate at least one of a switching transient impedance and a charge spur from the RF path.

9. The radio frequency front end system of claim 8 wherein the second isolator includes at least one of a second passive isolator and a second active isolator.
10. The radio frequency front end system of claim 8 wherein the second isolator is a second active isolator that includes a second attenuator and a second low noise amplifier LNA.
11. The radio frequency front end system of claim 8 wherein the RF path is coupled to a first RF module and the second RF coupler circuit is coupled to a second RF module.
12. The radio frequency front end system of claim 8 further comprising a second termination impedance and a second termination switch configured to couple the second termination impedance to a second termination port.
13. A radio frequency device comprising:
 - a transceiver; and
 - a radio frequency front end system coupled to the transceiver, the radio frequency front end system comprising an RF path configured to propagate an RF signal between ports of the RF path, an RF coupler configured to extract a portion of a power of the RF signal propagating between the ports of the RF path, and a first RF coupler circuit coupled to the RF coupler and including a first isolator configured to isolate at least one of a switching transient impedance and a charge spur within a frequency range of the RF signal from the RF path.

14. The radio frequency device of claim 13 wherein the first isolator includes at least one of a first passive isolator and a first active isolator.
- 5 15. The radio frequency device of claim 14 wherein the first isolator is a first active isolator that includes a first attenuator coupled to a first low noise amplifier LNA.
16. The radio frequency device of claim 13 wherein the RF path is coupled to a first RF module and the first RF coupler circuit is coupled to a second RF module.
- 10 17. The radio frequency device of claim 13 further comprising a first termination impedance and a first termination switch configured to couple the first termination impedance to a first termination port.
- 15 18. The radio frequency device of claim 13 further comprising a second RF coupler circuit coupled to the RF coupler and including a second isolator configured to isolate at least one of a switching transient impedance and a charge spur from the RF path, wherein the second isolator includes at least one of a second passive isolator and a second active isolator.
- 20 19. The radio frequency device of claim 18 wherein the second isolator is a second active isolator that includes a second attenuator coupled to a second low noise amplifier LNA.
- 25 20. The radio frequency device of claim 18 wherein the RF path is coupled to a first RF module and the second RF coupler circuit is coupled to a second RF module, the radio frequency device further comprising a second termination impedance and a second termination switch configured to couple the second termination impedance to a second termination port.