operation of the charge pump. The plurality of switches are configured to operate with non-overlap between the charging operation and the discharging operation. The charge pump includes an inverter having an output electrically connected to a first end of the switched capacitor, and the plurality of switches includes a pair of charging switches connected between a second end of the switched capacitor and a reference voltage and a pair of discharging switches connected between the second end of the switched capacitor and the charge pump output terminal.

[0005] In various examples, the charge pump is powered by a power high supply voltage and a ground voltage, the charge pump voltage less than the ground voltage.

[0006] In several examples, the charge pump includes an inverter having an output electrically connected to a first end of the switched capacitor. According to some examples, the plurality of switches includes a pair of charging switches connected between a second end of the switched capacitor and a reference voltage, and a pair of discharging switches connected between the second end of the switched capacitor and the charge pump output terminal. In accordance with a number of examples, the pair of charging switches is closed during the charging operation and open during the discharging operation, and the pair of discharging switches is closed during the discharging operation and open during the charging operation. According to various examples, during a transition from the charging operation to the discharging operation, one charging switch of the pair of charging switches is open and the other charging switch of the pair of charging switches is closed. In accordance with some examples, during the transition from the charging operation to the discharging operation, one discharging switch of the pair of discharging switches is open and the other discharging switch of the pair of discharging switches is closed. According to a number examples, a first charging switch of the pair of charging switches is controlled by a first clock phase signal, an input of the inverter receives a second clock phase signal delayed relative to the first clock phase signal, and a second charging switch of the pair of charging switches is controlled by a third clock signal phase delayed relative to the second clock phase signal. In accordance with various examples, a first discharging switch of the pair of discharging switches is controlled by an inverted version of the first clock phase signal and a second discharging switch of the pair of discharging switches is controlled by an inverted version of the third clock phase signal. According to some examples, the inverter is powered by a power high supply voltage and a ground voltage.

[0007] In several examples, the charge pump further includes an oscillator configured to generate a first plurality of clock signal phases, and combinatorial logic configured to process the first plurality of clock signal phases to generate a second plurality of

clock signal phases, at least a portion of the switches controlled by the second plurality of clock signal phases.

[0008] In an example, the charge pump includes a plurality of stages including a first stage and a second stage, the first stage including the plurality of switches and the switched capacitor. According to a number of examples, the plurality of switches are controlled in part by a clock signal from the second stage.

[0009] In a second aspect, the present disclosure relates to a method of generating a charge pump voltage. The method includes charging a switched capacitor using a plurality of switches during a charging operation of a charge pump, transitioning the charge pump from the charging operation to a discharging operation with non-overlap, connecting the switched capacitor to a charge pump output terminal during the discharging operation, and controlling a first end of the switched capacitor using an output of an inverter and controlling a second end of the switched capacitor using the plurality of switches.

[0010] In various examples, the method further includes powering the charge pump using a power high supply voltage and a ground voltage, and providing a providing a charge pump output voltage less than the ground voltage at the charge pump output terminal.

[0011] In an example, the method further includes controlling a first end of the switched capacitor using an output of an inverter. According to a number of examples, the method further includes controlling a second end of the switched capacitor using the plurality of switches. In accordance with some examples, the plurality of switches includes a pair of charging switches connected between a second end of the switched capacitor and a reference voltage, and a pair of discharging switches connected between the second end of the switched capacitor and the charge pump output terminal. According to several examples, the method further includes closing the pair of charging switches during the charging operation, opening the pair of discharging switches during the charging operation, opening the pair of charging switches during the discharging operation, and closing the pair of discharging switches during the discharging operation. In accordance with a number of examples, the method further includes opening one charging switch of the pair of charging switches and closing the other charging switch of the pair of charging switches during a transition from the charging operation to the discharging operation. According to some examples, the method further includes opening one discharging switch of the pair of discharging switches and closing the other discharging switch of the pair of discharging switches during a transition from the charging operation to the discharging operation. In

accordance with several examples, the method further includes controlling a first charging switch of the pair of charging switches with a first clock phase signal, providing an input of the inverter with a second clock phase signal delayed relative to the first clock phase signal, and controlling a second charging switch of the pair of charging switches with a third clock signal phase delayed relative to the second clock phase signal. According to a number of examples, the method further includes controlling a first discharging switch of the pair of discharging switches with an inverted version of the first clock phase signal, and controlling a second discharging switch of the pair of discharging switches with an inverted version of the third clock phase signal.

[0012] In some examples, the method further includes generating a first plurality of clock signal phases using an oscillator, processing the first plurality of clock signal phases to generate a second plurality of clock signal phases using combinatorial logic, and controlling at least a portion of the switches using the second plurality of clock signal phases.

[0013] In several examples, the charge pump includes a plurality of stages including a first stage and a second stage, the first stage including the plurality of switches and the switched capacitor, the method further comprising controlling the plurality of switches in part by a clock signal from the second stage.

[0014] In a third aspect, the present disclosure relates to a charge pump. The charge pump includes a charge pump output terminal configured to provide a charge pump voltage, a switched capacitor, and a plurality of switches configured to charge the switched capacitor during a charging operation of the charge pump and to connect the switched capacitor to the charge pump output terminal during a discharging operation of the charge pump. The plurality of switches is configured to operate with non-overlap between the charging operation and the discharging operation. The charge pump also includes an inverter having an output electrically connected to a first end of the switched capacitor, the plurality of switches electrically connected to a second end of the switched capacitor.

[0015] In various examples, the charge pump voltage is less than a ground voltage.

[0016] In some examples, the charge pump further includes an inverter having an output electrically connected to a first end of the switched capacitor. According to a number of examples, the plurality of switches includes a pair of charging switches connected between a second end of the switched capacitor and a reference voltage, and a pair of discharging switches connected between the second end of the switched capacitor and the

WHAT IS CLAIMED IS:

1. A front end system comprising:

a radio frequency switch;

a switch controller configured to bias the radio frequency switch with a charge pump voltage in a first state of a switch enable signal; and

a charge pump configured to generate the charge pump voltage at a charge pump output terminal, the charge pump including a switched capacitor and a plurality of switches configured to charge the switched capacitor during a charging operation of the charge pump and to connect the switched capacitor to the charge pump output terminal during a discharging operation of the charge pump, the plurality of switches configured to operate with non-overlap between the charging operation and the discharging operation;

wherein the charge pump includes an inverter having an output electrically connected to a first end of the switched capacitor, and the plurality of switches includes a pair of charging switches connected between a second end of the switched capacitor and a reference voltage and a pair of discharging switches connected between the second end of the switched capacitor and the charge pump output terminal.

2. The front end system of claim 1 wherein the charge pump is powered by a power high supply voltage and a ground voltage, the charge pump voltage less than the ground voltage.

3. The front end system of claim 1 wherein the pair of charging switches is closed during the charging operation and open during the discharging operation, and the pair of discharging switches is closed during the discharging operation and open during the charging operation.

4. The front end system of claim 3 wherein during a transition from the charging operation to the discharging operation, one charging switch of the pair of charging switches is open and the other charging switch of the pair of charging switches is closed.

5. The front end system of claim 4 wherein during the transition from the charging operation to the discharging operation, one discharging switch of the pair of discharging switches is open and the other discharging switch of the pair of discharging switches is closed.

6. The front end system of claim 1 wherein a first charging switch of the pair of charging switches is controlled by a first clock phase signal, an input of the inverter receives a second clock phase signal delayed relative to the first clock phase signal, and a second charging switch of the pair of charging switches is controlled by a third clock signal phase delayed relative to the second clock phase signal.

7. The front end system of claim 6 wherein a first discharging switch of the pair of discharging switches is controlled by an inverted version of the first clock phase signal and a second discharging switch of the pair of discharging switches is controlled by an inverted version of the third clock phase signal.

8. The front end system of claim 1 wherein the charge pump further includes an oscillator configured to generate a first plurality of clock signal phases, and combinatorial logic configured to process the first plurality of clock signal phases to generate a second plurality of clock signal phases, at least a portion of the switches controlled by the second plurality of clock signal phases.

9. The front end system of claim 1 wherein the charge pump includes a plurality of stages including a first stage and a second stage, the first stage including the plurality of switches and the switched capacitor.

10. The front end system of claim 9 wherein the plurality of switches are controlled in part by a clock signal from the second stage.

11. A method of generating a charge pump voltage, the method comprising:

charging a switched capacitor using a plurality of switches during a charging operation of a charge pump;

transitioning the charge pump from the charging operation to a discharging operation with non-overlap;

connecting the switched capacitor to a charge pump output terminal during the discharging operation; and

controlling a first end of the switched capacitor using an output of an inverter and controlling a second end of the switched capacitor using the plurality of switches.

12. The method of claim 11 further comprising closing a pair of charging switches of the plurality of switches during the charging operation, opening a pair of discharging switches of the plurality of switches during the charging operation, opening the pair of charging switches during the discharging operation, and closing the pair of discharging switches during the discharging operation.

13. The method of claim 12 further comprising opening one charging switch of the pair of charging switches and closing the other charging switch of the pair of charging switches during a transition from the charging operation to the discharging operation.

14. The method of claim 13 further comprising opening one discharging switch of the pair of discharging switches and closing the other discharging switch of the pair of discharging switches during a transition from the charging operation to the discharging operation.

15. A charge pump comprising:

a charge pump output terminal configured to provide a charge pump voltage;

a switched capacitor;

a plurality of switches configured to charge the switched capacitor during a charging operation of the charge pump and to connect the switched capacitor to the charge pump output terminal during a discharging operation of the charge pump, the plurality of switches configured to operate with non-overlap between the charging operation and the discharging operation; and

an inverter having an output electrically connected to a first end of the switched capacitor, the plurality of switches electrically connected to a second end of the switched capacitor.

16. The charge pump of claim 15 wherein the plurality of switches includes a pair of charging switches closed during the charging operation and open during the discharging operation, and a pair of discharging switches closed during the discharging operation and open during the charging operation.

17. The charge pump of claim 16 wherein during a transition from the charging operation to the discharging operation, one charging switch of the pair of charging switches is open and the other charging switch of the pair of charging switches is closed.