CLAIMS

1. A near field communication, NFC, device for use in preparing a carrier signal for active load modulation transmission, the NFC device comprising:

a local clock generator configured to generate a reference clock signal;

a clock extractor configured to recover a clock signal generated by an NFC initiator device;

a frequency tracking module, FTM, configured to perform a frequency tracking operation based on an input clock signal to produce a FTM output with its frequency aligned with the input clock signal wherein the input clock signal is the reference clock signal or the recovered clock signal; and

a phase tracking module, PTM, configured to perform a phase tracking operation on the FTM output based on the recovered clock signal to produce a PTM output with its phase aligned with the recovered clock signal;

wherein the PTM output at a desired frequency and phase is served as the carrier signal for use in load modulating data of the NFC device to form a load modulated signal to be actively transmitted to the NFC initiator device.

2. The NFC device of claim 1, wherein the FTM comprising:

a phase-frequency detector, PFD, a loop filter, LF, a voltage controlled oscillator, VCO, and a frequency divider, FD, connected sequentially to form an analog phase-locked loop (PLL) system to perform the frequency tracking operation to synthesis a desired frequency based on the input clock signal;

wherein the PFD comprises a circuity configured to receive the input clock signal and a feedback signal from the FD, compare phase and/or frequency of the feedback signal with the input clock signal, and produce a control signal in response to an offset in phase and/or frequency between the feedback signal and the input clock signal;

wherein the LF comprises a circuitry configured to receive the control signal from the PFD, perform a filtering operation on the control signal, and produce a control value associated to the offset in phase and/or frequency between the feedback signal and the input clock signal;

wherein the VCO comprises a circuitry configured to receive the control value from the LF and produce a VCO output with its phase and/or frequency adjusted based on the control value wherein the VCO output is served as the FTM output;

wherein the FD comprises a circuitry configured to receive the VCO output from the VCO, divide frequency of the VCO output by a number which is changeable to any suitable value to alter frequency of the VCO output to be equal or closer to frequency of the input clock signal, and produce a feedback signal to be fed into the PFD;

wherein the feedback signal is aligned with the input clock signal when the feedback signal and the input clock signal are in-phase and their frequencies are equal or close to each other within an acceptable frequency accuracy.

3. The NFC device of claim 1, wherein the FTM comprising:

a time-to-digital converter, TDC, a digital loop filter, DLF, a digitally controlled oscillator, DCO, and a frequency divider, FD, connected sequentially to form an all-digital phase-locked loop, PLL, system to perform the frequency tracking operation to synthesis a desired frequency based on the input clock signal;

wherein the TDC comprises a circuity configured to receive the input clock signal and a feedback signal from the FD, compare phase of the feedback signal with the input clock signal, and produce a digital signal in response to a phase offset between the feedback signal and the input clock signal;

wherein the DLF comprises a circuitry configured to receive the digital signal from the TDC, perform a filtering operation on the received digital signal, and produce a digital control signal associated to the phase offset between the feedback signal and the input clock signal;

wherein the DCO comprises a circuitry configured to receive the digital control signal from the DLF and produce a DCO output with its phase adjusted based on the digital control signal wherein the DCO output is served as the FTM output;

wherein the FD comprises a circuitry configured to receive the DCO output, divide frequency of the DCO output by a number which is changeable to any suitable value to alter frequency of the DCO output to be equal or closer to frequency of the input clock signal, and produce a feedback signal to be fed into the TDC;

wherein the feedback signal is aligned with the input clock signal when the feedback signal and the input clock signal are in-phase and their frequencies are equal or close to each other within an acceptable frequency accuracy.

4. The NFC device of claim 2 or 3, wherein the FTM further comprising:

a multiplexer comprises a circuitry configured to select the input clock signal which is either the reference clock signal from the local clock generator or the recovered clock signal from the clock extractor.

5. The NFC device of claim 2 or 3, wherein the input clock signal is the reference clock signal which is independent of the clock signal generated by the initiator device, the PLL system of the FTM is able to operate continuously in a closed loop even during active load modulation transmission.

6. The NFC device of claim 2 or 3, wherein the input clock signal is the recovered clock signal which is dependent on the clock signal generated by the initiator device, the PLL system of the FTM is required to convert to an open loop during active load modulation transmission.

7. The NFC device of claim 1, wherein the local clock generator is a temperature-compensated crystal oscillator.

8. The NFC device of claim 2, wherein the PTM comprising:

a phase interpolation, PI, unit, a phase sampler, and a digital loop filter, DLF, connected sequentially to form a feedback loop system to perform the phase tracking operation to track a desired clock phase based on the recovered clock signal;

wherein the phase sampler comprises a circuitry configured to receive the recovered clock signal and a PI output from the PI unit, compare phase of the recovered clock signal with the PI output, and produce a digital signal in response to a phase offset between the recovered clock signal and the PI output;

wherein the DLF comprises a circuity configured to receive the digital signal from the phase sampler, perform a filtering operation on the digital signal, and produce a digital control signal associated to the phase offset between the recovered clock signal and the PI output;

wherein the PI unit comprises a circuitry configured to receive a first plurality of FTM outputs with equally spaced phases by a first phase difference from the FTM, interpolate the first plurality of FTM outputs to form a second plurality of FTM outputs with equally spaced phases by a second phase difference wherein the second plurality of FTM outputs is greater than the first plurality of FTM outputs, and select one of the second plurality of FTM outputs to be output from the PI unit as an PI output based on the digital control signal received from the DLF such that the PI output has the closest phase to the recovered clock signal among the second plurality of FTM outputs wherein the PI output is served as the PTM output and fed into the phase sampler;

wherein the PI output is aligned with the recovered clock signal when the PI output and the recovered clock signal are in-phase or close to each other within an acceptable phase accuracy.

9. The NFC device of claim 2 or 3, wherein the PTM comprising:

a phase interpolation, PI, unit, a time-to-digital converter, TDC, and a phase selection, PS, unit connected to form a system to perform the phase tracking operation to track a desired clock phase based on the recovered clock signal;

wherein the PI unit comprises a circuitry configured to receive a first plurality of FTM outputs with equally spaced phases by a first phase difference from the FTM, interpolate the first plurality of FTM outputs to form a second plurality of FTM outputs with equally spaced phases by a second phase difference wherein the second plurality of FTM outputs is greater than the first plurality of FTM outputs, and send the second plurality of FTM outputs to the TDC and the PS unit concurrently;

wherein the TDC comprises a circuitry configured to receive the recovered clock signal and the second plurality of FTM outputs from the PI unit, compare phase of the recovered clock signal with the second plurality of FTM outputs, and produce a digital control signal associated

to phase relationship between the recovered clock signal and the second plurality of FTM outputs;

wherein the PS unit comprises a circuitry configured to receive the digital control signal from the TDC and the second plurality of FTM outputs from the PI unit, and select one of the second plurality of FTM outputs to be output from the PS unit as a PS output based on the digital control signal such that the PS output has the closest phase to the recovered clock signal among the second plurality of FTM outputs wherein the PS output is served as the PTM output;

wherein the PS output is aligned with the recovered clock signal when the PS output and the recovered clock signal are in-phase or close to each other within an acceptable phase accuracy.

10. The NFC device of claim 8, wherein the feedback loop system of the PTM is converted to an open loop during active load modulation transmission.

11. A method for preparing a carrier signal for active load modulation transmission by a near field communication, NFC, device, the method comprising:

generating a reference clock signal by a local clock generator in the NFC device;

recovering a clock signal generated by an NFC initiator device by a clock extractor in the NFC device;

performing a frequency tracking operation based on an input clock signal by a frequency tracking module, FTM, in the NFC device to produce a FTM output with its frequency aligned with the input clock signal wherein the input clock signal is the reference clock signal or the recovered clock signal; and

performing a phase tracking operation on the FTM output based on the recovered clock signal by a phase tracking module, PTM, in the NFC device to produce a PTM output with its phase aligned with the recovered clock signal;

wherein the PTM output at a desired frequency and phase is served as the carrier signal for use in load modulating data of the NFC device to form a load modulated signal to be actively transmitted to the NFC initiator device.

12. The method of claim 11, wherein the step of performing the frequency tracking operation to synthesis a desired frequency comprising:

forming an analog phase-locked loop, PLL, system comprises a phase-frequency detector, PFD, a loop filter, LF, a voltage controlled oscillator, VCO, and a frequency divider, FD, in the NFC device;

receiving an input clock signal which is the reference clock signal from the local clock generator or the recovered clock signal from the clock extractor;

comparing phase and/or frequency of a feedback signal from the FD with the input clock signal and producing a control signal in response to an offset in phase and/or frequency between the feedback signal and the input clock signal by the PFD;

performing a filtering operation on the control signal from the PFD and producing a control value associated to the offset in phase and/or frequency between the feedback signal and the input clock signal by the LF;

adjusting phase and/or frequency of the VCO based on the control value from the LF and producing a VCO output with adjusted phase and/or frequency wherein the VCO output is served as the FTM output; and

dividing frequency of the VCO output by a number which is changeable to any suitable value to alter frequency of the VCO output to be equal or closer to frequency of the input clock signal and producing a feedback signal to be fed into the PFD by the FD;

wherein the feedback signal is aligned with the input clock signal when the feedback signal and the input clock signal are in-phase and their frequencies are equal or close to each other within an acceptable frequency accuracy.

13. The method of claim 11, wherein the step of performing the frequency tracking operation to synthesis a desired frequency comprising:

forming an all-digital phase-locked loop, PLL, system comprises a time-to-digital converter, TDC, a digital loop filter, DLF, a digitally controlled oscillator, DCO, and a frequency divider, FD, in the NFC device;

receiving an input clock signal which is the reference clock signal from the local clock generator or the recovered clock signal from the clock extractor;

comparing phase of a feedback signal from the FD with the input clock signal and producing a digital signal in response to a phase offset between the feedback signal and the input clock signal by the TDC,

performing a filtering operation on the digital signal from the TDC and producing a digital control signal associated to the phase offset between the feedback signal and the input clock signal by the DLF;

adjusting phase of the DCO based on the digital control signal from the DLF and producing a DCO output with adjusted phase wherein the DCO output is served as the FTM output; and

dividing frequency of the DCO output by a number which is changeable to any suitable value to alter frequency of the DCO output to be equal or closer to frequency of the input clock signal and producing a feedback signal to be fed into the TDC by the FD;

wherein the feedback signal is aligned with the input clock signal when the feedback signal and the input clock signal are in-phase and their frequencies are equal or close to each other within an acceptable frequency accuracy.

14. The method claim 12 or 13, wherein the step of receiving the input clock signal comprises selecting the input clock signal through a multiplexer in the NFC device.

15. The method claim 12 or 13, wherein the input clock signal is the reference clock signal which is independent of the clock signal generated by the initiator device, the step of forming the PLL system comprises forming a closed loop that operates continuously even during active load modulation transmission.