US 20190103925A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2019/0103925 A1**

Wade et al. (43) **Pub. Date: Apr. 4, 2019**

(54) **WIRELESS SIGNAL NOISE REDUCTION**

(71) Applicant: **Square, Inc.**, San Francisco, CA (US)

(72) Inventors: **Jeremy Wade**, San Francisco, CA (US); **Afshin Rezayee**, Richmond Hill (CA)

(73) Assignee: **Square, Inc.**, San Francisco, CA (US)

(21) Appl. No.: **15/721,855**

(22) Filed: **Sep. 30, 2017**

Publication Classification

(51) **Int. Cl.**

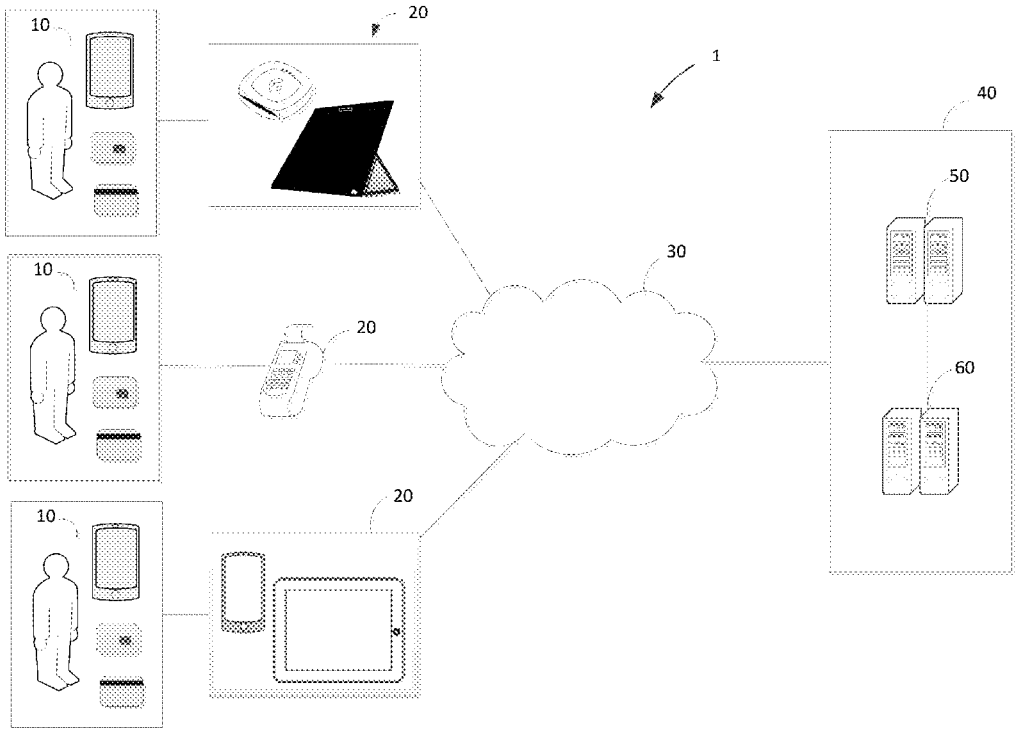
H04B 15/00	(2006.01)
H04B 5/00	(2006.01)
H04W 4/00	(2006.01)
G06Q 20/20	(2006.01)

(52) **U.S. Cl.**

CPC ***H04B 15/00*** (2013.01); ***H04B 5/0031*** (2013.01); *H04W 88/02* (2013.01); ***G06Q 20/202*** (2013.01); ***H04W 4/008*** (2013.01)

(57) **ABSTRACT**

A payment terminal has a clock management unit for providing clock signals to components of the payment terminal. The payment terminal also has a wireless communication interface for communicating wireless signals. A processing unit of the payment terminal may monitor operation of a wireless communication interface of the payment terminal and, when the payment terminal is communicating wirelessly, modify an initial clock signal provided to one or more components of the payment terminal that emit RF noise to modify a frequency at which the RF noise occurs. When the payment terminal is no longer transmitting, the processing unit may provide the initial clock signal to the RF noise source.



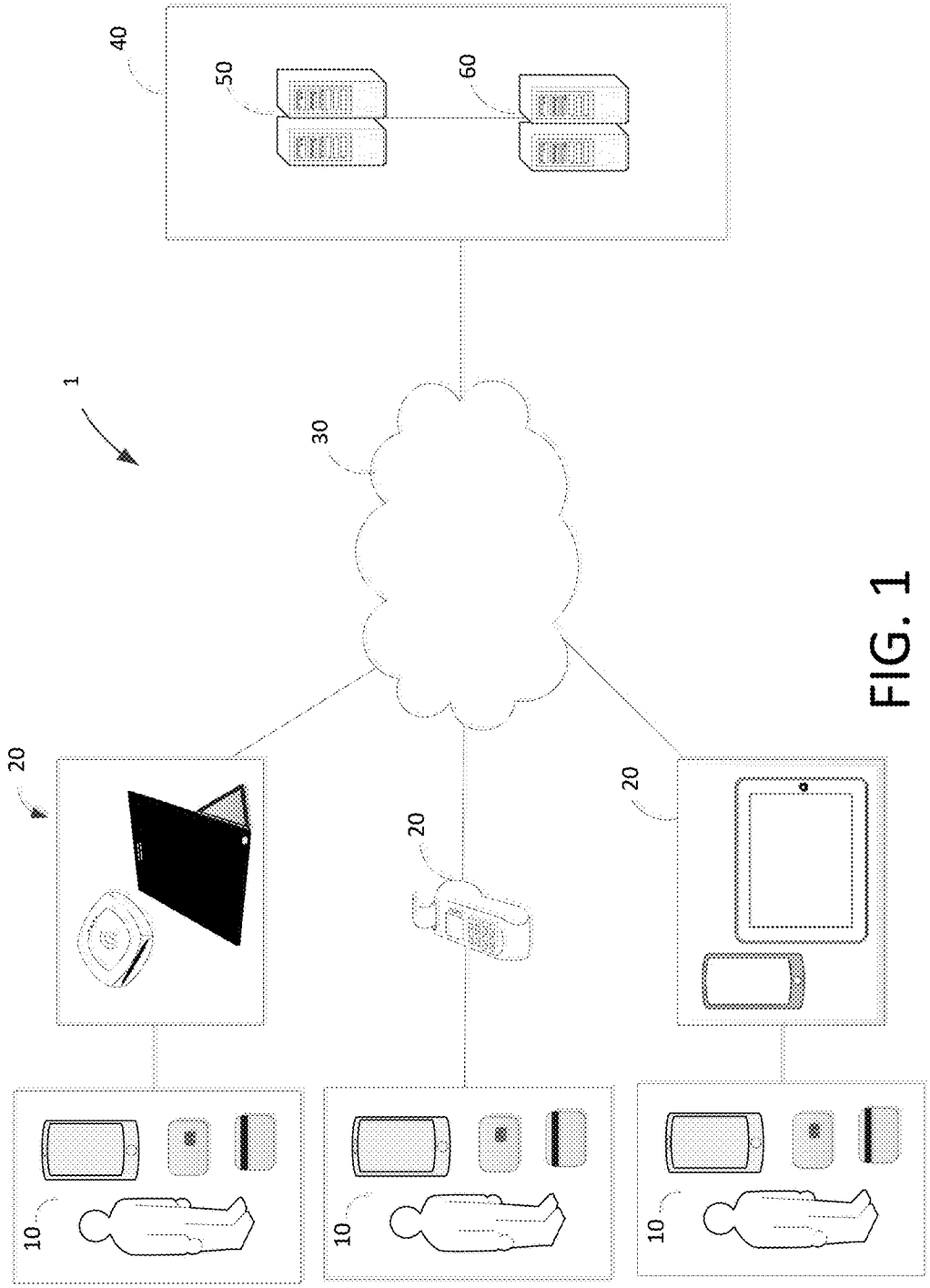


FIG. 1

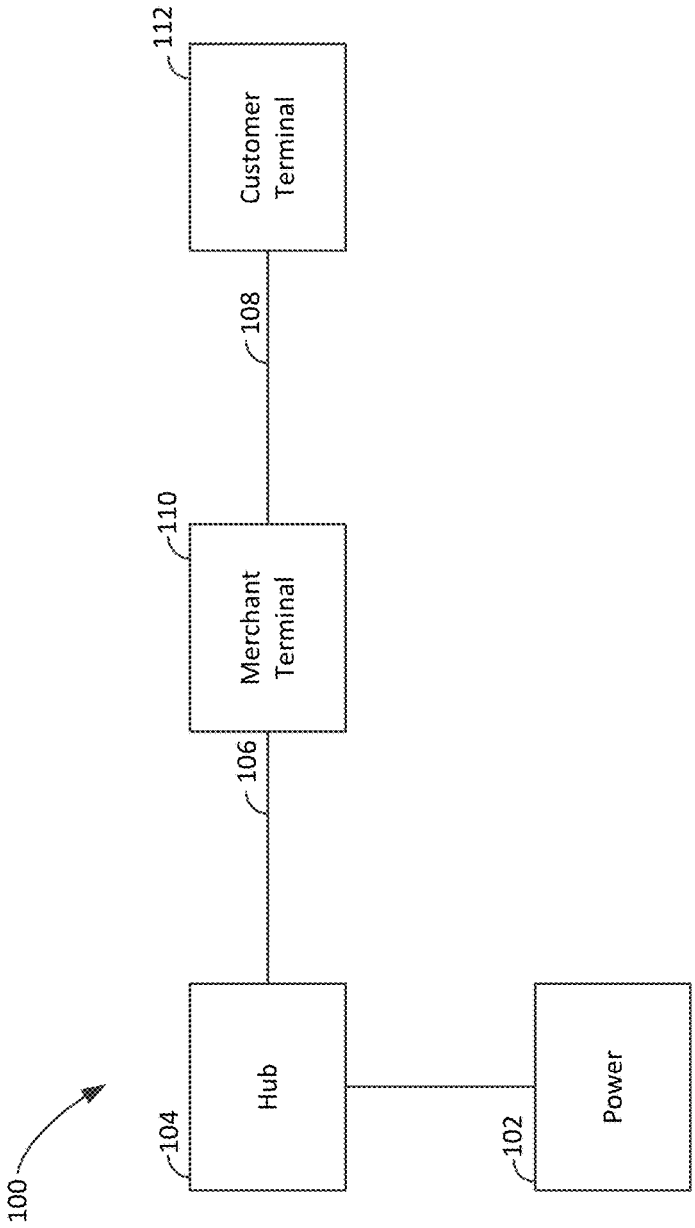

100
Hub
104
Power
102
Merchant Terminal
110
106
Customer Terminal
112
108

FIG. 2

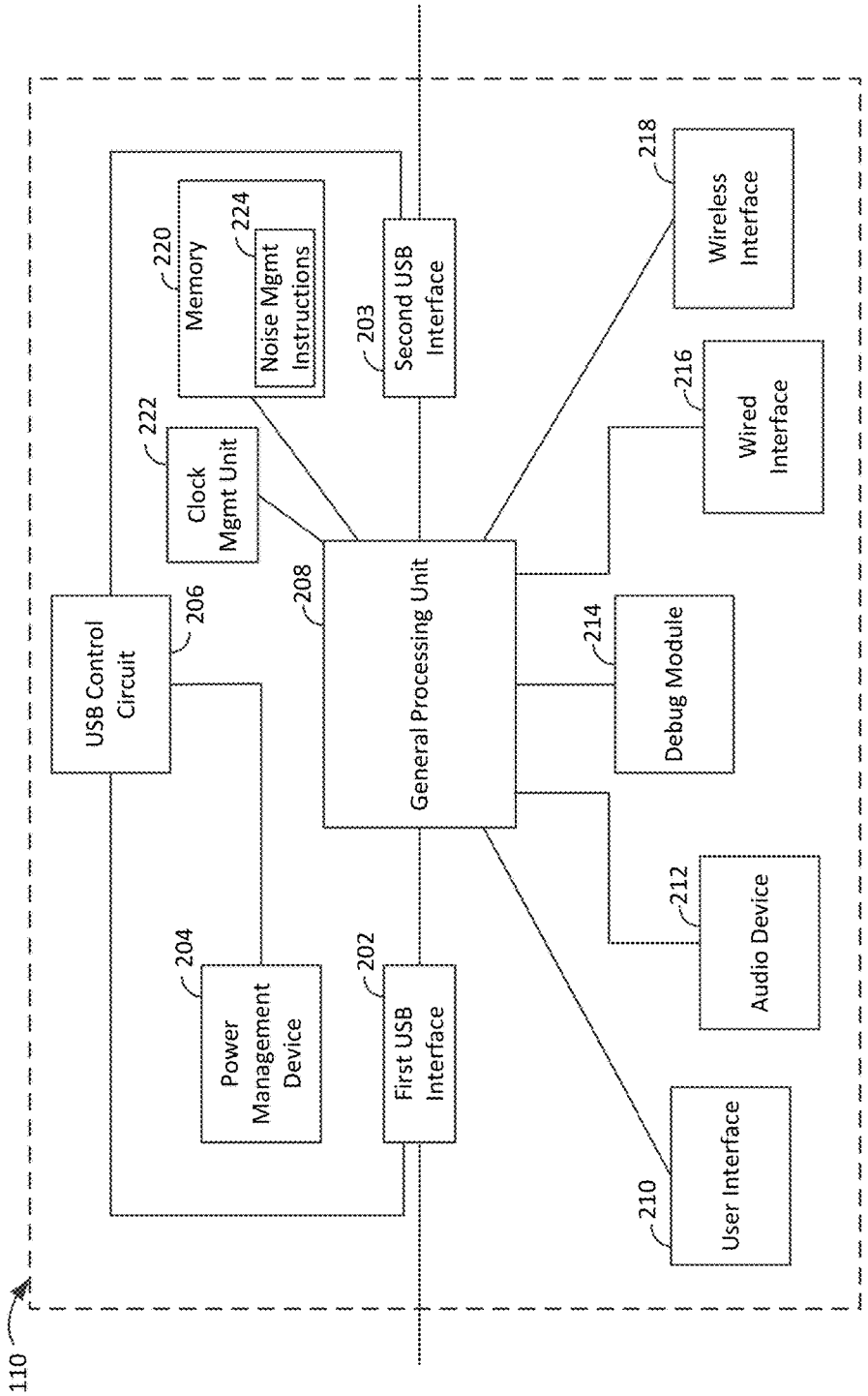

110
USB Control Circuit
206
Power Management Device
204
First USB Interface
202
Second USB Interface
203
Memory
220
Noise Mgmt Instructions
224
Clock Mgmt Unit
222
General Processing Unit
208
Wireless Interface
218
Wired Interface
216
Debug Module
214
Audio Device
212
User Interface
210

FIG. 3

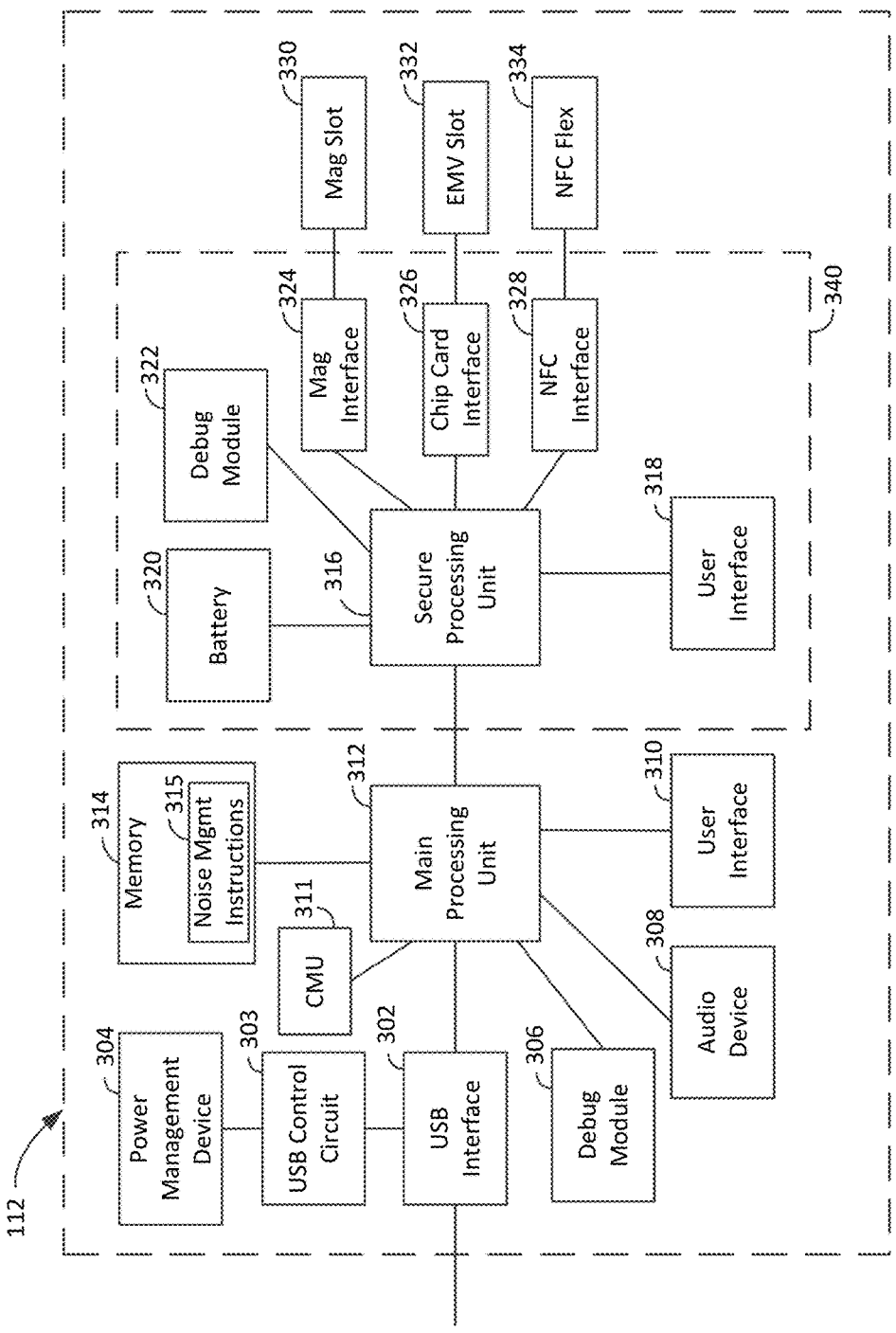

112
Power Management Device
304
USB Control Circuit
303
USB Interface
302
Debug Module
306
Audio Device
308
User Interface
310
Main Processing Unit
312
CMU
311
Memory
314
Noise Mgmt Instructions
315
Battery
320
Debug Module
322
Secure Processing Unit
316
User Interface
318
Mag Interface
324
Chip Card Interface
326
NFC Interface
328
Mag Slot
330
EMV Slot
332
NFC Flex
334
340

FIG. 4

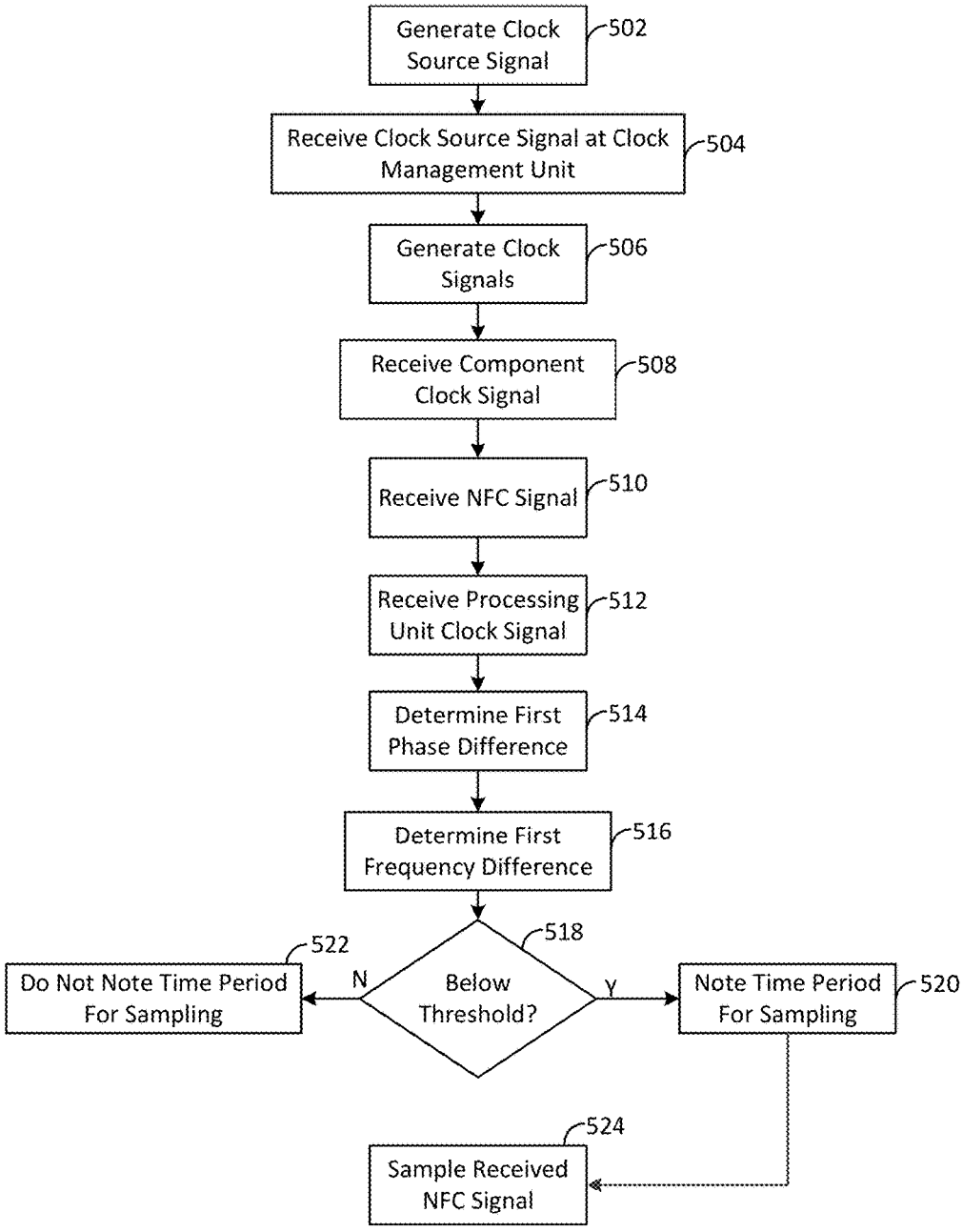

Generate Clock Source Signal
502
Receive Clock Source Signal at Clock Management Unit
504
Generate Clock Signals
506
Receive Component Clock Signal
508
Receive NFC Signal
510
Receive Processing Unit Clock Signal
512
Determine First Phase Difference
514
Determine First Frequency Difference
516
Below Threshold?
518
N
Y
Do Not Note Time Period For Sampling
522
Note Time Period For Sampling
520
Sample Received NFC Signal
524

FIG. 5

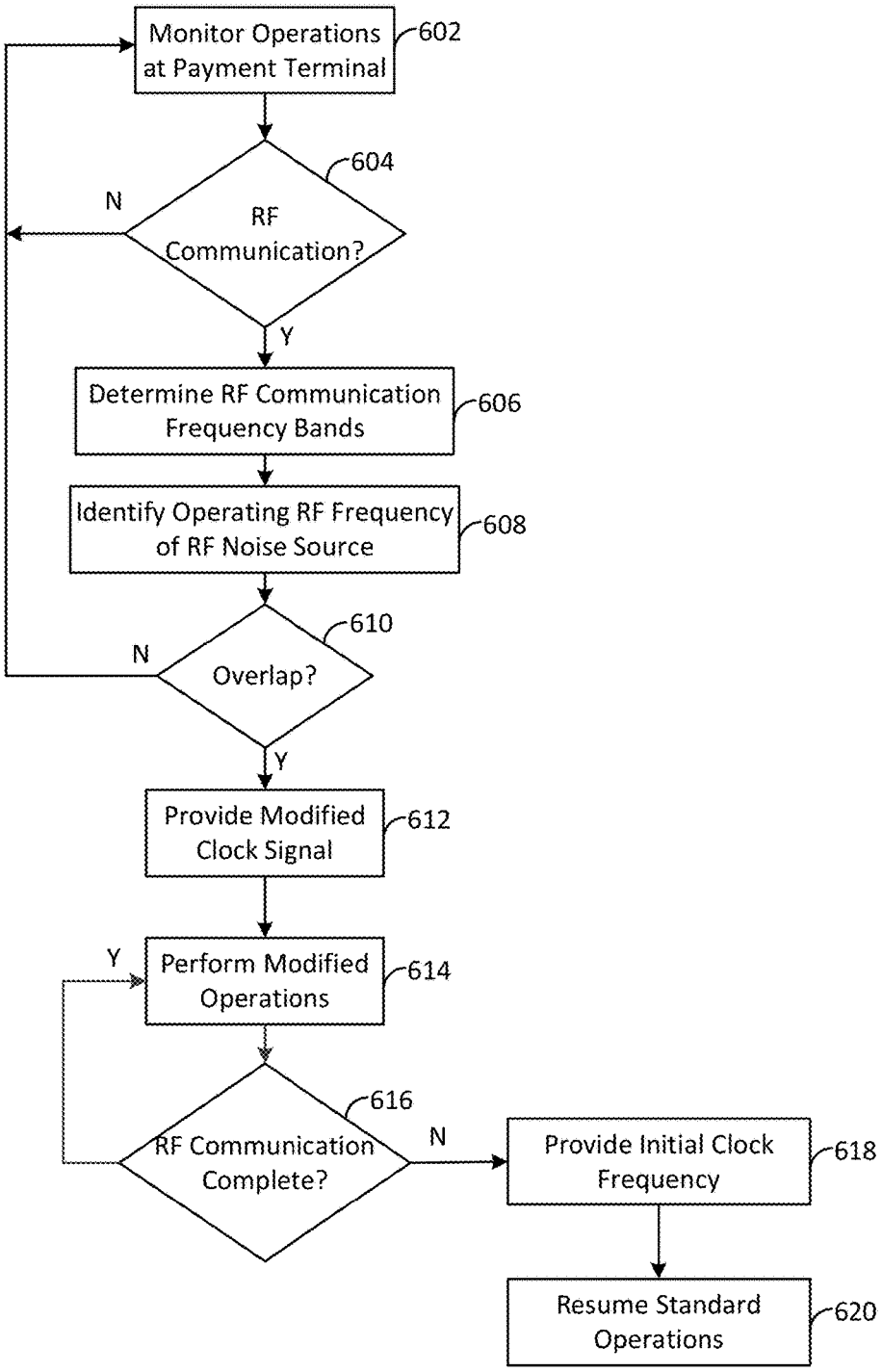

Monitor Operations at Payment Terminal
602
RF Communication?
604
N
Y
Determine RF Communication Frequency Bands
606
Identify Operating RF Frequency of RF Noise Source
608
Overlap?
610
N
Y
Provide Modified Clock Signal
612
Perform Modified Operations
614
Y
RF Communication Complete?
616
N
Provide Initial Clock Frequency
618
Resume Standard Operations
620

FIG. 6

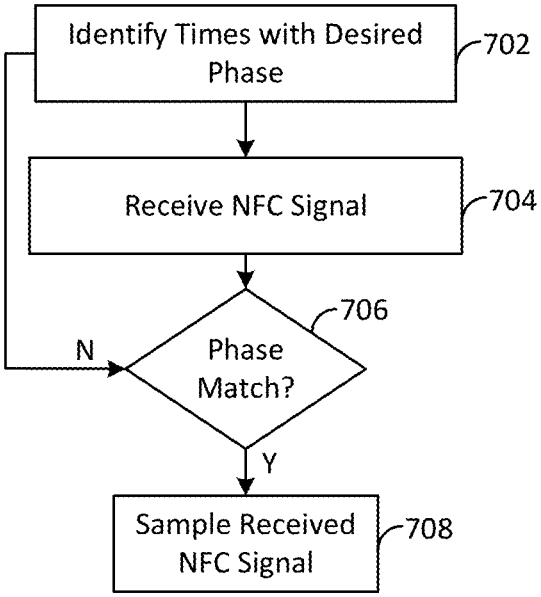

Identify Times with Desired Phase
702
Receive NFC Signal
704
706
Phase Match?
N
Y
Sample Received NFC Signal
708

FIG. 7

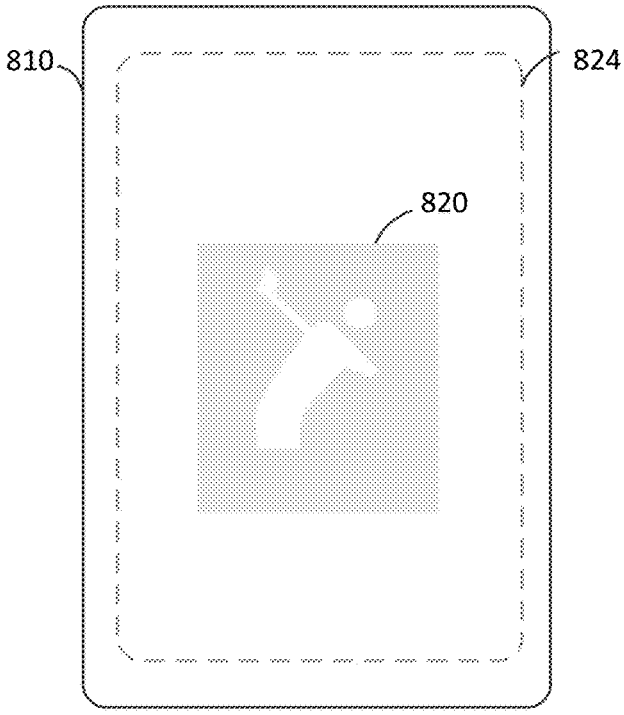


FIG. 8A

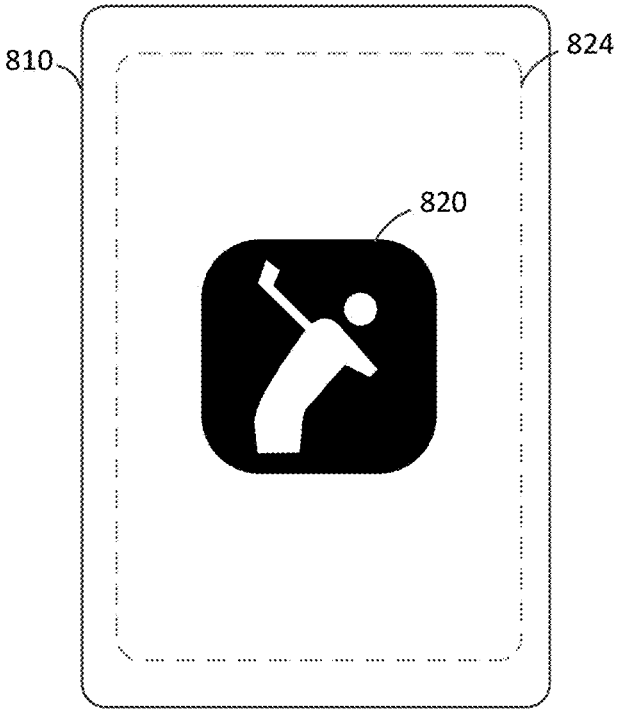


FIG. 8B

WIRELESS SIGNAL NOISE REDUCTION

BACKGROUND

[0001] Radio frequency ("RF") communication devices are capable of communicating wireless signals with other RF communication devices, and may be used in various transactions, such as payment transactions. An RF communication device may have an antenna and related circuitry for receiving and transmitting wireless signals from another RF communication device. The RF communication devices may communicate wireless messages using various RF communication protocols, such as near field communication ("NFC") and Bluetooth. A first RF communication device may generate a wireless carrier signal at a suitable frequency, such as 13.56 MHz, 2.4 GHz, etc., and transmit that signal over its antenna. When the antenna of a second RF communication device is within range of the antenna of the first RF communication device, the two devices may communicate wirelessly.

[0002] The RF communication devices may communicate data by applying additional energy to the carrier signal to modulate the signal at a suitable frequency, depending upon the communication protocol. The additional energy may modulate an amplitude, frequency, or phase the carrier signal at the suitable frequency. A second RF communication device may interpret modulation of the amplitude, frequency, or phase of the carrier signal at the frequency as data from the first RF communication device, such as binary data bits. In some cases, the RF communication devices may exchange modulated signals across a number of different sub-frequencies within one or more wireless communication frequency bands.

[0003] Signals exchanged between the RF communication devices may experience RF noise that interferes with underlying wireless data signal. Too much noise in a RF signal can distort the signal so that a RF communication device cannot detect modulation of the carrier signal, which can lead to errors in interpreting data carried by the wireless signal. The RF noise may interfere if it has sufficient amplitude at frequency or harmonics that at least partially overlaps with the wireless communication frequencies of the RF communication devices.

[0004] The RF communication devices may encounter various sources of RF noise during operation. Electromagnetic fields may be present in environments where the RF communication devices are operating, and may affect wireless signals. In addition, RF noise may be emitted during operation of electronic circuitry. For example, components of an RF communication device, such as a processor or switching circuitry may emit RF noise while operating. The RF noise emitted by the components of the RF communication device may have a frequency that overlaps the frequency of signals communicated by the RF communication devices. This RF noise can lead to errors in the processing of signals communicated between the RF communication devices, resulting in increased processing times, poor data transmission quality, or data loss.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] The above and other features of the present disclosure, its nature and various advantages will be more apparent upon consideration of the following detailed description, taken in conjunction with the accompanying drawings in which:

[0006] FIG. **1** shows an illustrative block diagram of a payment system in accordance with some embodiments of the present disclosure;

[0007] FIG. **2** depicts an illustrative block diagram a power supply, USB hub, merchant terminal and customer terminal of a point-of-sale system in accordance with some embodiments of the present disclosure;

[0008] FIG. **3** depicts an illustrative block diagram of components of the merchant terminal in accordance with some embodiments of the present disclosure;

[0009] FIG. **4** depicts an illustrative block diagram of components of the customer terminal in accordance with some embodiments of the present disclosure;

[0010] FIG. **5** depicts a non-limiting flow diagram illustrating exemplary steps of a noise management method optimizing communications of NFC signals at a point-of-sale system in accordance with some embodiments of the present disclosure;

[0011] FIG. **6** depicts a non-limiting flow diagram illustrating exemplary steps of a noise management method for optimizing communications of NFC signals at a point-of-sale system in accordance with some embodiments of the present disclosure;

[0012] FIG. **7** depicts a non-limiting flow diagram illustrating exemplary steps of a noise management method for optimizing communications of NFC signals at a point-of-sale system in accordance with some embodiments of the present disclosure;

[0013] FIG. **8**A depicts a front perspective view of a screen of a customer terminal showing a graphical output on the screen in accordance with some embodiments of the present disclosure; and

[0014] FIG. **8**B depicts a front perspective view of a customer terminal showing a graphical output on the screen in accordance with some embodiments of the present disclosure.

DETAILED DESCRIPTION

[0015] A payment system may have one or more point-of-sale (POS) terminals that facilitate payment transactions. As part of these payment transactions the POS terminal exchanges information with other devices via wireless radio frequency (RF) communication techniques, WiFi, Bluetooth classic, Bluetooth low-energy, or NFC. The merchant terminal may exchange payment information and customer information with a customer terminal. The terminal may receive payment information from a customer's payment device (e.g., from credit card with a magstripe or EMV chip, or a NFC-enabled electronic device) and communicate the payment information to other devices such as additional local terminals and remote servers of payment service systems and financial institutions. In this manner, the POS terminal communicates and exchanges a variety of information via wireless communication as part of processing payment transactions.

[0016] RF noise may be present in electronic signals communicated at the POS terminal, and may be emitted by various components of the POS terminal. The RF noise may occur because of the presence of electromagnetic energy that has a frequency at or near a frequency of a channel used by the merchant terminal or customer terminal to communicate

a wireless signal. Further, wireless signals may experience noise because of interference from various sources of RF noise in the environment around the POS terminal. All such RF noise can affect wireless RF communication between the POS terminal and other devices.

[0017] Although RF noise may generally be present in signals produced and communicated as part of operations of the POS terminal, the RF noise can be managed to reduce the noise and thus increase the signal to noise ratio. For example, effects of RF noise on processing of wireless RF signals can be minimized by processing a received RF signal at times when RF noise levels are low, such as below a threshold noise level. In addition, RF noise emitted by other components of the POS terminal operating at a frequency that overlaps with the RF communication frequency may be reduced by modifying the components' operating frequency to a frequency that is outside the RF frequency until RF communication is completed.

[0018] Instructions stored in memory at the POS terminal may provide steps for optimizing noise source behavior for RF communication. One or more processing units of the POS terminal can execute the instructions to control a clock management unit that generates clock signals and provides them to components of the POS terminal. The instructions can be executed to compare characteristics of the signals (e.g., phase, amplitude, frequency, etc.) to identify a noise threshold, and to process communications at times when noise falls below the threshold. The instructions also can be executed to reduce effects of noise on wireless communications by modifying operating frequencies of components that emit RF noise during wireless communications. The instructions may be executed to modify operating frequencies of the RF noise-emitting components by modifying clock signals provided to the components, and to return the operating frequency of the noise-emitting component to its initial operating frequency when wireless communication has been completed. The operation of components that emit RF noise may also be modified in other ways, such as by modifying the operation of the RF emitters during wireless communications. Reduced sets of operations such may be performed to avoid operations that result in large levels of RF noise emissions.

[0019] FIG. **1** depicts an illustrative block diagram of a payment system **1** in accordance with some embodiments of the present disclosure. In one embodiment, payment system **1** includes a payment device **10**, payment terminal **20**, network **30**, and payment server **40**. In an exemplary embodiment, payment server **40** may include a plurality of servers operated by different entities, such as a payment service system **50** and a bank server **60**. These components of payment system **1** facilitate electronic payment transactions between a merchant and a customer.

[0020] The electronic interactions between the merchant and the customer take place between the customer's payment device **10** and the merchant's payment terminal **20**. The customer has a payment device **10** such as a credit card having magnetic stripe, a credit card having an EMV chip, or a NFC-enabled electronic device such as a smart phone running a payment application. The merchant has a payment terminal **20** such as a payment terminal or other electronic device that is capable of processing payment information (e.g., encrypted payment card data and user authentication data) and transaction information (e.g., purchase amount and point-of-purchase information), such as a smart phone or tablet running a payment application. The payment terminal **20** may include more than one payment terminal device, such as when the payment terminal comprises a merchant terminal and a customer terminal for processing payment information.

[0021] In some embodiments (e.g., for low-value transactions or for payment transactions that are less than a payment limit indicated by a NFC or EMV payment device **10**) the initial processing and approval of the payment transaction may be processed at payment terminal **20**. In other embodiments, payment terminal **20** may communicate with payment server **40** over network **30**. Although payment server **40** may be operated by a single entity, in one embodiment payment server **40** may include any suitable number of servers operated by any suitable entities, such as a payment service system **50** and one or more banks of the merchant and customer (e.g., a bank server **60**). The payment terminal **20** and the payment server **40** communicate payment and transaction information to determine whether the transaction is authorized. For example, payment terminal **20** may provide encrypted payment data, user authentication data, purchase amount information, and point-of-purchase information to payment server **40** over network **30**. Payment server **40** may determine whether the transaction is authorized based on this received information as well as information relating to customer or merchant accounts, and responds to payment terminal **20** over network **30** to indicate whether or not the payment transaction is authorized. Payment server **40** may also transmit additional information such as transaction identifiers to payment terminal **20**.

[0022] Based on the information that is received at payment terminal **20** from payment server **40**, the merchant may indicate to the customer whether the transaction has been approved. In some embodiments such as a chip card payment device, approval may be indicated at the payment terminal, for example, at a screen of a payment terminal. In other embodiments such as a dedicated customer terminal, smart phone, or watch operating as a NFC payment device, information about the approved transaction and additional information (e.g., receipts, special offers, coupons, or loyalty program information) may be provided to the NFC payment device for display at a screen of the smart phone or watch or storage in memory.

[0023] FIG. **2** depicts an illustrative block diagram of a payment system **100** in accordance with some embodiments of the present disclosure. In one embodiment, payment system **100** includes a power supply **102**, USB hub **104**, USB connector **106**, USB connector **108**, merchant terminal **110**, and customer terminal **112**. These components of point-of-sale system **100** facilitate electronic payment transactions between a merchant and a customer.

[0024] In an embodiment, the power supply **102** may connect to an AC power source and convert the AC voltage into a DC voltage for use by the components of the payment system **100**. A DC voltage (e.g., 12 volts) may be provided to the USB hub **104**. USB hub **104** may convert the received DC voltage into a plurality of DC voltages for use in powering circuitry of the USB hub **104**. The USB hub **104** allows for the merchant terminal **110** to communicate with a plurality of other USB peripherals, such as a receipt printer, cash drawer, barcode scanner, scale, keyboard, USB-Ethernet dongle/USB MiFi, and other similar peripheral devices. As described herein, the USB hub **104** may also include power supply circuitry that selectively allows the

USB hub to provide a power supply signal (e.g., a 12V signal) to merchant terminal **110** via USB connector **106**, and via power supply circuitry of merchant terminal **110** and USB connector **108**, to customer terminal **112**.

[0025] The electronic interactions between the merchant and the customer may take place between the merchant terminal **110** and the customer terminal **112**. In one embodiment, the merchant terminal **110** supports an interactive computing device that is capable of processing payment information (e.g., encrypted payment card data and user authentication data) and transaction information (e.g., purchase amount and point-of-purchase information) with the customer terminal **112** and a remote payment server (not depicted). The merchant terminal **110** may include a plurality of interfaces as described herein in order to receive and provide power, to communicate with the customer terminal **112** and other devices such as a remote payment server, and to physically interface with other components such as the customer terminal **112**. The interactive computing device of the merchant terminal **110** may execute the software instructions of a point-of-sale application to manage user interactions with a merchant, communications with the customer terminal **112**, and communications with remote payment servers. The merchant is provided an interface through which the merchant can enter selections of purchased items, access customer information (e.g., loyalty information), check inventory, calculate taxes and fees, and otherwise perform necessary customer service and transaction steps.

[0026] Electromagnetic noise, such as RF noise may be present as a result of operation of the various devices in FIG. **2**, including power source **102**, USB hub **104**, USB connector **106**, USB connector **108**, merchant terminal **110**, customer terminal **112**, and other components. For example, RF noise may be emitted when current is supplied to USB hub **104** from power source **102**. Power supplied via USB connector **106** also can result in RF noise emission. In addition, noise may be produced and emitted by virtue of operations of the merchant terminal **110** and customer terminal **112**, such as during processing operations, generation of internal power sources, and communications via USB connector **108**. The RF noise may occur at a number of frequencies and harmonics thereof, including within frequency ranges used by the merchant terminal **110** and customer terminal **112** during wireless RF communications (e.g., NFC, Bluetooth, etc.). As a result, such noise can have detrimental effects on signals communicated by the merchant terminal **110** and customer terminal **112**. If the noise causes sufficient distortion of the wireless signals communicated by the merchant terminal **110** and customer terminal **112**, the signal to noise ratio of the wireless transmission may be reduced and data processing errors may occur at these devices. This may lead to increased transaction processing times or failures of transactions. As described in greater detail below, in some embodiments, noise management instructions stored in memory at the merchant terminal **110** and customer terminal **112** may be executed to limit the impacts of noise in order to optimize wireless communications from the merchant terminal **110** and customer terminal **112**.

[0027] The customer terminal **112** may operate as a payment terminal that receives payment information from a customer, and may provide a variety of interfaces to interact with the merchant terminal **110** and a customer. A user interface of the customer terminal **112** may allow the user to interact with the customer terminal **112** in order to interact with the merchant (e.g., select items for purchase, answer queries, confirm purchases, provide PINs and signatures, etc.), receive payment information (e.g., from a swipe card, chip card, or NFC-enabled payment device) from a customer, communicate with the merchant terminal **110** (e.g., wirelessly or via USB connector **108**), receive power from merchant terminal **110** (e.g., via USB connector **108**), and physically attach to the merchant terminal **110** (e.g., via connecting enclosures of each of the customer terminal **112** and the merchant terminal **110**).

[0028] FIG. **3** depicts a block diagram of an example merchant terminal **110** in accordance with some embodiments of the present disclosure. Although particular components are depicted in a particular arrangement in FIG. **3**, it will be understood that merchant terminal **110** may include additional components, one or more of the components depicted in FIG. **3** may not be included in merchant terminal **110**, and the components of merchant terminal **110** may be rearranged in a variety of suitable manners. In an exemplary embodiment, the merchant terminal **110** may comprise a first USB interface **202**, a second USB interface **203**, a power management device **204**, a USB control circuit **206**, a processing unit **208**, a user interface **210**, an audio device **212**, a debug module **214**, a wired interface **216**, a wireless interface **218**, and a memory **220**.

[0029] Processing unit **208** of merchant terminal **110** may include a processor capable of performing the processing functions of the merchant terminal **110** as described herein, and may be embodied by any suitable hardware, software, memory, and circuitry as is necessary to perform those functions. Processing unit **208** may include any suitable number of processors, and may perform the operations of merchant terminal **110** based on instructions in any suitable number of memories and memory types. In an example embodiment, the processing unit **208** may be a System-on-Chip (SoC) processor having a dual-core processor. In addition, in some embodiments, processing unit **208** of merchant terminal **110** may include clock management hardware, such as one or more chips for managing clock signals provided to the components of the merchant terminal. For example, in some embodiments, the processing unit **208** may receive a clock source signal and generate and provide clock signals such as a switching regulator clock signal, NFC clock signal, and a processing unit clock signal. The processing unit **208** may perform additional clock signal management functions for achieving the functionality described herein.

[0030] Further, the processing unit **208** may emit RF noise as part of its operations. A frequency of the RF noise may correspond to a frequency of one or more clock source signals provided to the processing unit **208** to control operations of the processing unit **208**, and harmonics thereon. In this regard, the processing unit may operate at an operating frequency that corresponds to the clock signal frequency provided to the processing unit **208**. An operating frequency of the processing unit **208** may thus be modified by modification to one or more clock signals provided to the processing unit **208**. RF noise emitted by the processing unit **208** may similarly be modified based on modification to the operating frequency of the processing unit **208**.

[0031] Processing unit **208** may execute instructions stored in memory **220** of merchant terminal **110** (e.g., noise management instructions **224**) to control the operations and

processing of merchant terminal **110**, and memory **220** may also store information necessary for the operation of merchant terminal **110**. As used herein, "memory" may refer to any suitable tangible or non-transitory storage medium. Examples of tangible (or non-transitory) storage media include disks, thumb drives, and memory, etc., but does not include propagated signals. Tangible computer readable storage medium include volatile and non-volatile, removable and non-removable media, such as computer readable instructions, data structures, program modules or other data. Examples of such media include RAM, ROM, EPROM, EEPROM, SRAM, flash memory, disks or optical storage, magnetic storage, or any other non-transitory medium that stores information that is accessed by a processor or computing device. In an example embodiment, memory **220** may include a flash memory and a RAM memory (e.g., a 16GB eMMC NAND flash and a 2GB LPDDR3 RAM).

[0032] First USB interface **202** and second USB interface **203** may provide for connection of other devices or components to the merchant terminal **110** as appropriate. Although any type of USB connector and interface may be used in accordance with the present disclosure, in an embodiment each of first USB interface **202** and second USB interface **203** may be a USB type B receptacle for interfacing with a type B connector of a USB connector (e.g., USB connector **106** or **108**, for connecting to USB hub **104** or customer terminal **112**). In an embodiment first USB interface **202** and second USB interface **203** may be interchangeable, such that merchant terminal **110** may function in an identical manner regardless of which of the USB interfaces is coupled to USB hub **104** or customer terminal **112**. In some embodiments (not depicted in FIG. **3**), the merchant terminal **110** may include additional interfaces, such as additional USB ports, Lightning, Firewire, Ethernet, etc.

[0033] Although power may be provided to merchant terminal **110** in any suitable manner, in an embodiment, DC power may be provided from USB hub **104** when it is connected to the merchant terminal via first USB interface **202** or second USB interface **203**. A USB control circuit **206** may include circuitry for interacting with the USB hub **104** to receive the incoming DC power signal and to distribute that signal to other components of the merchant terminal **110** (e.g., via power management device **204**) and to the customer terminal **112** (e.g., via the other USB interface of first USB interface **202** and second USB interface **203**). A power management device **204** (e.g., a discrete power management integrated circuit) may receive power provided from USB hub **104** through one of the USB interfaces (first USB interface **202** or second USB interface **203**) and USB control circuit **206**, and may perform functions related to power requirements of a host system (e.g., DC to DC conversion, battery charging, linear regulation, power sequencing and other miscellaneous system power functions).

[0034] In some embodiments, the power management device **204** may include switching regulator hardware for modifying power signals provided to the resources and components of merchant terminal **110**. In some embodiments, the switching regulator hardware may be various types of switching regulators, such as a buck, boost, or other types of switching regulator. The switching regulator hardware may boost voltage provided from the USB hub **104** before providing it to other components of the merchant terminal **110**. As a result of such modification, the switching regulator hardware may emit noise at various frequencies, including noise at frequencies in RF frequency bands that may affect RF communication signals transmitted and received by the merchant terminal **110**. In some embodiments, the merchant terminal **110** may comprise one or more switching regulators, each of which may emit RF noise or noise in other frequency bands as part of its operations. As described further below, one or more processors (e.g., processing unit **208**) of the merchant terminal **110** may execute instructions to compensate for RF noise emitted by the switching regulator hardware by optimizing and coordinating operations of switching regulator hardware and other components of the merchant terminal **110**.

[0035] Merchant terminal **110** may also include a user interface **210**. User interface **210** may provide various interfaces and outputs to the merchant terminal **110** to be viewed by a merchant. An example user interface **210** may include hardware and software for interacting with a user, such as a touchscreen interface, voice command interface, keyboard, mouse, gesture recognition, any other suitable user interface, or any combination thereof. In one embodiment, the user interface **210** may be a touchscreen interface that displays an interactive user interface for programs and applications such as a point-of-sale application running on the merchant terminal **110**. The user interface **210** may comprise other components in other embodiments.

[0036] In some embodiments, the user interface **210** may be positioned adjacent to components of the merchant terminal **110** configured to communicate wireless signals. The user interface **210** may emit RF noise as part of its operation, which may cause distortion of RF signals sent and received by the wireless interface **218**, such as when one or more frequency bands of the RF noise overlaps one or more RF communication frequency bands. In some embodiments, a frequency of the noise emitted by the user interface **210** may correspond to an operating frequency of the user interface **210**. For example, when the user interface **210** is implemented as a touchscreen interface, the touchscreen may be configured to operate (e.g., provide outputs and receive user inputs) at an initial operating frequency, such as approximately 50-100 Hz. Such initial operating frequency may be based on a clock signal provided at an initial clock frequency (e.g., from a clock management unit coupled to the processing unit **208**). This initial clock frequency may cause the user interface **210** to perform operations at the initial operating frequency: that is, the initial operating frequency of the user interface **210** may be based on the initial clock frequency provided to the user interface **210**. In this regard, one or more frequency bands of the noise emitted by the user interface **210** when operating at the initial operating frequency may overlap one or more RF communication frequency bands of RF communication interfaces of the merchant terminal **110**, such as an NFC frequency or Bluetooth frequency of communications from wireless interface **218**. As will be described further below, the user interface **210** may be operable to perform operations at a modified operating frequency, such as in response to receiving a modified clock frequency from the clock management unit (e.g., in response to modification by the processing unit **208** or clock management unit **222**). Such modified operations may result in the user interface **210** emitting noise at one or more modified noise frequencies. In some embodiments, none of the one or more modified noise frequencies may overlap any of the one or more RF com-

munication frequencies of the merchant terminal **110**. Other modifications to operations of the user interface **210** may be performed in other embodiments, including by techniques other than modifying an operating frequency of the user interface **210**.

[0037] Merchant terminal **110** may also include an audio device **212**. Audio device **212** may provide audio for the merchant terminal **110**. An example audio device **210** may comprise an audio amplifier and a speaker for providing appropriate audio for the merchant terminal **110**. The merchant terminal **110** may comprise other components in other embodiments.

[0038] Merchant terminal **110** may also include a debug module **214**. In an embodiment, a debug module may provide an interface and processing for performing debug operations (e.g., by a technician utilizing a debug device), such as identifying and removing defects that prevent correct operation of the merchant terminal **110** and the various components thereof In some embodiments, the functionality of debug module **214** may only be initiated in response to a predetermined self-test input, such that the debug interface is not externally accessible through a communication interface.

[0039] Merchant terminal **110** may also include a wired interface **216**, which may include a suitable interface for wired communication, such as USB, Lightning, FireWire, Ethernet, any other suitable wired communication interface, or any combination thereof, to perform, for example, the wired communication with other devices of the payment system **100** and payment servers (e.g., via a secure internet connection).

[0040] Merchant terminal **110** may also include a wireless communication interface **218**. The wireless communication interface **218** may include suitable hardware and software for providing a wireless communication interface such as radio frequency (RF), Bluetooth classic, Bluetooth low energy, WiFi, cellular, short message service (SMS), NFC, any other suitable wireless communication interface, or any combination thereof. In an example embodiment, the wireless communication interface **218** may facilitate communications between the merchant terminal **110** and peripherals, as well as with payment servers (e.g., via a secure internet connection).

[0041] In some embodiments, wireless communication interface **218** may be configured for communicating (e.g., sending and receiving) wireless signals at one or more frequencies used for wireless communications. For example, signals sent and received at the wireless interface **218** may include signals communicated based on one or more frequencies of the respective protocols described herein, such as an NFC carrier signal at a 13.56 MHz frequency, an 800 kHz NFC data modulation frequency, 2.4 GHz for Bluetooth classic protocol, Bluetooth channels in a 20-25 MHz band, etc. Each signal may have a phase, amplitude, frequency, modulation method, and other characteristics. In some embodiments, wireless signals communicated by the merchant device **110** may be communicated based on one or more other wireless communication frequencies. In addition, the signals sent and received at the wireless communication interface **218** may include RF noise at various frequencies. The RF noise may be present in signals communicated at various frequencies, including frequencies that overlap communication frequency bands of signals sent and received at the wireless communication interface **218**. RF signals may be received at an antenna of the wireless communication interface **218**, and may be provided for processing at the merchant terminal **110**, such as by processing unit **208**. In this regard, various components of the merchant terminal **110** may function as a receive circuit for receiving wireless communications (e.g., NFC, Bluetooth, etc.).

[0042] In some embodiments, wireless communication interface **218** may be positioned approximately adjacent to or in close proximity to the user interface **210**. As described above, the user interface **210** may emit RF noise across various frequencies as part of its operation. Such RF noise can interfere with communication of signals at the wireless communication interface **218** when one or more noise frequencies overlap one or more communication frequencies of the merchant terminal **110**. According to the techniques described herein, noise frequency bands of noise emitted by components of the merchant terminal **110**, such as the user interface **218**, can be shifted during periods when communications are sent or received at the wireless communication interface **218** so that no overlap of such frequencies occurs.

[0043] Clock management unit **222** may include software, hardware or various combinations thereof for generating and managing clock signals provided to various components of the merchant terminal **110**, such as to a clock input pin of various components of the merchant terminal **110**. In some embodiments, the clock management unit **222** may be implemented as one or more chips, and may comprise suitable logic for generating and providing clock signals as desired. Exemplary clock signals generated by the clock management unit include one or more clock signals provided to one or more switching regulators, a wireless communication interface **218**, and processing unit **208**. Each clock signal provided by the clock management unit **222** may have a desired phase, amplitude, frequency, and duty cycle. In addition, the clock management unit **222** may be configured for receiving a clock source signal, such as from the processing unit **208**, and to generate and provide one or more clock signals based on the clock source signal.

[0044] Noise management instructions **224** may be stored in memory **220** and may include instructions for optimizing communication of wireless signals and for coordinating operations between a wireless communication source and a RF noise source of the merchant terminal **110**. The noise management instructions **224** may include instructions for controlling operations of essentially any or various combinations of resources of the merchant terminal **110** to achieve the optimization and coordination operations described herein, and may include instructions for performing various tasks described herein simultaneously or at various times. In addition, functionality ascribed to the noise management instructions **224** may be distributed among other instructions stored in memory **220**, and may be implemented using software, firmware, hardware, or various combinations thereof

[0045] Noise management instructions **224** may include instructions for controlling a clock management unit of the merchant terminal **110** to generate a plurality of clock signals. In some embodiments, the plurality of clock signals may include various types of clock signals provided to components or resources of the merchant terminal **110**. For example, clock signals that may be generated by the clock management unit of merchant terminal **110** can include a switching regulator clock signal, an NFC clock signal, and

a processing unit clock signal. Each of the plurality of clock signals generated by the clock management unit in response to execution of noise management instructions **224** may have a phase, frequency, amplitude, and duty cycle, and may be controlled or configured as described herein. In some embodiments, other signals in addition to the system described herein may be generated based on instructions **224**.

[0046] Noise management instructions **224** may include instructions for generating a switching regulator clock signal. In some embodiments, one or more switching regulators of the merchant terminal **110** may emit RF noise. The RF noise may be based on an operating frequency of the one or more switching regulators. By controlling a clock signal provided to the one or more switching regulators, a clock management unit (e.g., processing unit **208** executing noise management instructions **224**) of the merchant terminal **110** may be configured to identify RF noise. Noise management instructions **224** may include instructions for providing the switching regulator clock signal to the one or more switching regulators of the merchant terminal **110**. The switching regulator clock signal may have a phase and frequency, and in some embodiments, the same switching regulator clock signal may be provided to multiple switching regulators of the merchant terminal **110**. In this regard, each of the switching regulators of the merchant terminal **110** may operate based on the same clock signal, which may have a phase, frequency, amplitude, and duty cycle. In other embodiments, different clock signals may be provided to different switching regulators. In this regard, noise management instructions **224** may include instructions for determining a phase and frequency of the switching regulator clock signal that may be used to identify RF noise.

[0047] In some embodiments, noise management instructions **224** may include instructions for generating a wireless clock signal such as an NFC clock signal at the clock management unit **222**. The NFC clock signal may be provided to the processing unit **208** of the merchant terminal **110** and/or the wireless interface **218** for performing wireless communications (e.g., at wireless interface **218**), such as via RF communication using NFC. In other embodiments involving different communications methods, the wireless clock signal may correspond to a frequency for the communication method (e.g., Bluetooth). In some embodiments, the NFC clock signal may have a phase and frequency that corresponds to a phase and frequency of one or more wireless communication frequencies of the merchant terminal **110**. For example, in some embodiments, the NFC clock signal may have a phase and frequency that corresponds to a phase and frequency of the NFC carrier signal (e.g., 13.56 MHz), as modulated during communication (e.g., at 800 kHz). A phase and frequency of the NFC clock signal may constitute a baseline phase and frequency for detecting noise in a received wireless communication signal. For example, a received wireless communication signal may have noise on it that causes variations of the data signal, such that an amplitude, phase, and/or frequency differs from the phase and frequency of the NFC clock signal by an amount greater than a pre-defined threshold. Noise management instructions **224** may include instructions for determining that an amount by which the amplitude, phase and/or frequency of the NFC clock signal and the received wireless communication exceeds the threshold and thus represents unacceptable noise. Note that in some embodiments, noise management instructions may include instructions for receiving a RF signal at the merchant terminal **110**, such as from wireless communication interface **218**. The merchant terminal **110** may receive other types of wireless signals in other embodiments, and such other wireless signals may include RF noise. Noise management instructions **224** may include instructions for processing each wireless signal received at a merchant terminal **110** according to the techniques described herein. Other techniques for processing wireless signals received at merchant terminal **110** may be possible in other embodiments.

[0048] In some embodiments, noise management instructions **224** may include instructions for determining a plurality of possible sampling times for the received wireless signal (e.g., a received modulated NFC signal) based on a phase and frequency of a clock signal provided to the processing unit **208**. The processing unit **208** may process data based on a frequency of the clock signal provided to the processing unit **208**. A rate at which sampling of the received NFC signal may be may be performed thus may be determined based on a frequency and phase of a clock signal provided to the processing unit **208**, and further based on when possible sampling times correspond to times when data is received and noise is minimized. As noted above, the wireless communication signal received at the merchant terminal **110** may have a phase and frequency which may be based on a wireless carrier signal phase and frequency, and a RF noise source may also have a phase and frequency. Thus, the times at which processing unit **208** may perform sampling of the wireless communication signal may be based on a phase and frequency of the processing unit clock signal and times when the data of the received wireless signal us less likely to be impacted by noise. In this regard, noise management instructions **224** may include instructions for identifying a plurality of possible sampling times that may be compared with time periods during in which noise present in a received wireless communication signal is below a threshold.

[0049] Noise management instructions **224** may include instructions for identifying a noise threshold for determining times at which the noise present in a received wireless communication signal is reduced. A noise threshold may be indicative of a value of noise that may allow processing of the wireless communication signal with a desired (e.g., reduced) number of errors. By processing (e.g., sampling) the received wireless communication signal during such times when noise falls below the noise threshold, errors in processing the received wireless signal at the processing unit **208** may be reduced. Noise management instructions **224** may include instructions for determining a noise threshold based on measured or predicted differences between phases and frequencies of various signals at the merchant device **110**, but in some embodiments, a threshold may be determined based on a first phase difference and a first frequency difference. In an exemplary embodiment, the first phase difference may be based on a difference between a phase of the switching regulator clock signal and a phase of the NFC clock signal. The first frequency difference may be based on a difference between a frequency of the switching regulator clock signal and a frequency of the NFC clock signal. Again, other information may be used to identify a suitable noise threshold in other embodiments.

[0050] Noise management instructions **224** may include instructions for identifying time periods when RF noise is

below a noise threshold. By identifying the time periods when a noise value (e.g., an aggregate value of RF noise emitted by components such as the one or more switching regulators) falls below the threshold, the received wireless communication signal may be sampled for processing at such times at the processing unit **208**. In this regard, portions of the wireless communication signal sampled for processing at the processing unit **208** may have RF noise that is below the noise threshold, reducing noise-related errors. The noise management instructions **224** may include instructions for aggregating RF noise present due to the one or more switching regulators and RF noise present in the received wireless communication signal (e.g., as may be received by the NFC receive circuit at wireless communication interface **218**), determining a value associated with the RF noise, and comparing it with the threshold. Such aggregation and comparison may be performed at a desired number of time periods, such as based on one or more of the switching regulator clock signal, NFC clock signal, and processing unit clock signal. In this regard, the noise management instructions **224** may include instructions for identifying a plurality of time periods at which the RF noise falls below the threshold.

[0051] Noise management instructions **224** may include instructions for comparing sampling times for the processing unit **208** (e.g., based on the processing unit clock signal) with the plurality of time periods during which RF noise is below the noise threshold and identifying the time periods which correspond with the sampling times. By comparing times from the plurality of time periods with the plurality of possible sampling times for the processing unit **208**, periods when sampling of the received wireless communication signal with RF noise that is below the noise threshold may be possible. In this regard, the noise management instructions **224** may include instructions for causing the processing unit **208** to perform sampling of the signal at time periods from the plurality of time periods that correspond to sampling times from the plurality of possible sampling times. In this regard, the received wireless communication signal sampled by the processing unit **208** may be processed at times during which RF noise present at the merchant device **110** is below the noise threshold. Other techniques for processing the received wireless communication signal during times when RF noise at the merchant device **110** is below a noise threshold may be possible in other embodiments.

[0052] In some embodiments, the noise management instructions **224** may include instructions for coordinating operations between a wireless communication source of the merchant terminal **110** and a source of RF noise within the merchant terminal **110**. By coordinating operations the wireless communication components of the merchant terminal **110** and various sources of RF noise within the merchant terminal **110**, signal quality and communication efficiency of wireless communication signals communicated by the merchant terminal **110** may be improved. Processing unit **208** may execute noise management instructions **224** to perform such coordination according to the techniques described herein, but it will be understood that similar techniques for coordinating operations of the components of the merchant terminal **110** for management of RF noise may be possible in other embodiments.

[0053] Noise management instructions **224** may include instructions for monitoring operation of wireless communication resources of merchant terminal **110**, such as clock signals provided to processing unit **208** and signals received via wireless communication interface **218** to identify periods of time during which wireless communications are occurring. For example, operations of sources of RF noise may be modified or altered as desired in order to modify frequency bands of RF noise emitted by the RF noise source. In this regard, an operating frequency of one or more of the noise sources may be modified by modifying a clock signal provided to the one or more noise sources. In this regard, modification of the clock signal frequency may result in modification of a frequency of the RF noise. RF noise thus may be shifted to one or more frequency bands that do not overlap with any portion of the wireless communication frequency band in use at the merchant terminal.

[0054] Noise management instructions **224** may include instructions for identifying an operating frequency of one or more RF noise sources, such as based on a clock signal provided to the RF noise source. Resources of the merchant terminal **110** may emit RF noise during operation. RF noise may be emitted by processing unit **208**, user interface **218**, one or more switching regulators, or other components that operate at a frequency. A frequency of RF noise emitted by the RF noise source may be based upon an operating frequency of the noise source, which in turn may be based upon a frequency of a clock signal provided to the RF noise source. In this regard, one or more frequencies of RF noise may correspond to one or more operating frequencies of the RF noise source. An operating frequency may be modified by modifying a frequency of a clock signal provided to the RF noise source (e.g., from clock management unit **222**). In this regard, the noise management instructions may include instructions for modifying one or more frequencies of RF noise by modifying a clock signal frequency of the one or more RF noise sources.

[0055] Noise management instructions **224** may include instructions for determining that the merchant terminal **110** is communicating at one or more wireless communication frequencies. Noise management instructions **224** may include instructions for identifying periods when the merchant terminal is communicating wirelessly, such as based on characteristics (e.g., phase, frequency, etc.) of one or more clock signals provided to processing unit **208**. For example, wireless communication may be occurring when a clock signal frequency provided to the wireless communication interface corresponds to a wireless communication frequency, when a transmission voltage or current is being provided to a transmit signal, or when the processing unit is performing communications functions.

[0056] Noise management instructions **224** may include instructions for determining that one or more frequencies of RF noise emitted by a RF noise source overlap at least a portion of RF communication frequencies that the merchant terminal **110** is using for wireless communication. For example, noise management instructions **224** may compare one or more RF noise frequencies with frequencies used in various wireless communication protocols at the merchant terminal **110**, such as Bluetooth channel frequency bands (e.g., indicated on a Bluetooth channel map stored in memory **220**), NFC frequencies, etc. If a frequency of RF noise falls within a range of frequencies for wireless communication, the noise management instructions may determine that a frequency of the RF noise overlaps at least a portion of the one or more wireless communication frequencies. Other techniques for determining whether an RF noise

frequency overlaps one or more wireless frequency bands are possible in other embodiments.

[0057] Noise management instructions **224** may include instructions for modifying an operating phase or frequency of one or more RF noise sources. The one or more RF noise sources may normally operate at an initial operating frequency. For example, a processing unit **208** may receive an initial clock signal that causes the processing unit **208** to perform processing operations at an operating frequency that corresponds to the initial clock signal frequency. In an embodiment, user interface **218** may receive an initial clock signal that has an initial clock signal frequency and may perform operations of user interface **218** (e.g., touchscreen **218**) at an operating frequency that corresponds to the initial clock signal frequency. Note that one or more clock signals may be provided to the one or more RF noise sources, and in some embodiments, such clock signals may be provided by clock management unit **222** of merchant terminal **110**. As noted above, an operating frequency of an RF noise source may correspond to a frequency of RF noise emitted by the RF noise source. In this regard, an initial operating frequency of the RF noise source may be modified, such as by modifying an initial clock signal frequency provided to the RF noise source. A frequency of RF noise emitted by the RF noise source thus may be modified based on the modified operating frequency.

[0058] In some embodiments, operations that are performed by the RF noise source may be a standard set of operations, and the operations may be modified to a reduced set of operations to limit RF noise emitted by the RF noise source. In some embodiments, noise management instructions **224** may include instructions for causing the one or more RF noise sources to perform a modified (e.g., reduced) set of operations, such as by reducing power for certain operations or foregoing normal processing operations. In some embodiments, the reduced set of operations may correspond to operations that are possible at the modified operating frequency based on receipt of a modified clock signal. In addition, noise management instructions **224** may include instructions for determining that the merchant terminal **110** is no longer communicating wirelessly (e.g., based on monitoring of signals provided to the wireless communication interface **218**) and causing one or more RF noise sources to return to performing standard operations. In some embodiments, a clock signal provided to the one or more RF noise sources may return to an initial operating frequency once wireless communications are complete.

[0059] FIG. **4** depicts a block diagram of an exemplary customer terminal **112** in accordance with some embodiments of the present disclosure. Although particular components are depicted in a particular arrangement in FIG. **4**, it will be understood that customer terminal **112** may include additional components, one or more of the components depicted in FIG. **4** may not be included in customer terminal **112**, and the components of customer terminal **112** may be rearranged in a variety of suitable manners. In one embodiment, customer terminal **110** may comprise a USB interface **302**, a power management device **304**, a debug module **306**, an audio device **308**, a user interface **310**, a clock management unit **311**, a main processing unit **312**, a memory **314**, a secure enclave **340**, a magnetic swipe slot **330**, an EMV slot **332**, and an NFC flex circuit **334**.

[0060] Clock management unit **311** may include software, hardware or various combinations thereof for generating and managing clock signals provided to various components of the customer terminal **112**, such as to a clock input pin of various components of the customer terminal **112**. In some embodiments, the clock management unit **311** may be implemented as one or more chips, and may comprise suitable logic for generating and providing clock signals as desired. Exemplary clock signals generated by the clock management unit include one or more clock signals provided to one or more switching regulators, a NFC interface **328**, and main processing unit **312**. Each clock signal provided by the clock management unit **311** may have a desired phase, amplitude, frequency, and duty cycle. In addition, the clock management unit **311** may be configured for receiving a clock source signal, such as from the main processing unit **312**, and to generate and provide one or more clock signals based on the clock source signal. Note that, although clock management unit **311** is depicted as being coupled to main processing unit **312**, the clock management unit **311** may be coupled to provide clock signals to various resources of customer terminal **112** to achieve the functionality described herein, including to main processing unit **312**, secure processing unit **316**, user interface **310** and **318**, and NFC interface **328**.

[0061] Main processing unit **312** of customer terminal **112** may include a processor capable of performing the processing functions of the customer terminal **112** as described herein, and may be embodied by any suitable hardware, software, memory, and circuitry as is necessary to perform those functions. Main processing unit **312** may include any suitable number of processors, and may perform the operations of customer terminal **112** based on instructions in any suitable number of memories and memory types. In an example embodiment, the main processing unit **312** may be a System-on-Chip (SoC) processer having a dual-core processor (e.g., a Dual core ARM Cortex A7/A9).

[0062] Main processing unit **312** may execute instructions stored in memory **314** of customer terminal **112** to control the operations and processing of customer terminal **112**, and the memory **314** may also store information necessary for the operation of customer terminal **112**. In an example embodiment, memory **314** may include a flash memory and a RAM memory (e.g., a 16GB eMMC NAND flash and a 2GB LPDDR3 RAM). Memory **314** may include instructions (e.g., noise management instructions **315**) for optimizing NFC communication and coordinating operation of RF communication sources with RF noise sources at the customer terminal **112**.

[0063] USB interface **302** may provide for a connection to the merchant terminal **110** in order to receive power from merchant terminal **110** and to communicate with the merchant terminal **110**. Although any type of USB connector and interface may be used in accordance with the present disclosure, in an embodiment USB interface **302** may be a USB type B receptacle for interfacing with a micro USB type B connector of a USB connector (e.g., USB connector **106** or **108**, for connecting to merchant terminal **110**). In some embodiments (not depicted in FIG. **4**), customer terminal **112** may include additional wired or wireless interfaces such as additional USB ports, Lightning, Firewire, Ethernet, WiFi, Bluetooth, etc.

[0064] Although power may be provided to customer terminal **112** in any suitable manner, in an embodiment DC power may be provided from merchant terminal **110** when it is connected to the customer terminal **112** via the USB

interface **302**. A USB control circuit **303** may include circuitry for interacting with the merchant terminal **110** to receive the incoming DC power signal and to distribute that signal to other components of the customer terminal **112** (e.g., via power management device **304**). In some embodiments, USB control circuit **303** may enable additional functionality, such as initiating a reprogramming mode for the customer terminal based on a received voltage at USB interface **302**. A power management device **304** (e.g., a discrete power management integrated circuit) may receive power provided from merchant terminal **110** through the USB interface **302** and USB control circuit **303**, and may perform functions related to power requirements of the customer system (e.g., DC to DC conversion, battery charging, linear regulation, power sequencing and other miscellaneous system power functions).

[0065] Customer terminal **112** may also include a user interface **310**. User interface **310** may provide various interfaces and outputs to the customer terminal **112** to be viewed by a customer. An example user interface **310** may include hardware and software for interacting with a customer, such as a touchscreen interface, voice command interface, keyboard, mouse, gesture recognition, any other suitable user interface, or any combination thereof. In one embodiment, the user interface **310** may be a touchscreen device that displays an interactive user interface for the customer to engage in purchase transactions (e.g., select items for purchase, answer queries, confirm purchases, provide PINs and signatures, etc.) at the customer terminal **112**.

[0066] In some embodiments, the user interface **310** may be positioned adjacent to components of the customer terminal **112** configured to perform wireless communication. The user interface **310** may emit RF noise as part of its operation, which may cause distortion of signals sent and received by the NFC interface **328** when one or more frequency bands of the noise overlap one or more communication frequency bands. In some embodiments, a frequency of the noise emitted by the user interface **310** may correspond to an operating frequency of the user interface **310**. For example, when the user interface **310** is implemented as a touchscreen interface, the touchscreen may be configured to operate (e.g., provide outputs and receive user inputs) at an initial operating frequency, such as approximately 50-100 Hz . Such initial operating frequency may be based on a clock signal provided at an initial clock frequency (e.g., from a clock management unit **311** coupled to the main processing unit **312** and secure processing unit **316**). This initial clock signal may cause the user interface **310** to perform operations at the initial operating frequency: that is, the initial operating frequency of the user interface **310** may be based on the initial clock frequency provided to the user interface **310**. In this regard, one or more frequencies of the noise emitted by the user interface **310** when operating at the initial operating frequency may overlap one or more wireless communication frequencies of RF communication interfaces of the customer terminal **112**, such as an NFC frequency band or Bluetooth frequency band of communications from NFC interface **328**. As will be described further below, the user interface **310** may be operable to perform operations at a modified operating frequency, such as in response to receiving a modified clock signal from the clock management unit (e.g., in response to modification by the main processing unit **312** or secure processing unit **316**). Such modified operations may result in the user interface **310** emitting noise at one or more modified noise frequencies. In some embodiments, none of the one or more modified noise frequencies may overlap any of the one or more RF communication frequencies of the customer terminal **112**. Other modifications to operations of the user interface **310** may be performed in other embodiments, including by techniques other than modifying an operating frequency of the user interface **310**.

[0067] Customer terminal **112** may also include an audio device **308**. Audio device **308** may provide audio for the customer terminal **112**. An example audio device **308** may comprise an audio amplifier and a speaker for providing appropriate audio for the customer terminal **112**. The audio device **308** may comprise other components in other embodiments.

[0068] Customer terminal **112** may also include a debug module **306**. In an embodiment, a debug module **306** may provide an interface and processing for performing debug operations (e.g., by a technician utilizing a debug device), such as identifying and removing defects that prevent correct operation of the customer terminal **112** and the various components thereof. In an embodiment, debug module **306** may be secured using various techniques. Debug module **306** may restrict or reject communications (e.g., a signal) received from the debug module **306** unless the communication is from an approved device. For example, instructions stored in memory, such as memory **314**, may include instructions (e.g., noise management instructions **315**) for optimizing NFC communication and coordinating operation of RF communication sources with RF noise sources at the customer terminal **112**. In some embodiments, the functionality of debug module **306** may only be initiated in response to a predetermined self-test input, such that the debug interface is not externally accessible through a communication interface. In some embodiments, debug module **306** may be secured physically, such as by use of a filter, switch or other device. Other techniques for securing debug module **306** may be used in other embodiments.

[0069] The secure enclave **340** may be a secure portion of the customer terminal **112** that performs critical functionality such as interacting with payment devices and cryptography, and that stores sensitive information such as cryptographic keys, passwords, and user information. In an embodiment, the secure enclave **340** may be located in a distinct location of the customer terminal **112** to isolate the secure enclave **340** from other circuitry of the customer terminal **112** and to allow protective measures (e.g., tamper detection switches, anti-tamper meshes, anti-tamper domes, isolated compartments, etc.) to be installed near and around the secure enclave **340** (not depicted in FIG. **4**). In an example embodiment, the secure enclave **340** may be situated at a portion of the customer terminal **112** in a manner that provides additional physical clearance for protective measures.

[0070] In an embodiment, the secure enclave **340** may include a secure processing unit **316**, a user interface **318**, a battery **320**, a debug module **322**, a magnetic swipe interface **324**, a chip card interface **326**, and an NFC interface **328**.

[0071] Although secure processing unit **316** may be implemented with any suitable processor, hardware, software, or combination thereof, in an embodiment, secure processing unit **316** may be implemented as microcontroller unit (MCU). Secure processing unit **316** may perform transaction processing and cryptographic operations, based on instruc-

tions and information (e.g., customer data, encryption keys, etc.) stored in a memory of secure processing unit **316** (not separately depicted in FIG. **4**), which may be any suitable memory as described herein. Secure processing unit **316** may communicate with main processing unit **312** in order to receive and respond to requests for processing of payment information. Communications may be performed using any suitable internal bus and communication technique (e.g., UART, SPI, I^2C, and GPIO).

[0072] The secure enclave **340** of customer terminal **112** may also include a battery **320**. In some embodiments, the battery **320** may function as a primary power source to certain components of the secure enclave **340** (e.g., memory storing critical payment, customer, and encryption information), such that when the battery power is removed the information is lost. The battery **320** may function in this manner in response to a tamper attempt, such that in response to the tamper attempt, the secured information is destroyed.

[0073] The secure enclave **340** of customer terminal **112** may also include a debug module **322**. In an embodiment, a debug module **322** may provide an interface and processing for performing debug operations (e.g., by a technician utilizing a debug device) directly with the components of the secure enclave. In some embodiments, the functionality of debug module **322** may only be initiated in response to a predetermined self-test input, such that the debug interface is not externally accessible through a communication interface.

[0074] The secure enclave **340** of customer terminal **112** may also include a user interface **318**. In an embodiment, user interface **318** (e.g., a keypad, touchscreen, etc.) may be located within the secure enclave such that certain content is provided to the secure enclave **340** rather than the general processing circuitry of the customer terminal **112**. In this manner, critical information such as PIN numbers, signatures, and passwords may be provided only to the secure enclave **340** in the first instance, and then forwarded to the main processing unit **312** in encrypted or unencrypted form, as required. In some embodiments, the user interface **318** may emit RF noise during operation in a manner similar to that of user interface **310**, such as when user interface **318** is implemented as a touchscreen. In this regard, operations of user interface **318** may be controlled using essentially the same or similar techniques as described herein with regard to user interface **310** to optimize NFC communication or manage noise emitted by one or more RF noise sources, including user interface **318**.

[0075] Secure enclave **340** of customer terminal **112** may also include a magnetic swipe interface **324**, chip card interface **326**, and NFC interface **328**. Each of these components may include interface circuitry for receiving and processing signals from a payment interface, such as a magnetic reader head **330**, a chip card slot **332** (e.g., providing power and communications to the chip card), and an NFC circuit, components of which may be located on an NFC flex circuit **334** remote from secure enclave **340**. For example, instructions stored in memory, such as memory **314**, may include instructions for disabling secure enclave **340** and limiting or rejecting communications at magnetic swipe interface **324**, chip card interface **326**, and NFC interface **328**. Other techniques for interfaces of secure enclave **340** may be used in other embodiments.

[0076] In some embodiments, NFC interface **328** may be configured for communicating (e.g., sending and receiving) wireless signals at frequencies used for wireless communications. For example, signals sent and received at the NFC interface **328** may include signals communicated based on one or more frequency frequencies of the respective protocols described herein, such as an NFC carrier signal at a 13.56 MHz frequency, an 800 kHz NFC data modulation frequency. Each signal may have a phase, amplitude, frequency, or other characteristics. In some embodiments, signals may be communicated based on one or more other wireless communication frequency bands. In addition, the signals sent and received at the NFC interface **328** may include noise coupled thereon at various frequencies. The noise may be present in signals communicated at various frequencies, including frequencies that overlap communication frequency bands of signals sent and received at the NFC interface **328**. Signals received at the NFC interface **328** may be provided for processing at the customer terminal **112**, such as by secure processing unit **316** or main processing unit **312**. In this regard, various components of the customer terminal **112** may function as a receive circuit for receiving wireless communications (e.g., NFC, Bluetooth, etc.).

[0077] In some embodiments, NFC interface **328** may be positioned approximately adjacent to or in close proximity to the user interfaces **310** and **318**. As described above, the user interfaces **310** and **318** may emit noise in various frequency bands as part of its operation. Such noise can interfere with communication of signals at the NFC interface **328** when one or more noise frequency bands overlap one or more communication frequency bands of the customer terminal **112**. According to the techniques described herein, noise frequency bands of noise emitted by components of the customer terminal **112**, such as the user interfaces **310** and **318**, can be shifted during periods when communications are sent or received at the NFC interface **328** so that no overlap of such frequency bands occurs.

[0078] Noise management instructions **315** may be stored in memory **314** and may include instructions for optimizing communication of wireless signals and for coordinating operations between a wireless communication source and a wireless noise source of the customer terminal **112**. In an exemplary embodiment, noise management instructions **315** may operate include some or all of the functionality of noise management instruction **224**, as applied to the particular RF noise sources (e.g., power management device **304**, user interface **310**, main processing unit **312**, secure processing unit **316**, user interface **318**, and chip card interface **326**), communication interfaces (e.g., NFC interface **328** and NFC Flex **334**, a Bluetooth transponder (not depicted), etc.), and control circuitry (e.g., CMU **311**) of the customer terminal **112**.

[0079] FIG. **5** depicts a non-limiting flow diagram illustrating exemplary steps of a noise management method for optimizing communications of NFC signal at a point-of-sale system in accordance with some embodiments of the present disclosure. In an embodiment, the steps of FIG. **5** may be directed to and performed by a merchant terminal **110** or customer terminal **112** for optimizing receipt of a RF signal by sampling the signal at times when RF noise is below a threshold value. For simplicity, the term "payment terminal" may refer to either or a combination of the merchant terminal **110** or customer terminal **112**. In addition, payment terminal components referenced herein may refer to corre-

sponding components of either the merchant terminal **110** or customer terminal **112** or various suitable combinations thereof. Further, the operations below are described in the context of communication using NFC signals, but it will be understood that communication of RF communication signals according to other protocols are possible. It will be further understood that in some embodiments (not depicted in FIG. **5**), identification of times when the RF signal may be sampled and noise is below a threshold value may be performed in other manners, as described herein.

[0080] At step **502**, a clock source signal may be generated. The clock source signal may be generated by a clock source of the payment terminal, which may comprise hardware, software, or various combinations thereof In some embodiments, the payment terminal may comprise one or more clock sources. The clock source signal generated at step **502** may provide a clock signal for performing processing operations to one or more components of the payment terminal. Note that the clock source signal may have a desired phase, frequency, duty cycle, or other characteristics for achieving the functionality described herein. Note also that the clock source signal generated by the clock source may be provided to various numbers of processing units of the payment terminal in other embodiments. After the clock source of the payment terminal has generated the clock source signal processing may continue to step **504**.

[0081] At step **504** the clock source signal may be received at a clock management unit (e.g., clock management units **222** or **311**) of the payment terminal, such as when provided from the clock source. In some embodiments, the payment terminal include various types of hardware, software, or various combinations thereof for controlling and managing clock signals provided to one or more of the various components of the payment terminal. In some embodiments, the clock management unit may be implemented in hardware and may be in communication with one or more processors, (e.g., processing unit **208**, processing unit **312**, processing unit **316**, etc.), power sources, displays, or other components. The clock management unit may be configured to generate and provide a plurality clock signals based on receipt of the clock source signal. After the clock management unit receives the clock source signal, processing may proceed to step **506**

[0082] At step **506**, a plurality of clock signals may be generated at the clock management unit of the payment terminal. In some embodiments, the plurality of clock signals generated by the clock management unit may include various types of clock signals provided to various components of the payment terminal. For example, the plurality of clock signals may include a switching regulator clock signal, display clock signals, an NFC clock signal, and a processing unit clock signal. In addition, each of the plurality of clock signals may comprise various characteristics as desired. For example, the switching regulator clock signal may have the first phase and first frequency, the NFC clock signal may have a second phase and second frequency, the processing unit clock signal may have a third phase and third frequency and a display may have a fourth phase and a fourth frequency. In some embodiments, each of the plurality of clock signals may have different phases, frequencies, amplitudes, and/or duty cycles. After the clock management unit of the payment terminal has generated the plurality of clock signals, processing may continue to step **508**.

[0083] As step **508** a component clock signal such as the switching regulator clock signal may be received, such as by one or more switching regulators of the payment terminal. In some embodiments, the payment terminal may comprise one or more components that may be configured for performing the functionality of a switching regulator such as a buck, boost, or other-switching regulator type. Exemplary components of the payment terminal which may include or embody the functionality of a switching regulator may include a power management device (e.g., power management device **204**, power management device **304**, etc.). In this regard, the switching regulator clock signal may be configured to synchronize operation of the one or more switching regulators of the payment terminal based on the switching regulator clock signal or signals. In addition, the switching regulator clock signal may have a first phase and first frequency when provided to the one or more switching regulators, such that a one or more switching regulators operate at an operating frequency that is based upon the first phase in the first frequency of the switching regulator clock signal. In this regard, a frequency of RF noise emitted by the one or more switching regulators during operation may have a phase and frequency that corresponds to the operating frequency of the one or more switching regulators and harmonics thereof. Thus, the phase and frequency of RF noise emitted by the one or more switching regulators may correspond to first phase and first frequency at which the one or more switching regulators of the payment terminal operate. After the one or more switching regulators has received the switching regulator clock signal, processing may proceed to step **510**.

[0084] At step **510** a receive circuit of the payment terminal may receive a received NFC signal. In some embodiments, the payment terminal may include various components for receiving wireless RF signals communicated according to various wireless communication techniques (e.g., NFC, Bluetooth, etc.). Each such wireless communication protocol may involve transmission of signals at a particular wireless communication signal frequency (e.g., carrier signal frequency, modulation frequency, etc.), such as across one or more wireless frequency channels. The components of the payment terminal configured to communicate the wireless communication signals may include various types of hardware and/or software for receiving such wireless communication signals from other sources (e.g., NFC devices, payment terminals, etc.). In this regard, the receive circuit of the payment terminal may receive an NFC signal which is based on the NFC carrier signal (e.g., 13.5 MHz). In some embodiments, wireless signals communicated and received at the payment terminal may include RF noise. In this regard, received NFC signal may include RF noise, which may mean to increase processing errors at payment terminal in some embodiments, other types of noise may be present in the received RF signal, and may be received by the receiver circuit of the payment terminal for processing. Thereafter, processing may proceed to step **512**.

[0085] As the **512**, the processing unit clock signal may be received by the processing unit. In some embodiments, the processing unit clock signal provided by the clock management unit of the payment terminal may be based on a signal that will enable sampling of the received NFC signal by the processing unit. As noted above, the processing unit clock signal may have a third phase in third frequency, which may be configured as desired to enable sampling of the received

NFC signal. As an example, sampling rates for the received NFC signal may be based on characteristics of the processing unit (e.g., hardware processing limitations). After the processing unit has received the processing unit clock signal, processing may proceed to step **514**.

[0086] At step **514**, the processing unit may determine the first phase difference between the first phase of the switching regulator clock signal and second phase of the NFC clock signal and/or received noise and data signals based on these signals. In some embodiments, the processing unit (e.g., processing unit **208**, a processing unit **312**, or secure processing unit **316**) may perform a comparison of the switching regulator clock signal with the NFC clock signal, such as by executing the noise management instructions stored in memory. In some embodiments, the processing unit may be configured to determine the first phase difference by monitoring various types of information, such as an operating frequency of the one or more switching regulators, noise frequencies, and an operating frequency of components of the NFC receive circuit of the payment terminal (e.g., wireless interface **218**, NFC interface **328**, etc.). After the first phase difference has been determined, processing may proceed to step **516**.

[0087] At step **516**, a frequency difference between first frequency of the switching regulator clock signal and a second frequency of the NFC clock signal may be determined. In some embodiments, the processing unit may determine a first frequency difference by executing the noise management instructions, such as may be stored in memory at the payment terminal. To determine the first frequency difference, in some embodiments, the processing unit may compare the first frequency of the switching regulator clock signal with the second frequency of the NFC clock signal. In some embodiments, operating frequencies of components of the payment terminal that receive the switching regulator clock signal and NFC clock signal may be compared and an assumption regarding the second frequency difference may be performed in other embodiments. After the first frequency difference has been determined, processing may proceed to step **518**.

[0088] At step **518**, a plurality of time periods may be identified at which the noise is below a threshold. In some embodiments, the processing unit, such as when executing noise management instructions, may be configured to compare a value associated with a level of RF noise with a threshold value indicative of a threshold amount of RF noise. In some embodiments, the threshold may be determined based on the first phase difference and the first frequency difference determined at steps **514** and **516** above. In some embodiments, the processing unit may compare RF noise levels (e.g., identified by executing noise management instructions stored in memory). If a value of the RF noise falls below the threshold, processing may proceed to step **520**, where the processing unit may identify a time period corresponding to the determination and identify the time period as a potential time for performing sampling of the received NFC signal. The processing unit may repeat such comparison and determination for a desired number of time periods, until a desired (e.g., minimum) number of time periods have been identified (e.g., such as an amount that exceeds a bit error rate threshold for processing received NFC signals at the payment terminal). If the RF noise exceeds the threshold, at step **522**, the processing unit may note a corresponding time but will not identify the time period as one of the plurality of time periods for which sampling of the received NFC signal may be possible. For such time periods for which an RF noise level is not less than the threshold, the processing unit may determine that sampling is not appropriate or that RF noise levels may result in an amount of bit errors that exceeds a desired amount. After the plurality of possible time periods at which RF noise does not exceed a threshold has been identified, processing may proceed to step **524**.

[0089] At step **524**, the received NFC signal may be sampled at the time periods identified for which the RF noise level is below the threshold and which also corresponds to at least one of the plurality of possible sampling times for the received NFC signal. Accordingly, the processing unit may determine which time periods match one or more of the plurality of possible sampling times previously determined. In this regard, the processing unit, by executing the noise management instructions, may determine that sampling of the received NFC signal is possible for at least one of the plurality of time periods based on the possible sampling times for the received NFC signal identified step **512**. In this regard, the processing unit may sample the received NFC signal at time periods when RF noise levels fall below a desired threshold, thereby improving processing of the received NFC signal and reducing errors. In some embodiments, the phase and/or frequency of a clock source signal provided to the processing unit may be modified to correspond to particular sampling times.

[0090] FIG. **6** depicts a non-limiting flow diagram illustrating exemplary steps of a noise management method for optimizing communications of NFC signals at a point-of-sale system in accordance with some embodiments of the present disclosure. As noted above with regard to FIG. **5**, in an embodiment, the steps of FIG. **6** may be directed to and performed by a merchant terminal **110** or customer terminal **112** for coordinating operations of components of the payment terminal that may produce RF noise while a RF communication source of the payment terminal is communicating wireless RF signals. For simplicity, the term "payment terminal" may refer to either or a combination of the merchant terminal **110** or customer terminal **112**. In addition, payment terminal components referenced herein may refer to corresponding components of either the merchant terminal **110** or customer terminal **112** or various suitable combinations thereof. Further, the operations below are described in the context of communication using RF communications, but it will be understood that communication of RF communication signals according to other protocols are possible. It will be further understood that in some embodiments (not depicted in FIG. **6**), identification of RF noise sources and RF noise frequencies may be performed in other manners, as described herein.

[0091] At step **602** operations the payment terminal may be monitored, such as by a processing unit of the payment terminal. Operations of the wireless communication interfaces of the payment terminal (e.g., wireless communication interface **218** or NFC interface **328**) may be monitored to determine when wireless RF communications occurs at the payment terminal. In some embodiments, the processing unit (e.g., processing unit **208**, **314**, or **316**) may perform such monitoring by monitoring one or more clock signals provided to components of the payment terminal. In particular, the processing unit may monitor a clock signal provided to wireless communication components of the

payment terminal, such as may be used to transmit or receive wireless RF signals. In this regard, the processing unit to determine times when wireless communications are occurring at the payment terminal (e.g., by executing noise management instructions stored in memory at the payment terminal).

[0092] At step **604**, the processing unit to determine whether wireless RF communications are occurring at the payment terminal. The processing unit may do so by monitoring the operating frequency of RF communication source (e.g. wireless communication interface **218**, NFC interface **328**, etc.). If wireless RF communication is not currently occurring at the payment terminal, processing may return to step **602** where operations of the payment terminal may continue to be monitored until RF communication occurs. If wireless communication is occurring, then the processing may proceed to step **606**.

[0093] At step **606**, the processing unit may determine that wireless communication is occurring at the payment terminal, such as when a clock signal provided to one or more components of the payment terminal comprising a RF communication source has a frequency that corresponds to one or more wireless RF communication frequencies, or when a power provided or consumed by a transponder indicates that communications are occurring. For example, the processing unit may determine that the frequency of a clock signal provided to the RF communication source is within an RF communication frequency. After the processing unit has determined that the RF communication source of the payment terminal is communicating wirelessly, processing may then continue to step **608**.

[0094] At step **608**, the processing unit may identify an operating frequency of an RF noise source at the payment terminal. In some embodiments, the RF noise source may include one or more components of the payment terminal, such as one or more processing units (e.g., processing unit **208**, main processing unit **314**, or secured processing unit **316**), communication interfaces (wireless interface **218**, NFC interface **328**, user interfaces **210**, **310**, and **318**, etc.), user interfaces, or power sources. In some embodiments, a frequency of RF noise emitted by the RF noise source within payment terminal may correspond to an operating frequency of the component that is the source of RF noise or harmonics thereof. In this regard, the operating frequency of the RF noise source may be based on or correspond to a clock signal frequency that is provided to the RF noise source. The clock signal provided to an RF noise source identified by the processing unit may have an initial clock signal frequency at which the RF noise source may perform standard operations. The RF noise source may thus perform a set of standard operations when the initial clock signal frequency is provided to the RF noise source. Note that the standard set of operations may include various types of suitable operations, and can vary based on the type of component of the payment terminal that is the source of the RF noise. For example, in some embodiments, when a user interface of the payment terminal (e.g., user interfaces **210**, **310**, or **318**) is implemented as a touchscreen, the touchscreen may perform operations at an initial clock frequency, such as displaying content to a user and receiving touch inputs, or various other types of operations that may be standard operations of the touchscreen interface. In some embodiments, the processing unit of the payment terminal may be configured to provide the initial clock frequency by default based on hardware, software, or various combinations thereof, and thus the touchscreen may perform a standard set of operations under normal circumstances. It is to be understood that the standard set of operations performed by the component that is the RF noise source may vary based on the type of component. After the processing unit has identified an operating frequency of the art of noise source, processing may proceed to step **610**.

[0095] At step **610**, an operating frequency of the RF noise source may be compared with one or more RF communication frequencies within which the RF communication source of the payment terminal is performing wireless RF communications. If the operating frequency of the one or more RF noise sources indicates that none of the one or more noise frequency frequencies overlaps with at least a portion of the one or more RF communication frequencies, processing may return to step **602** and the processing unit may continue to monitor the operation of components of the payment terminal for noise. However, if the processing unit determines that the one or more RF noise frequencies overlaps with at least a portion of the one or more RF communication frequencies that the payment terminal is using to communicate wirelessly, processing may proceed to step **612**.

[0096] At step **612**, the processing unit may identify a modified clock signal frequency that the processing unit may provide to the one or more RF noise sources in order to modify the operating frequency of the RF noise source, and thereby modify the RF noise frequencies so that the RF noise frequencies do not overlap with the RF communication frequencies. For example, if an operating frequency of an RF noise source causes the RF noise source to emit RF noise that overlaps a portion of the NFC frequencies (e.g., at 13.56 MHz modulated at 800 kHz), the processing unit may select an operating frequency for the RF noise source that will modify the frequencies of the RF noise emitted by the RF noise source. In this regard, a modified clock signal that corresponds to a modified operating frequency of the RF noise source may be identified by the processing unit. The processing unit may identify a modified clock signal for each of the one or more RF noise sources for which it has determined that RF noise frequencies overlap with any portion of the RF communication frequencies in use by the payment terminal. In this regard, the processing unit may provide a modified clock signal at a modified frequency to the one or more RF noise sources based on such determination. After a modified clock signal frequency has been provided to the one or more RF noise resources, and the one or more RF noise sources has received the modified clock frequency, processing may proceed to step **614**.

[0097] At step **614**, the one or more RF noise sources may perform reduced or modified operations based on receipt of the modified clock frequency from the processing unit (or in some embodiments, instead of receiving a modified clock frequency). As an example, when an RF noise source is operating according to an initial clock frequency, the RF noise resource may be configured to perform standard operations. In some embodiments, the RF noise source may perform a modified or reduced set of operations, such as by reducing power, performing only a limited subset of functions, or other similar steps that reduce processing or operational demands for the noise source. In some embodiments, the processing unit may take additional actions when the RF noise sources are operating at the modified operating fre-

quency. For example, the processing unit may provide a particular output to a touchscreen of the payment terminal that cancels noise (e.g., by interposing known noise signals on the user interface **210**, **310**, or **318**). After the RF noise source has begun performing reduced operations, processing may proceed to step **616**

[0098] At step **616** the processing unit may determine whether the payment terminal has completed RF communication such that the RF communication source is no longer communicating. The processing unit may determine that the RF communication sources is no longer communicating based on various information, such as a clock signal provided to the RF communication source, the operating frequency of modifications was, power consumption of wireless interfaces, data received from the RF communication sources, etc. If the RF communication source is still communicating, the processing unit may continue to provide the modified clock frequency to the RF noise source and/or perform the reduced or modified operations such that the RF noise source continues to output a reduced amount of noise. However, if the processing unit determines that the RF communication source is no longer communicating wirelessly, processing may continue to step **618**, where the processing unit may cease providing the modified clock frequency to the RF noise source, may provide the initial clock frequency. Thereafter, process processing may continue to step **620**, where the noise source may resume the standard set of operations.

[0099] FIG. **7** depicts a non-limiting flow diagram illustrating exemplary steps of an alternative noise management method for optimizing communications of NFC signals at a point-of-sale system in accordance with some embodiments of the present disclosure. The steps of FIG. **7** may be carried out in addition to or in place of the steps described herein for determining a time for sampling a received NFC signal at a payment terminal, for example with regard to FIG. **5**. For simplicity, the term "payment terminal" may refer to either or a combination of the merchant terminal **110** or customer terminal **112**. In addition, payment terminal components referenced herein may refer to corresponding components of either the merchant terminal **110** or customer terminal **112** or various suitable combinations thereof. Further, the operations below are described in the context of communication using NFC signals, but it will be understood that communication of RF communication signals according to other protocols are possible.

[0100] With regard to FIG. **7**, it will be assumed that a clock management unit receives a clock source signal and is providing a plurality of clock signals to components of the payment terminal, as described with regard to FIG. **5**. In an embodiment, the steps of FIG. **7** may be directed to and performed by a payment terminal for optimizing receipt of a RF signal by sampling the signal at times when a phase of the received NFC signal matches a desired phase of the processing unit clock signal. It will be further understood that in some embodiments (not depicted in FIG. **7**), identification of phases at which the RF signal may be sampled in other manners, as described herein.

[0101] At step **702** the processing unit may identify a phase at which a received RF signal may be sampled. Although times at which a received RF sample may be identified based on various information (e.g., processing unit clock frequency as in FIG. **5**), in some embodiments, the processing unit may identify a plurality of possible sampling times based on correlation of a phase of the processing unit clock signal. In this regard, a plurality of possible sampling times may be identified based on the phase of the processing unit clock signal. After a phase of the processing unit clock signal at which sampling may be possible has been identified, processing may proceed to step **704**.

[0102] At step **704** a receive circuit of the payment terminal may receive an NFC signal, such as from a wireless transaction device. In some embodiments, the received NFC signal may have a phase, frequency, amplitude and duty cycle. The processing unit of the payment terminal may be operable to note a phase of the received NFC signal as the payment terminal's receive circuit receives the NFC signal. After the NFC signal has been received, processing may proceed to step **706**.

[0103] At step **706**, the processing unit may determine whether a phase of the received NFC signal matches a phase of a processing unit clock signal. In some embodiments, whether the phases of the NFC signal and processing unit clock signal match may be determined based on a difference between the phases, or based on a comparison of whether a phase of the received NFC signal is within a threshold difference of the phase of the processing unit clock signal. If the phase difference exceeds the threshold difference, the processing unit may determine that the phases do not match, and processing may return to step **702**. If the phase difference is below a threshold difference, the processing unit may determine that the phases match, and processing may proceed to step **708**. At step **708**, the processing unit may sample the received NFC signal for processing by the processing unit of the payment terminal.

[0104] FIGS. **8**A and **8**B depict a front perspective view of a user interface of a payment terminal in accordance with some embodiments of the present disclosure. The user interface of FIGS. **8**A and **8**B is depicted as a touchscreen displaying a graphical output. In the embodiment of FIGS. **8**A and **8**B, an exemplary user interface is depicted, and it is to be understood that although the user interface of FIGS. **8**A and **8**B may have certain characteristics and configuration, the user interface is representative of operation at of either a merchant terminal **110** or payment terminal **112**. The exemplary payment terminal of FIGS. **8**A and **8**B comprises user interface **800** and capable of displaying an output **820**. The output **820** displayed in FIGS. **8**A and **8**B is depicted as a graphical output such as may be displayed to a user of the payment terminal, but it will be understood that the output **820** is an exemplary and can be altered or comprise various types of output which the interface **810** is capable of providing in other embodiments. In addition, it will be understood that even though the payment terminals of FIGS. **8**A and **8**B may be depicted as having particular components and implemented in a particular configuration and arrangement, other combinations arrangement of components are possible.

[0105] In addition, the payment terminal of FIGS. **8**A and **8**B is configured for exchanging wireless messages with a user for completing payment transactions wirelessly. In some embodiments, the payment terminal also may include components for accomplishing wireless RF communication such as antenna **824**, as well as at least one processing unit (not specifically shown in FIGS. **8**A and **8**B), memory for storing instructions (not specifically shown in FIGS. **8**A and **8**B), a power supply (not specifically shown in FIGS. **8**A and

8B), or any or all of the components which may be included with the various embodiments of a payment terminal as described herein.

[0106] As shown in FIG. **8**A, interface **810** of the payment terminal is implemented as a touchscreen interface. The user interface **810** is depicted as being adjacent (e.g. positioned close in proximity within the payment terminal) to a wireless antenna **824** that is capable of transmitting and receiving wireless RF communication from various sources (e.g., NFC, Bluetooth, etc.). In the embodiment of FIG. **8**A, the interface **810** is depicted as performing operations with a modified user interface (e.g., with lower power usage, modified frequency, and/or offsetting noise characteristics). As noted herein, the components of the payment terminal, such as interface **810** may emit RF noise. In this regard RF noise by interface **810** may cause undesirable errors in processing of wireless indication signals. A processing unit of the payment terminal may execute noise management instructions in order to optimize operations of the payment terminal and manage noise emitted by components of the payment terminal.

[0107] In some embodiments of FIG. **8**A, a processing unit of the payment terminal may execute instructions to determine wireless communication frequencies that are in use by the payment terminal. In an exemplary embodiment, the processing unit may determine the RF communication frequency bands based on a RF communication protocol in use by the payment terminal, such as by determining a clock signal frequency provided to or operating frequency for the payment terminal's RF communication source. Other techniques and information may be provided to and used by the processing unit to determine that the payment terminal is communicating wirelessly and identify one or more RF communication frequency bands in other embodiments.

[0108] In some embodiments, the processing unit of the payment terminal of FIGS. **8**A and **8**B likewise may identify one or more RF noise frequencies bands associated with one or more components of the payment terminal, such as based on a clock frequency provided to one or more components such as the user interface. If an operating frequency corresponds to a frequency of RF noise emitted by the component that will overlap any portion of the one or more RF communication frequencies, the processing unit may identify a modified or reduced clock frequency to provide to the component that is the source of the RF noise. In the embodiment of FIGS. **8**A and **8**B, the user interface **210** (touchscreen) emits RF noise at a frequency that overlaps a portion of the one or more RF communication frequencies. In this regard, the processing unit may note the initial clock signal provided to the user interface **210** and identify a modified clock signal to provide that will modify a frequency of RF noise the user interface is emitting. That is, a modified operating frequency may be provided that causes an RF noise source to emit RF noise at one or more frequencies that does not overlap any portion of the one or more RF communication frequencies of the payment term.

[0109] In an exemplary embodiment, output **820** is depicted as operating at a modified clock frequency, as demonstrated by display of a graphic output **820** that has an increased transparency. In some embodiments the noise emitted by the display may be modified in other manners, such as by modifying a power supplied to or consumed by the user interface (e.g., by changing a displayed image to have less contrast, brightness, etc.) or introducing image patterns that result in cancellation or reduced noise. Although such modifications to the graphics graphic **820** display the interface may or may not be perceptible to a user viewing the interface **810**, by performing modified operations of the interface, according to the modified operating frequency, RF noise generated during operation of the user interface **810** may be reduced, or in some embodiments, modified such that the one or more RF noise frequencies do not overlap with the one or more RF frequencies at which the terminal is communicating.

[0110] The processing unit may monitor wireless communication at the payment terminal to determine when the payment terminal is no longer communicating wirelessly. When the processing unit determines that the payment terminal is no longer communicating wirelessly at the RF communication frequency, the processing unit return the user interface **810** to normal operations. In response, as depicted in FIG. **8**B, when the user interface **810** returns to normal operation, the user interface **810** may resume standard operations, such that content displayed by the user interface **810** is provided at a standard operating frequency. For example, content **20** may be displayed at a higher contrast, brightness, with more power to display, or at a more suitable frequency for the particular user interface **810**.

[0111] The foregoing is merely illustrative of the principles of this disclosure and various modifications may be made by those skilled in the art without departing from the scope of this disclosure. The above described embodiments are presented for purposes of illustration and not of limitation. The present disclosure also can take many forms other than those explicitly described herein. Accordingly, it is emphasized that this disclosure is not limited to the explicitly disclosed methods, systems, and apparatuses, but is intended to include variations to and modifications thereof, which are within the spirit of the following claims.

[0112] As a further example, variations of apparatus or process parameters (e.g., dimensions, configurations, components, process step order, etc.) may be made to further optimize the provided structures, devices and methods, as shown and described herein. In any event, the structures and devices, as well as the associated methods, described herein have many applications. Therefore, the disclosed subject matter should not be limited to any single embodiment described herein, but rather should be construed in breadth and scope in accordance with the appended claims.

1. A method for coordinating operations between a radio frequency (RF) communications source and a RF noise source of a transaction processing device, comprising:

executing instructions, by a processing unit of the transaction processing device, to determine that the RF communications component is communicating at a first RF communications frequency, wherein the RF communications component comprises a near field communication (NFC) transponder or a Bluetooth transponder;

identifying, by the processing unit, an operating frequency of the RF noise source, wherein the RF noise source comprises one or more of the processing unit or a touch-screen display, wherein the operating frequency of the RF noise source is based on a clock signal, wherein the clock signal has an initial clock frequency, and wherein the RF noise source performs a set of standard operations at the operating frequency;

identifying, by the processing unit, one or more noise frequencies of the RF noise source based on the operating frequency of the RF noise source;

executing instructions, by the processing unit, to determine that the one or more of the noise frequencies interferes with the first RF communications frequency;

modifying, by the processing unit, based on the determination that the one or more of the noise frequencies interferes with the first RF communications frequency, the clock signal from the initial clock frequency to a modified clock frequency, wherein a modified operating frequency is based on the modified clock frequency, wherein one or more modified noise frequencies are based on the modified operating frequency, and wherein none of the one or more modified noise frequencies interfere with the first RF communications frequency;

performing, by the RF noise source, a modified set of operations at the modified operating frequency;

executing instructions, by the processing unit, to determine that the RF communications component is no longer communicating at the first RF communications frequency;

restoring, by the processing unit, the clock signal from the modified clock frequency to the initial clock frequency based on the determination that the RF communications component is no longer communicating at the first RF communications frequency; and

performing, by the RF noise source, the standard operations at the operating frequency based on the modification of the clock signal to the initial clock frequency.

2. The method of claim **1**, wherein the RF noise source comprises a touch-screen, and wherein the reduced set of operations comprises:

generating, by the processing unit, a modified output for display at the touch-screen;

providing, by the processing unit, the modified output to the touch-screen; and

displaying, at the touch-screen, the modified output, wherein the modified output emits less RF noise than a standard output of the touch screen.

3. The method of claim **2**, wherein the modified output comprises a noise reducing pattern.

4. The method of claim **1**, wherein the determining that the one or more of the noise frequencies interferes with the first RF communications frequency comprises, comparing, by the processing unit, the one or more of the noise frequencies with one or more feedback sources, wherein the feedback sources indicate one or more ranges of frequencies for wireless communication.

5. The method of claim **4**, wherein the one or more feedback sources comprises a Bluetooth channel map for the Bluetooth transponder.

6. The method of claim **4**, wherein the one or more feedback sources comprises one or more bit rate error values for the NFC transponder.

7. A method for reducing radio frequency (RF) noise of a wireless communication device, comprising:

executing instructions, by a processing unit of the wireless communication device, to determine that a RF communications component is communicating at a first RF communications frequency;

executing instructions, by the processing unit, to determine that one or more noise frequencies interfere with the first RF communications frequency;

modifying, by the processing unit, the operation of a RF noise source from a standard frequency to a modified frequency, based on the determination of the interfering frequencies;

executing instructions, by the processing unit, after the modification of the frequency of the RF noise source, to determine that the RF communications component is no longer communicating at the first RF communications frequency; and

restoring the operation of the RF noise source from the modified frequency to the standard frequency, based on the determination that the RF communications component is no longer communicating at the first RF communications frequency.

8. The method of claim **7**, wherein the RF communications component comprises a near field communication (NFC) transponder or a Bluetooth transponder.

9. The method of claim **7**, wherein the modification comprises providing a modified clock source frequency to the RF noise source, wherein the one or more noise frequencies are modified based on the modified clock source frequencies, wherein the modified one or more noise frequencies do not interfere with the first RF communications frequency, and wherein the restoring comprises providing a standard clock source frequency to the RF noise source.

10. The method of claim **7**, wherein the modification comprises a reduced set of operations for the RF noise source, and wherein the restoring comprises performing a standard set of operations.

11. The method of claim **10**, wherein the RF noise source comprises a touch-screen, and wherein the reduced set of operations comprises:

generating, by the processing unit, a modified output for display at the touch-screen;

providing, by the processing unit, the modified output to the touch-screen; and

displaying, at the touch-screen, the modified output, wherein the modified output emits less RF noise than a standard output of the touch screen.

12. The method of claim **11**, wherein the modified output comprises a noise-reducing pattern.

13. The method of claim **7**, wherein the determining that the one or more of the noise frequencies interferes with the first RF communications frequency comprises, comparing, by the processing unit, the one or more of the noise frequencies with one or more feedback sources, wherein the feedback sources indicate one or more ranges of frequencies for wireless communication.

14. The method of claim **13**, wherein the RF communications component comprises a Bluetooth transponder and wherein the one or more feedback sources comprises a Bluetooth channel map for the Bluetooth transponder.

15. The method of claim **13**, wherein the RF communications component comprises a near field communication (NFC) transponder and the one or more feedback sources comprises one or more bit rate error values for the NFC transponder.

16. A wireless communication device for reducing radio frequency (RF) noise, comprising:

a RF communications component;

a RF noise source;

a memory having instructions stored therein; and

a processing unit coupled to the RF communications component, RF noise source, and memory and configured to execute instructions stored therein to perform operations comprising:

determining that the RF communications component is communicating at a first RF communications frequency;

determining that one or more noise frequencies interfere with the first RF communications frequency;

modifying the operation of the RF noise source from a standard frequency to a modified frequency, based on the determination of the interfering frequencies;

determining that the RF communications component is no longer communicating at the first RF communications frequency; and

restoring the operation of the RF noise source from the modified frequency to the standard frequency, based on the determination that the RF communications component is no longer communicating at the first RF communications frequency.

17. The device of claim **16**, wherein the RF communications component comprises a near field communication (NFC) transponder or a Bluetooth transponder.

18. The device of claim **16**, wherein the modifying comprises providing a modified clock source frequency to the RF noise source, wherein the one or more noise frequencies are modified based on the modified clock source frequencies, wherein the modified one or more noise frequencies do not interfere with the first RF communications frequency, and wherein the restoring comprises providing a standard clock source frequency to the RF noise source.

19. The device of claim **16**, wherein the modifying comprises performing a reduced set of operations for the RF noise source, and wherein the restoring comprises performing a standard set of operations.

20. The device of claim **19**, wherein the RF noise source comprises a touch-screen, and wherein the reduced set of operations comprises:

generating a modified output for display at the touch-screen; and

providing the modified output to the touch-screen, wherein the touch-screen displays the modified output, and wherein the modified output emits less RF noise than a standard output of the touch screen.

21-23. (canceled)

24. A non-transitory computer-readable storage medium comprising instructions stored therein, which when executed by one or more processors, cause the one or more processing units to perform operations comprising:

determining that a RF communications component is communicating at a first RF communications frequency;

determining that one or more noise frequencies interfere with the first RF communications frequency;

modifying the operation of the RF noise source from a standard frequency to a modified frequency, based on the determination of the interfering frequencies;

determining that the RF communications component is no longer communicating at the first RF communications frequency; and

restoring the operation of the RF noise source from the modified frequency to the standard frequency, based on the determination that the RF communications component is no longer communicating at the first RF communications frequency.

25. The non-transitory computer-readable storage medium of claim **24**, wherein the RF communications component comprises a near field communication (NFC) transponder or a Bluetooth transponder.

26. The non-transitory computer-readable storage medium of claim **24**, wherein the modifying comprises providing a modified clock source frequency to the RF noise source, wherein the one or more noise frequencies are modified based on the modified clock source frequencies, wherein the modified one or more noise frequencies do not interfere with the first RF communications frequency, and wherein the restoring comprises providing a standard clock source frequency to the RF noise source.

27. The non-transitory computer-readable storage medium of claim **24**, wherein the modifying comprises a reduced set of operations for the RF noise source, and wherein the restoring comprises performing a standard set of operations.

28. The non-transitory computer-readable storage medium of claim **27**, wherein the RF noise source comprises a touch-screen, and wherein the reduced set of operations comprises:

generating a modified output for display at the touch-screen; and

providing the modified output to the touch-screen, wherein the touch-screen displays the modified output, and wherein the modified output emits less RF noise than a standard output of the touch screen.

29. The non-transitory computer-readable storage medium of claim **28**, wherein the modified output comprises a noise-reducing pattern.

30. The device of claim **20**, wherein the modified output comprises a noise-reducing pattern.

31. The device of claim **16**, wherein the determining that the one or more of the noise frequencies interferes with the first RF communications frequency comprises, comparing the one or more of the noise frequencies with one or more feedback sources, wherein the feedback sources indicate one or more ranges of frequencies for wireless communication.

32. The device of claim **31**, wherein the RF communications component comprises a Bluetooth transponder and wherein the one or more feedback sources comprises a Bluetooth channel map for the Bluetooth transponder.

33. The device of claim **31**, wherein the RF communications component comprises a near field communication (NFC) transponder and the one or more feedback sources comprises one or more bit rate error values for the NFC transponder.

* * * * *