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[Continued on next page]

(54) Title: MOBILE READER

(57) Abstract: The patent aims to embed RFID reader functionality inside a mobile phone, which proposes to use one of the mobile phone' s own RF sources for the forward link to power the UHF tags. This can obviates the need to integrate yet another RF source into the mobile phone, thereby reducing cost and making the integration much simpler. It is proposed to use a TTO RFID air interface protocol such as ISO/IEC18000-64or IP-X. A TTO protocol does not require any modulation of the carrier. TTO RFID tags can respond within about150μs and can transmit an ID in 300μs. The only hardware modification to the mobile phone would be the addition of a small, low cost receiver.

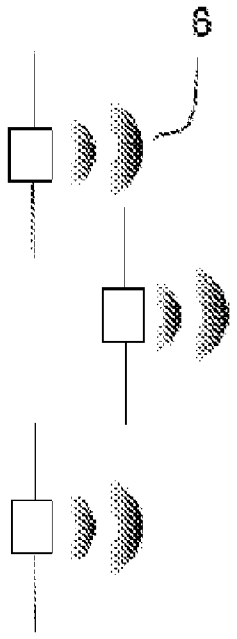

Figure 1

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(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

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MOBILE READER

BACKGROUND OF THE INVENTION

This invention relates to the integration of a UHF RFID reader into a mobile phone.

The inventor is aware of radio frequency identification (RFID) systems which include at least one RFID reader, also known as an interrogator, and a plurality of electronic transponders, also known as RFID tags. The RFID tags are typically passive, being energised by a broadcast RF signal or power-up beam from the interrogator, but can also be active or semi-active, having an additional power source like a battery. The reader communicates with the tags by modulating commands and data onto the power-up beam (the so-called "forward link"), while the tags communicate with the reader by reflecting a varying amount of the energy from the power-up beam back to the reader, also known as "backscatter" (the so-called "return link"). The rules which define the parameters of the communication between the tags and reader are known as the air protocol.

There are a large number of different RFID air protocols in use in the world today. These protocols can be broadly classified according to whether the reader initiates the communication between tag and reader, or whether the tag initiates the communication. If the reader initiates the communication, the protocol is called a "Reader Talks First" or RTF protocol. If the tag initiates the communication, the protocol is called a "Tag Talks First" or TTF protocol. An extreme case of a TTF protocol is the "Tag Talks Only" or TTO protocol, in which the reader never modulates the power-up beam to talk to the tags.

TTO protocols such as ISO/IEC 18000-64 and IP-X do not require any commands from the reader. All that is needed, is that the tags be illuminated by enough RF energy to power the tags, at which time the tags wake up and backscatter unique IDs and possibly additional data back to the reader. Some kind of anti-collision mechanism is required when multiple tags are present. TTO tags achieve this by transmitting their IDs and

data and random intervals, so that the reader only needs to listen and record the received IDs and data.

Despite the lack of reader commands, the anti-collision performance of TTO protocols are on a par with that of other (RTF) RFID protocols. However, they excel in applications where high speed is required, since the tags automatically wake-up and transmit their IDs when they become powered, either by entering a reader beam, or when a reader is turned on to illuminate the tags. TTO tag transmissions can be as short as 300 us, and tags can power-up and respond very fast, typically within 150 us. It is thus possible to get a successful tag backscatter even if the tags are only powered for less than 1 ms. TTO systems also generate very little reader interference, unlike RTF systems, making it possible to operate multiple TTO readers simultaneously.

Mobile phones have become ubiquitous and powerful, and have become attractive tools to act as a handheld devices in RFID systems. Many RFID systemscan interface to handheld terminal devices, including mobile phones. Usually this interface is via a serial or USB link, Bluetooth or Wi-Fi, with the terminal device or mobile phone either tethered to the RFID readeror somehow mounted on a handheld RFID reader. This kind of arrangement is bulky, clumsy and expensive, since it requires a full-blown RFID reader (albeit a handheld or portable RFID reader) as well as a mobile terminal.

If the RFID reader could be integrated into a mobile phone so that all mobile phones would also be able to read RFID tags, the resulting device would be smaller and more ergonomic, and could enable the use of RFID in new applications such as payment systems and anti-counterfeit applications. Such systems have been proposed, e.g. US8355670, US8260199 and US8577290, in which systems are described that integrates NFC (Near field communications RFID) reader modules into mobile phones. NFC RFID readers typically operate at 13.56 MHz, and such modules would typically include an NFC antenna and power RF source, as well as a receiver and decoder. Such NFC modules are nowadays integrated into certain smart phones, e.g. into the Samsung Galaxy 3. It might be more correct to say that the NFC modules are "piggy-backed" onto the mobile phone, since they operate completely independent of the mobile phone, and typically just communicate with the mobile phone via a USB link. NFC tags are

relatively expensive, typically requiring multi-layer printed coil antennas. Reading range is typically very small, of the order of a few millimetres, and typically only a single tag can be read at a time.

US7826865 proposes an integrated circuit with both RFID and cellular communications capabilities, and which could operate in either an RFID or a cellular mode. Such an IC would be expensive to develop and would presumably have to replace the RF section in a mobile phone. However, mobile phones are nowadays mainly built using SOC devices, which integrate the controller and RF and baseband sections on one chip. It would therefore be problematic to integrate such a chip into existing mobile phone architectures.

The patent aims to remove or at least improve the above mentioned problems relating to integrating an RFID reader into a mobile phone.

SUMMARY OF THE INVENTION

The main aim of this patent is to embed RFID reader functionality inside a mobile phone, while overcoming the problems of short reading range and cost associated with current and proposed methods to achieve this. Unlike current system which use NFC (13.56 MHz) RFID readers embedded in mobile phones, it is proposed to use UHF RFID. UHF RFID has much longer reading range than NFC, is much faster and can read multiple tags simultaneously. UHF tags are also potentially much cheaper than NFC tags, since they can be implemented using only a chip and a single layer printed antenna.

The patent proposes to use one of the mobile phone's own RF sources for the forward link to power the UHF tags. The most likely candidate is the transmission used for cellular communications, which can be at power levels up to 3 W and is in the UHF band (typically 850 MHz – 1900 MHz). Modern mobile phones also have built in Wi-Fi and Bluetooth transmitters, operating at around 2.45 GHz. These are alternative candidates for the forward link, although at lower power levels. Using one of the mobile phone's own RF sources and antennas, obviates the need to integrate yet another

RF source into the mobile phone, thereby reducing cost and making the integration much simpler.

If the phone's cellular transmitter is used, the phone can be programmed to transmit an unmodulated carrier in a cellular channel to serve as a power-up signal for the tags, or the phone can e.g. be instructed to place a dummy call or send a dummy message.

Since it would be illegal to modulate the cell phone carrier with RFID protocol commands and data, it is proposed to use a TTO RFID air interface protocol such as ISO/IEC 18000-64 or IP-X. A TTO protocol does not require any modulation of the carrier. Backscatter bit rate is around 256 kbit/s, which is far below 3G and 4G mobile phone bit rates. This means that even a CDMA or WCDMA modulated carrier can be used for the RFID downlink, since it is easy to filter the RFID backscatter from the cellular modulation. The CDMA or WCDMA will just raise the noise floor of the RFID backscatter. TTO RFID tags can respond within about 150 μs and can transmit an ID in 300 μs. This implies that the mobile phone transmission needs to last for as little as 500 μs. Since the downlink is not modulated, TTO RFID readers interfere very little with each other. Many mobile phones would be able to read the same tag or tags simultaneously.

The only hardware modification to the mobile phone would be the addition of a small, low cost receiver. For short range applications a simple AM receiver would suffice. For a really low cost implementation, the raw bitstream from the AM receiver could be sent directly to a hardware port on the mobile phone controller, where it can be decoded in software. Alternatively, the RFID bit stream can be decoded and the decoded bytes sent to a USB port on the mobile phone. For better performance, especially in the presence of cellular modulation such a CDM or WCDMA on the carrier, a coherent detector can be used to receive the RFID backscatter. Such a coherent receiver would use a copy of the outgoing signal to mix with the received RFID backscatter, giving better performance in the presence of noise and giving longer reading range.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1shows an implementation of the patent in which an AM detector is added to a mobile phone to receive the tag backscatter.

Figure 2shows an implementation of the patent in which a synchronous detector is added to a mobile phone to receive the tag backscatter.

DESCRIPTION OF AN EMBODIMENT

The first preferred embodiment is described with reference to Figure 1. Figure 1 shows a mobile phone (1) with only the relevant parts of the mobile phone shown diagrammatically inside it, namely the controller (2), synthesizer (3), power amplifier (4) and antenna (5). The controller, apart from running the phone operating system driving the display, making calls, connecting to the internet with Wi-Fi, etc,, is also responsible for controlling the frequency synthesizer to operate the uplink and downlink according to the local regulations in a channel and as instructed by the base station. There are differences in how this is achieved in so-called "1G", "2G", "3G" and "4G" systems and their variants, which falls outside the scope of this patent to describe, but all of these transmit a carrier in the 850, 900, 1800 or 1900 MHz bands at power levels up to 3 W. This carrier can power a UHF TTO tag or tags (6) at a range of several meters, which can respond by backscattering their IDs.

A simple AM receiver (7), consisting of an antenna (8) and an AM detector and amplifier (9) is added to the mobile phone, either as an external attachment or embedded within the phone. This AM detector can detect the backscattered IDs and data and can send either a raw or a decoded bit stream to the controller of the mobile phone, where it can be utilised. If a raw bit stream is sent to the controller, it can be decoded in software in the controller itself, obviating the need for a hardware decoder as part of the receiver.

This first embodiment has a cost advantage and impacts minimally on the mobile phone's own hardware. It only needs a connection to the controller to feed the raw or decoded ID bit stream to the phone's controller. The connection could be to a USB port,

serial port or another hardware port on the controller. Its main drawback would be that reading range would be short since the AM receiver might not be very sensitive, is not frequency selective and is easily degraded by noise (external or phase noise on the phone's own transmitted signal).

A second preferred embodiment is described with reference to Figure 2. As before, Figure 2 shows a mobile phone (1) with only the relevant parts of the mobile phone shown diagrammatically inside it, namely the controller (2), synthesizer (3), power amplifier (4) and antenna (5).

A coherent down converter (7), consisting of an antenna (8), a mixer (9) and a baseband amplifier (10) is added to the mobile phone, either as an external attachment or embedded within the phone. A portion of the output from the mobile phone's synthesiser (3) is coupled to a mixer (9) or quadrature down converter, either by means of a directional coupler, circulator, or other means. As in the first embodiment, the received ID and data is sent to the controller of the mobile phone, where it can be utilised.

This second embodiment will probably be more sensitive and less easily disturbed by external or phase noise. It will be frequency selective, so noise sources outside the band will be rejected. Internal phase noise will be cancelled, since the mixer will mix with a copy of the internally generated carrier.

The second embodiment will probably be more expensive than the first, and needs a tighter integration into the phone's hardware. Apart for a connection to the phone's controller, it will also need a connection to the phone's RF section, specifically a directional coupler, circulator or such means to tap a portion of the synthesized RF signal of the phone to be used in the down mixer.

Possible applications of thetechnology would be to read tags attached to commercial products to verify the authenticity of the product, or to read a tag embedded into an advertising poster, in order to obtain more information from the internetabout the product or event that is advertised, or e.g. to place an order for the product. Obviously, the technology can also be used anywhere that a handheld RFID reader might be used,

e.g. in industrial or commercial applications in supply chain management and item tracking.

CLAIMS

1. A system consisting of a mobile phone with embedded UHF RFID reader functionality and one or more UHF RFID tags, in which the tagsare powered by the mobile phone's own RF transmission.
2. A system as defined in claim 1 in which mobile phone transmission is in the 850, 900, 1800 or 1900 MHz bands.
3. A system as defined in claim 1 in which the tag backscatter is detected by means of an AM detector embedded in the mobile phone.
4. A system as defined in claim 1 in which the tag backscatter is detected by means of a coherent down converter or quadrature down converter, using a portion of the mobile phone's own UHF transmission to demodulate the tag backscatter.
5. A system as defined in claim 1 in which the tag antennas are resonant either at 850 MHz, 900 MHz, 1800 MHz or 1900 MHz or any combination of these frequencies.
6. A system as defined in claim 1 in which the tag antennas are resonant at any or all mobile phone carrier frequencies.
7. A system as defined in claim 6 in which the tag antennas' bandwidth is wide enough to cover the entire 850 MHz, 900 MHz, 1800 MHz or 1900 MHz mobile phone bands or any subset of these bands or all of these bands.
8. A system as defined in claim 1 in which the tags execute a TTO protocol.
9. A system as defined in claim 8 in which the TTO protocol is as defined in ISO/IEC 18000-6D, ISO/IEC 18000-64 or later versions of these protocols.
10. A system as defined in claim 8 in which the TTO protocol is as defined in the IP-X protocol.
11. A system as defined in claim 3 or claim 4 in which the tag backscatter is decoded by hardware means external to the mobile phone's own hardware.

12. A system as defined in claim 3 or claim 4 in which the tag backscatter is decoded by software means running in the mobile phone's own controller.

13. A system as defined in claim 1 in which the mobile phone is programmed to transmit an unmodulated carrier for at least 500μs.

14. A system as defined in claim 1 in which the mobile phone's normal CDMA or WCDMA transmission is used to power the tags.

15. A system as defined in claim 3 or claim 4 in which the RFID receiver has its own antenna separate from the mobile phone's antenna(s).

16. A system as defined in claim 3 or claim 4 in which the RFID receiver's input is coupled to the mobile phone's transmit antenna.

17. A system as defined in claim 3 or claim 4 in which the carrier transmitted by the phone for cellular communications is used to power the tags.

18. A system as defined in claim 3 or claim 4 in which any other carrier transmitted by the phone, e.g. for Wi-Fi or Bluetooth purposes, is used to power the tags.

19. A system as defined in claim 3 or claim 4 in which the output from the RFID receiver is communicated wirelessly to the mobile phone, e.g. by means of Bluetooth or Wi-Fi.

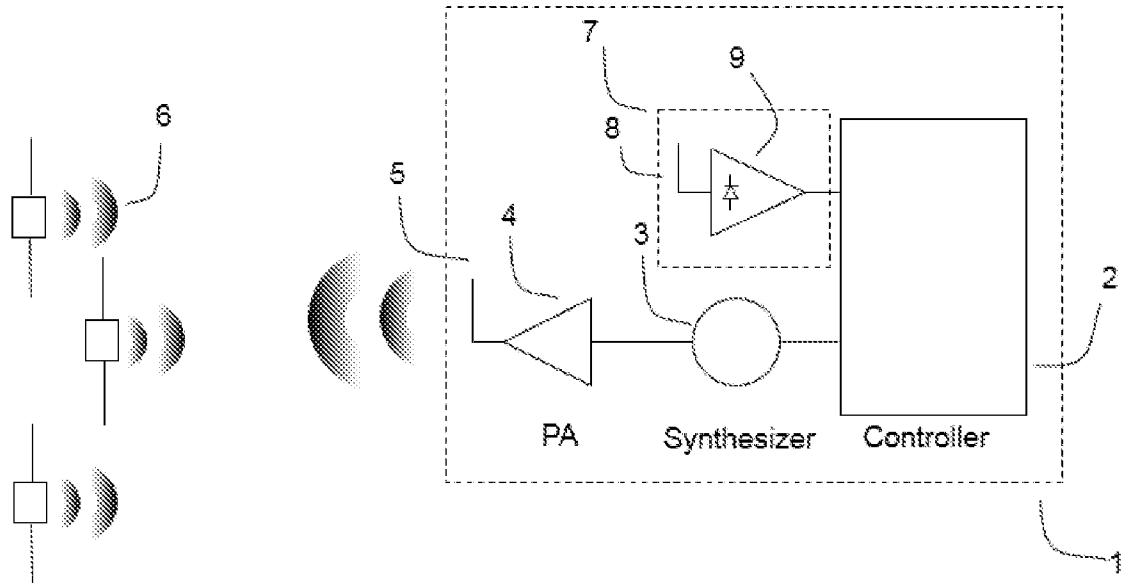

Figure 1

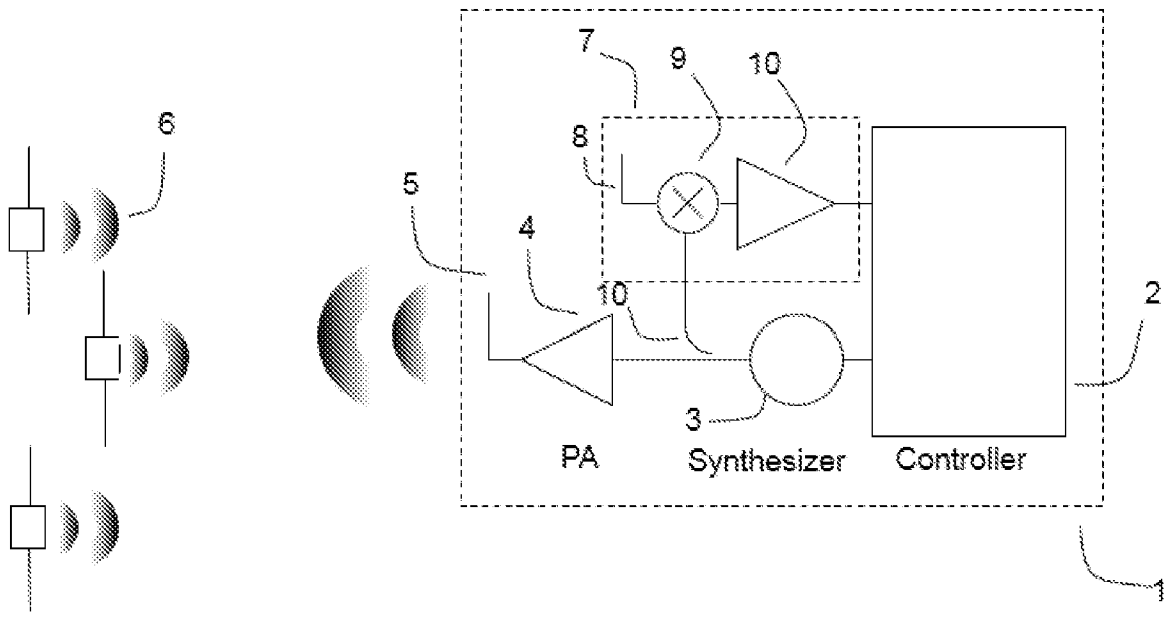

Figure 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2014/074515

A. CLASSIFICATION OF SUBJECT MATTER

G06K 7/00(2006.01)i; G06K 19/07(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G06K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT;CNKI;WPI;EPODOC:radio, frequency, anntenna, transmitter, tranceiver, share, electrioncal, tag, ID, RFID, reader

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 103577775 A (LIU, YUNYU) 12 February 2014 (2014-02-12) description, paragraphs [0016]-[0026] and figures 1, 2	1-19
X	CN 1826608 A (NOKIA CORP.) 30 August 2006 (2006-08-30) claims 42-47, decription, page 3, lines 13-24 and figure 1	1-19
A	CN 103500348 A (ICOMP TECHNOLOGYDALIAN CO., LTD.) 08 January 2014 (2014-01-08) the whole document	1-19
A	US 2007205865 A1 (BROADCOM CORPORATION) 06 September 2007 (2007-09-06) the whole document	1-19

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
08 December 2014	**31 December 2014**

Name and mailing address of the ISA/CN	Authorized officer
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2014/074515

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
CN 103577775 A	12 February 2014	Non e	
CN 1826608 A	30 August 2006	AT 453171 T	15 January 2010
		KR 20060028702 A	31 March 2006
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