The Integration of RF Front-End Device with Embedded Antenna

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***Abstract*—A communication device operating for exchanging energy in plurality of bands of radiation frequencies include a plurality of compressed antennas, each antenna for operating with one or more of the bands of radiation frequencies. The communication device also includes a transmitter section for processing transmitter signals and a receiver section for processing receiver signals, and connection means connecting the plurality of compressed antennas to the transmitter section and the receiver section. In some embodiments, the communication device includes one or more diplexers to switch antennas from one band to another. In some embodiments, the communication device includes one or more duplexers to switch antennas between the receiver section and transmitter section.**

***Index Terms*—Antenna, Diplexer, Duplexer, Radio-frequency Switch**

I. Introduction

In current mobile communications environment, the embedded antenna is generally placed inside the case of the communication device in close proximity to conductive components. In such close proximity, the antenna near and intermediate field become significant and cannot be neglected to determine far field radiation pattern [1], [2]. Therefore, antenna designers have to design case by case for embedded antenna. The designers have to pay considerable attention to interference that could occur from front end device. In order to minimize the interference, the designers should add more active RF components which may lead to higher cost, space and power consumption. As a solution, the integration between embedded antenna and the front end RF device can optimize these factors.

This paper is a research on the field of communication devices that communicate using radiation of electronic magnetic energy. The research scope focuses on antennas and front ends for such communication devices taking into consideration Diplexer, RF switch, and Duplexer particularly for communication devices that are carried by persons or devices that will benefit from having small sized antennas.

The front-end device of a mobile device is an expensive, space consuming and power consuming section. Typically, antennas used in multiband communication devices are wide in length. Even though it is possible to compress multi-antenna in one mobile communications devices, an antenna may cover the area larger than one spectrum band. Therefore, the diplexer or RF switch has to be used to separate the spectrum band. Typically, the diplexer or RF switch is often located after the wideband antenna and the duplexer is used in order to isolate the transmitter and the receiver.

Therefore, this research seeks to propose that an optimized solution could be to integrate the embedded antenna and the RF component. This could result in higher antenna costs but the overall cost of the entire RF device in mobile communications could be minimized due to this solution since costs will be lowered by saving on RF components, RF circuit space and increasing the battery life.

II. The RF Active Device

A. Duplexer

A duplexer can be utilized for both transmission and reception especially for mobile communications. Whenever a single antenna is used for transmitting and receiving, an RF switch or duplexer must be used [3]. In switching the antenna from transmit and receive mode could be an issue since it must be guaranteed that maximum energy is utilized. In essence, whenever an antenna is used, a duplexer must be there separate signal power between transmitting and receiving power. New technology need the high-quality duplexer due to the necessary of high isolation between transmitting signal (TX) and receiving signal (RX).

B. Diplexer

A RF diplexer or antenna diplexer is a unit that allows the use of multiband on a single RF antenna. Frequently also referred to as antenna duplexer, it allows transceivers that are operating on different frequencies to use one antenna [4]. Besides, an antenna diplexer may also be used to enable a single antenna to work on transmissions on one frequency band and reception on another [2]. In essence, the diplexer is the passive device that is used to distinct the spectrum band. Apart from being used in cases where a single antenna can work on multiple bands, a diplexer is also utilized when multiple antennas are used for separating the transmitting spectrum and receiving spectrum for each antenna.

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III. Integration the Front-End Device with Embedded Antenna.

Typically, antennas used for mobile multi-band communication devices are wideband and diplexers are needed to separate bands and duplexers are needed to separate receive (Rx) and transit (Tx) portions of each band.

In standard dual-band cellular telephone design there is typically one diplexer and two duplexers in line between the antenna and the telephone's active components including Low Noise Amplifiers (LNA) and RF chipsets. The total cost of these components is frequency as much as 10% or more of the total cost of the communication device

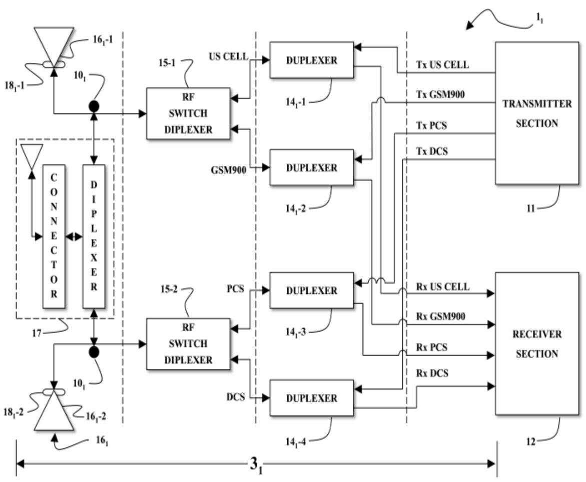

Figure 1

From Fig. 1, a schematic view of a quad-band cellular telephone communication mobile device which a RF Front End device having connector, diplexer function integrated into the antenna without need of typical connector or diplexer components. The Fig.ure includes an irregular compressed antenna and bent monopole antennas which receives and/or transmit radio wave radiation for the telephone communication device [3]. These antennas are connected directly through antenna interfaces to the RF switches/diplexers without need for the typical connector, diplexer unit that alternatively connects at connection points.

The RF switch/diplexer connects to duplexer which transmits or receives through channel TxUS Cellular from the transmitter or channel RxUS Cellular to the receiver section. The RF switch/diplexer connects to duplexer which transmits or receive though channel RxGSM900 from the transmitter or channel TxGSM900 to the receiver section. The RF switch/diplexer connects to duplexer which transmits or receives through channel TxPCS front the transmitter section or channel RxPCS to the receiver section. The RF switch/diplexer connects to duplexer which transmit or receives through channel TxDCS from the transmitter section or channel RxDCS to the receiver section.

A quad-band telephone will usually have one diplexer to separate between the low spectrum band (GSM900 and US Cell) and the high band (DCS and PCS), two RF switches and four duplexers further increasing the complexity and cost of front-end or more designs [5].

A communication device operates for exchanging energy in a plurality of bands of radiation frequencies and includes a plurality of compressed antennas, each antenna for operating with one or more of the bands of radiation frequencies. The communication device also includes a transmitter section for processing transmitter signals, a receiver section for processing receiver signals and connection means connecting the plurality of compressed antennas to the transmitter section and the receiver section.

In some embodiments, the communication device includes one or more diplexers to switch antennas from one band to another.

In some embodiments, the communication device includes one or more duplexers to switch antennas between the receiver section and the transmitter section.

In an embodiment where the number of bands equals four and the number of antennas equals four, the communication device is quad-band device.

In an embodiment where the number of bands equals four and the member of antenna all of bands are connected to the transmitter section and the receiver section through duplexers without need of diplexers.

In an embodiment where in the antennas includes a transmitter antenna and a receiver antenna for each band, all of the bands are connected to the transmitter section and the receiver section without need of duplexers and without need of diplexers.

In one embodiment, one or more of the compressed antennas includes two or more radiation elements, each element for operating in a different one of the bands, at least one of the radiation elements includes, a plurality of electrically conducting segments, each segment having a segment length, where the segments are electrically connected in series to form a radiation element connector exchange of energy in one of the bands where the radiation elements have the segments arrayed in a compressed pattern situated to create isolation between the multiple bands.

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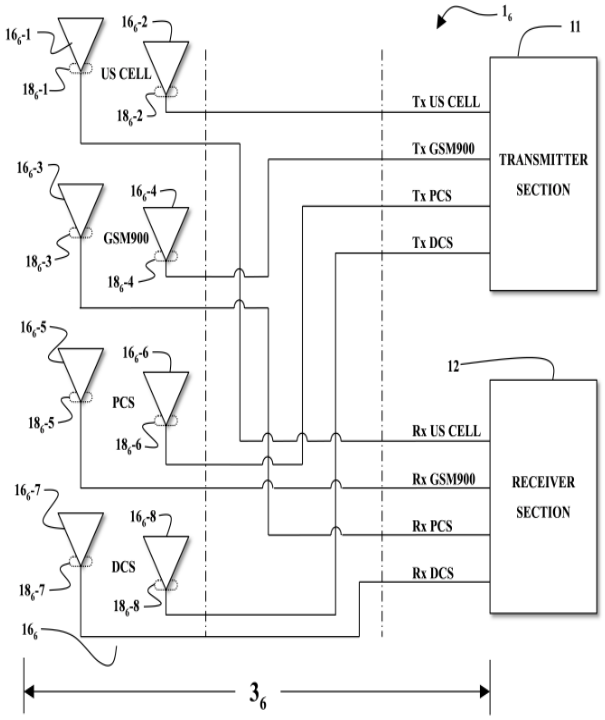

Figure 2

Fig. 2 depicts a schematic of a quad-band cellular telephone communication device with a front-end antenna section having connector, diplexer functions, having RF switch/diplexer functions and having duplexer functions integrated into the antenna section. The Fig.ure includes eight radiation elements, namely, eight antennas with corresponding antenna interfaces. One receiving RxUS antenna connects for the US cellular band through the RxUS Cell channel to the receive section [5]. The transmitting TxUS Cell antenna connects for the US cellular band through the TxUSCell channel the transmitter section. The receiving GSM900 antenna connects for the GSM900 band through the RxGSM900 channel to the receiver section. The transmitting GSM 900 antenna connects for the TxGSM900 band through the transmitter section. The receiving DCS antenna connects for the PCS band through the RxDCS channel to the receiver section. The transmitting DCS antenna connects for the TxDCS band through the transmitter section. The receiving PCS antenna connects for the PCS band through the RxPCS channel to the receiver section. The transmitting PCS antenna connects for the TxPCS band through the transmitter section.

Shown in Fig. 3 is a top view of a multiband antenna for use with the communication device from Fig. 2. The antenna is formed of multiple radiation elements including two single loop irregular compressed antennas; one large and one small connecting at one end to connector pad and connecting at the other end to connector pad. There is one double loop antenna that radiating double bands for the higher band use only inner loop and for lower band use double loop connecting both ends connector pads.

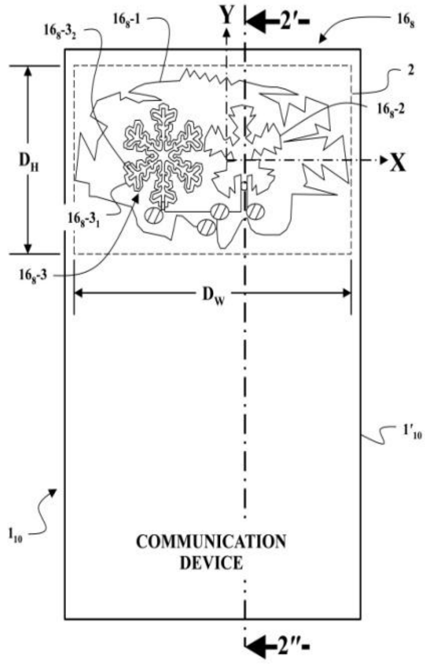

Figure 3

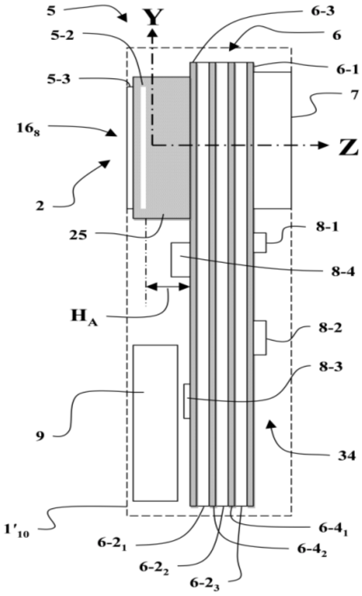

Figure 4

In Fig. 3, communication device shown can either be cell phone, pager or other similar devices which can be used safe to be employed in close proximity to people. The communication device includes an antenna area allocated for an antenna which receives and/or transmits radio wave radiation from the communication device. Typically, the antenna is affixed to the inside of the case of communication device by a pressure sensitive adhesive, injection molding, insert molding or any form of suitable manner of attachment. The case may be flat or curved antennas in some embodiments or it could lie in one or more planes where those planes should take the shape of the case hence can either be flat or curved.

In Fig. 4, the communication device of Fig. 3 is shown in a schematic, cross-sectional, end view. In Fig. 4, a circuit board includes, by way of example, an outer conducting layer, internal insulating layers, internal conducting layers, and another outer conducting layer. Typically, the conducting layers can function as a ground plane and a power supply plan. The printed circuit board supports the electronic components associated with communication devices and miscellaneous components. Communication device also includes a battery. Consequently, a conductive layer that forms a loop antenna is offset from the printed circuit board by agap which tends to reduce coupling between the antenna and the printed circuit board. The ability of the compressed antenna to operate well with suitable offset (should be around 20 mm or less) from the circuit board is a feature of the antenna that make them attractive for use in hand-help and other small communication devices.

IV. Conclusion

The present invention is a communication device operating for exchanging energy in a plurality of bands of radiation frequencies and includes a plurality of compressed antennas, each antenna for operating with one or more of the bands of radiation frequencies. The communication device also includes transmitter section for processing transmitter signals, a receiver section for processing receiver signals and connection means connecting the plurality of compressed antennas to the transmitter section and receiver section. In some embodiments, the communication device includes one or more diplexers to switch antennas from one band to another. In some embodiments, the communication device includes one or more duplexers to switch antennas between the receiver section and transmitter section. In an embodiment where the number of bands equals four and the number of antenna equals four, the communication device is quad-band device. In an embodiment where the number of bands equals the number of antennas all of the bands are connected to the transmitter section and the receiver section through duplexers without the need of diplexers. In an embodiment wherein the antennas include a transmitter antenna and a receiver antenna for each band, all of the bands are connected to the transmitter section and the receiver section without the need of duplexers and without the need of diplexers. In one embodiment, one or more of the compressed antennas includes two or more radiation elements; each element for operating in a different one of the bands, at least one of the radiation elements includes a plurality of electrically conducting segments, each segment having a segment, length, where the segments are electrically connected in series to form a radiation element for exchange of energy in one of the bands where the radiation elements have the segments arrayed in a compressed pattern situated to create isolation between the multiple bands.

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Settapong Malisuwan was born on 24th March 1966 in Bangkok, Thailand. He received his PhD in electrical engineering (telecommunications), specializing in mobile communication systems from Florida Atlantic University (State University System of Florida), Boca Raton in 2000. He received an MSc in electrical engineering in mobile communications system, from George Washington University in 1996, an MSc in electrical engineering in telecommunication engineering from Georgia Institute of Technology in 1992 and a BSc in electrical engineering from the Chulachomklao Royal Military Academy, Nakhon-Nayok, Thailand in 1990. He served in the Royal Thai Armed Forces for more than 25 years and is currently the Vice Chairman of National Broadcasting and Telecommunications, Bangkok, Thailand. His research interests are in efficient spectrum management and Telecommunications policy and management in Thailand. Col. Dr. Settapong Malisuwan is currently the Elected Vice Chairman and Board Member in the National Broadcasting and Telecommunications Commission, Thailand.

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