US 20080233954A1

(19) United States

(12) Patent Application Publication

(10) Pub. No.: US 2008/0233954 A1

(43) Pub. Date: Sep. 25, 2008

Ibrahim et al.

(54) METHOD AND SYSTEM FOR PROCESSING RESULTS DERIVED FROM DETECTING CHANNELS SUITABLE FOR FM TRANSMISSION IN AN INTEGRATED FM TRANSMIT/RECEIVE SYSTEM

(76) Inventors: **Brima Ibrahim**, Aliso Viejo, CA (US); **John Walley**, Ladera Ranch, CA (US); **Scott Bibaud**, Santa Ana, CA (US); **Bojko Marholev**, Irvine, CA (US); **Prasan Pai**, Mission Viejo, CA (US); **Siukai Mak**, Poway, CA (US); **Asif Grushkevich**, La Jolla, CA (US)

Correspondence Address:
MCANDREWS HELD & MALLOY, LTD
500 WEST MADISON STREET, SUITE 3400
CHICAGO, IL 60661

(21) Appl. No.: **11/832,858**

(22) Filed: **Aug. 2, 2007**

Related U.S. Application Data

(60) Provisional application No. 60/895,665, filed on Mar. 19, 2007.

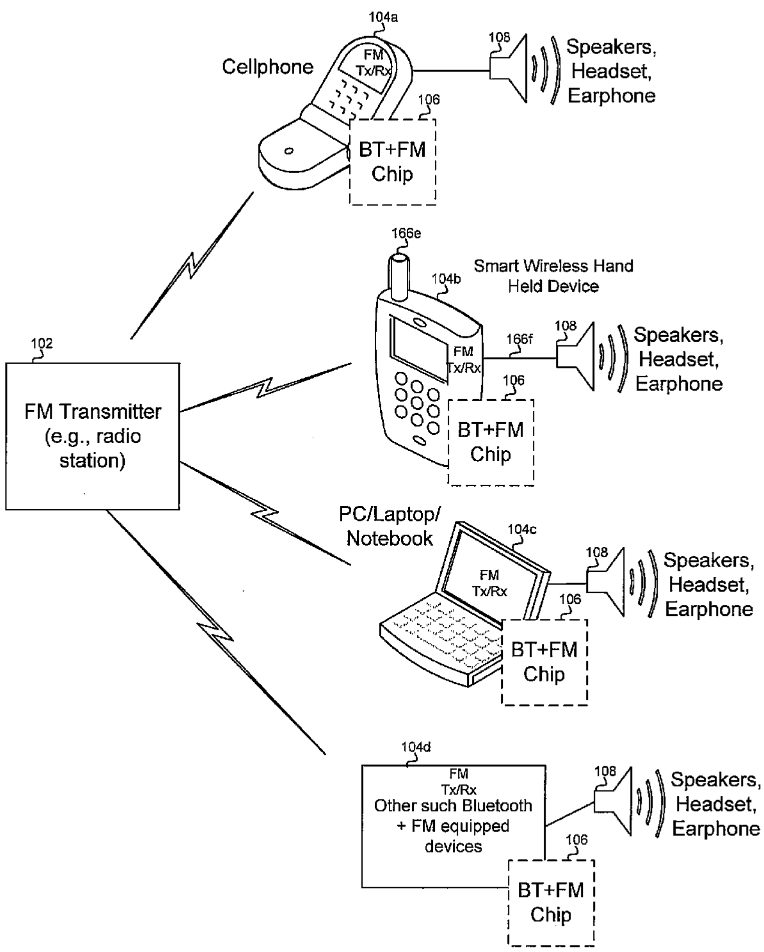
Publication Classification

(51) Int. Cl.
H04Q 7/20 (2006.01)

(52) U.S. Cl. 455/434

(57) ABSTRACT

A method and system is provided for enabling communication, where a FM radio system including an integrated FM radio transmitter and FM radio receiver may use an in-band FM or out of band transmitter to communicate a dynamically generated list with alternate local FM channels to an in-band or out of band receiver of another FM radio device with a FM radio receiver. The generated list of local FM channels may be ranked according to the least neighboring channel interference and may be selected for tuning the FM radio device. The FM radio system and the FM radio device may both scan to generate a substantially matched list of local FM channels. In response to detecting a new signal of a transmitted channel by the FM radio system, the FM radio device may tune to the same channel using an open loop, closed loop or semi-open loop method.



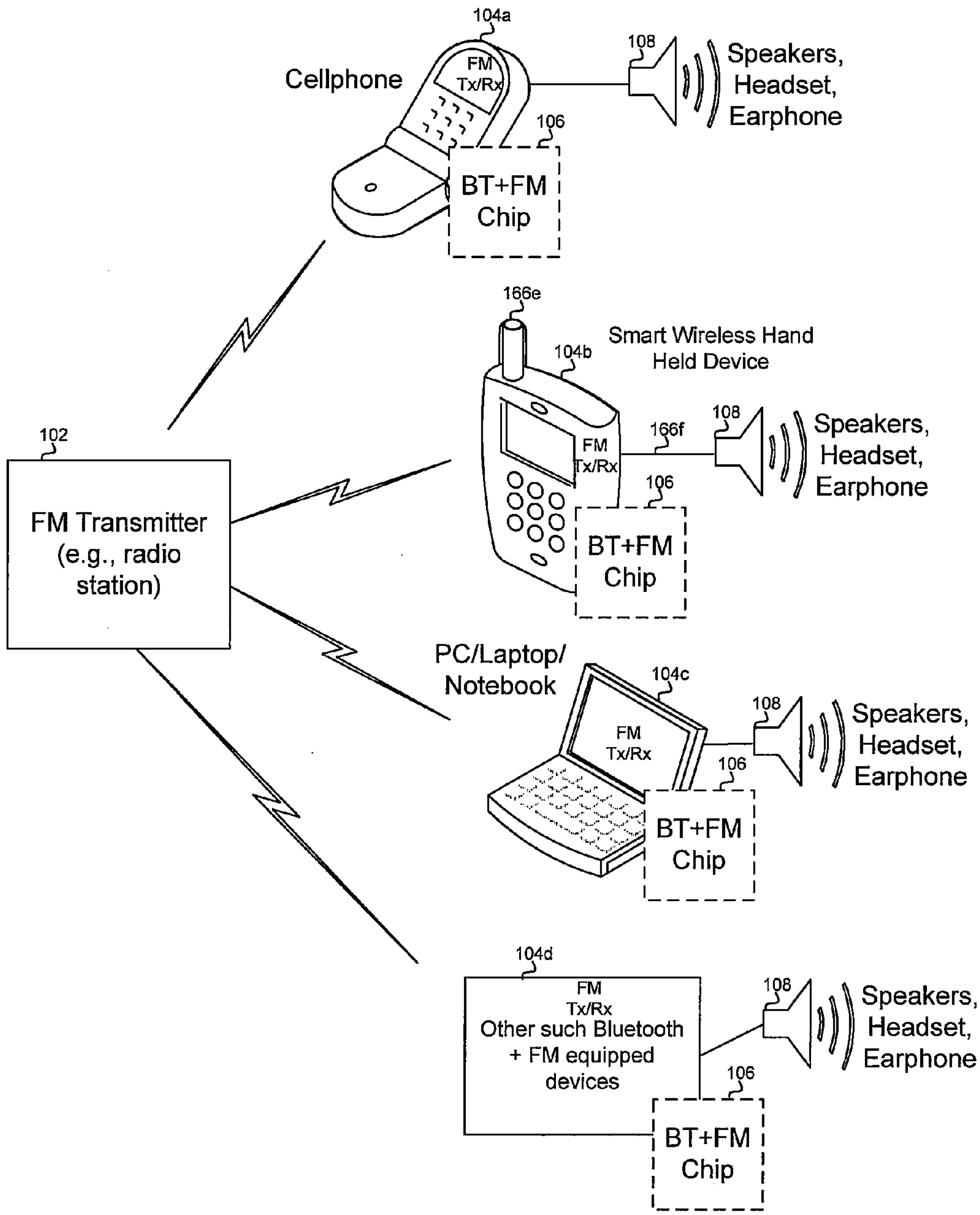

104a
Cellphone
FM
Tx/Rx
108
Speakers,
Headset,
Earphone
106
BT+FM
Chip
166e
Smart Wireless Hand
Held Device
104b
FM
Tx/Rx
166f
108
Speakers,
Headset,
Earphone
106
BT+FM
Chip
102
FM Transmitter
(e.g., radio
station)
PC/Laptop/
Notebook
104c
FM
Tx/Rx
108
Speakers,
Headset,
Earphone
106
BT+FM
Chip
104d
FM
Tx/Rx
Other such Bluetooth
+ FM equipped
devices
108
Speakers,
Headset,
Earphone
106
BT+FM
Chip

FIG. 1

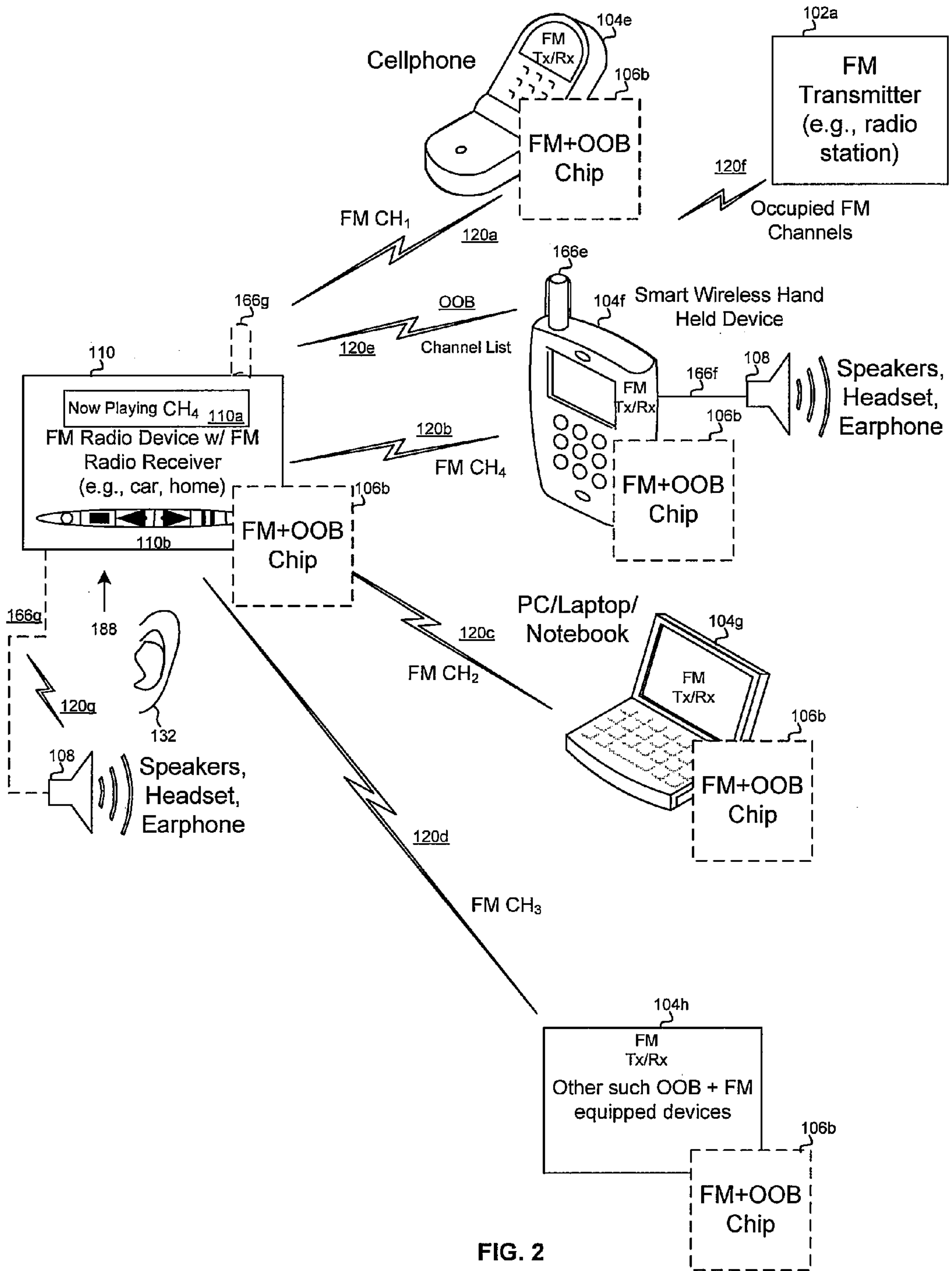

Cellphone
104e
FM
Tx/Rx
106b
FM+OOB
Chip
102a
FM
Transmitter
(e.g., radio
station)
120f
Occupied FM
Channels
FM CH1
120a
166e
OOB
120e
Channel List
104f
Smart Wireless Hand
Held Device
166g
110
Now Playing CH4
110a
FM Radio Device w/ FM
Radio Receiver
(e.g., car, home)
110b
FM
Tx/Rx
166f
108
Speakers,
Headset,
Earphone
120b
FM CH4
106b
FM+OOB
Chip
PC/Laptop/
Notebook
104g
120c
FM CH2
FM
Tx/Rx
166g
188
120g
132
108
Speakers,
Headset,
Earphone
120d
FM CH3
104h
FM
Tx/Rx
Other such OOB + FM
equipped devices

FIG. 2

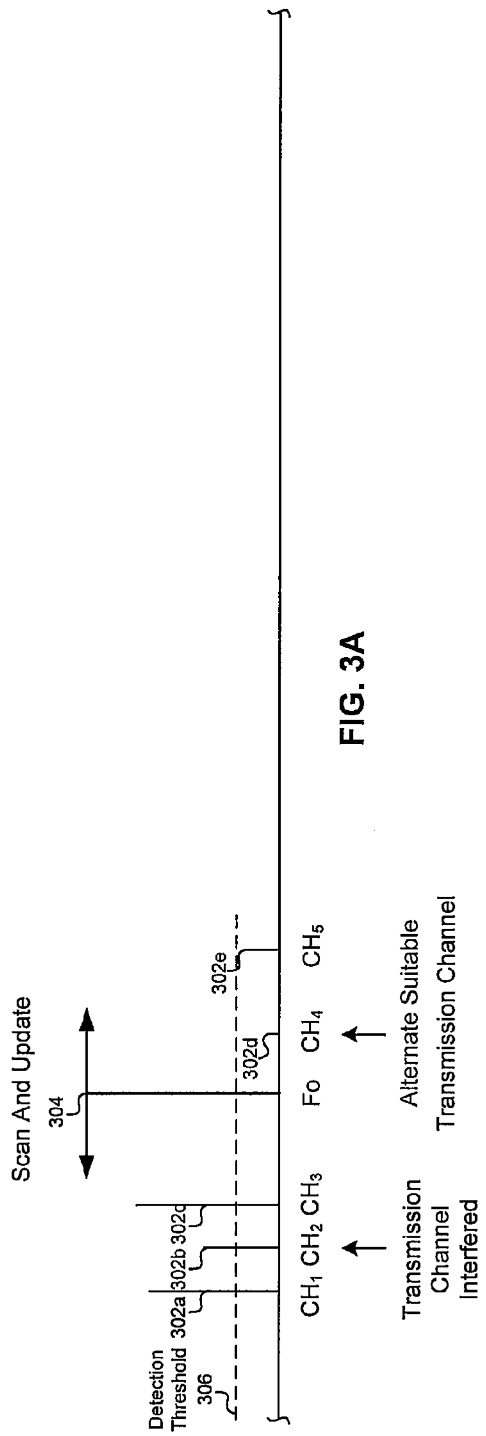

Scan And Update
304
Detection Threshold
306
302a
302b
302c
302d
302e
CH1 CH2 CH3
Fo
CH4
CH5
Transmission Channel Interfered
Alternate Suitable Transmission Channel

FIG. 3A

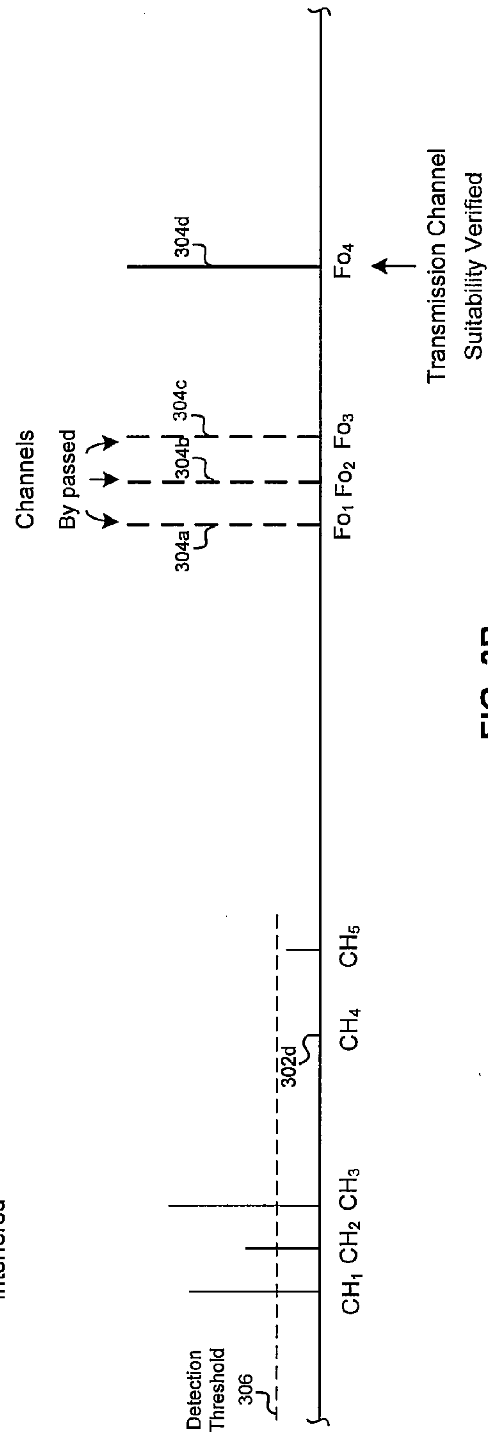
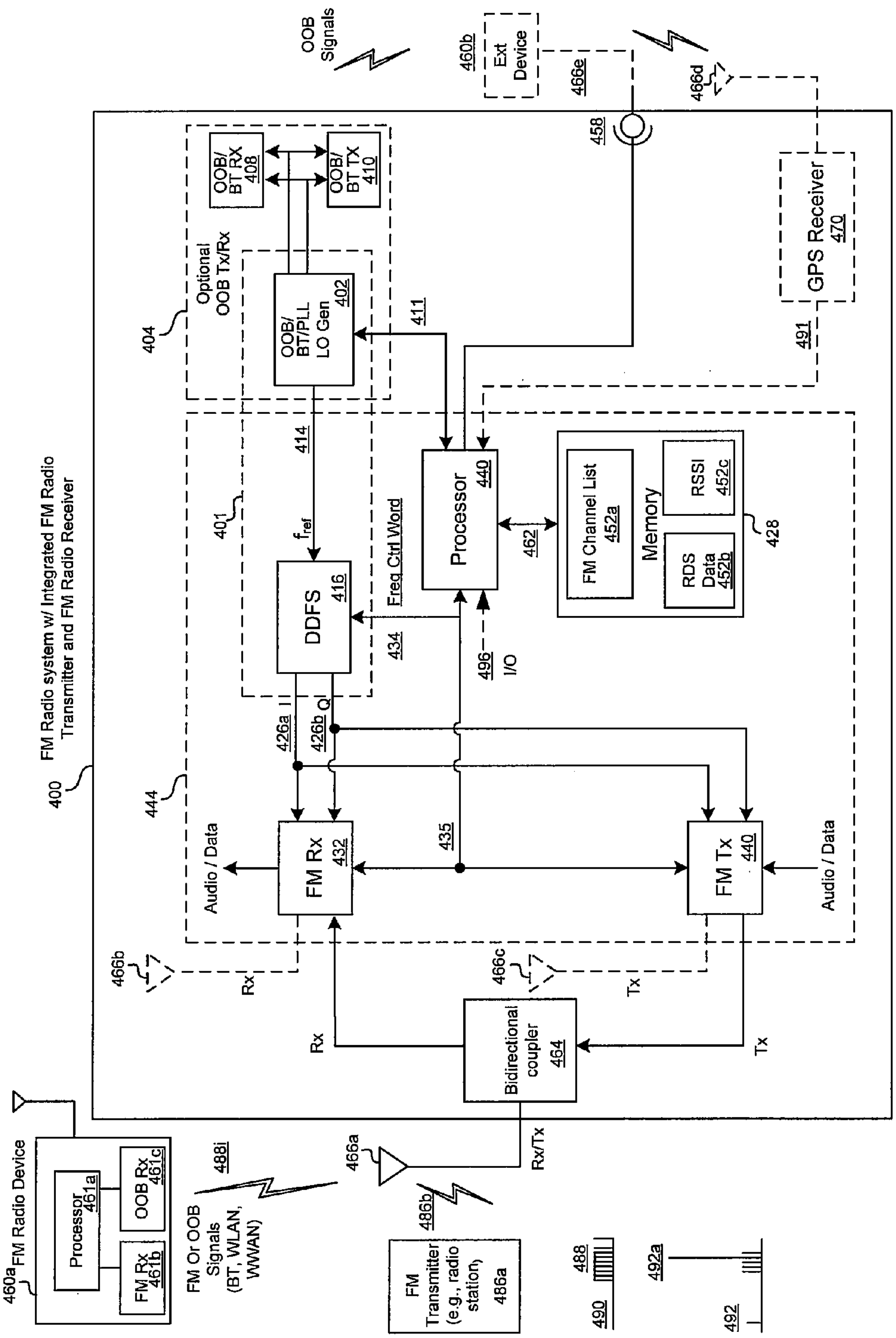

Detection Threshold
306
302d
CH1 CH2 CH3
CH4
CH5
Channels By passed
304a
304b
304c
304d
Fo1 Fo2 Fo3
Fo4
Transmission Channel Suitability Verified

FIG. 3B



FM Radio system w/ Integrated FM Radio Transmitter and FM Radio Receiver
400
OOB Signals
460b
Ext Device
466e
466d
458
404
Optional OOB Tx/Rx
OOB/ BT RX 408
OOB/ BT TX 410
OOB/ BT/PLL LO Gen 402
411
GPS Receiver 470
491
401
414
f_{ref}
Freq Ctrl Word
DDFS 416
434
Processor 440
462
Memory
FM Channel List 452a
RSSI 452c
RDS Data 452b
428
496
I/O
444
426a I
426b Q
Audio / Data
FM Rx 432
435
FM Tx 440
466b
466c
Rx
Tx
Bidirectional coupler 464
Rx/Tx
466a
FM Radio Device
460a
Processor 461a
FM Rx 461b
OOB Rx 461c
488i
FM Or OOB Signals (BT, WLAN, WWAN)
486b
FM Transmitter (e.g., radio station) 486a
488
490
492a
492

FIG. 4

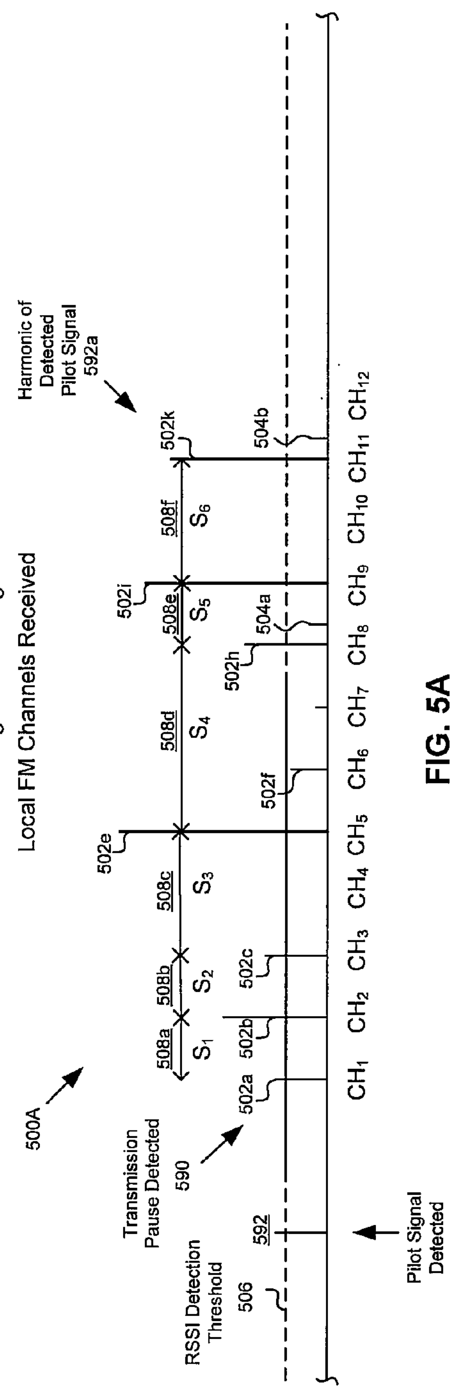

Scanning Or Detecting
Local FM Channels Received
500A
RSSI Detection Threshold
506
592
Transmission Pause Detected
590
Pilot Signal Detected
Harmonic of Detected Pilot Signal
592a
502a
502b
502c
502e
502f
502h
502i
502k
504a
504b
508a
508b
508c
508d
508e
508f
S1
S2
S3
S4
S5
S6
CH1 CH2 CH3 CH4 CH5 CH6 CH7 CH8 CH9 CH10 CH11 CH12

FIG. 5A

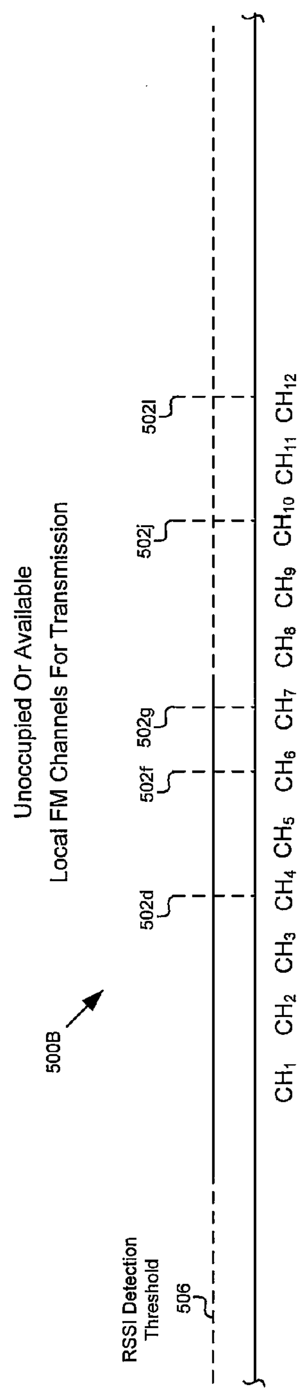

Unoccupied Or Available
Local FM Channels For Transmission
500B
RSSI Detection Threshold
506
502d
502f
502g
502j
502l
CH1 CH2 CH3 CH4 CH5 CH6 CH7 CH8 CH9 CH10 CH11 CH12

FIG. 5B

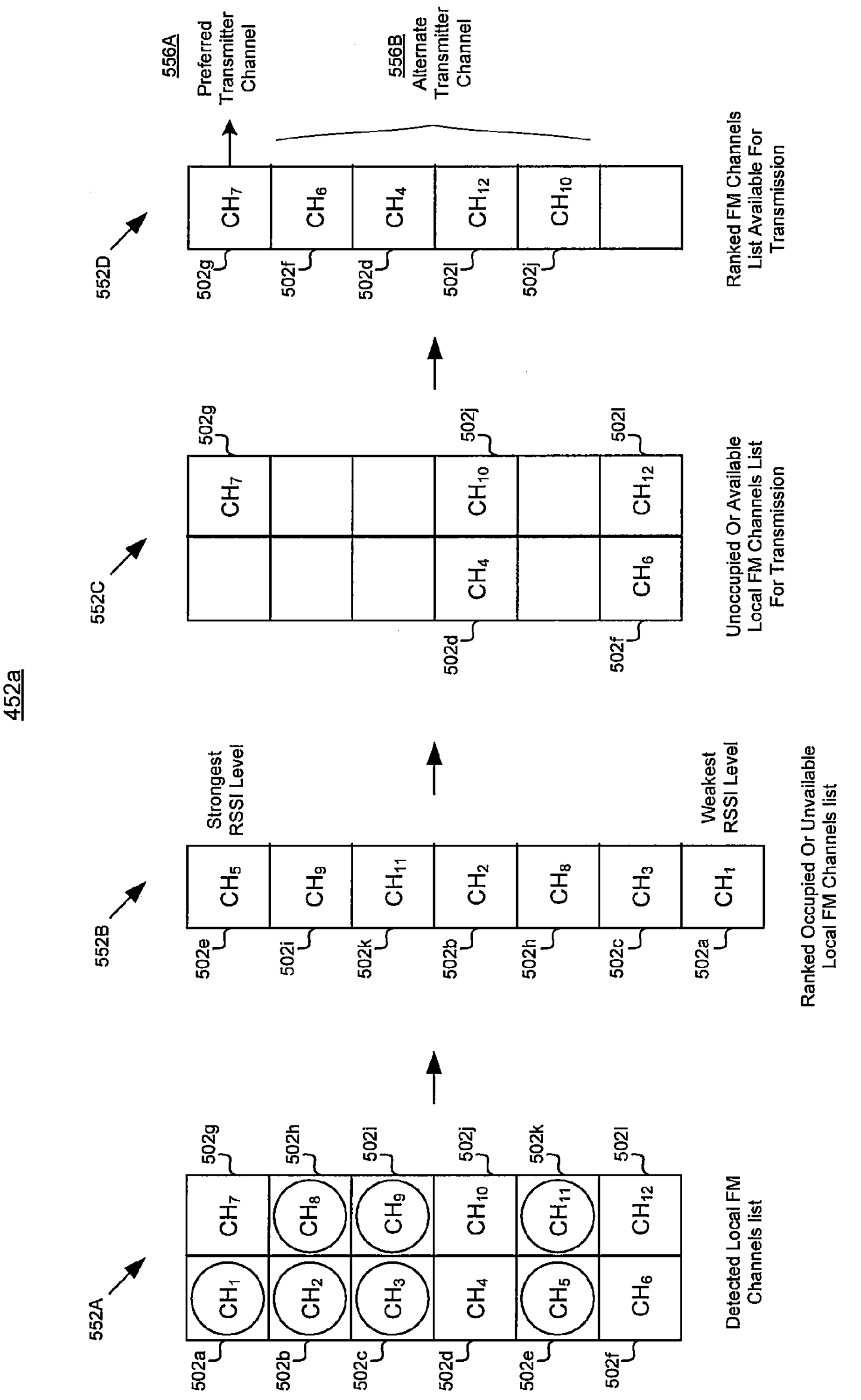
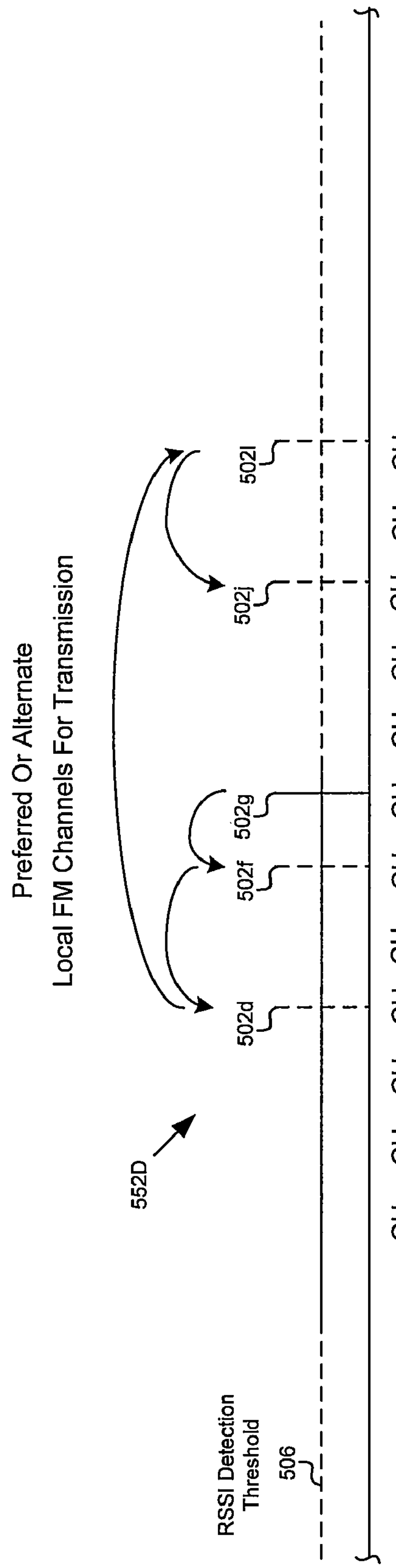

452a
552A
Detected Local FM Channels list
502a
502b
502c
502d
502e
502f
502g
502h
502i
502j
502k
502l
CH1
CH2
CH3
CH4
CH5
CH6
CH7
CH8
CH9
CH10
CH11
CH12
552B
Strongest RSSI Level
Weakest RSSI Level
CH5
CH9
CH11
CH2
CH8
CH3
CH1
Ranked Occupied Or Unavailable Local FM Channels list
552C
CH7
CH10
CH12
CH4
CH6
Unoccupied Or Available Local FM Channels List For Transmission
552D
CH7
CH6
CH4
CH12
CH10
556A Preferred Transmitter Channel
556B Alternate Transmitter Channel
Ranked FM Channels List Available For Transmission

FIG. 5C



Preferred Or Alternate
Local FM Channels For Transmission
552D
502d
502f
502g
502j
502l
RSSI Detection Threshold
506
CH1 CH2 CH3 CH4 CH5 CH6 CH7 CH8 CH9 CH10 CH11 CH12

FIG. 5D

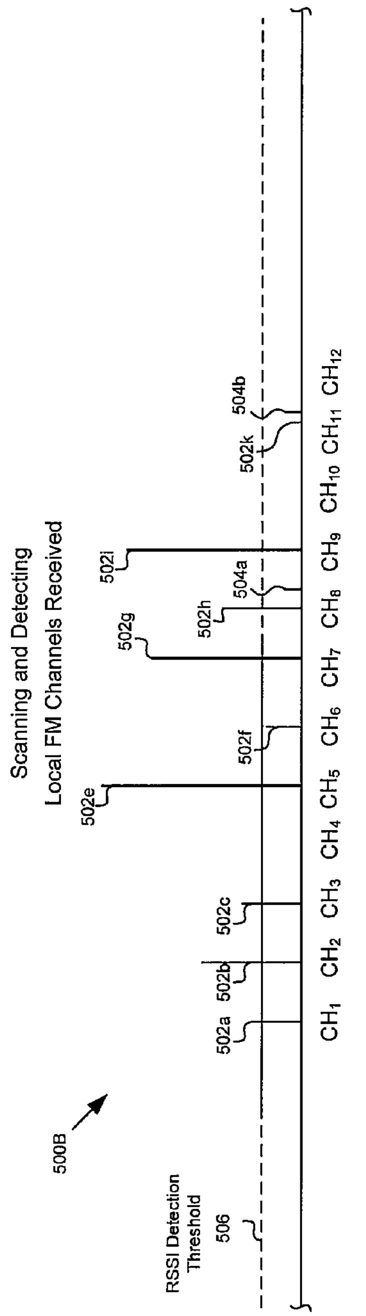

Scanning and Detecting
Local FM Channels Received
500B
RSSI Detection
Threshold
506
502a
502b
502c
502e
502f
502g
502h
502i
504a
502k
504b
CH1 CH2 CH3 CH4 CH5 CH6 CH7 CH8 CH9 CH10 CH11 CH12

FIG. 5E

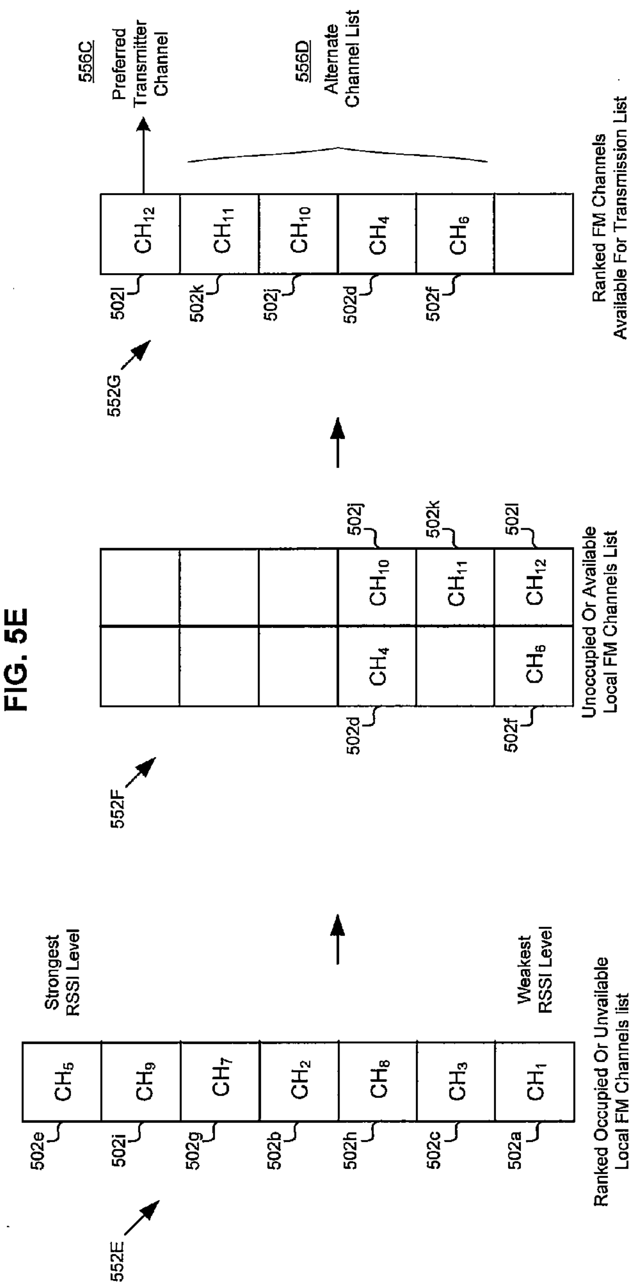

552E
Strongest
RSSI Level
Weakest
RSSI Level
502e CH5
502i CH9
502g CH7
502b CH2
502h CH8
502c CH3
502a CH1
Ranked Occupied Or Unavailable
Local FM Channels list
552F
502d CH4
502f CH6
502j CH10
502k CH11
502l CH12
Unoccupied Or Available
Local FM Channels List
552G
502l CH12
502k CH11
502j CH10
502d CH4
502f CH6
556C
Preferred
Transmitter
Channel
556D
Alternate
Channel List
Ranked FM Channels
Available For Transmission List

FIG. 5F

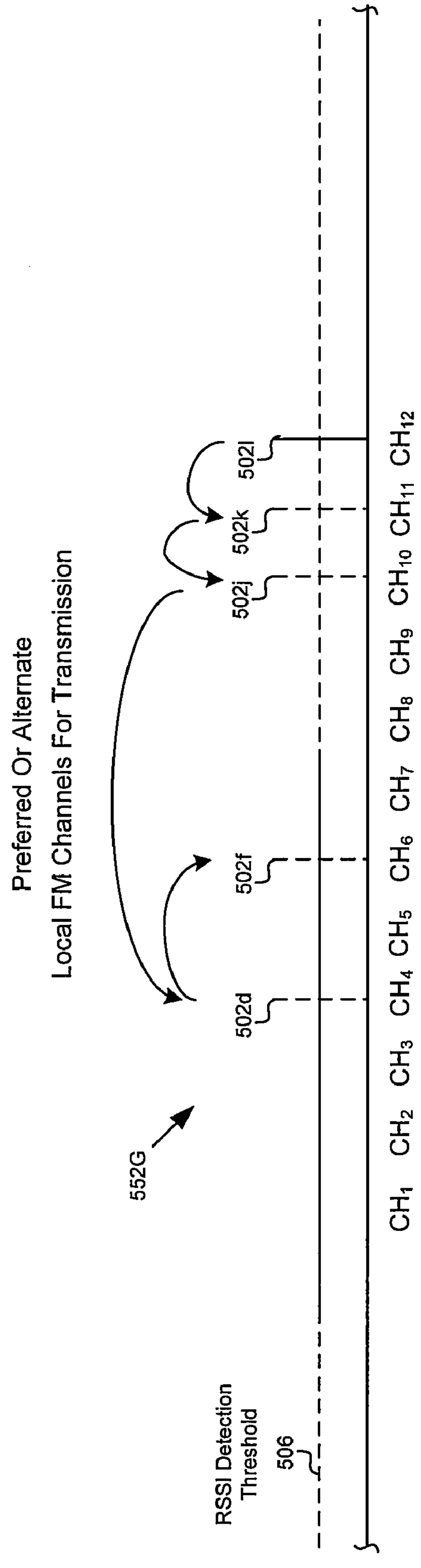

Preferred Or Alternate
Local FM Channels For Transmission
552G
502d
502f
502j
502k
502l
RSSI Detection
Threshold
506
CH_1 CH_2 CH_3 CH_4 CH_5 CH_6 CH_7 CH_8 CH_9 CH_{10} CH_{11} CH_{12}

FIG. 5G

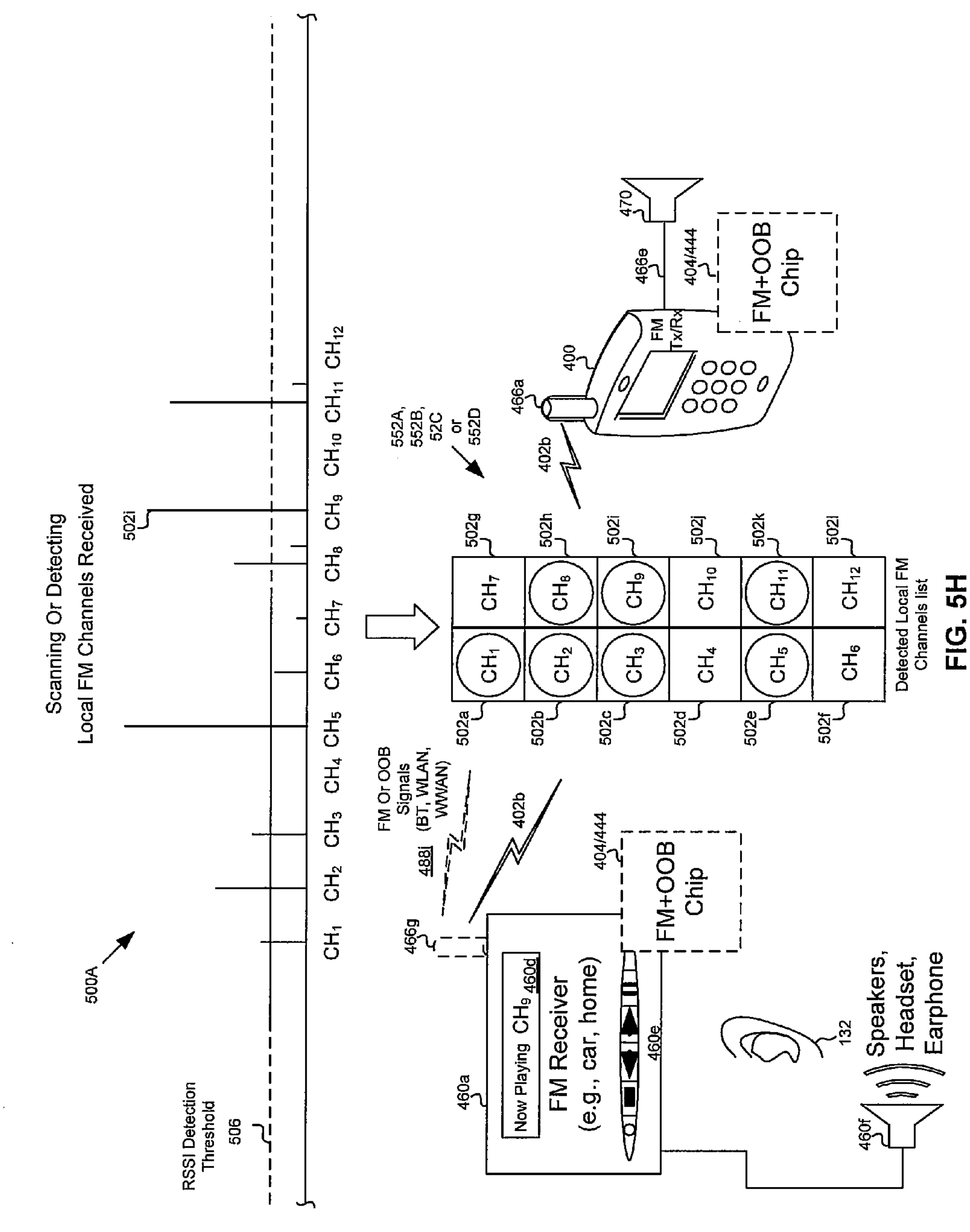

500A
Scanning Or Detecting
Local FM Channels Received
RSSI Detection
Threshold
506
502i
CH1 CH2 CH3 CH4 CH5 CH6 CH7 CH8 CH9 CH10 CH11 CH12
502a 502b 502c 502d 502e 502f
502g 502h 502i 502j 502k 502l
Detected Local FM
Channels list
552A,
552B,
52C
or
552D
FM Or OOB
Signals
(BT, WLAN,
WWAN)
488i
402b
466g
466a
400
FM
Tx/Rx
466e
470
404/444
FM+OOB
Chip
460a
Now Playing CH9 460d
FM Receiver
(e.g., car, home)
460e
132
460f
Speakers,
Headset,
Earphone

FIG. 5H

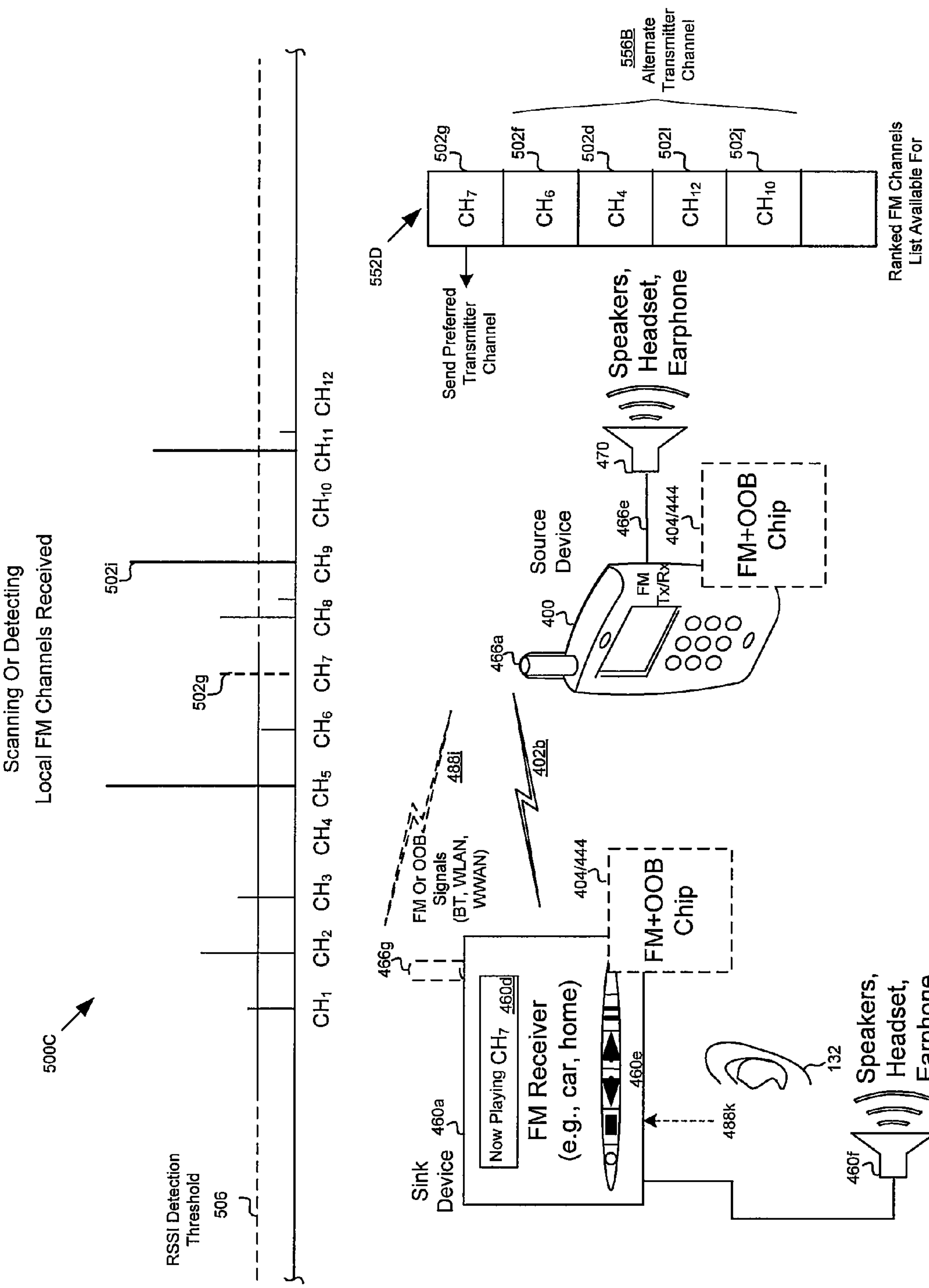

500C
Scanning Or Detecting Local FM Channels Received
RSSI Detection Threshold
506
502i
502g
CH1 CH2 CH3 CH4 CH5 CH6 CH7 CH8 CH9 CH10 CH11 CH12
552D
Send Preferred Transmitter Channel
CH7
CH6
CH4
CH12
CH10
502g
502f
502d
502l
502j
556B
Alternate Transmitter Channel
Ranked FM Channels List Available For Transmission
Sink Device
460a
Now Playing CH7 460d
FM Receiver (e.g., car, home)
460e
466g
FM Or OOB Signals (BT, WLAN, WWAN)
488i
402b
404/444
FM+OOB Chip
488k
132
460f
Speakers, Headset, Earphone
466a
400
Source Device
FM Tx/Rx
466e
404/444
FM+OOB Chip
470
Speakers, Headset, Earphone

FIG. 5I

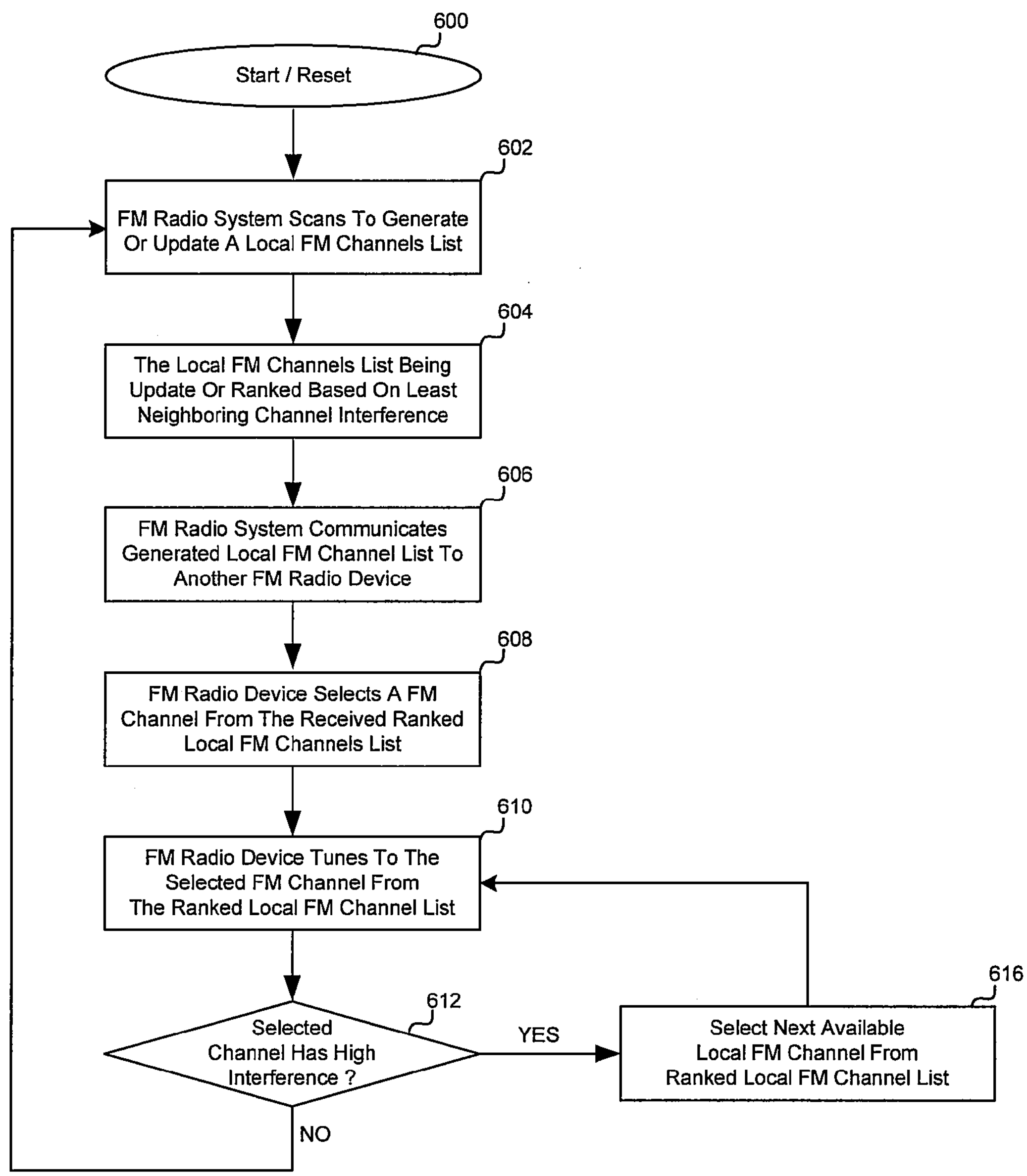

600
Start / Reset
602
FM Radio System Scans To Generate Or Update A Local FM Channels List
604
The Local FM Channels List Being Update Or Ranked Based On Least Neighboring Channel Interference
606
FM Radio System Communicates Generated Local FM Channel List To Another FM Radio Device
608
FM Radio Device Selects A FM Channel From The Received Ranked Local FM Channels List
610
FM Radio Device Tunes To The Selected FM Channel From The Ranked Local FM Channel List
612
Selected Channel Has High Interference ?
YES
NO
616
Select Next Available Local FM Channel From Ranked Local FM Channel List

FIG. 6A

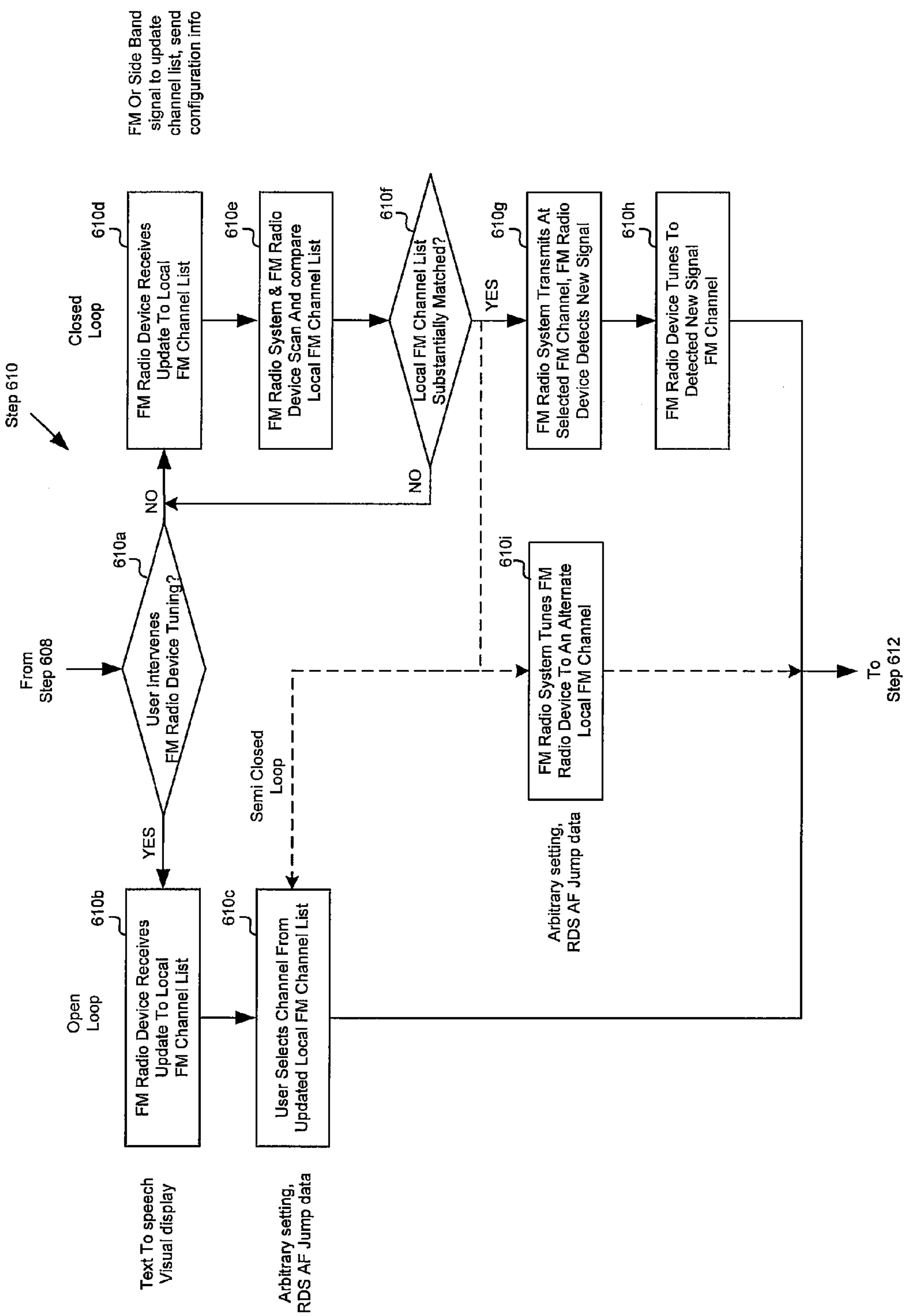

Step 610
From
Step 608
User Intervenes
FM Radio Device Tuning?
610a
YES
NO
Open
Loop
FM Radio Device Receives
Update To Local
FM Channel List
610b
Text To speech
Visual display
User Selects Channel From
Updated Local FM Channel List
610c
Arbitrary setting,
RDS AF Jump data
Semi Closed
Loop
Closed
Loop
FM Radio Device Receives
Update To Local
FM Channel List
610d
FM Or Side Band
signal to update
channel list, send
configuration info
FM Radio System & FM Radio
Device Scan And compare
Local FM Channel List
610e
Local FM Channel List
Substantially Matched?
610f
YES
NO
FM Radio System Transmits At
Selected FM Channel, FM Radio
Device Detects New Signal
610g
FM Radio Device Tunes To
Detected New Signal
FM Channel
610h
FM Radio System Tunes FM
Radio Device To An Alternate
Local FM Channel
610i
Arbitrary setting,
RDS AF Jump data
To
Step 612

FIG. 6B

METHOD AND SYSTEM FOR PROCESSING RESULTS DERIVED FROM DETECTING CHANNELS SUITABLE FOR FM TRANSMISSION IN AN INTEGRATED FM TRANSMIT/RECEIVE SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS/INCORPORATION BY REFERENCE

[0001] This application makes reference to, claims priority to, and claims the benefit of U.S. Provisional Application Ser. No. 60/895,665 filed on Mar. 19, 2007.

[0002] This application also makes reference to:
U.S. application Ser. No. 11/755,395 filed on May 30, 2007;
U.S. application Ser. No. ______ (Attorney Docket No. 18371US02) filed on even date herewith.

[0003] Each of the above stated application is hereby incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

[0004] Certain embodiments of the invention relate to wireless communication. More specifically, certain embodiments of the invention relate to a method and system for processing results derived from detecting channels suitable for FM transmission in an integrated FM transmit receive (FM Tx/Rx) system.

BACKGROUND OF THE INVENTION

[0005] Frequency Modulation (FM) is a form of modulation in wireless communication which represents information as variations in the instantaneous center frequency of a carrier wave. Frequency modulation was chosen as a modulation standard for high frequency signal transmission. A plurality of FM frequencies (channels) each separated by a frequency spacing may be broadcasted by a transmitter tower, a radio station or by a transmitting FM radio device.

[0006] A FM radio receiver of a FM radio includes a tuner with a tunable local oscillator (LO) may scan or search for broadcasted local FM frequency channels. Scanning may be performed by tuning the LO across the full tuning range of the LO or sweep the LO back and forth over a narrower tuning range to search for a signal of interest such as a FM channel. A FM channel may be detected or tuned if the FM radio receiver may successfully process a signal of sufficient signal amplitude, and/or the tuner may be able to establish an intermediate frequency (IF) signal that may be substantially the same or close to a defined offset of the FM radio receiver. When signals of two similar frequencies (from different broadcast stations or a neighboring broadcasting device) are received by the FM radio receiver, the FM radio receiver may process the stronger of two signals being broadcasted on the same frequency.

[0007] Radio Data System (RDS) or Radio Broadcast Data System (RBDS) standard format may be transmitted as a sub-carrier on the FM signals. The RDS/RDBS data format may contain information such as alternate frequencies of the broadcast station, the clock time, program identification with known channel frequency, channel spacing, station ID, country code or country identity, regional links and Enhanced Other Networks (EON) etc.

[0008] Further limitations and disadvantages of conventional and traditional approaches will become apparent to one of skill in the art, through comparison of such systems with some aspects of the present invention as set forth in the remainder of the present application with reference to the drawings.

BRIEF SUMMARY OF THE INVENTION

[0009] A method and system for processing results derived from detecting channels suitable for FM transmission in an integrated FM transmit receive (FM Tx/Rx) system, substantially as shown in and/or described in connection with at least one of the figures, as set forth more completely in the claims.

[0010] These and other advantages, aspects and novel features of the present invention, as well as details of an illustrated embodiment thereof, will be more fully understood from the following description and drawings.

BRIEF DESCRIPTION OF SEVERAL VIEWS OF THE DRAWINGS

[0011] FIG. **1** is a block diagram of an exemplary FM radio system with an integrated FM radio transmitter and FM radio receiver communicating to a FM radio transmitter, in accordance with an embodiment of the invention.

[0012] FIG. **2** is a block diagram of an exemplary FM radio system with an integrated FM radio transmitter and FM radio receiver dynamically communicating FM channels to another FM radio device having an FM radio receiver, in accordance with an embodiment of the invention.

[0013] FIG. **3**A is a diagram illustrating a dynamic scanning process of a FM radio system with an integrated FM radio transmitter and FM radio receiver in a FM frequency spectrum, in accordance with an embodiment of the invention.

[0014] FIG. **3**B is a diagram illustrating a dynamic local FM channel tuning by a FM radio system with an integrated FM radio transmitter and FM radio receiver based on a ranked local FM channel list or based on user intervention, in accordance with an embodiment of the invention.

[0015] FIG. **4** is an exemplary diagram of a FM radio system with an integrated FM radio transmitter and FM radio receiver on a Chip (SOC) with an integrated Bluetooth (BT) or Out Of Band (OOB) transceiver scanning local FM channels, in accordance with an embodiment of the invention.

[0016] FIG. **5**A is an exemplary diagram illustrating dynamic detection of occupied or unoccupied local FM channels, in accordance with an embodiment of the invention.

[0017] FIG. **5**B is an exemplary diagram illustrating extraction of unoccupied local FM channels available for transmission, in accordance with an embodiment of the invention.

[0018] FIG. **5**C illustrates an exemplary process of generating and ranking of local FM channels list available for transmission, in accordance with an embodiment of the invention.

[0019] FIG. **5**D is an exemplary diagram illustrating dynamic processing of alternate local FM channels for transmission based on least neighboring channel interferences, in accordance with an embodiment of the invention.

[0020] FIG. **5**E is an exemplary diagram illustrating dynamic detection of occupied or unoccupied local FM channels when channel distribution changes, in accordance with an embodiment of the invention.

[0021] FIG. **5**F illustrates an exemplary dynamic process of updating the local FM channel list for transmission based on least neighboring channel interferences, in accordance with an embodiment of the invention.

[0022] FIG. **5**G is an exemplary diagram illustrating dynamic processing of updated alternate FM channels for transmission based on least neighboring channel interferences, in accordance with an embodiment of the invention.

[0023] FIG. **5**H illustrates an exemplary simultaneous scanning of a FM radio system with an integrated FM Tx/Rx (as a source device) and another FM radio device with an FM receiver (as a sink device) to generate a substantially matched local FM channels list for available local FM transmission selection, in accordance with an embodiment of the invention.

[0024] FIG. **5**I illustrates an exemplary tuning of another FM radio device with an FM radio receiver to a selected local FM channel in response to a detection of a sudden increase of RSSI level of a channel signal, in accordance with an embodiment of the invention.

[0025] FIG. **6**A is a flow chart that illustrates exemplary steps for processing results derived from detecting channels suitable for FM transmission, in accordance with an embodiment of the invention.

[0026] FIG. **6**B is a flow chart that illustrates exemplary steps for open loop, closed loop or semi closed loop tuning of selected local FM channel, in accordance with an embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0027] Certain embodiments of the invention may be found in a method and system for processing results derived from detecting channels suitable for FM radio transmission in an integrated FM radio transmit and receive (FM radio Tx/Rx) system. In an aspect of the invention, an FM radio system may comprise an integrated FM radio transmitter and FM radio receiver (FM radio Tx/Rx) to scan and detect local FM channels to generate a local FM channel list available for FM transmission to another FM radio device. The another FM radio device may comprise an FM radio receiver.

[0028] In a dynamic environment with changing channel distribution and changing neighboring channel interferences, the integrated FM radio Tx/Rx system may dynamically update the FM channel list to select the most suitable or preferred local FM radio channel for FM radio transmission to another FM radio receiver. The FM radio receiver may tune to the same preferred or selected local FM channel transmitted by the integrated FM radio Tx/Rx system through open loop, closed loop or semi closed loop tuning.

[0029] In an embodiment of the invention, the integrated FM radio Tx/Rx system may comprise an integrated out-of-band (OOB) transmitter and the other FM radio device may comprise a FM radio receiver and an OOB receiver. The integrated FM Tx/Rx system may transmit a ranked local FM channel list to the FM radio receiver through OOB signals and the FM radio receiver may tune to a selected channel from the ranked local FM channel list. In another embodiment of the invention, both the integrated FM Tx/Rx system and the FM radio receiver may comprise an OOB transceiver to enable bidirectional communication. The open loop tuning may comprise user intervention where the user may tune the FM radio receiver to the preferred local FM channel following an updated channel list information from the integrated FM Tx/Rx system. In an embodiment of the invention, such updated channel list information may be communicated utilizing RDS/RDBS data to the user in the form of visual text display, text to speech audio format or a combination of visual and audio notifications. The user may tune the FM radio receiver to the suggested transmitted channel, or the user may tune to the next alternate FM channels available for transmission.

[0030] The closed loop tuning may comprise automatic tuning without user intervention where the FM radio receiver may tune to the same preferred local FM channel or to an alternate FM channel in response to receiving a ranked local FM channel list from the integrated FM Tx/Rx system. In an embodiment of the invention, both the integrated FM Tx/Rx system and the FM radio receiver may scan the FM spectrum to generate a substantially matched local channel list. Upon confirmation of the substantially matched local channel list, the integrated FM Tx/Rx system may transmit an available FM channel signal to the FM radio receiver.

[0031] The FM radio receiver may tune to a channel in response to detecting a new signal. In an exemplary embodiment of the invention, the FM radio receiver may detect a new signal based on a sudden RSSI level increase of the transmitted available FM channel signal and may subsequently tune the FM radio receiver to the same transmitted FM channel in response to such detection. In another exemplary embodiment of the invention, the FM radio receiver may indicate that a new signal (broadcasted by the integrated FM Tx/Rx system to the FM radio receiver) may be introduced to the FM spectrum based on monitoring a change in the Bit Error Ratio (BER) of the RDS/RDBS data. The transmitted FM channel may comprise the least neighboring channel interferences. The semi closed loop tuning method may comprise combining both closed loop and open loop tunings. In an embodiment of the invention, the open loop tuning may involve user's intervention.

[0032] FIG. **1** is a block diagram of an exemplary FM radio system with an integrated FM radio transmitter and FM radio receiver communicating to a FM radio transmitter, in accordance with an embodiment of the invention. Referring to FIG. **1**, there is shown an FM radio transmitter **102**, a plurality of FM radio systems, each with an integrated FM radio transmitter and FM radio receiver such as a cellular phone **104***a*, a smart wireless hand held device **104***b*, a computer **104***c*, and an exemplary FM and Bluetooth-equipped device **104***d*. The FM radio transmitter **102** may be implemented as part of a radio station or other broadcasting device, for example. Each of the cellular phone **104***a*, the smart wireless hand held device **104***b*, the computer **104***c*, and the exemplary FM and Bluetooth-equipped device **104***d* may comprise a single chip **106** with integrated FM and Bluetooth radios for supporting FM and Bluetooth data communications. The integrated Bluetooth data communication may be included as an optional feature in the exemplary FM radio systems. The FM radio transmitter **102** may enable communication of FM audio data to the plurality of FM radio systems shown in FIG. **1** by utilizing the single chip **106**. The plurality of FM radio systems, each with an integrated FM radio transmitter and FM radio receiver **104***a* to **104***d* in FIG. **1** may comprise and/or may be communicatively coupled to a listening device **108** such as a speaker, a headset, or an earphone, for example. In other embodiments of the invention, the functions of the single chip **106** may be implemented as discrete components.

[0033] The cellular phone **104***a* may be enabled to receive an FM transmission signal from the FM radio transmitter **102**. The user of the cellular phone **104***a* may then listen to the transmission via the listening device **108**. The cellular phone **104***a* may comprise a "one-touch" programming feature that enables pulling up specifically desired broadcasts, like weather, sports, stock quotes, or news, for example. The smart wireless hand held device **104***b* may be enabled to receive an FM transmission signal from the FM radio transmitter **102**. The user of the smart wireless hand held device **104***b* may then listen to the transmission via the listening device **108**. In an embodiment of the invention, the wire **166***f* connecting the smart wireless hand held device **104***b* to the listening device **108** may function as an external antenna similar to the antenna **166***e* for FM transmission and/or reception.

[0034] The computer **104***c* may be a desktop, laptop, notebook, tablet, and a PDA, for example. The computer **104***c* may be enabled to receive an FM transmission signal from the FM radio transmitter **102**. The user of the computer **104***c* may then listen to the transmission via the listening device **108**. The computer **104***c* may comprise software menus that configure listening options and enable quick access to favorite options, for example. In one embodiment of the invention, the computer **104***c* may utilize an atomic clock FM signal for precise timing applications, such as scientific applications, for example. While a cellular phone, a smart phone, computing devices, and other devices have been shown in FIG. **1**, the single chip **106** may be utilized in a plurality of other devices and/or systems that receive and use FM and/or Bluetooth signals. In one embodiment of the invention, the single chip **106** FM and Bluetooth radio may be utilized in a system comprising a WLAN radio. The U.S. application Ser. No. 11/286,844, filed on Nov. 22, 2005, discloses a method and system comprising a single chip FM and Bluetooth radio integrated with a wireless LAN radio, and is hereby incorporated herein by reference in its entirety. In another embodiment of the invention, the devices **104***a* to **104***d* shown in FIG. **1** may comprise an optional Global Positioning System (GPS) receiver to receive device location information.

[0035] In an alternate embodiment of the invention, the cellular phone **104***a*, smart wireless hand held device **104***b*, computer **104***c*, and the exemplary FM and Bluetooth-equipped device **104***d* may function as source devices (signal sources) to re-broadcast received signals from the transmitter **102** to one or more other sink devices (signal receptors) such as another FM radio devices with FM receivers. The single chip **106** may not be limited to integrating only Bluetooth technology, other out of band (OOB) wireless communication functions such as wireless local area network (WLAN), wireless wide area network (WWAN), cellular band or ZigBee may be integrated into the single chip **106**.

[0036] FIG. **2** is a block diagram of an exemplary FM radio system with an integrated FM radio transmitter and FM radio receiver dynamically communicating FM channels to another FM radio device having an FM radio receiver, in accordance with an embodiment of the invention. Referring to FIG. **2**, there is shown a FM radio transmitter **102***a*, a plurality of FM and OOB equipped FM radio systems with integrated FM radio transmitters and FM radio receivers such as a cellular phone **104***e*, a smart wireless hand held device **104***f*, a computer **104***g*, and an exemplary FM and OOB-equipped device **104***h*, and another FM radio device with an FM receiver **110**. The FM radio transmitter **102***a* may broadcast FM channels **120***f* (occupied and unavailable for local FM channel transmission) to the plurality of FM radio systems each with an integrated FM radio transmitter and FM radio receiver **104***b* to **104***h*.

[0037] In this example, the FM radio systems such as the cellular phone **104***e*, may transmit a telephone call for listening over the another FM radio device **110** such as an audio system of an automobile, via usage of the car's FM stereo system through FM signal **120***a* using FM channel CH**1**. In another example, the smart wireless hand held device **104***f*, may play media content such as songs to the another FM radio device **110** through broadcasting its media content through FM signal **120***e* using a selected FM channel CH**4** with least FM local channels interference from a local FM channel list. In an embodiment of the invention, the wire **166***f* connecting the smart wireless hand held device **104***f* to a listening device **108** may function as a high impedance external antenna for FM reception of FM signal **120***f* while a 50 ohm matched antenna **166***e* may be used for OOB transmission and/or reception of OOB signal **120***e*.

[0038] In another example, a computer, such as the computer **104***g*, may comprise an MP3 player or another digital music format player and may broadcast a FM signal **120***c* through an unoccupied FM channel CH**2** (deadband) to the another FM radio device **110** with a FM radio receiver. The music on the computer **104***g* may then be listened to on the another FM radio device **110** with few, if any, other external FM transmission devices or connections. While a cellular phone **104***a*, a smart wireless hand held device **104***b*, and computing devices **104***c* have been shown, a single chip **106***b* that may combine an optional OOB and FM transceiver and/or OOB and FM radio receiver to be utilized in a plurality of FM radio systems **104***e* to **104***h* or in the another FM radio device **110** to transmit and/or receive FM signals **120***a* to **120***d* and OOB signal such as signal **120***e*.

[0039] In this regard, the another FM radio device **110** with an FM radio receiver may comprise and/or may be optionally coupled to a listening device **108** using a wired connection **166***g* or using an optional Out Of Band (OOB) signal **120***g*. A device equipped with the OOB and FM transceivers, such as the single chip **106***b*, may be integrated into each of the integrated FM radio transmitter and FM radio receivers **104***a* to **104***d* to enable broadcasting its "out of band" respective signal **120***e* to the another FM radio device **110** outside the FM broadcasting band. The another FM radio device **110** may also comprise a visual display **110***a* to display the channel being played in the text format, and a channel tuning system **110***b* that enables a user **132** to intervene and select a preferred channel for FM reception through user input **188**.

[0040] In this example, the smart wireless hand held device **104***b* may use an OOB signal **120***e* to send a list of ranked local FM channels to the another FM radio device **110**, where the FM channel CH**4 120***b* may be the preferred channel with least neighboring channel interferences. The another FM radio device **110** may automatically tune to the preferred FM channel CH**4 120***b* and play the media content. In an embodiment of the invention, the FM radio device **110** may transmit through the in-band RDS/RDBS data to notify a user **132** of a channel CH**4** switch through text display on a visual display **110***a*, an alert tone or voice. Alternately, the FM radio device **110** may transmit through the in-band RDS/RDBS data to notify a user **132** to select a preferred channel from a list of alternate local FM channels by text message on a visual display **110***a*, or by text to voice through a speaker or headset **108**. The user **132** may either follow the recommendation of the local FM channel list to choose channel CH**4**, or the user **132** may judiciously tune the tuner **110***b* to check the other alternate channels on the local FM channel list before making a decision. The process of dynamically generating a local FM channel list may be discussed in FIGS. **5**A to **5**F.

[0041] FIG. 3A is a diagram illustrating a dynamic scanning process of a FM radio system with an integrated FM radio transmitter and FM radio receiver in a FM frequency spectrum, in accordance with an embodiment of the invention. Referring to FIG. 3A, a FM radio system with an integrated FM radio transmitter and FM radio receiver such as the smart wireless hand held device **104***f* may scan a FM spectrum to detect for an alternate FM channel such as channel CH4 **302***d* for local FM transmission.

[0042] Transmitted FM channel CH2 **302***b* may receive interferences from strong interfering neighboring channels CH1 **302***a* and CH3 **302***c*, or due to the channel CH2 **302***b* no longer available such as being used by a local FM broadcast station **102***a*. A local oscillator (LO) in the smart wireless handheld device **104***f* FM radio receiver may start scanning at LO frequency Fon. The LO may have an option to perform a full scan starting from CH1 **302***a* to generate and update a local FM channel list, or alternately the LO may start scanning from channel Ch5 **302***e*. The U.S. application Ser. No. 11/755,395 filed on May 30, 2007, discloses exemplary local FM channel tuning and detection, and is hereby incorporated herein by reference in its entirety.

[0043] FIG. 3B is a diagram illustrating a dynamic local FM channel tuning by a FM radio system with an integrated FM radio transmitter and FM radio receiver (FM Tx/Rx) based on a ranked local FM channel list or based on user intervention, in accordance with an embodiment of the invention. Referring to FIG. 3B, in this example a full scan may not be performed as in FIG. 3A, instead the FM radio receiver of the smart wireless handheld device **104***f* may dynamically "jump" to an alternate suitable transmission channel CH4 **302***d* based on a ranked local FM channel list.

[0044] In another embodiment of the invention, the LO of the FM radio receiver in the smart wireless handheld device **104***g* may arbitrarily "tune on the fly" to channel CH4 **302***d* directly without relying on prior information from the local FM channel list while the FM radio transmitter of the smart wireless handheld device **104***g* may be tuned to channel CH4 **302***d* before or after the FM radio receiver reaches the same channel CH4 **302***d* to verify its transmission availability. In both instances, the LO may by-pass tuning to LO frequencies Fo1 **304***a* to Fo3 **304***c* and settle on Fo4 **304***d* without a rescanning. The channel ranking and the FM channel list may be updated dynamically based on the availability verification or non interfering detection by the FM radio receiver. Further description on the dynamically generating and ranking of the FM channel list may be illustrated in FIGS. 5A to 5F.

[0045] FIG. 4 is an exemplary diagram of a FM radio system **400** with an integrated FM radio transmitter and FM radio receiver (FM Tx/Rx) on a Chip (SOC) with an integrated Bluetooth (BT) or Out Of Band (OOB) transceiver **404** scanning local FM channels **486***b*, in accordance with an embodiment of the invention. Referring to FIG. 4, there is shown a FM radio transmitter **486***a*, a FM radio system **400**, another FM radio device **460***a*. The FM radio transmitter **466***a* may comprise a radio station or a broadcasting device communicating FM channels **486***b* to the FM radio system **400** and or to the another FM radio device **406***a*. The FM radio system **400** may be an integrated Tx/Rx on a Chip (SOC) comprising an integrated Bluetooth (BT) or Out Of Band (OOB) transceiver **404**.

[0046] In an embodiment of the invention, the FM radio system **400** may comprise a BT transceiver **404** and an FM transceiver **444** with an integrated clock generator **401**. The BT transceiver **404** may comprise a BT/PLL LOGEN circuit **402**, a BT receiver circuit BT RX **408**, a BT transmit circuit BT TX **408**, and suitable logic, circuitry, and/or code that may enable communicating with an external device **460***b* with a baseband processor.

[0047] Accordingly, the BT PLL/LOGEN circuit **402** may comprise a PLL utilized to generate a signal utilized in the communication of BT data. One or more control signals may be provided by the BT transceiver **404** to the processor **440** and/or the memory **428**. Similarly, one or more control signals **411** may be provided by the memory **428** and/or the processor **440** to the BT transceiver **404**. In this regard, digital information may be exchanged between the BT transceiver **404** and the FM transceiver **444**. For example, changes in operating frequency of the BT PLL/LOGEN circuit **402** may be communicated to the memory **428** through control signal **411** and/or the processor **440** such that the frequency control word **434** to a DDFS **416** may be altered to compensate for the frequency change. In another embodiment of the invention, the BT transceiver **404** may comprise additional circuitry to support out of band (OOB) signal communication, or optionally replacing the BT transceiver with an OOB transceiver.

[0048] The FM transceiver **444** may comprise suitable logic, circuitry, and/or code that may enable the transmission and/or reception of local FM channel **486***b*. In this regard, the FM transceiver **444** may comprise a DDFS **416** clocked by the BT PLL/LOGEN circuit **402**. Accordingly, the FM transceiver **444** may be enabled to utilize reference generated clock signal **414** of widely varying frequency. In this regard, the DDFS **416** may enable utilizing the output reference generated clock signal **414** of the BT PLL/LOGEN circuit **402** to generate signals utilized by the FM transceiver **444**. In this manner, a reduction in power consumption and circuit size may be realized in the Integrated FM Tx/Rx system **400** by sharing a single BT PLL/LOGEN circuit **402** between the FM transceiver **444** and the BT transceiver **404**.

[0049] In an exemplary operation of the FM radio system **400** with an integrated FM Tx/Rx, one or more signals such as signals **435** provided by the processor **440** may configure the FM transceiver **444** to either transmit or receive FM signals. To receive FM radio signals, the processor **440** may provide one or more signals **435** to power up the FM Rx block **432** and power down the FM Tx block **430**. Additionally, the processor **440** may provide a frequency control word **434** to the DDFS **416** in order to generate an appropriate FM LO frequency (with IQ components **426***a* and **426***b*) based on the reference signal f_{ref} **414**. In this regard, f_{ref} **414** may comprise an output of the BT PLL/LOGEN circuit **402**.

[0050] For example, the BT PLL/LOGEN circuit **402** may operate at 900 MHz and the DDFS **416** may thus utilize the 900 MHz signal to generate, for example, signals in the "FM broadcast band", or approximately 78 MHz to 100 MHz. The FM broadcast band may expand to cover wider range such as 60 to 130 MHz in some FM radio devices. In another embodiment of the invention, the FM transceiver **444** may be capable of receiving or transmitting higher frequencies such as the cellular to millimeter wave range using an exemplary super heterodyne radio architecture described in the U.S. application Ser. No. 11/755,395 filed on May 30, 2007 and is hereby incorporated herein by reference in its entirety.

[0051] The processor **440** may interface with the memory **428** in order to determine the appropriate state of any control signals and the appropriate value of the frequency control word **434** provided to the DDFS **416**. To transmit FM signals the processor **440** may provide one or more signals **435** to power up the FM Tx block **430** and power down the FM Rx block **432**. Additionally, the processor **440** may provide a frequency control word **434** to the DDFS **416** in order to generate an appropriate FM LO frequency (with IQ components **426***a* and **426***b*) based on the reference signal f_{ref} **414**. Alternatively, the processor **440** may provide a series of control words **434** to the DDFS **416** in order to generate a FM signal. In this regard, the processor **440** may interface with the memory **428** in order to determine the appropriate state of any control signals **435** and the appropriate values of the control word **434** provided to the DDFS **416**.

[0052] The memory **428** may comprise a FM channel list **452***a* and RDS/RDBS data **452***b*. The FM channel list **452***a* may comprise one or more listings with dynamically updated local FM channels. The dynamically updated local FM channels **486***b* may comprise detected occupied local FM channels (not available for local FM transmission) and/or unoccupied local FM channels (available for local FM transmission through FM Tx block **464**). The RDS/RDBS **452***b* may comprise information identifying such as alternate frequencies of programs being broadcasted by local FM station, channel spacing, the number of blocks and frames transmitted (for BER determination), the clock time, broadcasted program identification with known station ID, country code or country identity, regional links and Enhanced Other Networks (EON) etc. The RDS/RDBS data **452***b* may be stored and retrieved from the memory **428** for dynamic tuning input and for validating occupied local FM channels being broadcasted.

[0053] In an embodiment of the invention, FM reception to detect local FM channels **486***b* and FM channel transmission may be performed simultaneously by receiving control signals **435** from the processor **440** and coupling the FM Rx block **432** to an optional receive antenna **466***b* and the FM Tx block **440** coupling to an optional antenna **466***c*. Alternately, FM reception and FM transmission may be multiplexed by coupling the FM Rx block **432** and the FM Tx block **440** to an antenna **466***a* through a bidirectional coupler. The antennae **466***a* and **466***c* may be used to transmit local FM channel list information **452***a* to an external FM radio receiver **461***b*/OOB receiver **461***c* equipped FM radio device **460***a* through out of band (OOB) signals **488***i* such as using Bluetooth BT, Wireless Local Area Network (WLAN) or Wireless Wide Area Network (WWAN). Alternately, the local FM channel list information **452***a* may be transmitted to the external FM radio receiver **461***b* of FM radio device **460***a* as an RDS/RDBS jump table using an in-band FM signal by closed loop tuning method.

[0054] In another embodiment of the invention, an optional GPS receiver **470** with antenna **466***d* may be coupled to the processor **440** as optional input **491** to provide country information or radio location information to assist in local FM channel and channel spacing determination. In another embodiment of the invention, the external device **460***b* may optionally be coupled to the FM radio system **400** with Integrated FM Tx/Rx to receive signal through a wire **466***d* coupled to a plug and a jack connector **458**. The wire **466** may be utilized as a reception antenna for the FM transceiver **444** while FM transmission may be performed through an internal antenna such as antenna **466***c*. Other inputs such as input **496** may serve similar functions as input **188** of FIG. **2** to facilitate channel tuning determination.

[0055] In another embodiment of the invention, pauses **490** of a transmission stream **488** may be an indication of a valid local FM channel being transmitted for dynamically generating or updating a local FM channel list **452***a*. A Pause frame may be used to halt the transmission of a sender for a specified period of time in a duplex communication mode where data may flow in both directions such as using FM Tx and FM Rx communication.

[0056] In another embodiment of the invention, a detection of a stereo pilot signal **492** (or pilot signal) may be used to identify a valid local FM channel **492***a* for dynamically generating or updating a local FM channel list **452***a*. The detection of a pilot signal **492** at a certain frequency may indicate a valid FM channel **492***a* may be detected at the second harmonics of the pilot signal **492**. For example, a 19 kHz pilot signal may indicate the presence of an FM channel audio signal at 38 kHz.

[0057] The another FM radio device **460***a* may comprise a processor **461***a*, a FM radio receiver **461***b* and an OOB receiver **461***c*. The FM radio receiver **461***b* may receive transmitted channel data from the FM radio transmitter **486***a* and/or the FM radio system **400**, depending on the channel the FM receiver **461***b* may be tuned to. In an embodiment of the invention, the OOB receiver **461***c* may receive FM channel information such as the ranked local FM channel list **552**D shown in FIG. **5**C from the OOB transmitter **410** of the FM radio system **400**.

[0058] FIG. **5**A is an exemplary diagram illustrating dynamic detection of occupied or unoccupied local FM channels, in accordance with an embodiment of the invention. Referring to FIG. **5**A, there is shown 12 exemplary local FM channels CH1 **502***a* to CH12 **502***l* in the local FM spectrum **500**A after a full scan. There is shown seven detected occupied local FM channels CH1 **502***a* to CH3 **502***c*, CH5 **502***e*, CH8 **502***h*, CH9 **502***i* and CH11 **502***k* where each of the respective occupied local FM channels may have signal amplitude exceeding the RSSI detection threshold **506**.

[0059] There is also shown FM channel CH6 **502***f* with a weak signal amplitude below the RSSI detection threshold **506** (near noise level), which may be a valid occupied channel after further verification with the RDS/RDBS data from the local FM station. In an embodiment of the invention, the FM channel CH6 **502***f* may be considered as an unoccupied channel available for local FM transmission.

[0060] There may be other spurious signals with weak signal amplitude in the local FM spectrum such as signals **504***a* and **504***b* that may not be regarded as usable local FM channels for transmission for reasons of irregular channel spacing, being too close to an interfering FM channel CH6 **502***h*, CH11 **502***k* or other reasons.

[0061] Alternately, there the FM channel CH1 **502***a* may be identified as a valid local FM channel being transmitted through a detection of an FM channel transmission pause **590** despite of its marginal RSSI level. Channel CH11 **502***k* may be identified as a valid local FM channel transmitted being a harmonic **592***a* of a detected stereo pilot signal **592**.

[0062] FIG. **5**B is an exemplary diagram illustrating extraction of unoccupied local FM channels available for transmission, in accordance with an embodiment of the invention. Referring to FIG. **5**B, there is shown a plurality of exemplary unoccupied local FM channels available for local FM transmission CH4 **502***d*, CH6 **502***f*, CH7 **502***g*, CH10 **502***j* and CH12 **502***l* extracted after a full scan of the local FM spectrum **500**A shown in FIG. **5**A.

[0063] The unoccupied local FM channels may be derived from detected occupied local FM channels. Vice versa, the occupied local FM channel may be inferred from the absence of a signal with significant amplitude such as above the RSSI detection level, in combination with at least one of the RDS/RDBS data information such as channel frequencies or channel spacing. Other exemplary inputs such as utilizing an optional GPS location information, channel frequency and channel spacing determination are disclosed in U.S. application Ser. No. 11/755,395, filed on May 30, 2007, which is hereby incorporated herein by reference, and may be used to generate a local FM channel list for suitable local FM channel transmission.

[0064] FIG. **5**C illustrates an exemplary process of generating and ranking of FM channels list available for transmission, in accordance with an embodiment of the invention. Referring to FIG. **5**C, there is shown one or more FM channel lists **552**A to **552**D may be derived from FIG. **5**A or FIG. **5**B. FM channel list **552**A may comprise local FM channels CH**1** **502***a* to CH**12** **502***l*. In FIG. **5**C, there is shown detected occupied local FM channels (circled channels) CH**1** **502***a* to CH**3** **502***c*, CH**5** **502***e*, CH**8** **502***h*, CH**9** **502***i* and CH**11** **502***k*, and unoccupied local FM channels CH**4** **502***d*, CH**6** **502***f*, CH**7** **502***g*, CH**10** **502***j* and CH**12** **502***l*.

[0065] The FM Channel list **552**B may be derived from the FM channel list **552**A. The FM Channel list **552**B may comprise of seven occupied local FM channels CH**1** **502***a* to CH**3** **502***c*, CH**5** **502***e*, CH**8** **502***h*, CH**9** **502***i* and CH**11** **502***k*. In an embodiment of the invention, the occupied local FM channels CH**5** **502***e*, CH**9** **502***i*, CH**11** **502***k*, CH**2** **502***b*, CH**8** **502***h*, to CH**3** **502***c* and CH**1** **502***a* may be ranked according to the respective RSSI amplitude in the FM Channel list **552**B. The FM channel CH**5** **502***e* being the strongest RSSI level and channel CH**1** **502***a* being the weakest RSSI level in the FM Channel list **552**B.

[0066] The FM Channel list **552**C may be derived from the FM channel list **552**A. The FM Channel list **552**C may comprise five exemplary unoccupied local FM channels CH**4** **502***d*, CH**6** **502***f*, CH**7** **502***g*, CH**10** **502***j* and CH**12** **502***l* being available for local FM transmission as shown in FIG. **5**B.

[0067] In an embodiment of the invention, the FM Channel list **552**C may be ranked according to increasing neighboring channel interferences to generate a FM Channel list **552**D. The FM Channel list **552**D may illustrate an exemplary ranking order of CH**7** **502***g*, CH**6** **502***f*, CH**4** **502***d*, CH**12** **502***l* and CH**10** **502***j*. The FM channel CH**7** **502***g* may be ranked as the preferred transmitter channel **556**A with the least neighboring channel interference. The FM channel CH**10** **502***j* may be ranked as the least preferred transmitter channel with highest neighboring channel interference in the alternate transmitter channels **556**B.

[0068] Referring to FIG. **5**A and FM channel list **552**D in FIG. **5**C, there is shown FM channel CH**7** **502***g* has two neighboring channels CH**6** **502***f* and CH**8** **502***h*. Neighboring channel CH**6** **502***f* may have a noise floor signal amplitude (below RSSI detection threshold) and neighboring channel CH**8** may have moderate to low signal amplitude. The FM channel CH**6** has neighboring channels CH**5** **502***e* and CH**7** **502***g*. Although neighboring channel CH**7** **502***g* may be at noise floor, neighboring FM channel CH**5** **502***e* may be shown as the strongest interfering channel in the FM frequency spectrum **500**A. Hence, the FM channel CH**7** **502***g* may be ranked or preferred above channel CH**6** **502***f*.

[0069] The channel CH**4** **502***d* has neighboring channels CH**3** **502***c* and channel CH**5** **502***e*. The FM channel CH**4** **502***d* may be inferior to channel CH**6** **502***f* for reason that neighboring channel CH**3** **502***c* is a valid occupied local FM channel above the noise floor, while channel CH**6** **502***f* being neighboring to channel CH**7** **502***g* at noise floor. Hence, the FM channel CH**6** **502***f* may be ranked above channel CH**4** **502***d*.

[0070] The channel CH**12** **502***l* has only one strong interfering neighboring channels CH**11** **502***k*. In an embodiment of the invention, the FM channel CH**4** **502***d* may be inferior to the FM channel CH**12** **502***l* for reason that the FM channel CH**4** **502***d* has two neighboring channel while the FM channel CH**12** **502***l* has one neighboring channel. In another embodiment of the invention, alternate FM channel CH**6** **502***f* may have closer proximity to channel CH**4** **502***d* (separated by two channel spacing) than to the FM channel CH**12** **502***l* (separated by six channel spacing. Hence, the FM channel CH**4** **502***d* may be ranked above the FM channel CH**12** **502***l*.

[0071] The Channel CH**10** **502***j* has two strong neighboring interfering channels CH**9** **502***i* and CH**11** **502***l*. The FM Channel CH**12** **502***l* has only one strong interfering neighboring channels CH**11** **502***k*. Hence, the FM channel CH**12** **502***l* may be ranked above channel CH**10** **502***j*.

[0072] The order of channel may vary depending on the ranking algorithm and other factors such as weighing factors, or spurious considerations may be included for ranking determination.

[0073] FIG. **5**D is an exemplary diagram illustrating dynamic processing of alternate local FM channels for transmission based on least neighboring channel interferences, in accordance with an embodiment of the invention. Referring to FIG. **5**D, the local FM channel list **552**D may be communicated to another FM radio device **460***a* with a FM and/or OOB receiver **461***c*. The FM receiver **461***b* of the another FM radio device **460***a* may tune to the corresponding selected or preferred channel CH**7** **502***g* with the least neighboring channel interferences. The FM receiver **461***b* of the another FM radio device **460***a* may upon receiving information such as a command from an in-Band FM signal **488***i* or upon user intervention, jump to the next available preferred unoccupied local FM channel CH**6** **502***f* on the ranked local FM channel list **552**D. In accordance with an exemplary embodiment of the invention, an RDS/RDBS jump instruction or command may be created and utilized to facilitate a jump to the next available preferred unoccupied local FM channel CH**6** **502***f*. Likewise, FM channel CH**4** **502***d*, FM channel CH**12** and FM channel CH**10** **502***j* may follow according to the order of increasing neighboring FM channel interferences in the alternate FM channels **556**D.

[0074] In another embodiment of the invention, the newly created exemplary RDS/RDBS jump instruction or command may be received as an in-band FM signal where the FM receiver **461***b* of the another FM radio device **460***a* may automatically tune by closed loop tuning method (to be discussed in FIG. 6B) to the next available preferred unoccupied local FM channel following the ranked local FM channel list **552**D. An example of such implementation may be the channel frequency of an FM radio in a moving automobile may jump to the next available preferred unoccupied local FM channel automatically based on the newly created RDS/RDBS jump instruction or command.

[0075] FIG. **5**E is an exemplary diagram illustrating a dynamic detection of occupied or unoccupied local FM channels when channel distribution changes, in accordance with an embodiment of the invention. FIG. **5**E illustrates dynamic changes make take place within local FM channel spectrum **500**B due to a channel distribution change of the FM radio system **400** with an integrated FM radio Tx/Rx receiver, or the local FM broadcasting channels distribution change at a different time instance. Referring to FIG. **5**E, a scan by the FM radio system **400** with an integrated FM radio Tx/Rx receiver may detect that the local FM channel CH**11** **502***k* may be switched to channel CH**7** **502***g*. A user using the preferred FM channel CH**7** **502***g* from the FM channel list **452***a* may experience a strong interference at this channel since channel CH**7** **502***g* may no longer be available for local FM transmission by the FM radio system **400** with an integrated FM Tx/Rx.

[0076] FIG. **5**F illustrates an exemplary dynamic process of updating the local FM channel list for transmission based on least neighboring channel interferences, in accordance with an embodiment of the invention. Referring to FIG. **5**F, there is shown an updated occupied local FM channel list **552**E may be generated from a scan by the FM radio system **400** with an integrated FM radio Tx/Rx. The updated occupied local FM channel list **552**E may comprise seven occupied local FM channels CH**5** **502***e*, CH**9** **502***l*, CH**7** **502***g*, CH**2** **502***b*, CH**8** **502***h*, to FM CH**3** **502***c* and FM CH**1** **502***a* and they may be ranked according to the respective RSSI amplitude in the FM Channel list **552**E.

[0077] The FM Channel list **552**F may be derived from the FM channel list **552**E. The FM Channel list **552**C may comprise of five unoccupied local FM channels CH**4** **502***d*, CH**6** **502***f*, CH**10** **502***j*, CH**11** **502***k* and CH**12** **502***l* that may be available for local FM transmission as shown in FIG. **5**B.

[0078] The FM Channel list **552**G may be updated and dynamically ranked according to neighboring channel interference. The FM Channel list **552**G may illustrate an exemplary ranking order of CH**12** **502***l*, CH**11** **502***k*, CH**10** **502***j*, CH**4** **502***d* and CH**6** **502***f*. The FM channel CH**12** **502***l* may be ranked as the preferred FM transmitter channel **556**C while the FM channel CH**6** **502***f* may be ranked as the least preferred transmitter channel in the alternate channel list **556**D. The ranking order in FM Channel list **552**G may use similar neighboring interfering channel algorithm described in FIG. **5**C.

[0079] The dynamic detection algorithm illustrated in FIGS. **5**A to **5**F may be enabled to determine which FM channels have the lowest noise floor, and accordingly select those channels as being suitable for transmission of FM data. The detection algorithm may be enabled to operate, for example, where there is a pause **490** in a transmitted FM stream **488**. The detection algorithm may utilize simultaneous FM radio Tx and FM radio Rx or multiplexed FM radio Tx and FM radio Rx to determine those channels suitable for transmitting or broadcasting FM data shown in FIG. **4**.

[0080] FIG. **5**G is an exemplary diagram illustrating dynamic processing of updated alternate FM radio channels for transmission based on least neighboring channel interferences, in accordance with an embodiment of the invention. FIG. **5**G is similar to FIG. **5**D except that the transmission order of the preferred FM channel CH**12** **502***l* and the alternate FM channels CH**11** **502***k*, CH**10** **502***j*, CH**4** **502***d* and CH**6** **502***f* may be rearranged in increasing neighboring channel interference reflected in the update in the local FM channel list **552**G.

[0081] FIG. **5**H illustrates an exemplary simultaneous scanning of a FM radio system **400** with an integrated FM Tx/Rx (as a source device) and another FM radio device **460***a* with an FM radio receiver (as a sink device) to generate a substantially matched local FM channels list for available local FM transmission selection, in accordance with an embodiment of the invention. Referring to FIG. **5**H, there is shown a substantially matched local FM channel list **552**A, **552**B, **552**C or **552**D may be generated from the FM frequency spectrum **500**A. Simultaneous scanning or scanning in close succession may be performed by the FM radio system **400** with an integrated FM radio Tx/Rx **444** and by another FM radio device **460***a* with an FM receiver. The FM radio system **400** may be a signal source as a source device transmitting FM channel information to a signal receptor, the another FM radio device **460***a* as a sink device.

[0082] In this example, the another FM radio device **460***a* with a FM radio receiver may be currently tuned to receive contents from the FM channel CH**9** **502***i* during the simultaneous FM scan **402***b*. The channel list **552**A of the FM scan **402***b* by the another FM radio device **460***a* with a FM radio receiver may be used to compare a substantially matched FM channel list **552**A FM scan **402***b* sent through the FM or OOB signal **488***i* by the FM radio system **400** with an integrated FM Tx/Rx.

[0083] FIG. **5**I illustrates an exemplary tuning of another FM radio device with an FM radio receiver to a selected local FM channel in response to a detection of a sudden increase of RSSI level of a channel signal, in accordance with an embodiment of the invention. Referring to FIG. **5**I, it is shown that a ranked local FM channel list **552**D with a selected FM channel CH**7** **502***g* for transmission based on least neighboring interferences may be generated or updated by the FM radio system **400** and communicated to the another FM radio device **460***a* through an FM or OOB signal **488***i*. Optionally, in another embodiment of the invention, a confirmation of such reception of the information, or a confirmation of a substantial matching of the FM channel list **552**A or **552**D from the FM scan **402***b* may be communicated back from the another FM radio device **460***a* to the FM radio system **400** through the FM or OOB signal **488***i*.

[0084] The FM radio system **400** may start transmitting FM channel data at the preferred FM channel CH**7** **502***g*, the another FM radio device **460***a* with a FM radio receiver may detect a new signal shown by a sudden rise of RSSI level located at the selected channel CH**7** **502***g*. Such new signal shown by a rise on RSSI level detection at channel Ch**7** **502***g* may act as a command signal to automatically tune the another FM radio device **460***a* to lock on to the selected FM channel CH**7** **502***g* to continue to receive FM channel data. In an embodiment of the invention, the visual display **460***d* may notify the user that the media content being played may be tuned to local FM channel Ch**7** **502***g*. In an embodiment of the invention, an audio alert tone or a text to voice may be transmitted over the RDS/RDBS data from the FM radio system **400** to inform the user of the channel CH**7** **502***g* switch. Alternately, the user may receive an audio alert tone or a text to voice command notification over the RDS/RDBS to initiate a user input **488***k* to tune the another FM radio device **460***a* to the selected FM channel CH**7** **502***g* through a semi automatic tuning or through manual FM tuner **460***e*.

[0085] In another embodiment of the invention, the another FM radio device **460***a* may monitor a change in the Bit Error Ratio (BER) of the RDS/RDBS data transmitted indicated by the new signal located at the selected channel CH**7** **502***g* (broadcasted by the FM radio system **400**) may be introduced to the FM frequency spectrum **500**C. The another FM radio device **460***a* may automatically tune to the selected channel CH**7** **502***g* using closed loop tuning method without user **132** intervention.

[0086] FIG. **6**A is a flow chart that illustrates exemplary steps for processing results derived from detecting channels suitable for FM transmission, in accordance with an embodiment of the invention. Reference designations in FIG. **2**, FIG. **4** and FIGS. **5**A to **5**F may be referenced to throughout the flow charts description at various steps in FIGS. **6**A and **6**B. Step **600** may represent an initial or a reset condition for a FM radio system **400** with an integrated FM Tx/Rx without prior knowledge of the location, channel frequencies and channel spacing information.

[0087] In step **602** the processor **440** of the FM radio system **400** with an integrated FM Tx/Rx may scan the FM spectrum **500**A to generate or update one or more local FM channel lists **552**A, **552***b*, **552**C or **552**D shown in FIG. **5**C. Channel list **552**A may comprise local FM channels CH**1** **502***a* to CH**12** **502***l* in the local FM channel spectrum after a full scan. Channel list **552**B may comprise ranked occupied local FM channels CH**5** **502***e*, CH**9** **502***i*, CH**11** **502***k*, CH**2** **502***b*, CH**8** **502***h*, to CH**3** **502***c* and CH**1** **502***a* according to the respective RSSI amplitude. Channel list **552**D may comprise ranked unoccupied FM channels CH**7** **502***g*, CH**6** **502***f*, CH**4** **502***d*, CH**12** **502***l* and CH**10** **502***j* available for transmission. In step **604**, the one or more local FM channel lists **552**A, **552***b*, **552**C or **552**D may be updated or may be used to derive a ranked local FM channel list **552**D based on least neighboring channel interference analysis. For example, unoccupied local FM channels CH**7** **502***g*, CH**6** **502***f*, CH**4** **502***d*, CH**12** **502***l* and CH**10** **502***j* may be updated or ranked in the FM Channel list **552**D based on increasing order of neighboring channel interference.

[0088] In step **606**, the FM radio system **400** may communicate the local FM channel list **552**A, **552***b*, **552**C or **552**D to another FM radio device **406***a* with a FM receiver. In an embodiment of the invention, the FM radio system **400** may use an OOB transmitter **410** to communicate the updated local FM channel list to an OOB receiver **461***c* of the another FM radio device **406***a*. The OOB communication may be a Bluetooth, wireless local area network (WLAN), wireless wide area network (WWAN), cellular band or ZigBee signal. In another embodiment of the invention, both the FM radio system **400** and the another FM radio device **406***a* may be equipped with an integrated OOB transceiver to enable bidirectional communication. Alternately, the FM radio system **400** may use an FM transmitter **440** to communicate the updated local FM channel list to an FM receiver **461***b* of the another FM radio device **406***a*.

[0089] In step **608**, the another FM radio device **406***a* may select a FM channel from the received ranked local FM channel list **552**D from the FM radio system **400**. In an embodiment of the invention, the preferred channel selected may be the least neighboring channel interference channel CH**7** **502***g*. In another embodiment of the invention, any one of the alternate channels **556**B from the ranked local FM channel list **552**D may be selected arbitrarily.

[0090] In step **610**, the FM radio receiver of the another FM radio device **406***a* may tune to the selected FM channel CH**7** **502***g* from the ranked local FM channel list **552**D through open loop tuning, closed loop tuning or semi-closed loop tuning. In step **612**, after the another FM radio device **406***a* tunes to the selected FM channel CH**7** **502***g*, the FM radio receiver of the FM radio system **400** and/or the FM radio receiver of the another FM radio device **406***a* may from time to time continue to scan the FM spectrum **500**A to check if the selected FM channel CH**7** may have any high neighboring channel interferences due to dynamic channel distribution in the broadcast stations, or due to location changes of the FM radio system **400**.

[0091] If a high neighboring channel interference may be detected in the existing transmitted channel CH**7** **502***g*, in step **616**, the FM radio system **400** may select the next available local FM channel such as CH**6** **502***f*, CH**4** **502***d*, CH**12** **502***l* or CH**10** **502***j* from the ranked local FM channel list. The FM radio system **400** may communicate through an FM or OOB signal **488***i* the new channel selection to the another FM radio device **406***a* to tune to the FM radio receiver of the another FM radio device **406***a* to the newly selected channel in step **610**. In step **612**, if the FM radio receiver of the FM radio system **400** may not detect high neighboring channel interference in the existing transmitted channel CH**7** **502***g*, the FM radio system **400** and/or the another FM radio device **406***a* may return to step **602** to continue to scan, monitor and/or update the local FM channel list.

[0092] FIG. **6**B is a flow chart that illustrates exemplary steps for open loop, closed loop or semi closed loop tuning of selected local FM channel, in accordance with an embodiment of the invention. Referring to FIG. **6**B, there is shown the exemplary tuning steps using open loop, closed loop or semi closed loop tuning of the selected local FM channel CH**7** **502***g* in step **610**. In step **610***a*, upon a local FM channel CH**7** **502***g* selection by the another FM radio device **406***a*, the another FM radio device **406***a* and the FM radio system **400** may implement a user intervention check in step **610***a*. If user intervention may be used, an open loop tuning may be implemented and continued in step **610***b*.

[0093] In step **610***b*, the FM radio receiver of the another FM radio device **406***a* may receive update to the local FM channel list **552**D by a re-scan, if necessary. The selected FM channel may be a channel with the least neighboring channel interference such as channel CH**7** **502***g*. The selected channel information may be derived from a format of the RDS/RDBS data **452***b* by the processor **440** and communicated to a user **132** through visual text display on the another FM radio device **406***a* or the FM radio system **400**. The selected channel information may be communicated to the user **132** in the form of text to voice audio means, or through a combination of both visual and audio notification.

[0094] In step **610***c*, the user **132** may select a channel based on the updated local Fm channel list, in this example, the CH**7** **502***g* based on the least neighboring channel interference recommended by local FM channel list **552**D. Alternately, the user **132** may select another arbitrary channel from the alternate channels **556**B in the ranked local FM channel list **552**D. After the open loop tuning may be completed, the process may continue, in step **612**, to check for the neighboring channel interference of the selected tuned channel by the user **132**.

[0095] In instances where user intervention may not be used in step **610***a*, a closed loop tuning process may be used starting step **610***d*. The closed loop tuning process may be an automatic tuning without user intervention, or may be modified to allow some user intervention as a semi-closed loop tuning process. In step **610***d*, the another FM radio device **406***a* may receive update to the local FM channel list **552**D by a re-scan, if necessary. In step **610***e*, the FM radio receiver in the FM radio system **400** and the FM radio receiver of the FM radio system **400** **6***a* may scan simultaneously or in close succession the FM spectrum **500**A. A local FM channel list **552***a*, **552**B, **552**C or **552**D may be generated by the FM radio system **400** and may be communicated to the another FM radio device **406***a* through a signal that may not affect the FM transmission such as using the FM or OOB signal **488***i*. In an alternate embodiment of the invention, the another FM radio device **406***a* may communicate the local FM channel list **552***a*, **552**B, **552**C or **552**D to the FM radio system **400** for channel match comparison.

[0096] In step **610***f*, the generated local FM channel list **552**A, **552**B, **552**C or **552**D may be compared for substantial match in the list. In instances where there may be no substantial match to the generated local FM channel list **552**A, **552**B, **552**C or **552**D, the process go to step **610***d* to re-scan for an update to the FM local channel list **552**A, **552**B, **552**C or **552**D. In instances where there may be a substantial match in step **610***f*, the tuning process may proceed to step **610***g* for a closed loop tuning with no user intervention, or to step **610***c* for semi-closed loop tuning with user intervention. In step **610***g*, the FM radio system **400** may transmit FM channel data to the another FM radio device **406***a* at the selected FM channel, CH7 **502***g* in this example. The FM radio receiver **461***b* of the FM radio device **406***a* may detect a new signal indicated by a sudden rise in RSSI level of signal or a change in the BER of the RDS/RDBS data at the selected channel CH7 **502***g*. In step **610***h*, the another FM radio device **406***a* may tune to the detected new signal channel CH7 **502***g* in response to a sudden rise of RSSI level or a change in the BER of the RDS/RDBS data at channel CH7 **502***g* and go to step **612** to check for channel CH7 **502***g* channel interference status after tuning.

[0097] In an alternate embodiment of the invention, the FM radio system **400** may programmed to jump to a next alternate channel on the local FM channel list **552**D, or to an arbitrary channel on the list without following the order of ranking.

[0098] The steps of the processes in FIGS. **6**A to **6**B may be rearranged in a different order or substituted with similar or equivalent operation to accomplish the same result without departing from the scope and the spirit of the invention.

[0099] In accordance with various embodiments of the invention, the method for enabling communication comprising in a FM radio system **400** comprising an integrated FM radio transmitter **440** and FM radio receiver **432**, dynamically generating a list **552**A, **552***b*, **552**C or **552**D with alternate local FM channels such as **502***a* to **502***l*, and communicating the generated list **552**A, **552***b*, **552**C or **552**D with alternate local FM channels **502***a* to **502***l* to another FM radio device **406***a*. The FM channels **502***a* to **502***l* of the generated list **552**A, **552***b*, **552**C or **552**D may be dynamically updated and communicated to an FM radio receiver of another FM radio device **406***a*.

[0100] In an embodiment of the invention, the FM radio transmitter **440** may communicate a selected FM channel CH7 **502***g* based on least neighboring channel interference from a ranked local FM channel list **552**D to tune the FM radio receiver of the another FM radio device **406***a* to the same selected FM channel CH7 **502***g*. In another embodiment of the invention, the FM radio system **400** may comprise an FM transmitter **440** or OOB transmitter **410** to communicate the local FM channel list **552**A, **552***b*, **552**C or **552**D with alternate local FM channels to an FM receiver **461***b* or OOB receiver **461***c* of the another FM radio device **406***a*. The FM transmitter **440** and FM receiver **461***b* or OOB transmitter **410** and OOB receiver **408** may communicate with one of FM, Bluetooth, WLAN and ZigBee signals **488***i*.

[0101] Another embodiment of the invention may provide a machine-readable storage, having stored thereon, a computer program having at least one code section executable by a machine, thereby causing the machine to perform the steps as described herein for FM transmission in an integrated FM transmit receive (FM Tx/Rx) system.

[0102] Accordingly, the present invention may be realized in hardware, software, or a combination of hardware and software. The present invention may be realized in a centralized fashion in at least one computer system or in a distributed fashion where different elements are spread across several interconnected computer systems. Any kind of computer system or other apparatus adapted for carrying out the methods described herein is suited. A typical combination of hardware and software may be a general-purpose computer system with a computer program that, when being loaded and executed, controls the computer system such that it carries out the methods described herein.

[0103] The present invention may also be embedded in a computer program product, which comprises all the features enabling the implementation of the methods described herein, and which when loaded in a computer system is able to carry out these methods. Computer program in the present context means any expression, in any language, code or notation, of a set of instructions intended to cause a system having an information processing capability to perform a particular function either directly or after either or both of the following: a) conversion to another language, code or notation; b) reproduction in a different material form.

[0104] While the present invention has been described with reference to certain embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted without departing from the scope of the present invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the present invention without departing from its scope. Therefore, it is intended that the present invention not be limited to the particular embodiment disclosed, but that the present invention will include all embodiments falling within the scope of the appended claims.

What is claimed is:

1. A method for enabling communication, the method comprising:
in a FM radio system comprising an integrated FM radio transmitter and FM radio receiver:
generating a list of local FM channels; and
communicating said generated list of local FM channels to another FM radio device.

2. The method according to claim **1**, comprising dynamically updating said generated list of local FM channels.

3. The method according to claim **2**, wherein said generated list of local FM channels comprises an alternate channel list.

4. The method according to claim **3**, comprising communicating said alternate channel list to said another FM radio device using an in-band FM signal.

5. The method according to claim **4**, wherein said FM radio receiver receives said communicated list of local FM channels, which is transmitted via said FM radio transmitter in said FM radio system.

6. The method according to claim **5**, wherein said another FM radio device selects from said received list of local FM channels, an FM channel for receiving FM signals.

7. The method according to claim **6**, wherein said FM radio receiver in said another FM radio device tunes to said selected FM channel for said receiving of said FM signals.

8. The method according to claim **1**, wherein said FM radio system comprises an out-of-band transmitter.

9. The method according to claim **8**, wherein said another FM radio device comprises a corresponding out-of-band receiver and a FM radio receiver.

10. The method according to claim **9**, comprising transmitting said communicated list of local FM channels from said FM radio system via said out-of-band transmitter.

11. The method according to claim **10**, wherein said another FM radio device receives via said corresponding out-of-band receiver, said communicated list of local FM channels.

12. The method according to claim **11**, wherein said another FM radio device selects from said received list of local FM channels, an FM channel for receiving FM signals.

13. The method according to claim **12**, wherein said FM radio receiver in said another FM radio device tunes to said selected FM channel for said receiving of said FM signals.

14. The method according to claim **9**, where in said out-of-band transmitter and said out-band-receiver utilizes one of: FM, Bluetooth, WLAN, or ZigBee.

15. The method according to claim **1**, comprising ranking said generated list of local FM channels based on least neighboring channel interference.

16. A system for enabling communication, the system comprising:

at least one processor for use in an FM radio system comprising an integrated FM radio transmitter and FM radio receiver;

said at least one processor generates a list of local FM channels; and

said at least one processor enables communication of said generated list of local FM channels to another FM radio device.

17. The system according to claim **16**, wherein said at least one processor dynamically updates said generated list of local FM channels.

18. The system according to claim **17**, wherein said generated list of local FM channels comprises an alternate channel list.

19. The system according to claim **18**, wherein said at least one processor in said FM transmitter enables communication of said alternate channel list to said another FM radio device via an in-band FM signal.

20. The system according to claim **19**, wherein said at least one processor in said FM radio receiver receives said communicated list of local FM channels, which is transmitted via said FM radio transmitter in said FM radio system.

21. The system according to claim **20**, wherein said at least one processor in said another FM radio device selects from said received list of local FM channels, an FM channel for receiving FM signals.

22. The system according to claim **21**, wherein said at least one processor in said another FM radio device enables said FM radio receiver to tune to said selected FM channel for said receiving of said FM signals.

23. The system according to claim **16**, wherein said FM radio system comprises an out-of-band transmitter.

24. The system according to claim **23**, wherein said another FM radio device comprises a corresponding out-of-band receiver, an FM radio receiver and at least one processor.

25. The system according to claim **24**, wherein said at least one processor in said FM radio system enables transmission of said communicated list of local FM channels from said FM radio system via said out-of-band transmitter.

26. The system according to claim **25**, wherein said at least one processor in said another FM radio device enables receiving via said corresponding out-of-band receiver, said communicated list of local FM channels.

27. The system according to claim **26**, wherein said at least one processor in said another FM radio device selects from said received list of local FM channels, a FM channel for receiving FM signals.

28. The system according to claim **27**, wherein said at least one processor in said another FM radio device enables said FM radio receiver in said another FM radio device to tune to said selected FM channel for said receiving of said FM signals.

29. The system according to claim **24**, where in said out-of-band transmitter and said out-band-receiver utilizes one of: FM, Bluetooth, WLAN, or ZigBee.

30. The system according to claim **16**, wherein said at least one processor ranking said generated list of local FM channels based on least neighboring channel interference.

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