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(56) Documents Cited:
GB 2393611 A **GB 2387509 A**
WO 2004/102926 A2 **WO 2004/095870 A1**
WO 2004/054286 A2

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(54) Abstract Title: **Accelerating a network search in a mobile communication device**

(57) A dual-mode mobile communication device 300 is able to perform an accelerated search for a network operating with a first radio access technology RAT 1, preferably WCDMA. The mobile device 300 scans a network operating with a second radio access technology RAT 2, preferably GSM, and detects a signal providing data relating to a timebase of RAT 2. The mobile device 300 then synchronises its crystal oscillator 330 with the derived timebase and scans a network operating with RAT 1 using the derived timebase of RAT 2. A second crystal oscillator (430, fig.4) may also be provided to synchronise with a detected timebase of RAT 1. Since the search for a GSM channel is much quicker than a search for a WCDMA channel and the difference between the GSM network clock and WCDMA network clock is within the equaliser acceptance window of the WCDMA system, an accelerated search for a WCDMA network is provided.

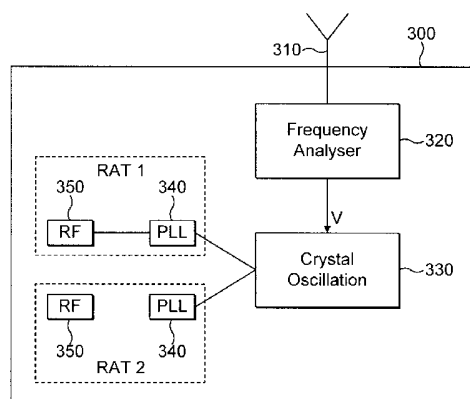


FIG. 3

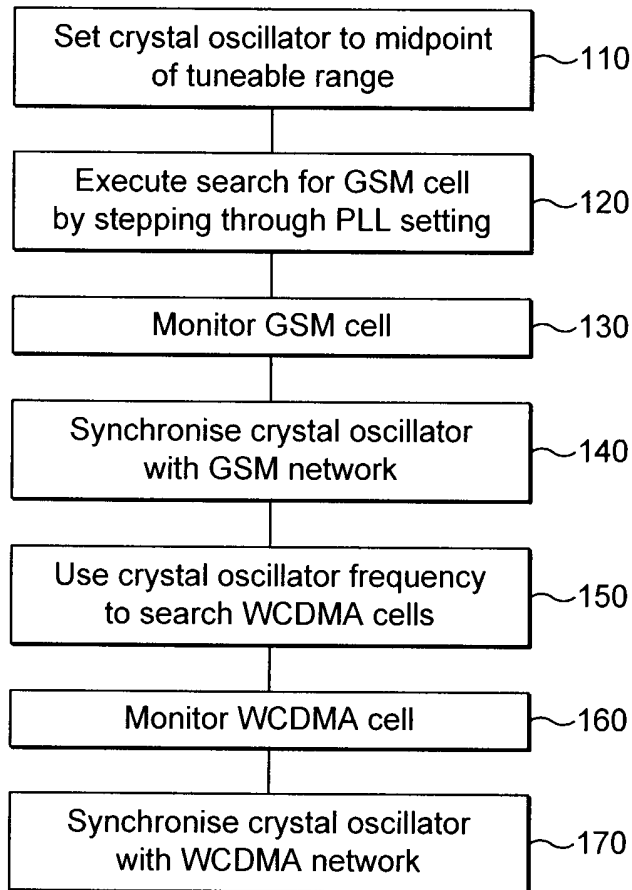


FIG. 1

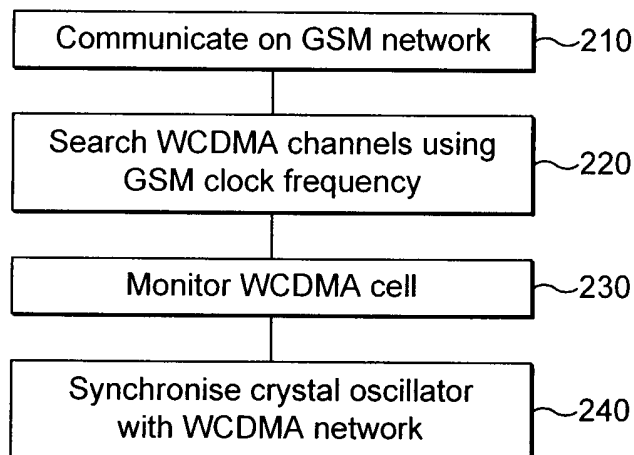


FIG. 2

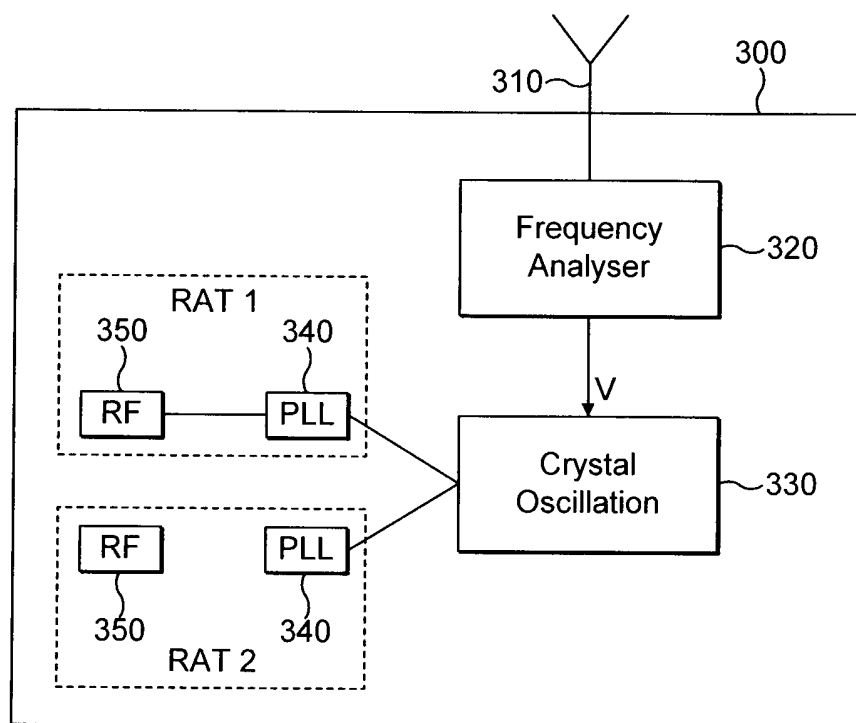


FIG. 3

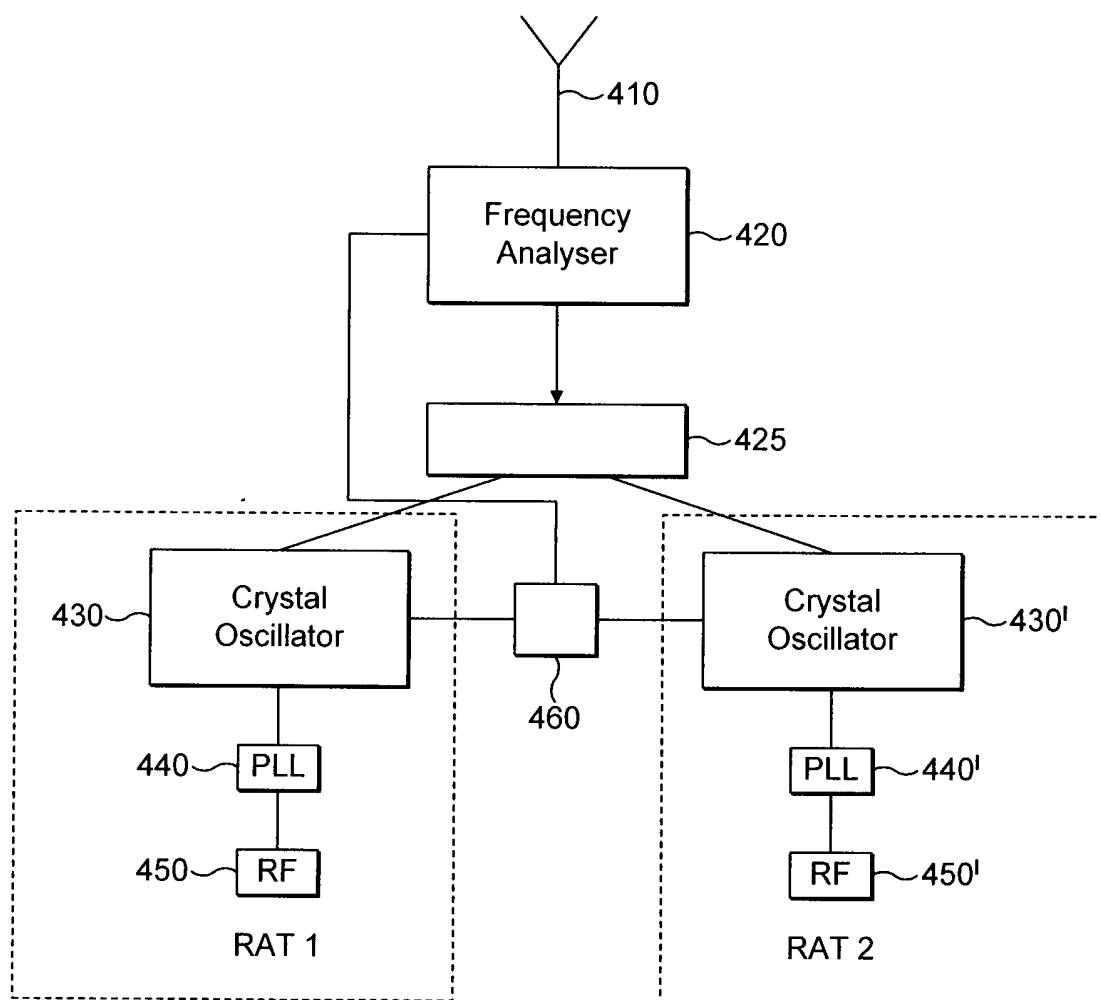


FIG. 4

An Apparatus for Accelerating a Network Search in a Mobile Communication**Device**

The present invention relates to a method and an apparatus for accelerating a
5 network search in a mobile communication device and, in particular, in a dual or
multi mode mobile communication device.

With the emergence of third generation mobile communication systems, mobile
phone manufacturers are developing multi mode handsets which are able to
access both second and third generation radio access technologies (RAT)s. In
10 such handsets the base station search procedure is complex and can take some
time to perform in its entirety. For commercial reasons, in a dual mode handset
the preferred technology will usually be the third generation technology and the
network search on the third generation system will be executed first. During
communication with a communicating (primary) RAT the non-communicating
15 (secondary) RAT is searched periodically.

There are two main steps that the handset must perform when searching for a
network;

- 1) synchronise a crystal oscillator within the handset with the frequency
of the network clock of the mobile communication system, and
- 20 2) identify the channel on which the local base station is communicating.

The time taken to search for and acquire a network is dead time as far as the
user is concerned since the handset is not communicating. Additionally,
performing network search on the secondary (i.e. non-communicating) RAT is a
power intensive operation. Therefore, it is preferable to reduce the time taken to
25 search for a network.

Regardless of the technology, mobile handsets use a crystal oscillator as a
reference clock for all operations. This oscillator is usually a voltage controlled
crystal oscillator (VCXO) or a voltage controlled temperature compensated
crystal oscillator (VCTCXO) in which the frequency of the oscillator can be
30 adjusted by adjusting the input voltage applied to the crystal. All frequencies

within the handset are generated from the crystal oscillator by way of phase locked loops (PLL) tracking loops. Typically, the frequency of the crystal is tuneable over a range of ± 10 parts per million (ppm) of its nominal frequency.

5 The voltage applied to the crystal oscillator is controlled by the handset software and, during communication with a network the frequency of the crystal oscillator is compared with the frequency of the received network signal and the applied voltage is automatically adjusted so that the frequency of the crystal oscillator matches that of the received network clock. Thus whenever the handset is receiving signals from the network, the crystal oscillator remains synchronized to
10 the network clock. However, when not receiving a signal, the frequency of the crystal oscillator may vary from the network due to various effects including voltage, temperature and ageing of the crystal oscillator.

Reception of signals on a cellular network relies on the frequency of the crystal oscillator being within a certain tolerance of the network clock. If the
15 synchronisation is outside the allowed tolerance of the handset then the incoming signals cannot be decoded. The tolerance of a particular handset depends on the equalizer, Radio Access Technology and type of reception being attempted. All systems use some type of synchronization reception for initial acquisition (i.e. power up) and for normal operation. Typically, the range of network clock
20 frequencies scanned (the acceptance window) during initial acquisition is larger than in normal operation since, in normal operation, the crystal oscillator has been tuned somewhat by the previous synchronization operations and is expected to be closer to the frequency of the network clock.

Known 2G/3G dual mode handsets support Global System for Mobile
25 Communications (GSM) and Wide-Band Code Division Multiple Access (WCDMA) RATs however, other combinations of RATs are available. Typically, a WCDMA equalizer has an acceptance window of ± 2 parts per million (ppm) for both initial and normal acquisition. Therefore, only signals having frequency within ± 2 ppm of that of the crystal oscillator are received and decoded. In
30 contrast, GSM equalizers have ± 10 ppm acceptance window for initial acquisition but only ± 2 or 3 ppm for normal operation. The reason that the initial acquisition window for WCDMA is much smaller than GSM is that WCDMA

is a more processing intensive system and a wider acceptance window is prohibited by processor speed and cost.

In dual mode GSM/WCDMA handsets, the preferred communication system is normally WCDMA. On power up the handset must be configured to search all WCDMA channels in order to find a network and base station. Since the ± 2 ppm acceptance window for synchronization is significantly smaller than ± 10 ppm tuneable range of the crystal oscillator, in order to ensure that all radio channels are searched, the voltage input to the crystal oscillator must be stepped in order to change the frequency of the crystal oscillator (to cover all possible frequencies of the network clock) and for each voltage input all channels must be scanned. The channels are scanned by stepping through the PLL setting, this operation is sometimes called frequency raster or band scan. The basic channel search procedure must be repeated five times (at different frequencies of the crystal oscillator) before the entire channel range has been fully covered. In practice the system follows the following steps;

- 1) The crystal frequency is set to the midpoint value of its tuneable range
- 2) The PLL is stepped through all channels
- 3) The crystal is set to midpoint $+4$ ppm
- 4) The PLL is stepped through all channels
- 5) The crystal is set to midpoint -4 ppm
- 6) The PLL is stepped through all channels
- 7) The crystal is set to midpoint $+8$ ppm
- 8) The PLL is stepped through all channels
- 9) The crystal is set to midpoint -8 ppm
- 10) The PLL is stepped through all channels

Of course, once a channel is found, the subsequent steps of the procedure are not required. Depending on the number of WCDMA bands in the handset, the procedure can take up to 3 minutes to complete. As discussed above, this time is seen as dead time as far as the user is concerned and the extensive searching requires a significant amount of power.

In GSM systems the acceptance window for synchronization is ± 10 ppm. This acceptance window is the same magnitude as the tuneable range of the crystal

oscillator. Therefore, when using GSM technology, a device is able to access all available channels for all tuneable crystal oscillator frequencies by setting the frequency of the crystal oscillator to the midpoint of its tuneable range and by simply stepping through the PLL settings. Thus, in the GSM case, no stepping of
5 the frequency of the crystal oscillator is required during the search procedure. Typically, the time taken to search all channels for the presence of a GSM cell is a few seconds.

Mobile phone industry standards (05.05 for GSM and 24.104 for WCDMA) define that the network clock of the GSM network must be within 0.1 ppm of that of the
10 WCDMA network. The Doppler effect can add a maximum of 0.46 ppm to the difference in observed clock frequencies between the two systems; this situation would occur when the handset is moving at high speed away from the GSM base station and, simultaneously, towards the WCDMA one (or vice versa). Internal handset errors can add a further 0.1 ppm.

15 We have appreciated that the frequency of the crystal oscillator determined for use with the GSM system can be guaranteed to be within 0.66 ppm of that required by the WCDMA system. Additionally, we have appreciated that this potential error is within the equaliser acceptance window of the WCDMA system and that this can be used to reduce the time taken to locate the WCDMA network
20 and base station.

Embodiments of the present invention reduce the time taken to search for a WCDMA network by executing a search for a GSM network on power up to obtain a reference value for the GSM network clock in preference to executing a full WCDMA search. Such embodiments take advantage of the wide acceptance
25 window of the GSM equalizer to produce a rapid GSM cell search and synchronization of crystal oscillator. Once the GSM cell is identified, the crystal oscillator is synchronized with the GSM network clock. Embodiments of the invention do not communicate with the GSM network (i.e. do not transmit any signals back to the network) but merely conduct a network search to determine
30 the frequency of the GSM network clock frequency. This frequency can be determined by scanning the network until a signal is detected and then monitoring the signal in order to determine the network clock frequency. This clock frequency is then used as an initial guess of the WCDMA

network frequency when conducting the WCDMA channel search. Since the maximum 0.66 ppm error is within the ± 2 ppm acceptance window for the WCDMA equalizer, by scanning the WCDMA channels at the frequency of the GSM network clock the handset can be sure to identify any available WCDMA channel in a single PLL search. Therefore, embodiments of the invention reduce the time taken to find a WCDMA base station since they scan all potential WCDMA channels without requiring the frequency of the VCXO to be stepped.

The present invention is defined in its various aspects in the appended claims, to which reference should now be made.

10 An embodiment of the present invention will now be described in detail by way of example with reference to the accompanying drawings in which:

Figure 1 is a flow diagram showing the steps taken to search for a network in the case when the device has no data on the correct setting for the crystal oscillator.

15 Figure 2 is a flow diagram showing the steps taken to search for a network in the case when the device has data on the correct setting for the crystal oscillator.

Figure 3 is a block diagram showing an embodiment of the present invention including a single oscillator used for two Radio Access Technologies.

Figure 4 is a block diagram showing an embodiment of the present invention in which each Radio Access Technology has a separate crystal oscillator.

20 Figure 1 is a flow diagram showing the steps taken by an embodiment of the invention in the case where the device has no data on the correct setting for the crystal oscillator of the mobile handset. This situation will arise on power up or when the device has been positioned in an area in which no service is available from any network.

25 In the first action at 110 the handset sets its crystal oscillator to the midpoint frequency of its tuneable range. The correlation between the ± 10 ppm acceptance window of the GSM equalizer and the ± 10 ppm tuneable frequency of the crystal oscillator provides that if the crystal oscillator is set to its midpoint frequency then it is guaranteed to be within 10 ppm of the GSM network clock.

Once the crystal oscillator is set, the handset executes a search for all GSM cells at 120 by stepping through the PLL settings and scanning all channels until it detects a signal from a GSM cell. Since the device is only receiving signals and is not attempting to communicate with the network it can use a signal received
5 from any GSM network in order to derive the GSM network clock frequency. A full PLL search (also called a band scan) typically takes around four seconds.

As soon as a signal from a GSM cell is received, the handset monitors that signal (regardless of GSM network) for a period of time long enough to establish the frequency of the GSM network clock at 130. The handset does not attempt two
10 way communications with the network but merely monitors the signals to determine the network clock frequency. At 140 the handset software synchronises the frequency of the crystal oscillator with the network clock. Typically, handsets take around 4 seconds to scan all GSM channels. However, this is the worst case. If a GSM service is present at all, then there will generally
15 be a number of cells receivable at any given location. Since the device is looking for any GSM network, a suitable cell can normally be found in, at most, 0.5 seconds. It takes a further 0.5 seconds to monitor the network and synchronise the crystal oscillator to the network clock.

As discussed above, 3GG industry standards require that the GSM network clock
20 is within 0.1 ppm of the WCDMA network clock. Additionally, the effects of Doppler and internal handset errors can add around a further 0.56 ppm possible error. Therefore, the crystal oscillator, synchronized for use with the GSM system, is guaranteed to be within about 0.66 ppm of that of the WCDMA system. Since this potential error of about 0.66 ppm is within the ± 2 ppm acceptance
25 window of the WCDMA equalizer, the handset is able to use the frequency of the GSM clock to search the WCDMA channels for a WCDMA cell.

In a dual mode handset the same crystal oscillator is used as the reference oscillator for both RATs. Since the crystal oscillator is already synchronized to the GSM network clock, the voltage applied to the crystal oscillator is not
30 changed when searching for the WCDMA network. The handset then accesses the circuitry associated with the WCDMA system and the WCDMA PLLs are stepped through all channels at 150 to locate a WCDMA cell.

If a WCDMA cell is found, the device commences communication with the WCDMA cell at 160. The handset then synchronises its crystal oscillator with the received frequency of the WCDMA network clock at 170.

- 5 If a WCDMA cell is not found during the search, the device can be sure that no WCDMA cells are available and will not have to search at other crystal oscillator frequencies in order to confirm that all possible WCDMA cells are searched.

The example of Figure 1 describes the operation of an embodiment of the invention when no data regarding the oscillation frequency of the network clock is available. Embodiments of the invention provide additional power saving and accelerated network searching in the situation when the crystal oscillator is
10 already synchronized to the GSM network, for example when the device has been camped on the GSM network. An example of the steps executed in such an embodiment is shown in Figure 2 (these steps correspond to steps 140-170 of Figure 1).

- 15 At 210 the handset is camped on to the GSM network. At this stage the crystal oscillator is synchronized with the GSM network clock and so (as discussed above) the frequency of the crystal oscillator is sufficiently accurate to use as a reference frequency to search the WCDMA networks and cells. At 220 the handset steps through the WCDMA PLL settings in search of a WCDMA cell,
20 using the frequency of the crystal oscillator.

At 230 the handset identifies a WCDMA cell and monitors the cell. At 240 the handset synchronises the crystal oscillator with the WCDMA network clock.

- Before executing the WCDMA channel search, embodiments of the invention may also run a rapid search procedure based on the last known cell. In this case
25 the PLL is set to the value of that associated with the last known cell and the frequency of the crystal oscillator is stepped through its full tuneable range from: midpoint, +4 ppm, -4 ppm, +8 ppm, -8 ppm. Such embodiments identify quickly if the last known cell is still available for communication. If so, then such embodiments do not need to execute a WCDMA channel and frequency search.

The embodiments of Figures 1 and 2 relate to handsets including a single crystal oscillator which is used as a reference frequency for communicating with both GSM and WCDMA technologies. However, the invention can also be implemented in embodiments including a separate crystal oscillator for each technology. Our co-pending British Application No. GB 0208486.1 describes a mobile communication device having an independent crystal oscillator for each RAT. The circuitry for driving each crystal oscillators is linked and programmed to interpret the frequency difference between the crystal oscillators in terms of the voltages applied to the crystal oscillator and constants. The device records the frequency difference between the network clocks and when swapping between RATs the device calculates the voltage that should be applied to the crystal oscillator based on the voltage currently applied to the other crystal oscillator, the known constants and the known difference in frequencies between the RATS. In this way the device is able to achieve the same oscillation offset that existed prior to handover.

In embodiments of the present invention which include separate crystal oscillators for different RATs, before executing a WCDMA search, the device executes a GSM search and synchronises its crystal oscillator with the signals received from any GSM network. The device then supplies a voltage to the crystal oscillator of the WCDMA system which will produce a frequency equal to that of the GSM crystal oscillator. Once the WCDMA crystal oscillator is driven at the same frequency as the GSM crystal oscillator, the handset commences stepping the PLL through its full range to search all channels in the same way as in the embodiments of Figures 1 and 2.

Figure 3 is a block diagram showing the basic circuitry of an embodiment of the present invention in which a mobile communication device includes a single crystal oscillator as a reference oscillator for more than one RAT. This is equivalent to the embodiment of Figure 1. Mobile communication device 300 includes an aerial 310 for receiving and transmitting signals during communication. The frequency analyzer 320 measures the frequency of the network clock as received during communication and determines the voltage that should be supplied to the crystal oscillator 330 in order to synchronise the crystal oscillator with the network clock. The crystal oscillator is connected to the PLL

340 and RF circuitry 350 of RAT 1 and the PLL 340' and RF circuitry 350' at RAT 2. Typically, all connections are maintained to the crystal oscillator and the clock signal is distributed to all parts of the device. If the parts are turned on then they use the clock, otherwise they do not use it.

- 5 Figure 4 is a block diagram showing the basic circuitry of an embodiment of the present invention in which a mobile communication device includes independent crystal oscillators for each RAT. In this case the crystal oscillators 430 and 430' for the first and second RATs are linked by circuitry 460. The circuitry is also connected to the frequency analyzer in order that it can supply the correct voltage
10 to the search RAT on a handover to match the frequency of the primary RAT.

Embodiments of the present invention exploit the dual or multimode nature of handset when the device does not have a value for the network clock and accelerate the search time for a WCDMA cell by reducing the required number of search operations. Consequently embodiments of the invention provide a power
15 saving.

Embodiments of the invention typically eliminate eight steps of the WCDMA search procedure by removing the need for the voltage to the crystal oscillator to be stepped during the WCDMA cell search and for a new search executed at different frequencies of the crystal oscillator. By appreciating that the maximum
20 measurable difference in frequency of the network clocks of the GSM and WCDMA technologies is within the acceptance level of a WCDMA equalizer, embodiments of the invention use the frequency of the GSM crystal oscillator when searching for a WCDMA cell. On power up, a rapid GSM network search is executed for the sole purpose of obtaining a reference value of the frequency of
25 the GSM network clock. Since the device is not communicating with the GSM network, it is able to use signals received from any network. The basic WCDMA channel search procedure in which the PLL is stepped through its range is executed only once (at the reference frequency derived from the GSM network clock) rather than multiple times at different frequencies as required by prior art
30 systems. Thus, a device is able to search all potentially available WCDMA channels by executing a rapid network search followed by a single WCDMA channel search.

It will be clear to those skilled in the art that embodiments of the present invention offer maximum power and time saving when the handset is searching for a WCDMA cell in an area without WCDMA coverage. In this case, eight steps are
5 eliminated from the search procedure which may save up to 150 seconds. In areas of WCDMA coverage, prior art handsets will, on average, have found a cell before the final step of the search procedure. However, the fact that embodiments of the present invention can guarantee to identify any WCDMA cell which is present in a single search enables them to provide a saving of power
10 and time over prior art systems in almost all cases.

In the worst case, if the handset is operating in an area without GSM coverage, and so the initial GSM search finds no networks, the device has only wasted around four seconds which is very small compared with the potential time saving provided by embodiments of the invention.

15 The preferred embodiments of the invention discussed above relate to dual mode GSM and WCDMA handsets. However, it will be appreciated that the invention is applicable to other combinations of radio access technologies. The important factors that are utilized are that a first RAT has an equaliser acceptance window much wider than that of a second RAT and that the measured frequency of the
20 network clock of a first RAT is always close enough to the frequency of the network clock of the second RAT to fall within the acceptance window of the equalizer. Therefore, by executing a network search of the first network and by using the frequency of the first network clock as an initial reference frequency for a channel search on the secondary network, the network searching time is
25 reduced since only a single channel search on the secondary network needs to be conducted.

Claims

1. A method for searching for a network operating with a first radio access technology (RAT) with a mobile communication device supporting the first RAT and a second RAT comprising the steps of:
 - 5 scanning at least one network operating with the second RAT;
detecting a signal from the at least one network operating with the second RAT, the signal providing data relating to a timebase of the second RAT;
deriving the timebase of the second RAT from the detected signal;
synchronising a crystal oscillator with the timebase derived from the
10 detected signal; and
scanning at least one network operating with a first RAT using the timebase derived from the detected signal.
2. A method for searching for a network operating with a first radio access technology (RAT) with a mobile communication device supporting the first RAT
15 and a second RAT according to claim 1 wherein the first RAT is a third generation radio access technology and the second RAT is a second generation radio access technology.
3. A method for searching for a network operating with a first radio access technology (RAT) with a mobile communication device supporting the first RAT
20 and a second RAT according to claim 1 or 2 comprising the further step of detecting a signal from the at least one network operating with the first RAT, the signal providing data relating to the timebase of the first RAT.
4. A method for searching for a network operating with a first radio access technology (RAT) with a mobile communication device supporting the first RAT
25 and a second RAT according to claim 1, 2 or 3 wherein the signals are only detected if the synchronization of the crystal oscillator with the timebase of the corresponding RAT is within a predetermined value.
5. A method for searching for a network operating with a first radio access technology (RAT) with a mobile communication device supporting the first RAT
30 and a second RAT according to claim 4 wherein the predetermined value

associated with the second RAT is greater than that associated with the first RAT.

6. A method for searching for a network operating with a first radio access technology (RAT) with a mobile communication device supporting the first RAT
5 and a second RAT according to claim 1, 2, 3, 4 or 5 wherein the frequency of the crystal oscillator is tuneable over a predefined range and the step of scanning at least one network operating with the second RAT is performed at the midpoint of the tuneable range.

7. A method for searching for a network operating with a first radio access
10 technology (RAT) with a mobile communication device supporting the first RAT and a second RAT according to claim 1, 2, 3, 4, 5 or 6 wherein the first RAT is WCDMA.

8. A method for searching for a network operating with a first radio access
15 technology (RAT) with a mobile communication device supporting the first RAT and a second RAT according to claim 1, 2, 3, 4, 5, 6 or 7 wherein the second RAT is GSM.

9. A method for searching for a network operating with a first radio access
20 technology (RAT) with a mobile communication device supporting the first RAT and a second RAT according to claim 1, 2, 3, 4, 5, 6, 7 or 8 comprising the further step of synchronizing a further crystal oscillator with the crystal oscillator, the further crystal oscillator being associated with the first RAT.

10. A method for searching for a network operating with a first radio access
25 technology (RAT) with a mobile communication device supporting the first RAT and a second RAT substantially as herein described with reference to the accompanying figures.

11. An apparatus for searching for a network operating with a first radio
access technology (RAT) with a mobile communication device supporting the first
RAT and a second RAT comprising:

30 means for scanning at least one network operating with the second RAT;
means for detecting a signal from the at least one network operating with

- the second RAT, the signal providing data relating to a timebase of the second RAT;
- means for deriving the timebase of the second RAT from the detected signal;
- 5 means for synchronising a crystal oscillator with the timebase derived from the detected signal; and
- means for scanning at least one network operating with a first RAT using the timebase derived from the detected signal.
12. An apparatus for searching for a network operating with a first radio
10 access technology (RAT) with a mobile communication device supporting the first RAT and a second RAT according to claim 11 wherein the first RAT is a third generation radio access technology and the second RAT is a second generation radio access technology.
13. An apparatus for searching for a network operating with a first radio
15 access technology (RAT) with a mobile communication device supporting the first RAT and a second RAT according to claim 11 or 12 further comprising means for detecting a signal from the at least one signal network operating with the first RAT, the signal providing data relating to the timebase of the first RAT.
14. An apparatus for searching for a network operating with a first radio
20 access technology (RAT) with a mobile communication device supporting the first RAT and a second RAT according to claim 11, 12 or 13 wherein the signals are only detected if the synchronization of the crystal oscillator with the timebase of the corresponding RAT is within a predetermined value.
15. An apparatus for searching for a network operating with a first radio
25 access technology (RAT) with a mobile communication device supporting the first RAT and a second RAT according to claim 14 wherein the predetermined value associated with the second RAT is greater than that associated with the first RAT.
16. An apparatus for searching for a network operating with a first radio
30 access technology (RAT) with a mobile communication device supporting the first RAT and a second RAT according to claim 11, 12, 13, 14 or 15 wherein the

frequency of the crystal oscillator is tuneable over a predefined range and the step of scanning at least one network operating with the second RAT is performed at the midpoint of the tuneable range.

- 5 17. An apparatus for searching for a network operating with a first radio access technology (RAT) with a mobile communication device supporting the first RAT and a second RAT according to claim 11, 12, 13, 14, 15 or 16 wherein the first RAT is WCDMA.
- 10 18. An apparatus for searching for a network operating with a first radio access technology (RAT) with a mobile communication device supporting the first RAT and a second RAT according to claim 11, 12, 13, 14, 15, 16 or 17 wherein the second RAT is GSM.
- 15 19. An apparatus for searching for a network operating with a first radio access technology (RAT) with a mobile communication device supporting the first RAT and a second RAT according to claim 11, 12, 13, 14, 15, 16, 17 or 18 further comprising a further crystal oscillator, the further crystal oscillator being associated with the first RAT and being synchronized with the crystal oscillator.
- 20 20. An apparatus for searching for a network operating with a first radio access technology (RAT) with a mobile communication device supporting the first RAT and a second RAT substantially as herein described with reference to the accompanying figures.



INVESTOR IN PEOPLE

Application No: GB0507716.9

Examiner: Dan Hickery

Claims searched: 1 to 20

Date of search: 15 September 2005

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
A	-	WO 2004/095870 A1 (NEC) whole document
A	-	WO 2004/054286 A2 (QUALCOMM) abstract, par.1012, 1046-1050, 1057-1058
A	-	GB 2393611 A (QUALCOMM)
A	-	GB 2387509 A (NEC)
A	-	WO 2004/102926 A2 (MOTOROLA)

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^X :

H4L

Worldwide search of patent documents classified in the following areas of the IPC⁰⁷

H04B; H04Q

The following online and other databases have been used in the preparation of this search report

Online: EPODOC, WPI