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Enhanced power saving method for handheld communication system and the handheld communication system thereof

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The present invention relates generally to a battery powered handheld communication system, such as a cordless phone system and a mobile phone system, and in particular to an enhanced power saving method for operating the battery powered communication system in an enhanced power saving standby mode in which the receiver
5 of the communication system changes the scan rate as a function of the standby time and enters a sleep mode if no incoming signal is received or no outgoing signal is transmitted in order to save the power consumed by the receiver.

The invention is also directed to an enhanced power saving cordless communication system which comprises a controller to change the scan rate of the
10 receiver as a function of the standby time in order to save the power consumed in the standby duration.

Prolonging the standby time of a battery powered cordless communication
15 system, especially a handheld cordless communication system, is a challenge to the communication industry. A handheld cordless communication system comprises in general a receiver for incoming signals and a transmitter for outgoing signals. For a conventional handheld cordless communication system, its operation is divided as a talk mode TM in which both the receiver and the transmitter are active and a standby mode
20 in which the transmitter is inactive with the power supplied thereto completely cut off and the receiver remains active to scan incoming signals from the surrounding air.

For a conventional cordless phone system, the power consumptions of the transmitter and the receiver thereof are respectively illustrated in Figs. 1 and 2 of the attached drawings. As illustrated in Fig. 1, the transmitter consumes no power at all
25 under the standby mode. However, as shown in Fig. 2, the receiver takes the same amount of power under both the talk mode and the standby mode to maintain itself active. As a result, the overall system power consumption of the conventional handheld cordless communication system is generally the sum of those of Figs. 1 and 2 and is as



illustrated in Fig. 3.

An interpretation of Figs. 1, 2 and 3 indicates that in the talk mode, both the transmitter and the receiver consume power, while in the standby mode, only the receiver takes power to maintain active. Since the receiver has to be maintained active, power supplied thereto cannot be cut off. Such a system requires quite a power consumption to maintain the receiver active all the time. Since the incoming signals are coming in a random fashion, maintaining the receiver active is quite a loss in the point of view of power-saving.

Another type of the handheld cordless communication system uses software algorithm to control the power supply. In a communication system of this kind, the power supply to the transmitter is the same as previously discussed, namely only in the talk mode. However, the power supply to the receiver is made intermittent, as shown in Fig. 4.

In such a kind of communication system illustrated in Fig. 4, the standby mode comprises a scanning mode when the receiver is active to scan incoming signals and a sleep mode when the receiver is deactivated and the power supplied thereto is completely cut off. In the scanning mode, the receiver is powered to scan incoming signals from the surrounding air within a predetermined period and once no incoming signal is detected in this pre-determined period, the power is shut down and the receiver enters the sleep mode. The receiver will sleep for a given fixed sleeping period and then activated to enter the scanning mode again. This procedure will be continuously repeated unless a call is made. Apparently, the power is completely cut off to both the receiver and the transmitter under the sleep mode. Normally, the scanning period, namely the pre-determined period within which the receiver is activated to scan incoming signals, is approximately $1/5$ or $1/10$ of the sleeping period of the sleep mode which as can be understood is the time interval between two successive scan modes.

In the above-mentioned conventional power saving communication system, the scan rate, which is used herein to denote the number of the scan modes occurring in a given length of time in the standby mode, is fixed. This kind of system does provide a significant reduction in the overall power consumption, which is illustrated in Fig. 5.

The conventional power saving communication system, although effective in cutting down power consumption, still wastes a great amount of power in the standby mode, especially in night time during which the communication system is generally not



used for a very long while.

Due to the development of the even smaller and lighter battery powered handheld communication system, the power consumption will be subject to a more severe restriction. Thus, a more effective algorithm is desired to handle the more severe requirement of power consumption for the battery powered handheld cordless communication systems.

In the current cordless phone market, one of the most advanced systems is the so-called multiple channel access (MCA) auto-scan cordless phone which comprises a base powered by an external power source and a battery powered handset with a multiplicity of electromagnetic link channels connecting between these two parts. The MCA auto-scan cordless phone, as implied by the name, scans all of the multiple link channels to seek and establish the best communication between the base and the handset.

To meet the requirement of the end users, the MCA auto-scan cordless phone system has to provide a fast but power saving link between the base and the handset to meet the PTT regulation and to prolong the overall operation time that the battery set of the handset can provide. To be fast, a high data rate of communication should be established between the base and the handset and, as known to the art, the PTT regulation should be followed regarding the data rate. The requirement of high data rate can be resolved by using high speed modulating/demodulating techniques, such as 1200 or 2400 bps (baud per second) modem chips. An example of the known circuit which adopts the high speed modulating/demodulating technique is illustrated in Fig. 6 which is proposed by SONY company. The circuit in Fig. 6 comprises a modulating/demodulating means with the speed of 1200 bps to process the signals communicated between the base and the handset, an MSK modem. The signals after modulation/demodulation are transmitted by a transmitter 63 via an audio control means 62. In standby mode, the receiver 64 scans the signals of the multiple channels with a fixed scanning rate. Further shown are a duplexer 65, a synthesizer 66, and an antenna 67, voice V_o and data D_a signals being present.

Although the high speed modulating/demodulating technique provides a high data rate, the power saving problem is still not overcome. The power saving problem is very severe for the MCA auto-scan cordless phone, for (1) it is powered by a limited battery power source and (2) it takes a great amount of power to scan all the channels continuously. The conventional power saving algorithm as discussed



hereinbefore has been widely used to resolve the power saving problem so as to prolong the overall standby time provided by a battery set. As discussed previously, such a conventional power saving algorithm is not very effective and thus it is desirable to have a more effective power saving method to further prolong the standby time that a
5 battery set can provide.

It is therefore an object of the present invention to provide a power saving method for a battery powered communication system, which method greatly cuts down
10 the power consumption of the receiver of the battery powered communication system during the standby mode by changing the incoming signal scan rate as a function of the standby time history.

In accordance with a first aspect of the present invention, a power saving method for a cordless communication system, especially a battery powered cordless
15 phone, is provided. According to the proposed power saving method, the scan rate is no longer fixed and changes as a function of the standby time. This provides a more efficient utilization of the battery power, especially during the time when the phone is used less frequently, for example in the night time. The scan rate is gradually lowered down step by step with the standby time when the phone is not operated for a long
20 while and the system will be restored to the original scan rate once a call is coming in or an outgoing call is attempted. As compared with the conventional fixed scan rate method, the present method does provide a better way in saving the battery power.

It is also an object of the present invention to provide an enhanced power saving architecture for an MCA auto-scan cordless phone system which by adopting the
25 power saving algorithm of the present invention greatly cuts down the power consumption in scanning the incoming signals through all the channels.

It is another object of the present invention to provide a power saving architecture for an MCA autoscan cordless phone, comprising a decoder circuit which allows the central processing unit (CPU) of the phone to "sleep" until a special
30 identification code carried by the incoming signal is matched so as to reduce power consumption.

According to another aspect of the present invention, an MCA auto-scan cordless phone architecture is provided. The MCA auto-scan cordless phone architecture



comprises a decoder operating in a principle similar to the decoder of a pager system. The basic composition of the pager system is as shown in Fig. 7. The pager system comprises a decoder 72 to determine if the signal received by a receiver 71 of the pager is the one to be received by the pager by checking if the detected signal carries an
5 address matching that pre-set in the pager decoder. Once the received signal matches the address of the pager system, the pager will enable a micro-controller 73 to activate a beep or a display 75 according to the data pre-stored in a user interface 74 to inform the user of the incoming signal. Similar principle is adopted in the MCA auto-scan cordless phone architecture provided by the instant invention that the decoder of the
10 cordless phone checks the address or identification code of other kinds carried by a signal detected by the receiver of the phone. Once the address or identification code is accepted, the decoder "wakes up" the sleeping CPU to proceed signal receiving.

According to a further object of the present invention, the MCA auto-scan cordless phone has a receiver to scan and receive signals from the surrounding air
15 operated by a scanning procedure programmed in accordance with the enhanced power saving algorithm of the present invention.

Other objects and advantages of the invention will be apparent from the
20 following description of a preferred embodiment taken in connection with the accompanying drawings, wherein:

Fig. 1 is a plot of the supplied power needed in operation by a transmitter of a general cordless communication system;

Fig. 2 is a plot of the supplied power needed in operation by a receiver of
25 a general cordless communication system;

Fig. 3 is a plot showing the total power consumption of both the transmitter and receiver shown in Figs. 1 and 2;

Fig. 4 is a plot of the supplied power needed in operation by a receiver of a conventional power saving communication system;

Fig. 5 is a plot showing the total power consumption of both the
30 transmitter and receiver of the conventional power saving communication system ;

Fig. 6 is a block diagram of a conventional multiple channel access (MCA) auto-scan cordless phone system;



Fig. 7 is a block diagram of a pager system;

Fig. 8 is a plot of the supplied power needed in operation by a receiver of an enhanced power saving communication system in accordance with the present invention;

5 Fig. 9 is a plot showing the total power consumption of both the transmitter and the receiver of the enhanced power saving communication system in accordance with the instant invention;

Fig. 10 is a block diagram of a preferred embodiment of the enhanced power saving communication system in accordance with the present invention;

10 Fig. 11 is a block diagram of the cordless decoder of Fig. 10;

Fig. 12 is a block diagram of the power saving circuit of Fig. 11; and

Fig. 13 is a flow chart illustrating the operation of the power saving circuit.

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An enhanced power saving communication system constructed in accordance with the present invention comprises a receiver to receive incoming signals and a transmitter to send out outgoing signals with a cordless electromagnetic link therebetween to exchange link data with each other. The operation of the

20 communication system is divided into TALK MODE TM in which both the transmitter and the receiver are active to enable the receipt and transmission of signals and data and STANDBY MODE SBM in which the transmitter is deactivated to save power consumption and the receiver is repeatedly activated and deactivated in an intermittent fashion. The STANDBY MODE period is thus further divided into SCANNING MODE
25 in which the receiver is active for scanning the incoming signals for a given scanning period and SLEEP MODE in which the receiver is deactivated to reduce power consumption.

With reference to the drawings and in particular to Fig. 8, wherein a power supplying curve of the enhanced power saving cordless communication system
30 constructed in accordance with the present invention and operated in accordance with the power saving method of the present invention is illustrated, it is observed that the scan rate of the receiver being activated to scan the incoming signals per unit time is changing in accordance with the standby time history. Namely, the scan rate is no



longer fixed as the conventional cordless phone systems and is now a function of the standby time.

The purpose of changing the scan rate in accordance with the standby time is to cut down the scan rate when the communication system is used less frequently, for example in night time, and to increase the scan rate when the communication system is used more frequently, for example in day time.

An example of changing the scan rate with the standby time is illustrated in Fig. 8 wherein the standby time is divided into different time zones by, for example, two hours, the first one being 0-2 hour, the second one 2-4 hour, the third one 4-6 and so on. In each of the time zones, a different delay level in scanning operation is set, for example, in the 0-2 time zone, the scanning is carried out every two seconds with a 400 ms scanning period. In the next (2-4) time zone, scanning is conducted at every 5 seconds with the same scanning period. The scanning is carried out at every 10 seconds for the third (4-6) time zone. Once an incoming call is picked up or an outgoing signal is attempted, the whole system will be reset to interrupt the above procedure and re-start the delay procedure from the first time zone.

The power consumption obtained in accordance with the above delay mode is plotted in Fig. 9. By comparing the plot of Fig. 9 with those of Figs. 3 and 4, it is observed that not only is the power consumption intermittent, but the average time interval (delay time) between two successive scanning periods is also increased. This indicates a further reduction in overall power consumption.

As mentioned hereinbefore, an application of the enhance power saving method of the instant invention is to embody in an MCA auto-scan cordless phone. This is illustrated by an embodiment shown in Fig. 10. The phone system shown in Fig. 10 comprises a receiver 10, an audio and control device 11, a transmitter 12, a synthesizer 13, and a multiplexer or duplexer 14. To increase the data rate between the base and the handset (both not shown) of the phone system and to reduce power consumption, a cordless decoder 15 is connected between the receiver and the audio and control device 11. The cordless decoder 15 is operated in accordance with a principle similar to that of a well-known pager system for checking if the address or identification code carried by a detected incoming signal match a built-in address or identification code within the system. Only when the incoming and the built-in addresses match, is the incoming



signal sent to the audio and control device 11 and then applied to the transmitter after being processed.

The circuit of the cordless decoder 15 is shown in Fig. 11, which comprises an MSK receiver 151 operated in accordance with the minimum shift keying (MSK) principle, a system address memory 152, an address checker 153, a synthesizer controller 154, a CPU interface 155, and a power saving circuit 156. When the signal coming to the system is received by the MSK receiver 151, the address carried by the signal is compared to the system address built in the memory 152 by the address checker 153. Once the two addresses match, the CPU interface 155 will be woken up to receive the incoming signals, data or commands. The synthesizer controller 154 is to program the synthesizer 13 shown in Fig. 10 to different frequencies associated with different channels of the MCA auto-scan cordless phone system in order to receive and/or check the signals in all the channels of the system.

Although the cordless decoder 15 of the present invention is operated with a principle similar to that of the known pager systems, it is understood that they are different in that:

- (1) the pager is an one-way communication device while the cordless phone is a bi-directional communication equipment;
- (2) the pager decoder only needs to detect one fixed frequency and thus no synthesizer controller is required, while the MCA auto-scan cordless phone has to scan a number of frequency channels and thus needs a synthesizer controller; and
- (3) The power consumption of the MCA auto-scan cordless phone is much greater than pager system for the pager has a fixed frequency and the MCA auto-scan cordless phone has to scan a number of frequency channels and thus the power saving feature is extremely important in the MCA auto-scan cordless phone system. As a consequence, the pager system may not need to enter SLEEP MODE, namely both the receiver and the transmitter are off, while in the cordless phone, power saving algorithm is widely adopted.

Due to these differences between the pager decoder and the cordless decoder used in the instant invention, they are substantially different in the operation.

The power saving circuit, which is denoted by reference numeral 156 in Fig. 11, is a major feature of the present invention and will be described with reference to Figs. 12 and 13 of the drawings. The power saving circuit 156 controls the operation



of the CPU interface 155 to have the CPU follow the delay mode of scanning incoming signals as described herein. In other words, the CPU of the system will be intermittently deactivated during the STANDBY MODE to save power and the length of the deactivated time of the CPU will change in accordance with the standby time of the
5 system.

An example of the power saving circuit 156 is illustrated in a block diagram form in Fig. 12, in which the CPU interface 155 and a message scanner 101 of the receiver 10 are also shown for illustrating the relationship therebetween. The power saving circuit 156 may comprise an accumulator 1561, a standby history recorder 1562
10 and a sleep time controller 1563. Preferably, the accumulator 1561 is an up counter to count the number that the receiver 10 carries out signal scanning in a period. The delay sequence is recorded in the standby history recorder 1562. The delay time and the associated scan rate are pre-built in the standby history recorder 1562. Once the count in the accumulator 1561 reaches the upper limit of a delay level, the standby history
15 recorder 1562 will be triggered to enter the next delay level. Further shown is a reset-OR-gate 121, supplying a reset signal Res, on outgoing call OCA and incoming call ICA.

The sleep time controller 1563 is to set the sleep mode SLM of the system. The procedure of setting the sleep mode will be described with reference to the
20 flow chart shown in Fig. 13. However, it should be understood that the flow chart of Fig. 13 is only an example and by no means to limit the scope of the present invention.

As shown in Fig. 13, the system starts with an initialization step 131 and then setting the sleep mode to the first delay level thereof with the sleep time controller 1563 at step 132 and entering the sleep mode at step 133. Thereafter at a suitable time
25 in accordance with the setting of the sleep mode, the message scanner 101 of the receiver 10 is activated to enter the scanning mode, carrying out message scanning at step 134 to determine if a call is coming in at step 135. If yes, set the sleep mode to the first level again at step 1320 and the procedure jumps off to a being-all-subroutine at 1321 to pick up the incoming call. Thereafter go back to step 133 to enter the first level
30 sleep mode again.

If there is no incoming call is found at step 135, then read the standby history from the standby history recorder 1562 at step 136 and increase the count of the accumulator 1561 by one and then updating the standby history recorder at step 137.



The first delay level is continuously maintained until the first time zone which is associated with the first delay level and which is assumed to be 0-2 hour in the illustrated embodiment is ended or an outgoing call is made. This is checked at step 138. If the standby time does not exceed the limit of the first time zone, namely 2 hours from the beginning of the standby mode, the procedure will return to step 134 to conduct another message scanning after a suitable elapse of time determined by the delay time set by the first delay level via a checking of outgoing call at step 142.

At step 142, if no outgoing call is detected, the routing is directed back to step 134, otherwise it sets the sleep mode to the first level again at step 1322 and the procedure jumps off to a calling-subroutine at step 143 to make the outgoing call. Thereafter go back to step 133 to enter the first level sleep mode again.

If it is checked at step 138 that the first time zone is exceeded, then at step 139 the system enters the second level of the sleep mode associated with the second time zone which in the illustrated example begins from the end of the second hour of the standby mode to the end of the fourth hour of the standby mode. Step 140 provides a checking of the exceeding of the second time zone. This step is similar to step 138 associated with the first delay level and branches to either a checking of outgoing call at step 142 if the second time zone is not exceeded or a step of entering the third delay level of the sleep mode (step 141) if the second time zone is exceeded.

Step 141 is the step when the system enters the third delay level associated with the third time zone which is the time period between the ends of the fourth and the sixth hours of the standby mode in the illustrated embodiment. Step 141 provides a similar checking function as those of steps 138 and 140 associated with the first and the second delay levels.

It is understood that the setting of the time zone and the number of the total time zones may be different from what just described and it is intended to include all kinds of settings of the delay levels and the time zones in the spirit of the present invention.

An experiment with an MCA auto-scan cordless phone will be given as follows to show the unbelievable power saving capability of the present invention:

EXPERIMENT CONDITION:

1. A 10 channel, 46/49 MHz auto-scan cordless phone handset;
2. MSK data transmission scheme at speed of 1200 bps;



3. Scanning time for all 10 channels: 400 ms;
4. Power consumption in TALK MODE: 40 mA;
5. Power consumption in SCANNING MODE: 14 mA;
6. Power consumption in SLEEP MODE: 0.4 mA; and
- 5 7. Battery capacity: 280 mA.hr.

EXPERIMENT RESULTS:

- A. Non-power saving system, as that associated with Figs. 1-3:
 - a. Continuous talk time: 7 hours;
 - b. Continuous standby time: 20 hours; and
 - 10 c. Response delay to ring signal: one second.
- B. Conventional power saving system, as that associated with Figs. 4 and 5:
 - a. Continuous talk time: 7 hours;
 - b. Continuous standby time: 105 hours; and
 - 15 c. Average response delay to ring signal: 1 second.
- C. Enhanced power saving system of the present invention, as that associated with Figs. 8 and 9:
 - a. Continuous talk time: 7 hours;
 - b. Continuous standby time: 298.5 hours;
 - 20 c. Average response delay to ring signal:
 - i. 1 second (< 2 hours standby)
 - ii. 2.5 seconds (2-4 hours standby)
 - iii. 5 seconds (> 4 hours standby).

25 From the above results, it is found that the standby time can be extremely prolonged from the 20 hours of the non-power saving system and the 105 hours of the conventional power saving system to the 298.5 hours of the present invention. The increasing is about 2-3 times of the conventional power saving system.

30 The only drawback is the slightly longer response delay to the first ring of an incoming call in the second and the third time zones. However, the delay is only approximately 3 ring tones (5 seconds) and it occurs only at the first incoming call after a long standby time. Once the first ring is detected, the system is restored to the most quick response mode so that the drawback is very minor to the end users.

It is apparent that although the invention has been described in connection



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with the preferred embodiments, it is contemplated that those skilled in the art may make changes to certain features of the preferred embodiments without departing from the spirit and scope of the invention as defined in the appended claims.



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CLAIMS:

1. A power saving method for a cordless communication system wherein the cordless communication system comprises a receiver to scan and receive signals from a surrounding air, which receiver enters a period of a standby mode when no signal is coming in to be received thereby and which is activated to scan the signals from the surrounding air in accordance with pre-set scan rates and deactivated for a length of preset delay time to reduce power consumption in an alternate fashion within the standby mode period, said power saving method comprising:
 - dividing the standby period into a number of sections to define a corresponding number of successive time zones;
 - 10 establishing a delay level for each of said time zones, each delay level being associated with a delay time period;
 - setting a scan rate for each of said delay levels;
 - continuously allowing the receiver to be activated in accordance with the delay level and the scan rate associated with the time zone where the receiver belongs to
 - 15 establish a standby time history of the receiver;
 - recording the standby time history and comparing the standby time history with the definition of said time zones to determine which time zone the receiver belongs to;
 - updating the standby time history to allow the receiver to enter the time zone next to the zone that the receiver originally belongs to to scan with the scan rate and to sleep for the delay time associated with the next time zone when the original time zone is exceeded; and
 - repeating the comparing and updating procedures until being interrupted by an attempt to make a communication via the cordless communication system.
- 25 2. A method as claimed in Claim 1 wherein the standby period is divided to define at least three time zones of which the first one has a highest scan rate and a least delay time, the second one has a second highest scan rate and a second least delay time and the third one has the lowest scan rate and the greatest delay time.





3. A method as claimed in Claim 2 wherein said receiver is reset to the first time zone when the standby history is interrupted by an attempt to make a communication.

4. In a multiple channel access auto-scan cordless phone system controlled
5 by central processing means, a wireless communication device comprising a decoding device for confirmation of signals received by the phone system comprising:

receiver means for receiving signals from the phone system;

memory for storing therein an identification for each of the multiple channels of the phone system;

10 checker means for comparing a code carried by the signals with the identifications so that when the code matches with one of the identifications, an actuating signal is generated to wake up the central processing means of the phone system to process the received signals;

synthesizer controller which provides each of the multiple channels with a
15 given communication frequency; and

a power saving circuit means which, when the phone system is in a standby mode which defines a number of successive time zones, provides the phone system with a corresponding number of different and time-based scan rates and delay time periods associated with the time zones to allow the phone to intermittently scan
20 signal from a surrounding air in accordance with one of the scan rates and sleep for a period of one of the delay time associated with a particular time zone.

5. A wireless communication device as claimed in Claim 4 wherein said power saving circuit means comprises:

an accumulator for up-counting the number of signal scanning conducted
25 by the phone system;

a standby history recorder which has the scan rates and delay time periods built therein to allow the phone system enter the time zone next to said particular time zone in response to the accumulator so as to change the scan rate and the delay time period in accordance with a counting result provided by the accumulator; and

30 a sleep time controller for controlling the sleeping and scanning of the phone system during the standby mode in accordance with the time zones set in the standby history recorders.

6. A power saving cordless communication system, comprising:





receiver means for scanning an incoming signal which comprising at least an identification portion and an audio portion in a standby period of the system at a scan rate and receiving the incoming signal, said standby period being divided into a number of successive time zones and the receiver means moving from one time zones to
5 a next one with time during the standby period;

decoding means for decoding and identifying the identification portion of the received signal;

audio and control means for processing the audio portion of the received signal and sending out the processed audio portion together with the identification
10 portion; and

transmitter means for transmitting signals;

the improvement comprising:

said decoding means comprising identifying means for checking the identification portion of the received signal with an identification code built in the
15 system; and

power saving means which provides said receiver means with a number of different scan rates respectively associated with the time zones of the standby period so as to allow said receiver means to scan incoming signals with different scan rate in accordance with the one of said time zones which said receiver means is in.



ABSTRACT:

Enhanced power saving method for handheld communication system and the handheld communication system thereof

An enhanced power saving method for operating a battery powered handheld communication system, particularly a cordless phone system, and the communication system constructed in accordance with the power saving method are disclosed. The power saving method comprises an algorithm which divides the standby
5 time of the communication system into a scanning mode and a sleep mode of several different levels to allow the system to enter the scanning mode intermittently. Each level of the sleep mode corresponds to a given length of delay time between two successive scanning periods. The communication system enters different levels of the sleep mode in accordance with the standby time history. The longer the standby time has passed,
10 the longer the sleep time of the level that the system may enter is to cut down the scan rate when the system is not used for a long while.

Fig. 12.

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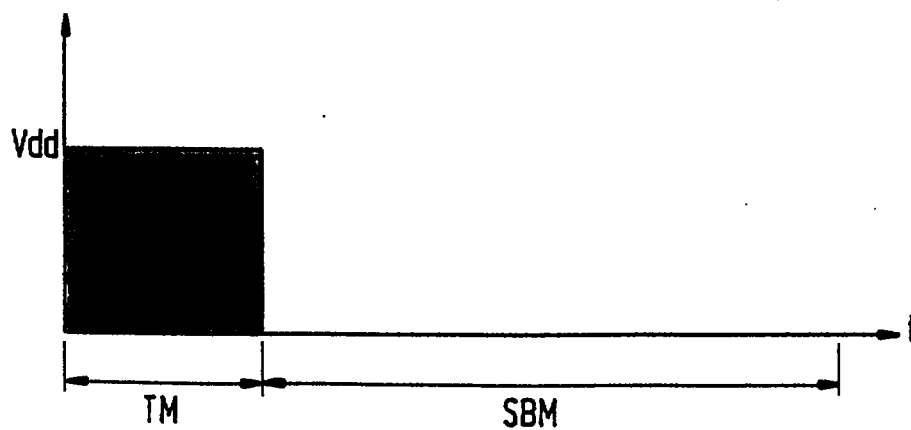


FIG. 1

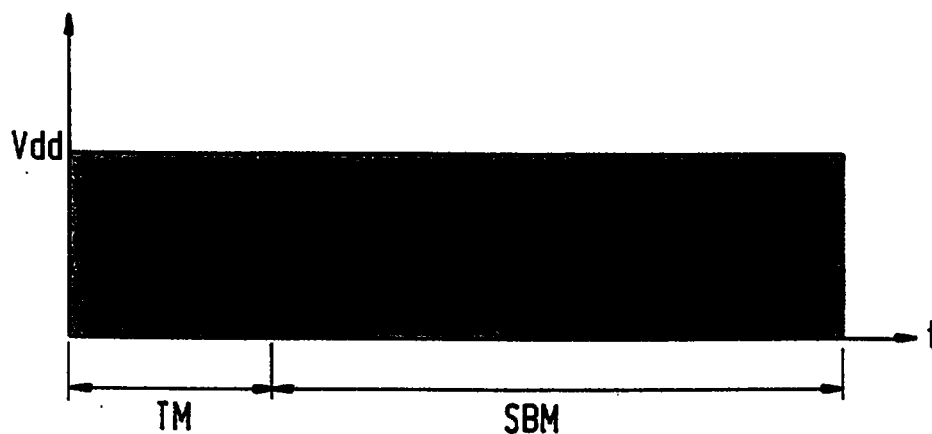


FIG. 2

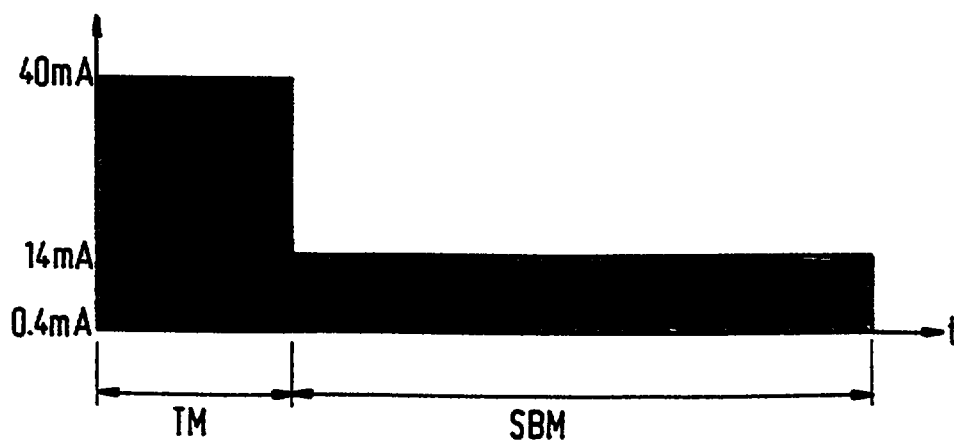


FIG. 3

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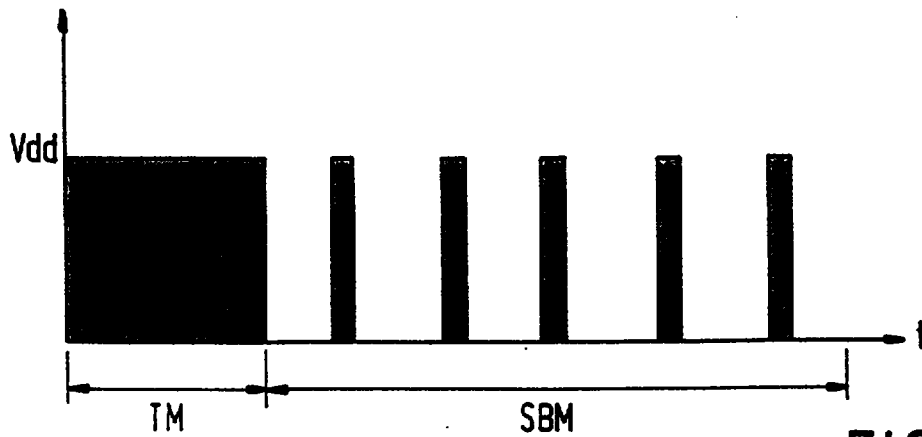


FIG. 4

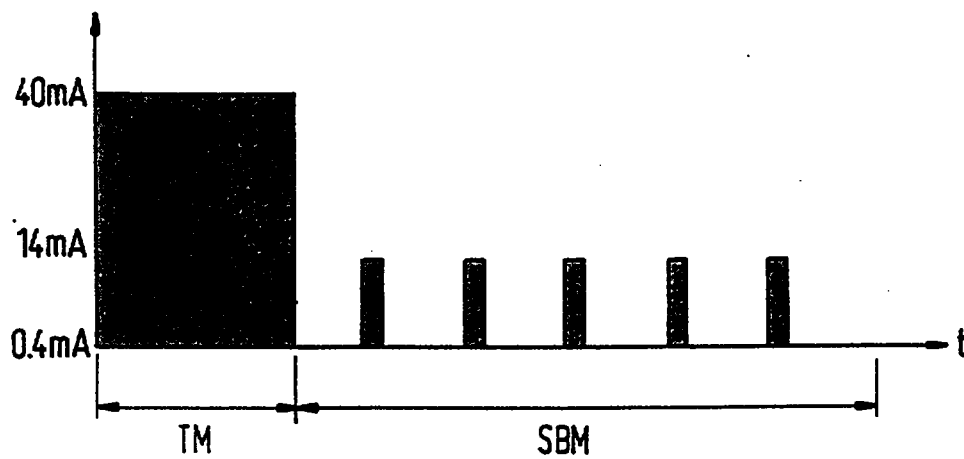


FIG. 5

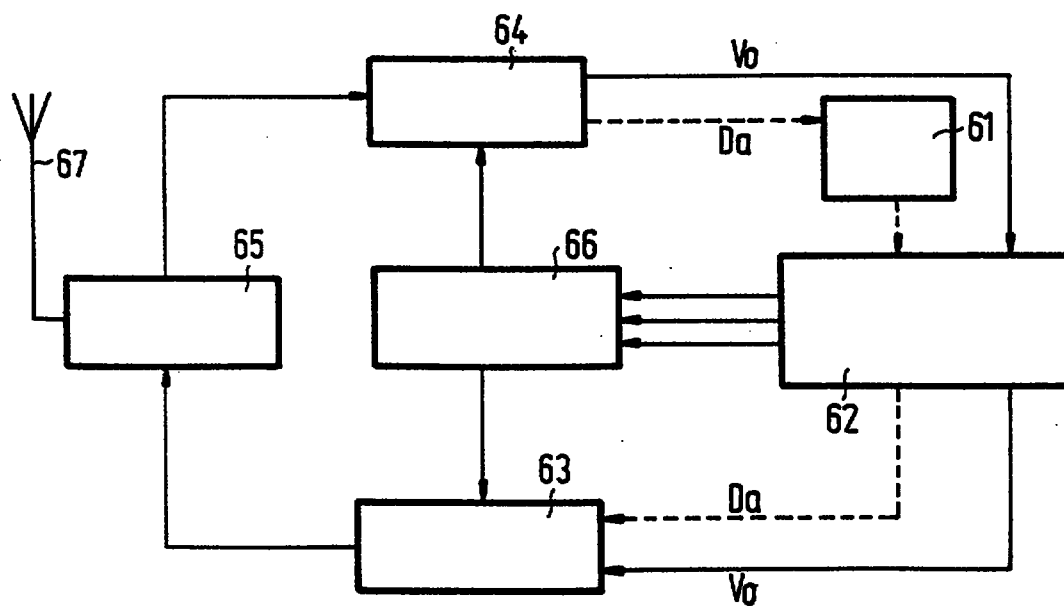


FIG. 6

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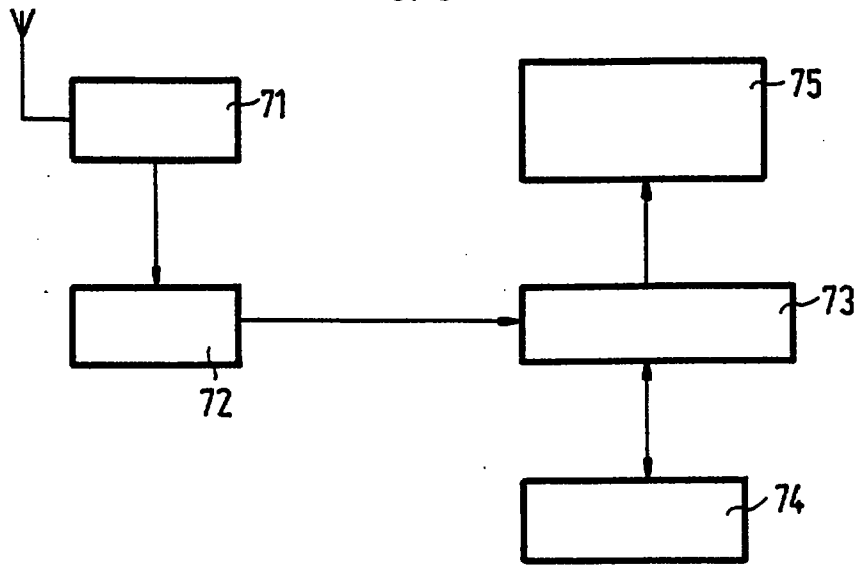


FIG. 7

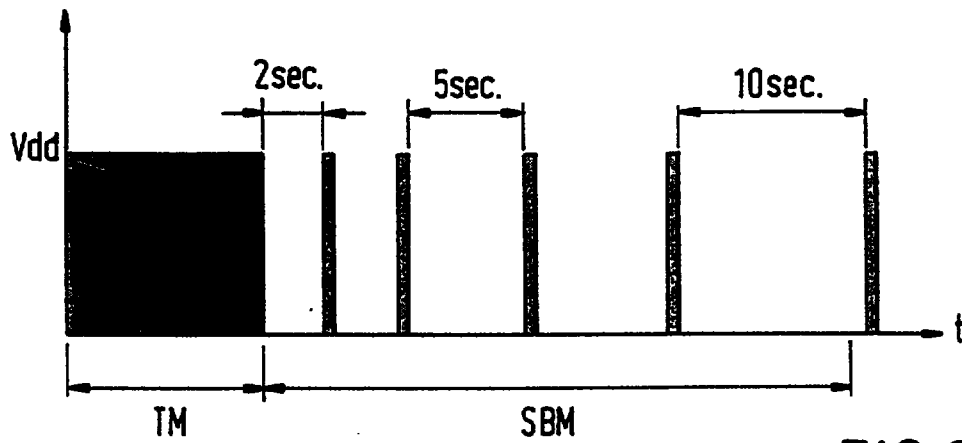


FIG. 8

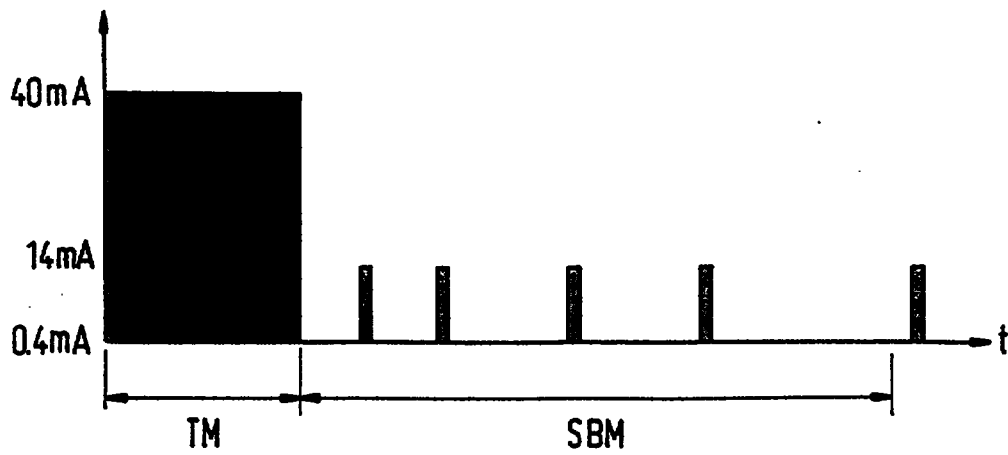


FIG. 9

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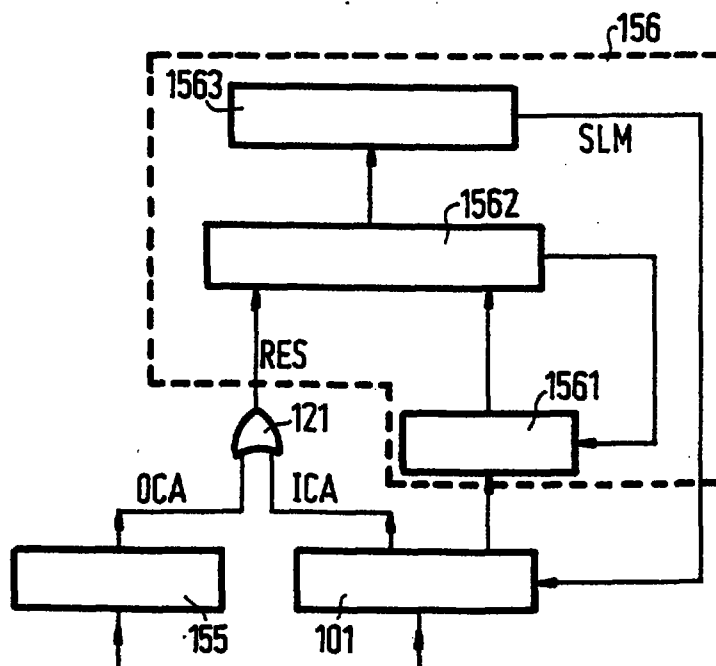
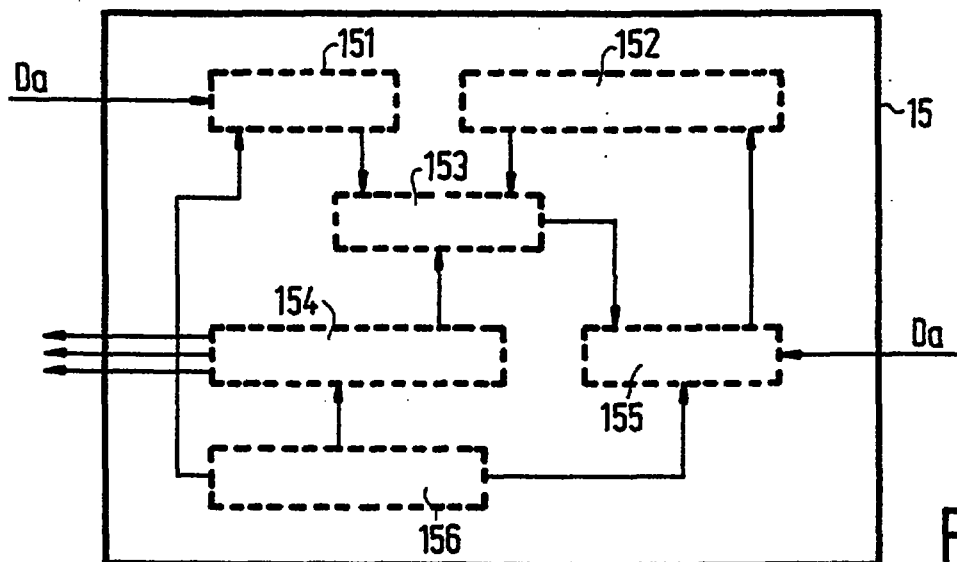


FIG.12

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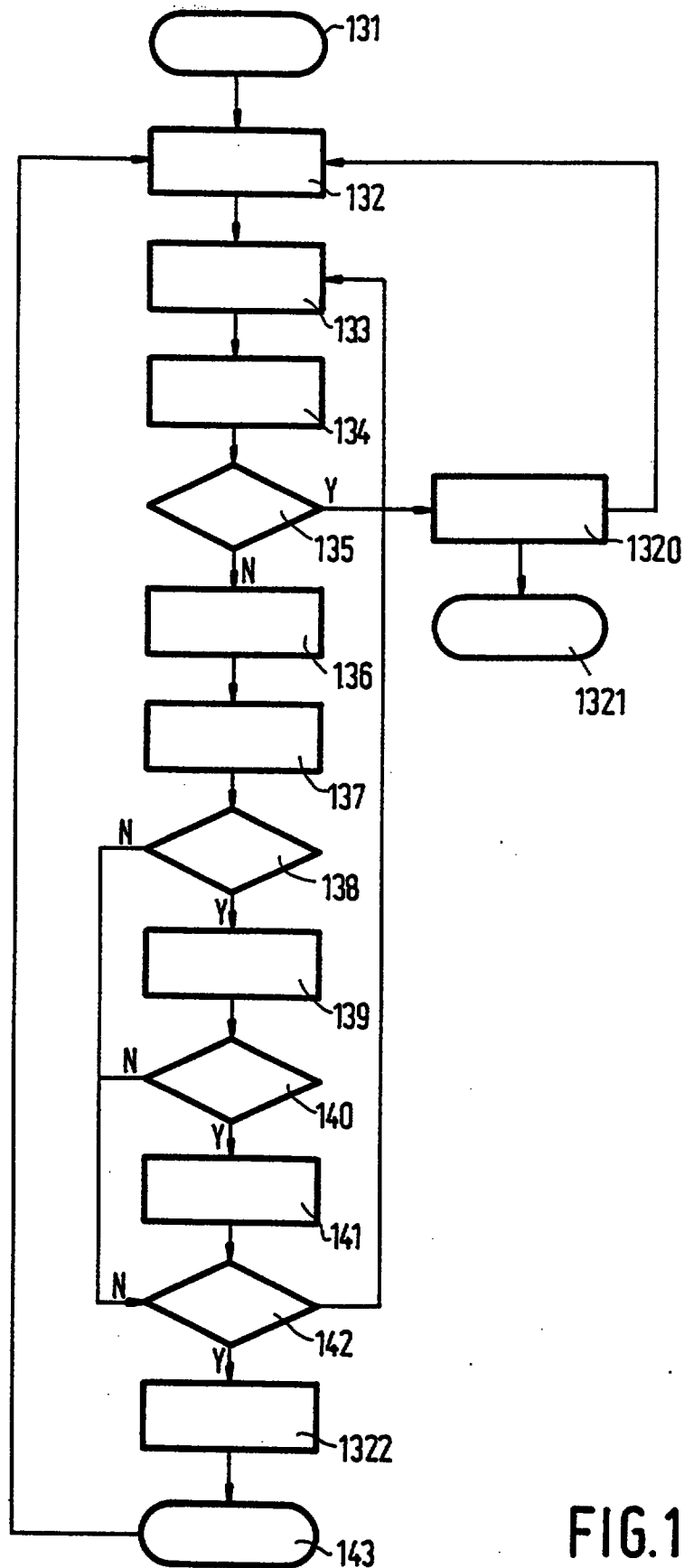


FIG. 13

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The present invention relates generally to a battery powered handheld communication system, such as a cordless phone system and a mobile phone system, and in particular to an enhanced power saving method for operating the battery powered communication system in an enhanced power saving standby mode in which the receiver of the communication system changes the scan rate as a function of the standby time and enters a sleep mode if no incoming signal is received or no outgoing signal is transmitted in order to save the power consumed by the receiver.

The invention is also directed to an enhanced power saving cordless communication system which comprises a controller to change the scan rate of the receiver as a function of the standby time in order to save the power consumed in the standby duration.

Prolonging the standby time of a battery powered cordless communication system, especially a handheld cordless communication system, is a challenge to the communication industry. A handheld cordless communication system comprises in general a receiver for incoming signals and a transmitter for outgoing signals. For a conventional handheld cordless communication system, its operation is divided as a talk mode TM in which both the receiver and the transmitter are active and a standby mode in which the transmitter is inactive with the power supplied thereto completely cut off and the receiver remains active to scan incoming signals from the surrounding air.

For a conventional cordless phone system, the power consumptions of the transmitter and the receiver thereof are respectively illustrated in Figs. 1 and 2 of the attached drawings. As illustrated in Fig. 1, the transmitter consumes no power at all under the standby mode. However, as shown in Fig. 2, the receiver takes the same amount of power under both the talk mode and the standby mode to maintain itself active. As a result, the overall system power consumption of the conventional handheld cordless communication system is generally the sum of those of Figs. 1 and 2 and is as

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illustrated in Fig. 3.

An interpretation of Figs. 1, 2 and 3 indicates that in the talk mode, both the transmitter and the receiver consume power, while in the standby mode, only the receiver takes power to maintain active. Since the receiver has to be maintained active, power supplied thereto cannot be cut off. Such a system requires quite a power consumption to maintain the receiver active all the time. Since the incoming signals are coming in a random fashion, maintaining the receiver active is quite a loss in the point of view of power-saving.

Another type of the handheld cordless communication system uses software algorithm to control the power supply. In a communication system of this kind, the power supply to the transmitter is the same as previously discussed, namely only in the talk mode. However, the power supply to the receiver is made intermittent, as shown in Fig. 4.

In such a kind of communication system illustrated in Fig. 4, the standby mode comprises a scanning mode when the receiver is active to scan incoming signals and a sleep mode when the receiver is deactivated and the power supplied thereto is completely cut off. In the scanning mode, the receiver is powered to scan incoming signals from the surrounding air within a predetermined period and once no incoming signal is detected in this pre-determined period, the power is shut down and the receiver enters the sleep mode. The receiver will sleep for a given fixed sleeping period and then activated to enter the scanning mode again. This procedure will be continuously repeated unless a call is made. Apparently, the power is completely cut off to both the receiver and the transmitter under the sleep mode. Normally, the scanning period, namely the pre-determined period within which the receiver is activated to scan incoming signals, is approximately $1/5$ or $1/10$ of the sleeping period of the sleep mode which as can be understood is the time interval between two successive scan modes.

In the above-mentioned conventional power saving communication system, the scan rate, which is used herein to denote the number of the scan modes occurring in a given length of time in the standby mode, is fixed. This kind of system does provide a significant reduction in the overall power consumption, which is illustrated in Fig. 5.

The conventional power saving communication system, although effective in cutting down power consumption, still wastes a great amount of power in the standby mode, especially in night time during which the communication system is generally not

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used for a very long while.

Due to the development of the even smaller and lighter battery powered handheld communication system, the power consumption will be subject to a more severe restriction. Thus, a more effective algorithm is desired to handle the more severe requirement of power consumption for the battery powered handheld cordless communication systems.

In the current cordless phone market, one of the most advanced systems is the so-called multiple channel access (MCA) auto-scan cordless phone which comprises a base powered by an external power source and a battery powered handset with a multiplicity of electromagnetic link channels connecting between these two parts. The MCA auto-scan cordless phone, as implied by the name, scans all of the multiple link channels to seek and establish the best communication between the base and the handset.

To meet the requirement of the end users, the MCA auto-scan cordless phone system has to provide a fast but power saving link between the base and the handset to meet the PTT regulation and to prolong the overall operation time that the battery set of the handset can provide. To be fast, a high data rate of communication should be established between the base and the handset and, as known to the art, the PTT regulation should be followed regarding the data rate. The requirement of high data rate can be resolved by using high speed modulating/demodulating techniques, such as 1200 or 2400 bps (baud per second) modem chips. An example of the known circuit which adopts the high speed modulating/demodulating technique is illustrated in Fig. 6 which is proposed by SONY company. The circuit in Fig. 6 comprises a modulating/demodulating means with the speed of 1200 bps 61 to process the signals communicated between the base and the handset, an MSK modem. The signals after modulation/demodulation are transmitted by a transmitter 63 via a audio control means 62. In standby mode, the receiver 64 scans the signals of the multiple channels with a fixed scanning rate. Further shown are a duplexer 65, a synthesizer 66, and an antenna 67, voice V_o and data D_a signals being present.

Although the high speed modulating/demodulating technique provides a high data rate, the power saving problem is still not overcome. The power saving problem is very severe for the MCA auto-scan cordless phone, for (1) it is powered by a limited battery power source and (2) it takes a great amount of power to scan all the channels continuously. The conventional power saving algorithm as discussed

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hereinbefore has been widely used to resolve the power saving problem so as to prolong the overall standby time provided by a battery set. As discussed previously, such a conventional power saving algorithm is not very effective and thus it is desirable to have a more effective power saving method to further prolong the standby time that a battery set can provide.

It is therefore an object of the present invention to provide a power saving method for a battery powered communication system, which method greatly cuts down the power consumption of the receiver of the battery powered communication system during the standby mode by changing the incoming signal scan rate as a function of the standby time history.

In accordance with a first aspect of the present invention, a power saving method for a cordless communication system, especially a battery powered cordless phone, is provided. According to the proposed power saving method, the scan rate is no longer fixed and changes as a function of the standby time. This provides a more efficient utilization of the battery power, especially during the time when the phone is used less frequently, for example in the night time. The scan rate is gradually lowered down step by step with the standby time when the phone is not operated for a long while and the system will be restored to the original scan rate once a call is coming in or an outgoing call is attempted. As compared with the conventional fixed scan rate method, the present method does provide a better way in saving the battery power.

It is also an object of the present invention to provide an enhanced power saving architecture for an MCA auto-scan cordless phone system which by adopting the power saving algorithm of the present invention greatly cuts down the power consumption in scanning the incoming signals through all the channels.

It is another object of the present invention to provide a power saving architecture for an MCA autoscan cordless phone, comprising a decoder circuit which allows the central processing unit (CPU) of the phone to "sleep" until a special identification code carried by the incoming signal is matched so as to reduce power consumption.

According to another aspect of the present invention, an MCA auto-scan cordless phone architecture is provided. The MCA auto-scan cordless phone architecture

comprises a decoder operating in a principle similar to the decoder of a pager system. The basic composition of the pager system is as shown in Fig. 7. The pager system comprises a decoder 72 to determine if the signal received by a receiver 71 of the pager is the one to be received by the pager by checking if the detected signal carries an address matching that pre-set in the pager decoder. Once the received signal matches the address of the pager system, the pager will enable a micro-controller 73 to activate a beep or a display 75 according to the data pre-stored in a user interface 74 to inform the user of the incoming signal. Similar principle is adopted in the MCA auto-scan cordless phone architecture provided by the instant invention that the decoder of the cordless phone checks the address or identification code of other kinds carried by a signal detected by the receiver of the phone. Once the address or identification code is accepted, the decoder "wakes up" the sleeping CPU to proceed signal receiving.

According to a further object of the present invention, the MCA auto-scan cordless phone has a receiver to scan and receive signals from the surrounding air operated by a scanning procedure programmed in accordance with the enhanced power saving algorithm of the present invention.

Other objects and advantages of the invention will be apparent from the following description of a preferred embodiment taken in connection with the accompanying drawings, wherein:

Fig. 1 is a plot of the supplied power needed in operation by a transmitter of a general cordless communication system;

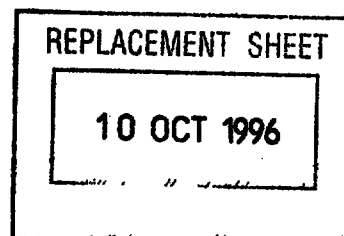
Fig. 2 is a plot of the supplied power needed in operation by a receiver of a general cordless communication system;

Fig. 3 is a plot showing the total power consumption of both the transmitter and receiver shown in Figs. 1 and 2;

Fig. 4 is a plot of the supplied power needed in operation by a receiver of a conventional power saving communication system;

Fig. 5 is a plot showing the total power consumption of both the transmitter and receiver of the conventional power saving communication system ;

Fig. 6 is a block diagram of a conventional multiple channel access (MCA) auto-scan cordless phone system;



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Fig. 7 is a block diagram of a pager system;

Fig. 8 is a plot of the supplied power needed in operation by a receiver of an enhanced power saving communication system in accordance with the present invention;

Fig. 9 is a plot showing the total power consumption of both the transmitter and the receiver of the enhanced power saving communication system in accordance with the instant invention;

Fig. 10 is a block diagram of a preferred embodiment of the enhanced power saving communication system in accordance with the present invention;

Fig. 11 is a block diagram of the cordless decoder of Fig. 10;

Fig. 12 is a block diagram of the power saving circuit of Fig. 11; and

Fig. 13 is a flow chart illustrating the operation of the power saving circuit.

An enhanced power saving communication system constructed in accordance with the present invention comprises a receiver to receive incoming signals and a transmitter to send out outgoing signals with a cordless electromagnetic link therebetween to exchange link data with each other. The operation of the communication system is divided into TALK MODE TM in which both the transmitter and the receiver are active to enable the receipt and transmission of signals and data and STANDBY MODE SBM in which the transmitter is deactivated to save power consumption and the receiver is repeatedly activated and deactivated in an intermittent fashion. The STANDBY MODE period is thus further divided into SCANNING MODE in which the receiver is active for scanning the incoming signals for a given scanning period and SLEEP MODE in which the receiver is deactivated to reduce power consumption.

With reference to the drawings and in particular to Fig. 8, wherein a power supplying curve of the enhanced power saving cordless communication system constructed in accordance with the present invention and operated in accordance with the power saving method of the present invention is illustrated, it is observed that the scan rate of the receiver being activated to scan the incoming signals per unit time is changing in accordance with the standby time history. Namely, the scan rate is no

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longer fixed as the conventional cordless phone systems and is now a function of the standby time.

The purpose of changing the scan rate in accordance with the standby time is to cut down the scan rate when the communication system is used less frequently, for example in night time, and to increase the scan rate when the communication system is used more frequently, for example in day time.

An example of changing the scan rate with the standby time is illustrated in Fig. 8 wherein the standby time is divided into different time zones by, for example, two hours, the first one being 0-2 hour, the second one 2-4 hour, the third one 4-6 and so on. In each of the time zones, a different delay level in scanning operation is set, for example, in the 0-2 time zone, the scanning is carried out every two seconds with a 400 ms scanning period. In the next (2-4) time zone, scanning is conducted at every 5 seconds with the same scanning period. The scanning is carried out at every 10 seconds for the third (4-6) time zone. Once an incoming call is picked up or an outgoing signal is attempted, the whole system will be reset to interrupt the above procedure and re-start the delay procedure from the first time zone.

The power consumption obtained in accordance with the above delay mode is plotted in Fig. 9. By comparing the plot of Fig. 9 with those of Figs. 3 and 4, it is observed that not only is the power consumption intermittent, but the average time interval (delay time) between two successive scanning periods is also increased. This indicates a further reduction in overall power consumption.

As mentioned hereinbefore, an application of the enhance power saving method of the instant invention is to embody in an MCA auto-scan cordless phone. This is illustrated by an embodiment shown in Fig. 10. The phone system shown in Fig. 10 comprises a receiver 10, an audio and control device 11, a transmitter 12, a synthesizer 13, and a multiplexer or duplexer 14. To increase the data rate between the base and the handset (both not shown) of the phone system and to reduce power consumption, a cordless decoder 15 is connected between the receiver and the audio and control device 11. The cordless decoder 15 is operated in accordance with a principle similar to that of a well-known pager system for checking if the address or identification code carried by a detected incoming signal match a built-in address or identification code within the system. Only when the incoming and the built-in addresses match, is the incoming

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signal sent to the audio and control device 11 and then applied to the transmitter after being processed.

The circuit of the cordless decoder 15 is shown in Fig. 11, which comprises an MSK receiver 151 operated in accordance with the minimum shift keying (MSK) principle, a system address memory 152, an address checker 153, a synthesizer controller 154, a CPU interface 155, and a power saving circuit 156. When the signal coming to the system is received by the MSK receiver 151, the address carried by the signal is compared to the system address built in the memory 152 by the address checker 153. Once the two addresses match, the CPU interface 155 will be woken up to receive the incoming signals, data or commands. The synthesizer controller 154 is to program the synthesizer 13 shown in Fig. 10 to different frequencies associated with different channels of the MCA auto-scan cordless phone system in order to receive and/or check the signals in all the channels of the system.

Although the cordless decoder 15 of the present invention is operated with a principle similar to that of the known pager systems, it is understood that they are different in that:

- (1) the pager is an one-way communication device while the cordless phone is a bi-directional communication equipment;
- (2) the pager decoder only needs to detect one fixed frequency and thus no synthesizer controller is required, while the MCA auto-scan cordless phone has to scan a number of frequency channels and thus needs a synthesizer controller; and
- (3) The power consumption of the MCA auto-scan cordless phone is much greater than pager system for the pager has a fixed frequency and the MCA auto-scan cordless phone has to scan a number of frequency channels and thus the power saving feature is extremely important in the MCA auto-scan cordless phone system. As a consequence, the pager system may not need to enter SLEEP MODE, namely both the receiver and the transmitter are off, while in the cordless phone, power saving algorithm is widely adopted.

Due to these differences between the pager decoder and the cordless decoder used in the instant invention, they are substantially different in the operation.

The power saving circuit, which is denoted by reference numeral 156 in Fig. 11, is a major feature of the present invention and will be described with reference to Figs. 12 and 13 of the drawings. The power saving circuit 156 controls the operation

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of the CPU interface 155 to have the CPU follow the delay mode of scanning incoming signals as described herein. In other words, the CPU of the system will be intermittently deactivated during the STANDBY MODE to save power and the length of the deactivated time of the CPU will change in accordance with the standby time of the system.

An example of the power saving circuit 156 is illustrated in a block diagram form in Fig. 12, in which the CPU interface 155 and a message scanner 101 of the receiver 10 are also shown for illustrating the relationship therebetween. The power saving circuit 156 may comprise an accumulator 1561, a standby history recorder 1562 and a sleep time controller 1563. Preferably, the accumulator 1561 is an up counter to count the number that the receiver 10 carries out signal scanning in a period. The delay sequence is recorded in the standby history recorder 1562. The delay time and the associated scan rate are pre-built in the standby history recorder 1562. Once the count in the accumulator 1561 reaches the upper limit of a delay level, the standby history recorder 1562 will be triggered to enter the next delay level. Further shown is a reset-OR-gate 121, supplying a reset signal Res, on outgoing call OCA and incoming call ICA.

The sleep time controller 1563 is to set the sleep mode SLM of the system. The procedure of setting the sleep mode will be described with reference to the flow chart shown in Fig. 13. However, it should be understood that the flow chart of Fig. 13 is only an example and by no means to limit the scope of the present invention.

As shown in Fig. 13, the system starts with an initialization step 131 and then setting the sleep mode to the first delay level thereof with the sleep time controller 1563 at step 132 and entering the sleep mode at step 133. Thereafter at a suitable time in accordance with the setting of the sleep mode, the message scanner 101 of the receiver 10 is activated to enter the scanning mode, carrying out message scanning at step 134 to determine if a call is coming in at step 135. If yes, set the sleep mode to the first level again at step 1320 and the procedure jumps off to a being-all-subroutine at 1321 to pick up the incoming call. Thereafter go back to step 133 to enter the first level sleep mode again.

If there is no incoming call is found at step 135, then read the standby history from the standby history recorder 1562 at step 136 and increase the count of the accumulator 1561 by one and then updating the standby history recorder at step 137.

The first delay level is continuously maintained until the first time zone which is associated with the first delay level and which is assumed to be 0-2 hour in the illustrated embodiment is ended or an outgoing call is made. This is checked at step 138. If the standby time does not exceed the limit of the first time zone, namely 2 hours from the beginning of the standby mode, the procedure will return to step 134 to conduct another message scanning after a suitable elapse of time determined by the delay time set by the first delay level via a checking of outgoing call at step 142.

At step 142, if no outgoing call is detected, the routing is directed back to step 134, otherwise it sets the sleep mode to the first level again at step 1322 and the procedure jumps off to a calling-subroutine at step 143 to make the outgoing call. Thereafter go back to step 133 to enter the first level sleep mode again.

If it is checked at step 138 that the first time zone is exceeded, then at step 139 the system enters the second level of the sleep mode associated with the second time zone which in the illustrated example begins from the end of the second hour of the standby mode to the end of the fourth hour of the standby mode. Step 140 provides a checking of the exceeding of the second time zone. This step is similar to step 138 associated with the first delay level and branches to either a checking of outgoing call at step 142 if the second time zone is not exceeded or a step of entering the third delay level of the sleep mode (step 141) if the second time zone is exceeded.

Step 141 is the step when the system enters the third delay level associated with the third time zone which is the time period between the ends of the fourth and the sixth hours of the standby mode in the illustrated embodiment. Step 141 provides a similar checking function as those of steps 138 and 140 associated with the first and the second delay levels.

It is understood that the setting of the time zone and the number of the total time zones may be different from what just described and it is intended to include all kinds of settings of the delay levels and the time zones in the spirit of the present invention.

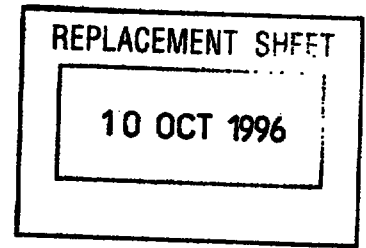
An experiment with an MCA auto-scan cordless phone will be given as follows to show the unbelievable power saving capability of the present invention:

EXPERIMENT CONDITION:

1. A 10 channel, 46/49 MHz auto-scan cordless phone handset;
2. MSK data transmission scheme at speed of 1200 bps;

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3. Scanning time for all 10 channels: 400 ms;
4. Power consumption in TALK MODE: 40 mA;
5. Power consumption in SCANNING MODE: 14 mA;
6. Power consumption in SLEEP MODE: 0.4 mA; and
7. Battery capacity: 280 mA.hr.

EXPERIMENT RESULTS:

- A. Non-power saving system, as that associated with Figs. 1-3:
 - a. Continuous talk time: 7 hours;
 - b. Continuous standby time: 20 hours; and
 - c. Response delay to ring signal: one second.
- B. Conventional power saving system, as that associated with Figs. 4 and 5:
 - a. Continuous talk time: 7 hours;
 - b. Continuous standby time: 105 hours; and
 - c. Average response delay to ring signal: 1 second.
- C. Enhanced power saving system of the present invention, as that associated with Figs. 8 and 9:
 - a. Continuous talk time: 7 hours;
 - b. Continuous standby time: 298.5 hours;
 - c. Average response delay to ring signal:
 - i. 1 second (< 2 hours standby)
 - ii. 2.5 seconds (2-4 hours standby)
 - iii. 5 seconds (> 4 hours standby).

From the above results, it is found that the standby time can be extremely prolonged from the 20 hours of the non-power saving system and the 105 hours of the conventional power saving system to the 298.5 hours of the present invention. The increasing is about 2-3 times of the conventional power saving system.

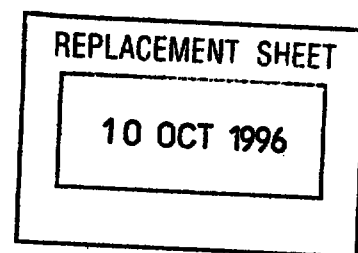
The only drawback is the slightly longer response delay to the first ring of an incoming call in the second and the third time zones. However, the delay is only approximately 3 ring tones (5 seconds) and it occurs only at the first incoming call after a long standby time. Once the first ring is detected, the system is restored to the most quick response mode so that the drawback is very minor to the end users.

It is apparent that although the invention has been described in connection

with the preferred embodiments, it is contemplated that those skilled in the art may make changes to certain features of the preferred embodiments without departing from the spirit and scope of the invention as defined in the appended claims.

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**CLAIMS:**

1. A power saving method for a cordless communication system wherein the cordless communication system comprises a receiver to scan and receive signals from a surrounding air, which receiver enters a period of a standby mode when no signal is coming in to be received thereby and which is activated to scan the signals from the surrounding air in accordance with pre-set scan rates and deactivated for a length of preset delay time to reduce power consumption in an alternate fashion within the standby mode period, said power saving method comprising:

dividing the standby period into a number of sections to define a corresponding number of successive time zones;

establishing a delay level for each of said time zones, each delay level being associated with a delay time period;

setting a scan rate for each of said delay levels;

continuously allowing the receiver to be activated in accordance with the delay level and the scan rate associated with the time zone where the receiver belongs to establish a standby time history of the receiver;

recording the standby time history and comparing the standby time history with the definition of said time zones to determine which time zone the receiver belongs to;

updating the standby time history to allow the receiver to enter the time zone next to the zone that the receiver originally belongs to to scan with the scan rate and to sleep for the delay time associated with the next time zone when the original time zone is exceeded; and

repeating the comparing and updating procedures until being interrupted by an attempt to make a communication via the cordless communication system.

2. A method as claimed in Claim 1 wherein the standby period is divided to define at least three time zones of which the first one has a highest scan rate and a least delay time, the second one has a second highest scan rate and a second least delay time and the third one has the lowest scan rate and the greatest delay time.



3. A method as claimed in Claim 2 wherein said receiver is reset to the first time zone when the standby history is interrupted by an attempt to make a communication.

4. In a multiple channel access auto-scan cordless phone system controlled by central processing means, a wireless communication device comprising a decoding device for confirmation of signals received by the phone system comprising:

receiver means for receiving signals from the phone system;

memory for storing therein an identification for each of the multiple channels of the phone system;

checker means for comparing a code carried by the signals with the identifications so that when the code matches with one of the identifications, an actuating signal is generated to wake up the central processing means of the phone system to process the received signals;

synthesizer controller which provides each of the multiple channels with a given communication frequency; and

a power saving circuit means which, when the phone system is in a standby mode which defines a number of successive time zones, provides the phone system with a corresponding number of different and time-based scan rates and delay time periods associated with the time zones to allow the phone to intermittently scan signal from a surrounding air in accordance with one of the scan rates and sleep for a period of one of the delay time associated with a particular time zone.

5. A wireless communication device as claimed in Claim 4 wherein said power saving circuit means comprises:

an accumulator for up-counting the number of signal scanning conducted by the phone system;

a standby history recorder which has the scan rates and delay time periods built therein to allow the phone system enter the time zone next to said particular time zone in response to the accumulator so as to change the scan rate and the delay time period in accordance with a counting result provided by the accumulator; and

a sleep time controller for controlling the sleeping and scanning of the phone system during the standby mode in accordance with the time zones set in the standby history recorders.

6. A power saving cordless communication system, comprising:

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receiver means for scanning an incoming signal which comprising at least an identification portion and an audio portion in a standby period of the system at a scan rate and receiving the incoming signal, said standby period being divided into a number of successive time zones and the receiver means moving from one time zones to a next one with time during the standby period;

decoding means for decoding and identifying the identification portion of the received signal;

audio and control means for processing the audio portion of the received signal and sending out the processed audio portion together with the identification portion; and

transmitter means for transmitting signals;

the improvement comprising:

said decoding means comprising identifying means for checking the identification portion of the received signal with an identification code built in the system; and

power saving means which provides said receiver means with a number of different scan rates respectively associated with the time zones of the standby period so as to allow said receiver means to scan incoming signals with different scan rate in accordance with the one of said time zones which said receiver means is in.

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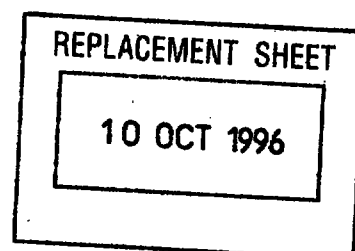
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ABSTRACT:

Enhanced power saving method for handheld communication system and the handheld communication system thereof

An enhanced power saving method for operating a battery powered handheld communication system, particularly a cordless phone system, and the communication system constructed in accordance with the power saving method are disclosed. The power saving method comprises an algorithm which divides the standby time of the communication system into a scanning mode and a sleep mode of several different levels to allow the system to enter the scanning mode intermittently. Each level of the sleep mode corresponds to a given length of delay time between two successive scanning periods. The communication system enters different levels of the sleep mode in accordance with the standby time history. The longer the standby time has passed, the longer the sleep time of the level that the system may enter is to cut down the scan rate when the system is not used for a long while.

Fig. 12.



1.

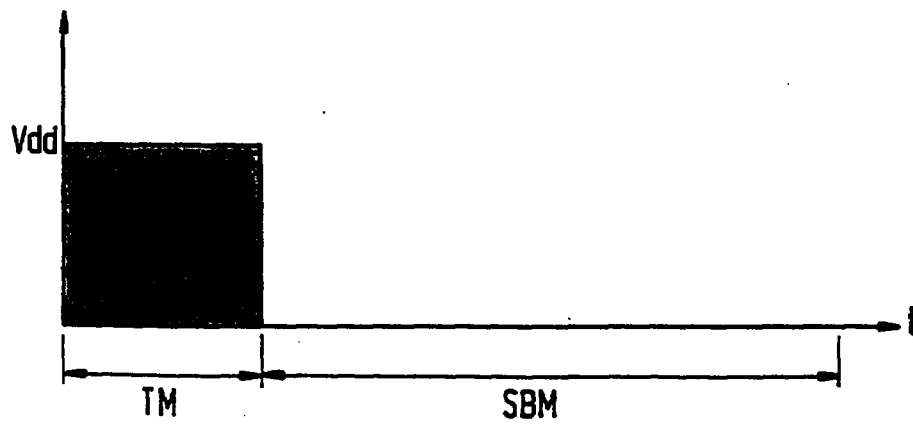


FIG. 1

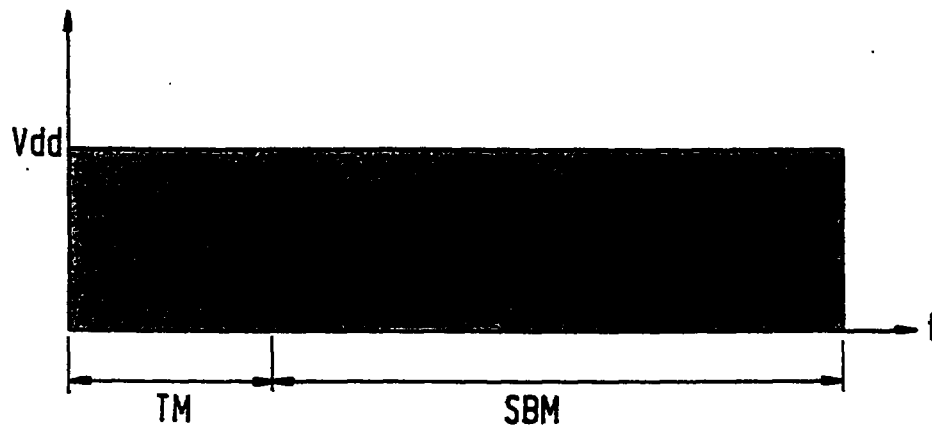


FIG. 2

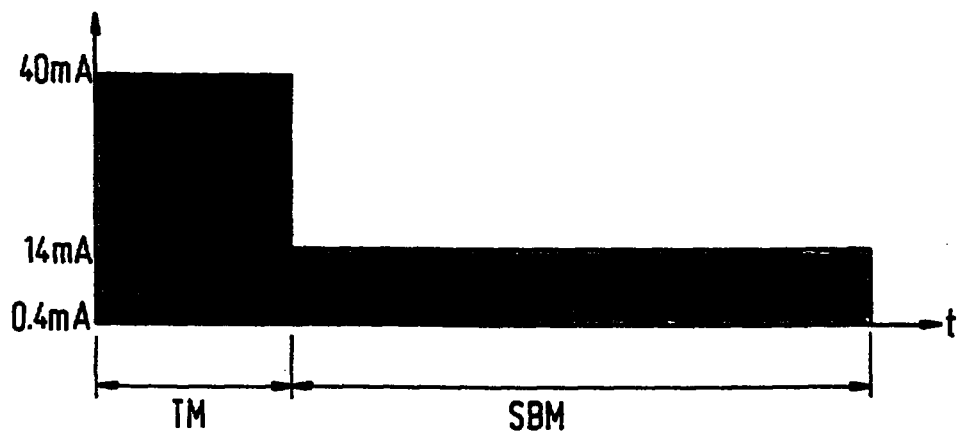


FIG. 3

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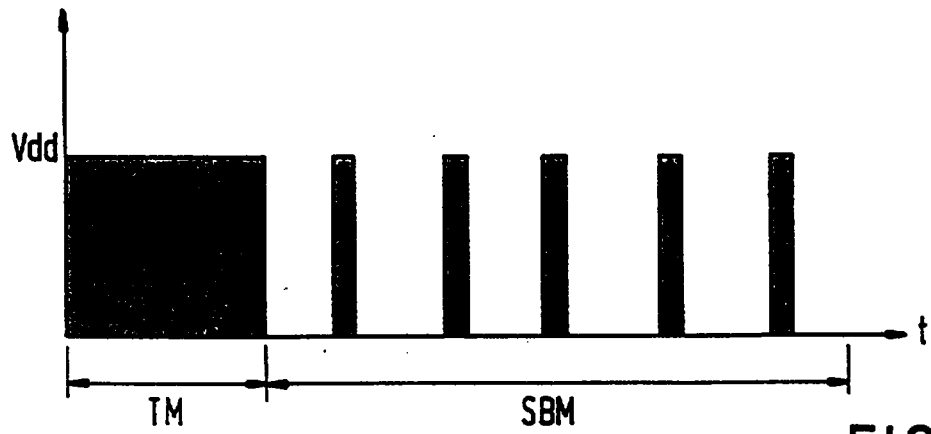


FIG. 4

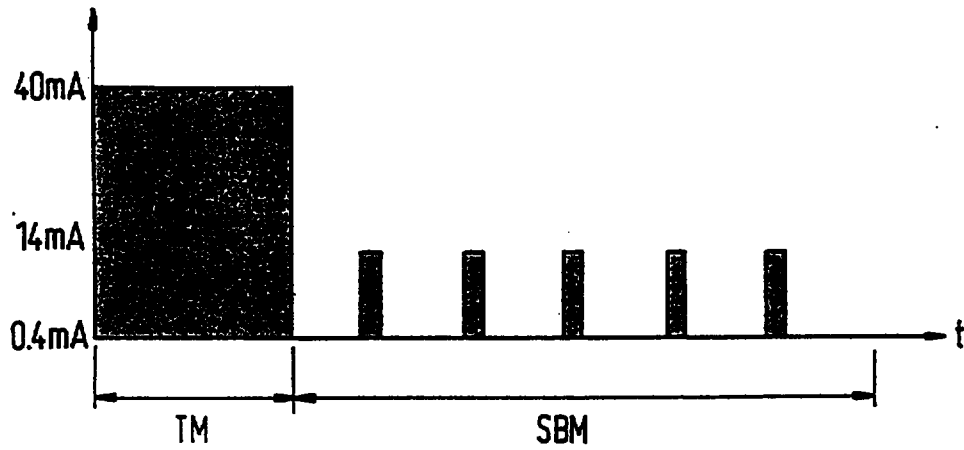


FIG. 5

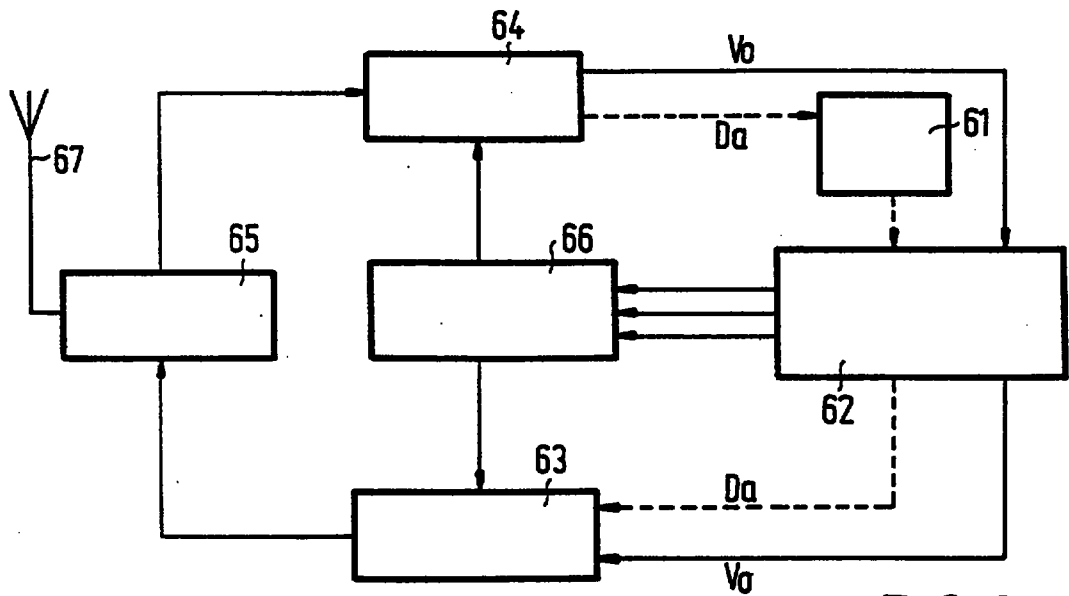


FIG. 6

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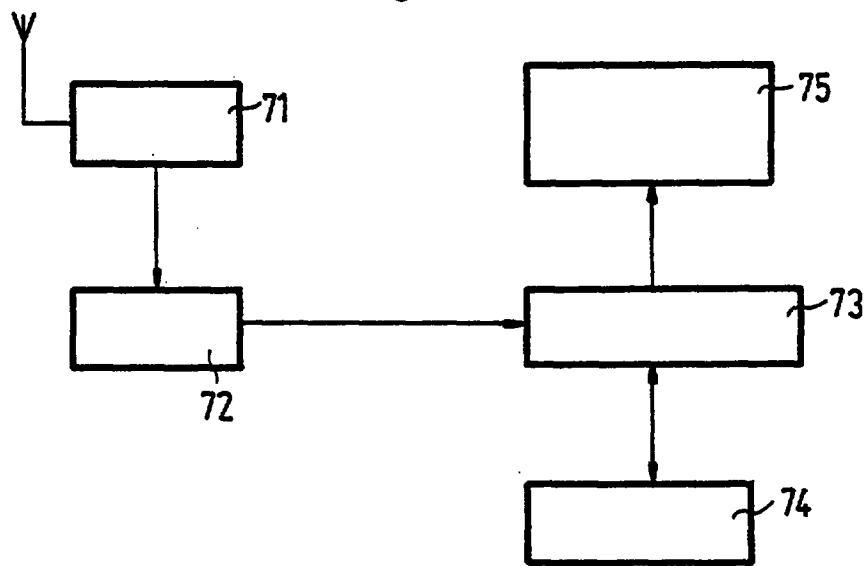


FIG. 7

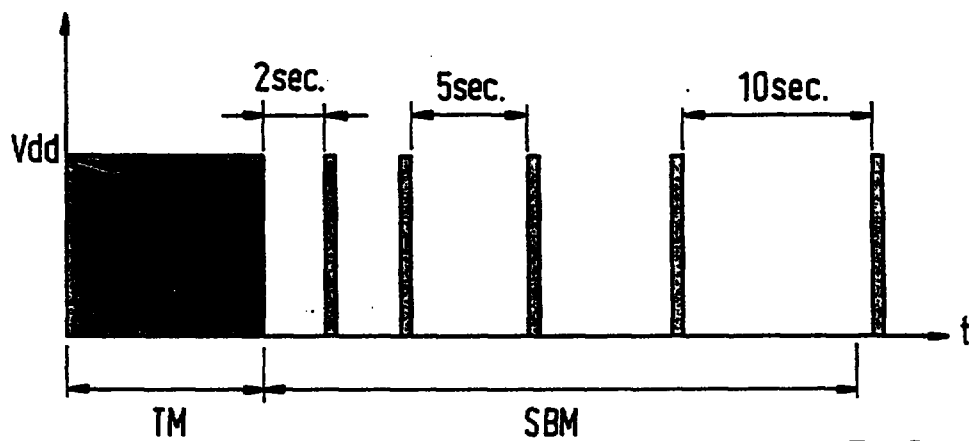


FIG. 8

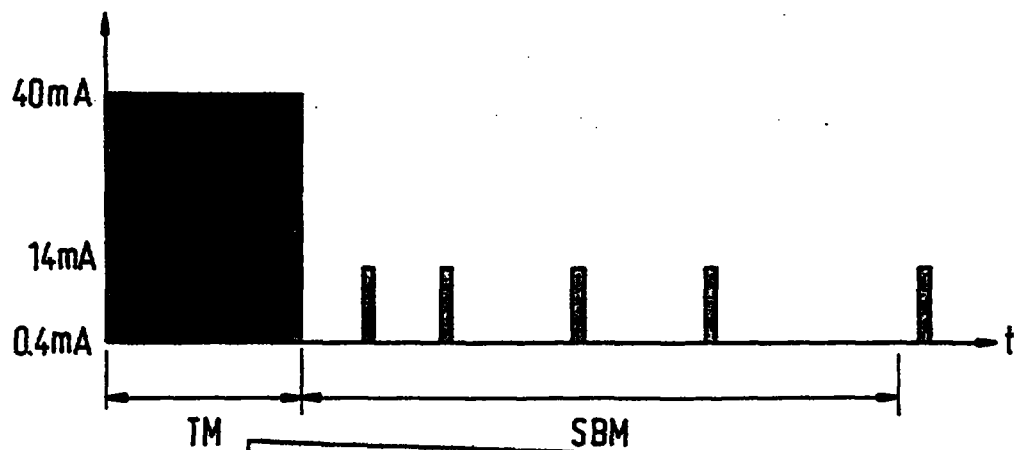
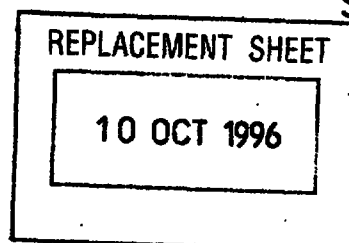


FIG. 9



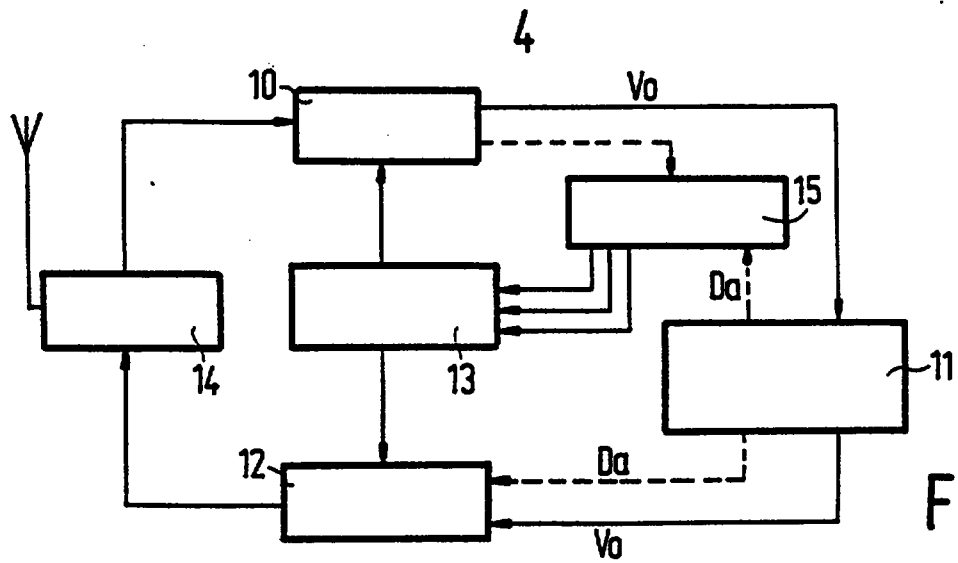


FIG. 10

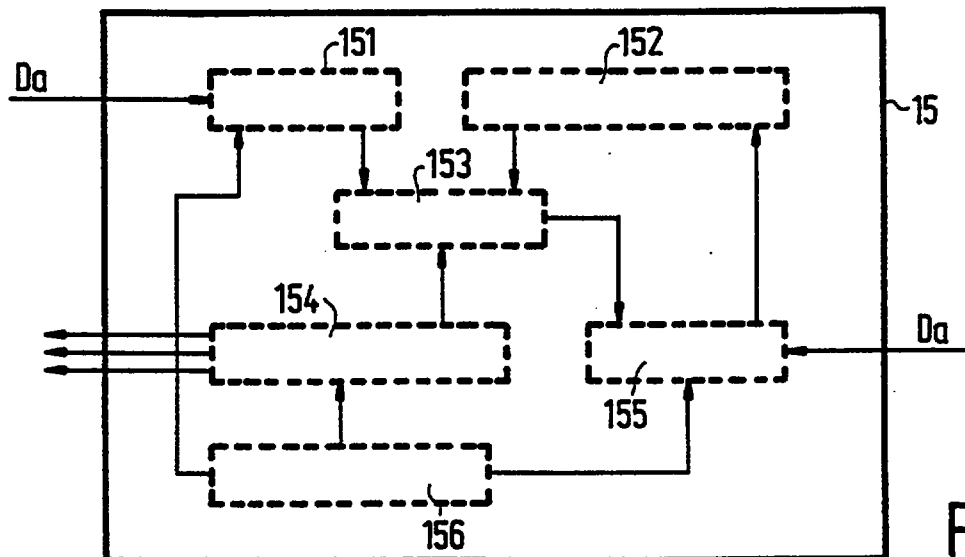


FIG. 11

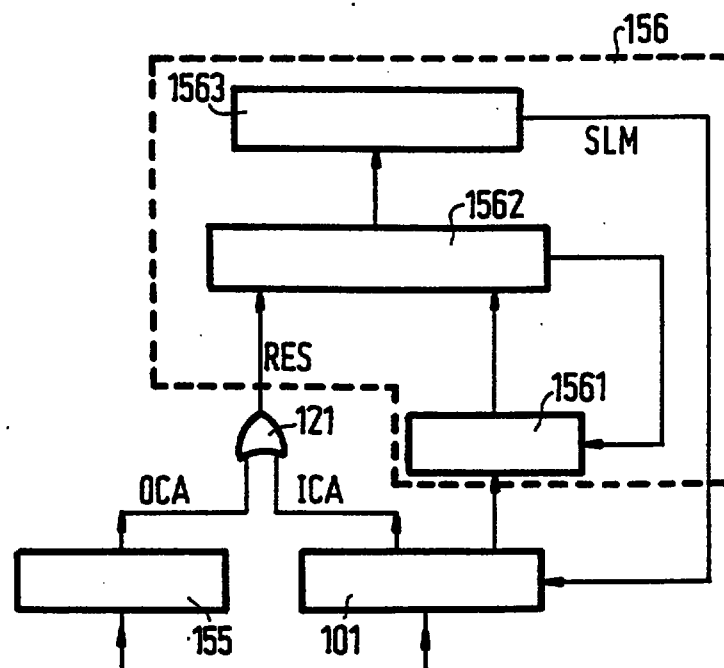
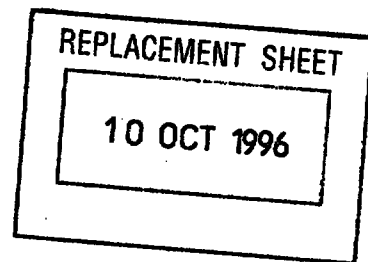


FIG. 12



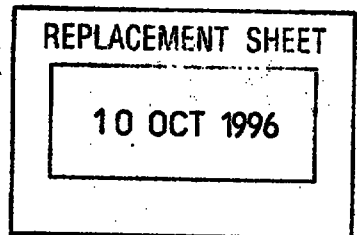
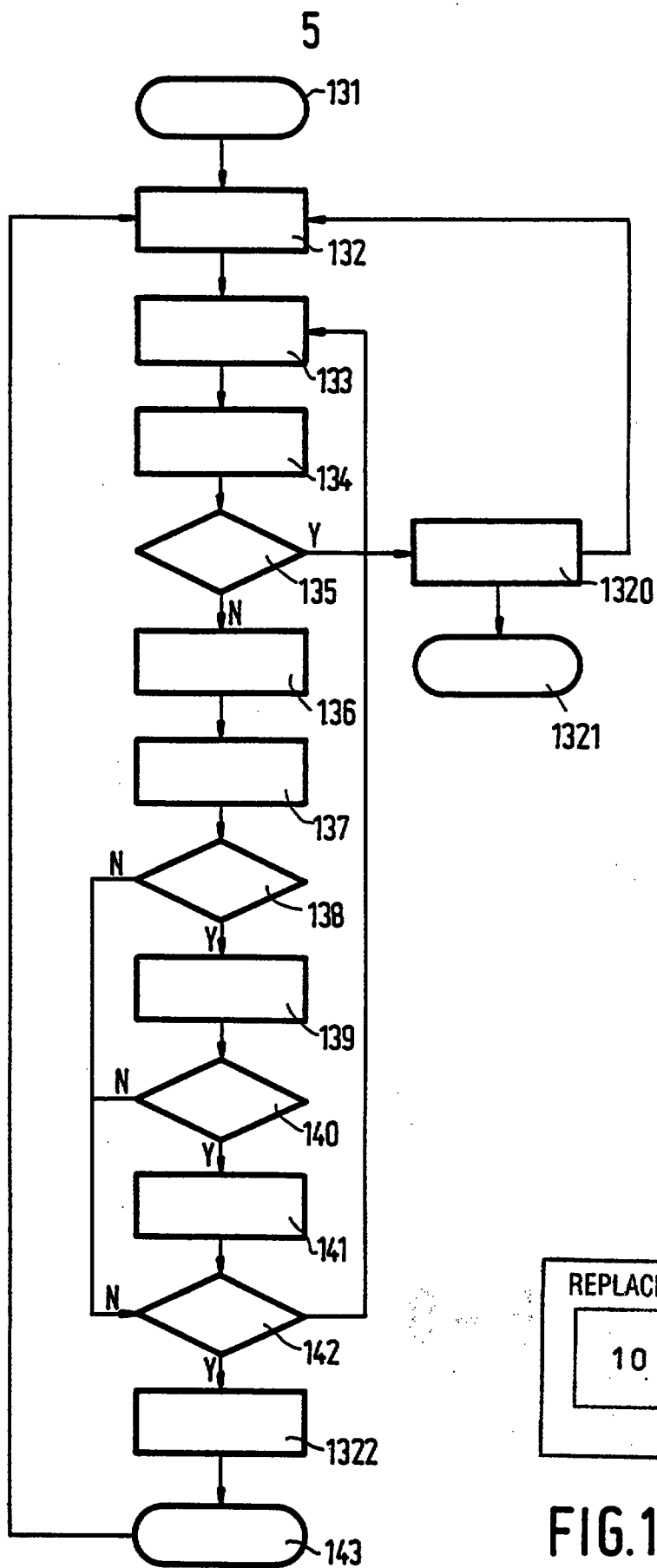


FIG.13