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Method and Apparatus for synchronising clocks being connected to a network system

The present invention relates to a method and to an apparatus for synchronising clocks being connected to a network system.

Background

Many devices (in particular white goods or brown goods) in a household may contain a clock. Some systems allow to connect all these devices and the related clocks to a common bus or network. The commands for controlling the clocks are in general limited to reading or writing a given time or to broadcasting the time of a given clock to one dedicated device or to the entire system or to a part of the system.

An example home bus system is described in Esprit Home Systems Specification 1.1, ESPRIT project 6782.

In such known systems it is not specified in which manner a clock should react if it receives the time broadcast by another clock. So, it is possible to initialise all clocks to a given time (e.g. by a user action, which creates a 'write time' broadcast to the entire system), but due to tolerances in the different clocks, so achieved synchronisation will not be maintained. Regular broadcasting by a special device 'master clock' has the disadvantage of introducing one device with different capabilities. In case there are several master clocks, conflicts may occur and the advantages of a high precision clock will fade away if a lower precision master clock overrides it.

Invention

It is one object of the invention to guarantee initial synchronisation and keeping of synchronisation between real time clocks in a bus connecting distributed devices. This object is reached by the methods disclosed in claims 1 and 3.

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It is a further object of the invention to disclose an apparatus which utilises the inventive method. This object is reached by the apparatus disclosed in claims 11 and 12.

A good synchronising system should care about the precision of different clock types:

- non initialised
- display only, no timer included
- battery driven low precision
- 50Hz driven
- quartz driven
- official time distributed via radio (for a specific time zone)
- user intervention

This list can be interpreted as a list of priorities, user intervention having the highest. Higher priority clocks should set the time of lower priority clocks (in case there are tuners in the system which receive the time from different time zones, it is supposed that only the time of one time zone will be transmitted to the rest of the system).

The first proposal for solving the problem is as follows:

- every clock broadcasts (datagram distribution) its time periodically
- the broadcast period is dependent on the precision (higher precision leads to a shorter period)
- every clock which receives a broadcast updates its time
- every clock which receives a broadcast resets its counter of the broadcast period
- user intervention initiates an immediate broadcast

In this manner only the clock with the highest precision broadcasts its time to the system, but whenever it fails the next lower precision clock takes over the broadcasting automatically. The broadcast periods are defined as factorial periods of a preselected time period, e.g. a minute (e.g. 5, 6, 12, 15, 20, 30, 60 seconds), and are synchronised to the preselected time unit.



Then, all clocks displaying hours (hh) and minutes (mm) only will receive their time with no extra cost.

Another proposal is, that all devices will broadcast the time with an equal period (say one minute), but with a different phase (in seconds, e.g. highest precision clock at hh:mm:50, next lower precision clock at hh:mm:52, etc.; or highest precision clock at hh:mm:00, next lower precision clock at hh:mm:02, etc.), but only if no broadcast was received in the preceding time period. In the latter case, traffic on the network is independent of the precision of the different clocks. The displays are either slightly out of time or will need internal second counting capability.

In both proposals, time broadcasting may be done to the entire system or to a group, or subgroup, of clocks only.

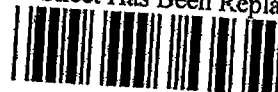
A disadvantage of the both above described kinds of synchronising is that the risk of collisions between two devices of equal precision is enhanced (causing higher traffic on the network), at least on media without collision avoidance (e.g. current carrier transmission on power lines), or if repetition is handled in the lower protocol layers only.

According to the invention, there are two proposals:

Phase of transmission depends on precision

- every clock receiving a time broadcast of the same or higher precision class does not broadcast for a certain amount of time (e.g. N minutes). The precision class of the broadcaster can be easily derived from the phase of the time broadcast (e.g. seconds count).
- this amount of time (e.g. N minutes) is a random or pseudo-random value, depending on some internal state of the instance of this device (and not only on the present time). Two possibilities: these values may be changed periodically or after each transmission.

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Frequency of transmission depends on precision

- every clock receiving a time broadcast of any precision class does not broadcast for a certain amount of time (e.g. N minutes).
- this amount of time (e.g. N minutes) is a random or pseudo-random value, it depends a.o. on the precision of this clock, so that higher precision clocks will wait (in average) for a shorter time.

In principle, the inventive method is suited for synchronising clocks being connected to a network system, whereby:

- said clocks may belong to different precision classes;
- the time of every clock is broadcast within said network system after expiry of a pre-selected time period, whereby a higher of said precision classes is associated with a shorter time period and time period counting means are related to each of said clocks;
- every clock which receives said broadcast updates its time and the related time period counting means are reset,

or whereby:

- said clocks may belong to different precision classes;
- the time of every clock is broadcast within said network system having a pre-selected phase, which is related to said precision class in such a way that the broadcast time related to a higher of said precision classes is earlier, and having a pre-selected broadcast time period, which is independent of said precision class;
- the time of a specific clock is broadcast only, when the clock has received no related time from a clock belonging to a higher precision class;
- every clock which receives said broadcast updates its time.

Advantageous additional embodiments of the inventive method are resulting from the respective dependent claims.

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In principle the inventive apparatus for synchronising clocks being connected to a network system is related to a method according to any of claims 1 to 10 and includes:

- a clock which may belong to different precision classes;
- bus interface means which broadcast the time of said clock within said network system after expiry of a pre-selected time period, which is related to said precision class in such a way that a higher of said precision classes is associated with a shorter time period, whereby time period counting means are related to said clock;
- interrupt means which interrupt time transmission from said clock to said bus interface means during a certain time period after each reception of time information by said bus interface means, whereby the time of said clock is broadcast only, when the bus interface means have received no related time from a clock belonging to a higher precision class and whereby the time of said clock is updated when receiving said broadcast time information and said time period counting means are reset,

or includes:

- a clock which may belong to different precision classes;
- bus interface means which broadcast the time of said clock within said network system having a pre-selected phase, which is related to said precision class in such a way that the broadcast time related to a higher of said precision classes is earlier, and having a pre-selected broadcast time period, which is independent of said precision class;
- interrupt means which interrupt time transmission from said clock to said bus interface means during a certain time period after each reception of time information by said bus interface means, whereby the time of said clock is broadcast only, when the bus interface means have received no related time from a clock belonging to a higher precision class and whereby the time of said clock is updated when receiving said broadcast time information.

Advantageous additional embodiments of the inventive apparatus are resulting from the respective dependent claim.

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Drawing

Preferred embodiments of the invention are described with reference to the accompanying drawing, which shows in:

Fig. 1 .

Preferred embodiments

In a real system there is some delay in datagram distribution (routers, time for medium access). This delay may vary considerably over the time. For this reason every clock should reset its internal time only in case of major and/or repeated differences to the time received. But this can be left to the designer of the clock - nevertheless the choice should be made keeping in mind the time difference between broadcasts of different precision classes, so that it is guaranteed that every clock will be overwritten, at least on the long term, by broadcasts of higher precision classes.

The distribution of time in the described manner is not limited to the time of day. E.g. the date may be distributed with the time in every time period, or could be distributed only on longer periods, but only by the device which succeeded to distribute its time.

A internal clock CLK continuously distributes the local time inside a device (coffee machine, cooker, dish washer, washing machine, heating system, air conditioner, FM receiver, TV set, VCR). A bus interface unit BIU receives time information RXVE from a bus. Time information TXMIT is sent to the bus only when the controlled switch CSW1 is closed. This switch is controlled by a delaying block DBL which interrupts time transmission during a certain time period after each reception of time information (and possibly allows transmission only at fixed intervals corresponding to the internal time).

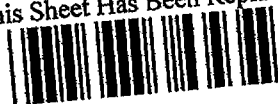
Incoming time information RXVE is allowed to set the internal clock CLK only when a second controlled switch CSW2 is closed. This switch may be closed continuously in a simple embodiment,

or can be controlled by a digital filter circuit FI which compares the internal (output of CLK) and the received time and allows updating only when a significant difference over a certain period is detected.

Supplementary blocks D1, D2 compensating the delay of time distribution within the network may be included.

Advantageously, in a bus system with more than one real time clock initial synchronisation will be achieved without user intervention (if at least one of the clocks is initialised). Synchronisation will be kept, while highest precision clocks take priority over lower precision ones. Even if the controlling clock fails, the next lower priority clock will automatically take over the task of controlling the system. Updating is still possible by manual intervention from any point of the system. Bus traffic is kept low.

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Claims

1. Method for synchronising clocks (CLK) being connected to a network system, characterised in:
 - said clocks may belong to different precision classes;
 - the time of every clock is broadcast (TXMIT) within said network system after expiry of a pre-selected time period, whereby a higher of said precision classes is associated with a shorter time period and time period counting means are related to each of said clocks;
 - every clock which receives said broadcast (RXVE) updates its time and the related time period counting means are reset.
2. Method according to claim 1, characterised in that every clock (CLK) receiving a time broadcast of any precision class does not broadcast its time within a further time period which is higher than said pre-selected time period.
3. Method for synchronising clocks (CLK) being connected to a network system, characterised in:
 - said clocks may belong to different precision classes;
 - the time of every clock is broadcast (TXMIT) within said network system having a pre-selected phase, which is related to said precision class in such a way that the broadcast time related to a higher of said precision classes is earlier, and having a pre-selected broadcast time period, which is independent of said precision class;
 - the time of a specific clock is broadcast only, when the clock has received no related time from a clock belonging to a higher precision class;
 - every clock which receives said broadcast (RXVE) updates its time.
4. Method according to claim 3, characterised in that every clock (CLK) receiving a time broadcast of the same or higher precision class does not broadcast its time within a further time period which is higher than said pre-selected time period.

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5. Method according to any of claims 1 to 4, **characterised in** that said further time period is a random or pseudo-random value, depending on some internal state of a device to which the clock (CLK) belongs and depending not only on the present time, whereby these values are changed periodically or after each time broadcast.
6. Method according to any of claims 1 to 5, **characterised in** that said time is broadcast (TXMIT) only to a part of the clocks belonging to said network system.
7. Method according to any of claims 1 to 6, **characterised in** that said pre-selected time period is a factorial period of a minute.
8. Method according to any of claims 1 to 7, **characterised in** that in case tuners related to said clocks (CLK) receive the time of different time zones, one of said zone times is selected for broadcasting within said network system.
9. Method according to any of claims 1 to 8, **characterised in** that when evaluating the internal time of a clock (CLK) and the time broadcast within said network system the delay of time distribution within said network system is compensated using appropriate delay means (D1, D2).
- 10 Method according to any of claims 1 to 9, **characterised in** that digital filter means (FI) compare the internal time of a clock (CLK) and the time (RXVE) broadcast within said network system and allow (CSW2) updating only when a difference exceeding a pre-selected threshold over a pre-selected observation period is detected.
- 11 Apparatus for synchronising clocks being connected to a network system, related to a method according to any of claims 1 to 10 and including:
 - a clock (CLK) which may belong to different precision classes;





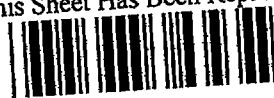
- bus interface means (BUI) which broadcast (TXMIT) the time of said clock within said network system after expiry of a pre-selected time period, which is related to said precision class in such a way that a higher of said precision classes is associated with a shorter time period, whereby time period counting means are related to said clock;
 - interrupt means (DBL, CSW1) which interrupt time transmission from said clock to said bus interface means during a certain time period after each reception of time information (RXVE) by said bus interface means, whereby the time of said clock is broadcast only, when the bus interface means have received no related time from a clock belonging to a higher precision class and whereby the time of said clock is updated when receiving said broadcast time information (RXVE) and said time period counting means are reset.
- 12 Apparatus for synchronising clocks being connected to a network system, related to a method according to any of claims 1 to 10 and including:
- a clock (CLK) which may belong to different precision classes;
 - bus interface means (BUI) which broadcast (TXMIT) the time of said clock within said network system having a pre-selected phase, which is related to said precision class in such a way that the broadcast time related to a higher of said precision classes is earlier, and having a pre-selected broadcast time period, which is independent of said precision class;
 - interrupt means (DBL, CSW1) which interrupt time transmission from said clock to said bus interface means during a certain time period after each reception of time information (RXVE) by said bus interface means, whereby the time of said clock is broadcast only, when the bus interface means have received no related time from a clock belonging to a higher precision class and whereby the time of said clock is updated when receiving said broadcast time information (RXVE).
- 13 Apparatus according to claim 11 or 12, characterised in that digital filter means (FI) compare the internal time of said clock (CLK) and the time (RXVE) broadcast within said network





system and allow updating of the clock time only when a difference exceeding a pre-selected threshold over a pre-selected observation period is detected.

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Abstract

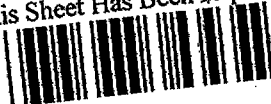
Many devices (in particular white goods or brown goods) in a household may contain a clock. Some systems allow to connect all these devices and the related clocks to a common bus or network. The commands for controlling the clocks are in general limited to reading or writing a given time or to broadcasting the time of a given clock to one dedicated device or to the entire system or to a part of the system. In such known systems it is not specified in which manner a clock should react if it receives the time broadcast by another clock. It is possible to initialise all clocks to a given time but due to tolerances in the different clocks, so achieved synchronisation will not be maintained. Regular broadcasting by a special device 'master clock' has the disadvantage of introducing one device with different capabilities. In case there are several master clocks, conflicts may occur and the advantages of a high precision clock will fade away if a lower precision master clock overrides it.

One solution is, that only the clock with the highest precision broadcasts its time to the system, but whenever it fails the next lower precision clock takes over the broadcasting automatically. The broadcast periods are defined as factorial periods of a preselected time period.

Another possibility is, that all devices will broadcast the time with an equal period but with a different phase and only if no broadcast was received in the preceding time period.

Fig.1

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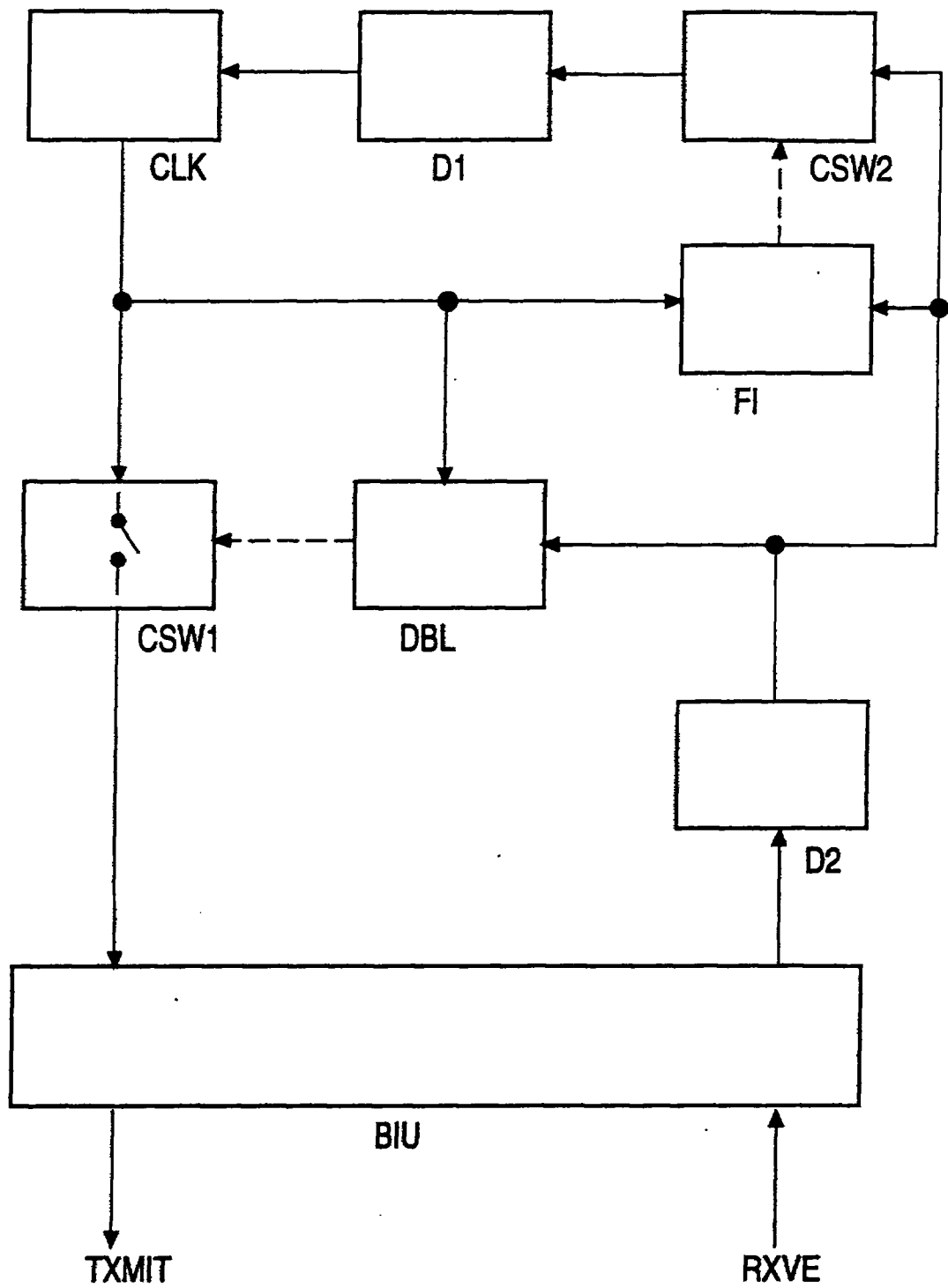


Fig.1

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~~Method and apparatus for synchronising clocks being connected to~~

a network system

The present invention relates to a method and to an apparatus for synchronising clocks being connected to a network system.

Background

Many devices (in particular white goods or brown goods) in a household may contain a clock. Some systems allow to connect all these devices and the related clocks to a common bus or network. The commands for controlling the clocks are in general limited to reading or writing a given time or to broadcasting the time of a given clock to one dedicated device or to the entire system or to a part of the system.

An example home bus system is described in Esprit Home Systems Specification 1.1, ESPRIT project 6782.

In such known systems it is not specified in which manner a clock should react if it receives the time broadcast by another clock. So, it is possible to initialise all clocks to a given time (e.g. by a user action, which creates a 'write time' broadcast to the entire system), but due to tolerances in the different clocks, so achieved synchronisation will not be maintained. Regular broadcasting by a special device 'master clock' has the disadvantage of introducing one device with different capabilities. In case there are several master clocks, conflicts may occur and the advantages of a high precision clock will fade away if a lower precision master clock overrides it.

Invention

It is one object of the invention to guarantee initial synchronisation and keeping of synchronisation between real time clocks in a bus connecting distributed devices. This object is reached by the methods disclosed in claims 1 and 3.

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It is a further object of the invention to disclose an apparatus which utilises the inventive method. This object is reached by the apparatus disclosed in claims 11 and 12.

A good synchronising system should care about the precision of different clock types:

- non initialised
- display only, no timer included
- battery driven low precision
- 50Hz driven
- quartz driven
- official time distributed via radio (for a specific time zone)
- user intervention

This list can be interpreted as a list of priorities, user intervention having the highest. Higher priority clocks should set the time of lower priority clocks (in case there are tuners in the system which receive the time from different time zones, it is supposed that only the time of one time zone will be transmitted to the rest of the system).

The first proposal for solving the problem is as follows:

- every clock broadcasts (datagram distribution) its time periodically
- the broadcast period is dependent on the precision (higher precision leads to a shorter period)
- every clock which receives a broadcast updates its time
- every clock which receives a broadcast resets its counter of the broadcast period
- user intervention initiates an immediate broadcast

In this manner only the clock with the highest precision broadcasts its time to the system, but whenever it fails the next lower precision clock takes over the broadcasting automatically. The broadcast periods are defined as factorial periods of a preselected time period, e.g. a minute (e.g. 5, 6, 12, 15, 20, 30, 60 seconds), and are synchronised to the preselected time unit.



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Then, all clocks displaying hours (hh) and minutes (mm) only will receive their time with no extra cost.

Another proposal is, that all devices will broadcast the time with an equal period (say one minute), but with a different phase (in seconds, e.g. highest precision clock at hh:mm:50, next lower precision clock at hh:mm:52, etc.; or highest precision clock at hh:mm:00, next lower precision clock at hh:mm:02, etc.), but only if no broadcast was received in the preceding time period. In the latter case, traffic on the network is independent of the precision of the different clocks. The displays are either slightly out of time or will need internal second counting capability.

In both proposals, time broadcasting may be done to the entire system or to a group, or subgroup, of clocks only.

A disadvantage of the both above described kinds of synchronising is that the risk of collisions between two devices of equal precision is enhanced (causing higher traffic on the network), at least on media without collision avoidance (e.g. current carrier transmission on power lines), or if repetition is handled in the lower protocol layers only.

According to the invention, there are two proposals:

Phase of transmission depends on precision

- every clock receiving a time broadcast of the same or higher precision class does not broadcast for a certain amount of time (e.g. N minutes). The precision class of the broadcaster can be easily derived from the phase of the time broadcast (e.g. seconds count).
- this amount of time (e.g. N minutes) is a random or pseudo-random value, depending on some internal state of the instance of this device (and not only on the present time). Two possibilities: these values may be changed periodically or after each transmission.

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Frequency of transmission depends on precision

- every clock receiving a time broadcast of any precision class does not broadcast for a certain amount of time (e.g. N minutes).
- this amount of time (e.g. N minutes) is a random or pseudo-random value, it depends a.o. on the precision of this clock, so that higher precision clocks will wait (in average) for a shorter time.

In principle, the inventive method is suited for synchronising clocks being connected to a network system, whereby:

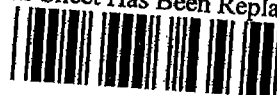
- said clocks may belong to different precision classes;
- the time of every clock is broadcast within said network system after expiry of a pre-selected time period, whereby a higher of said precision classes is associated with a shorter time period and time period counting means are related to each of said clocks;
- every clock which receives said broadcast updates its time and the related time period counting means are reset,

or whereby:

- said clocks may belong to different precision classes;
- the time of every clock is broadcast within said network system having a pre-selected phase, which is related to said precision class in such a way that the broadcast time related to a higher of said precision classes is earlier, and having a pre-selected broadcast time period, which is independent of said precision class;
- the time of a specific clock is broadcast only, when the clock has received no related time from a clock belonging to a higher precision class;
- every clock which receives said broadcast updates its time.

Advantageous additional embodiments of the inventive method are resulting from the respective dependent claims.

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In principle the inventive apparatus for synchronising clocks being connected to a network system is related to a method according to any of claims 1 to 10 and includes:

- a clock which may belong to different precision classes;
- bus interface means which broadcast the time of said clock within said network system after expiry of a pre-selected time period, which is related to said precision class in such a way that a higher of said precision classes is associated with a shorter time period, whereby time period counting means are related to said clock;
- interrupt means which interrupt time transmission from said clock to said bus interface means during a certain time period after each reception of time information by said bus interface means, whereby the time of said clock is broadcast only, when the bus interface means have received no related time from a clock belonging to a higher precision class and whereby the time of said clock is updated when receiving said broadcast time information and said time period counting means are reset,

or includes:

- a clock which may belong to different precision classes;
- bus interface means which broadcast the time of said clock within said network system having a pre-selected phase, which is related to said precision class in such a way that the broadcast time related to a higher of said precision classes is earlier, and having a pre-selected broadcast time period, which is independent of said precision class;
- interrupt means which interrupt time transmission from said clock to said bus interface means during a certain time period after each reception of time information by said bus interface means, whereby the time of said clock is broadcast only, when the bus interface means have received no related time from a clock belonging to a higher precision class and whereby the time of said clock is updated when receiving said broadcast time information.

Advantageous additional embodiments of the inventive apparatus are resulting from the respective dependent claim.

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Drawing

Preferred embodiments of the invention are described with reference to the accompanying drawing, which shows in:

Fig. 1 .

Preferred embodiments

In a real system there is some delay in datagram distribution (routers, time for medium access). This delay may vary considerably over the time. For this reason every clock should reset its internal time only in case of major and/or repeated differences to the time received. But this can be left to the designer of the clock - nevertheless the choice should be made keeping in mind the time difference between broadcasts of different precision classes, so that it is guaranteed that every clock will be overwritten, at least on the long term, by broadcasts of higher precision classes.

The distribution of time in the described manner is not limited to the time of day. E.g. the date may be distributed with the time in every time period, or could be distributed only on longer periods, but only by the device which succeeded to distribute its time.

A internal clock CLK continuously distributes the local time inside a device (coffee machine, cooker, dish washer, washing machine, heating system, air conditioner, FM receiver, TV set, VCR). A bus interface unit BIU receives time information RXVE from a bus. Time information TXMIT is sent to the bus only when the controlled switch CSW1 is closed. This switch is controlled by a delaying block DBL which interrupts time transmission during a certain time period after each reception of time information (and possibly allows transmission only at fixed intervals corresponding to the internal time).

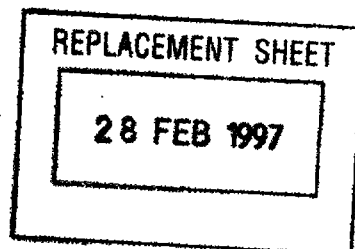
Incoming time information RXVE is allowed to set the internal clock CLK only when a second controlled switch CSW2 is closed. This switch may be closed continuously in a simple embodiment,



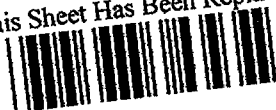
or can be controlled by a digital filter circuit FI which compares the internal (output of CLK) and the received time and allows updating only when a significant difference over a certain period is detected.

Supplementary blocks D1, D2 compensating the delay of time distribution within the network may be included.

Advantageously, in a bus system with more than one real time clock initial synchronisation will be achieved without user intervention (if at least one of the clocks is initialised). Synchronisation will be kept, while highest precision clocks take priority over lower precision ones. Even if the controlling clock fails, the next lower priority clock will automatically take over the task of controlling the system. Updating is still possible by manual intervention from any point of the system. Bus traffic is kept low.



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Claims

1. Method for synchronising clocks (CLK) being connected to a network system, characterised in:
 - said clocks may belong to different precision classes;
 - the time of every clock is broadcast (TXMIT) within said network system after expiry of a pre-selected time period, whereby a higher of said precision classes is associated with a shorter time period and time period counting means are related to each of said clocks;
 - every clock which receives said broadcast (RXVE) updates its time and the related time period counting means are reset.
2. Method according to claim 1, characterised in that every clock (CLK) receiving a time broadcast of any precision class does not broadcast its time within a further time period which is higher than said pre-selected time period.
3. Method for synchronising clocks (CLK) being connected to a network system, characterised in:
 - said clocks may belong to different precision classes;
 - the time of every clock is broadcast (TXMIT) within said network system having a pre-selected phase, which is related to said precision class in such a way that the broadcast time related to a higher of said precision classes is earlier, and having a pre-selected broadcast time period, which is independent of said precision class;
 - the time of a specific clock is broadcast only, when the clock has received no related time from a clock belonging to a higher precision class;
 - every clock which receives said broadcast (RXVE) updates its time.
4. Method according to claim 3, characterised in that every clock (CLK) receiving a time broadcast of the same or higher precision class does not broadcast its time within a further time period which is higher than said pre-selected time period.

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5. Method according to any of claims 1 to 4, characterised in that said further time period is a random or pseudo-random value, depending on some internal state of a device to which the clock (CLK) belongs and depending not only on the present time, whereby these values are changed periodically or after each time broadcast.
6. Method according to any of claims 1 to 5, characterised in that said time is broadcast (TXMIT) only to a part of the clocks belonging to said network system.
7. Method according to any of claims 1 to 6, characterised in that said pre-selected time period is a factorial period of a minute.
8. Method according to any of claims 1 to 7, characterised in that in case tuners related to said clocks (CLK) receive the time of different time zones, one of said zone times is selected for broadcasting within said network system.
9. Method according to any of claims 1 to 8, characterised in that when evaluating the internal time of a clock (CLK) and the time broadcast within said network system the delay of time distribution within said network system is compensated using appropriate delay means (D1, D2).
- 10 Method according to any of claims 1 to 9, characterised in that digital filter means (FI) compare the internal time of a clock (CLK) and the time (RXVE) broadcast within said network system and allow (CSW2) updating only when a difference exceeding a pre-selected threshold over a pre-selected observation period is detected.
- 11 Apparatus for synchronising clocks being connected to a network system, related to a method according to any of claims 1 to 10 and including:
a clock (CLK) which may belong to different precision classes;

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- bus interface means (BUI) which broadcast (TXMIT) the time of said clock within said network system after expiry of a pre-selected time period, which is related to said precision class in such a way that a higher of said precision classes is associated with a shorter time period, whereby time period counting means are related to said clock;
- interrupt means (DBL, CSW1) which interrupt time transmission from said clock to said bus interface means during a certain time period after each reception of time information (RXVE) by said bus interface means, whereby the time of said clock is broadcast only, when the bus interface means have received no related time from a clock belonging to a higher precision class and whereby the time of said clock is updated when receiving said broadcast time information (RXVE) and said time period counting means are reset.

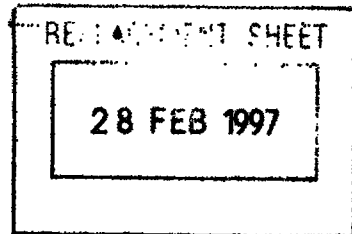
12 Apparatus for synchronising clocks being connected to a network system, related to a method according to any of claims 1 to 10 and including:

- a clock (CLK) which may belong to different precision classes;
- bus interface means (BUI) which broadcast (TXMIT) the time of said clock within said network system having a pre-selected phase, which is related to said precision class in such a way that the broadcast time related to a higher of said precision classes is earlier, and having a pre-selected broadcast time period, which is independent of said precision class;
- interrupt means (DBL, CSW1) which interrupt time transmission from said clock to said bus interface means during a certain time period after each reception of time information (RXVE) by said bus interface means, whereby the time of said clock is broadcast only, when the bus interface means have received no related time from a clock belonging to a higher precision class and whereby the time of said clock is updated when receiving said broadcast time information (RXVE).

13 Apparatus according to claim 11 or 12, characterised in that digital filter means (FI) compare the internal time of said clock (CLK) and the time (RXVE) broadcast within said network

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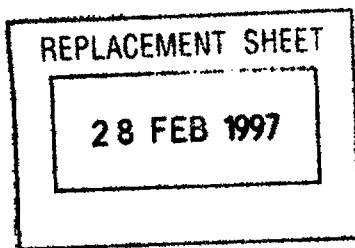
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system and allow updating of the clock time only when a difference exceeding a pre-selected threshold over a pre-selected observation period is detected.

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ABSTRACT OF THE DISCLOSURE

METHOD AND APPARATUS FOR SYNCHRONISING CLOCKS BEING CONNECTED
TO A NETWORK SYSTEM

Many devices (in particular white goods or brown goods) in a household may contain a clock. Some systems allow to connect all these devices and the related clocks to a common bus or network. The commands for controlling the clocks are in general limited to reading or writing a given time or to broadcasting the time of a given clock to one dedicated device or to the entire system or to a part of the system. In such known systems it is not specified in which manner a clock should react if it receives the time broadcast by another clock. It is possible to initialise all clocks to a given time but due to tolerances in the different clocks, so achieved synchronisation will not be maintained. Regular broadcasting by a special device 'master clock' has the disadvantage of introducing one device with different capabilities. In case there are several master clocks, conflicts may occur and the advantages of a high precision clock will fade away if a lower precision master clock overrides it.

One solution is, that only the clock with the highest precision broadcasts its time to the system, but whenever it fails the next lower precision clock takes over the broadcasting automatically. The broadcast periods are defined as factorial periods of a preselected time period.

Another possibility is, that all devices will broadcast the time with an equal period but with a different phase and only if no broadcast was received in the preceding time period.

Fig. 1

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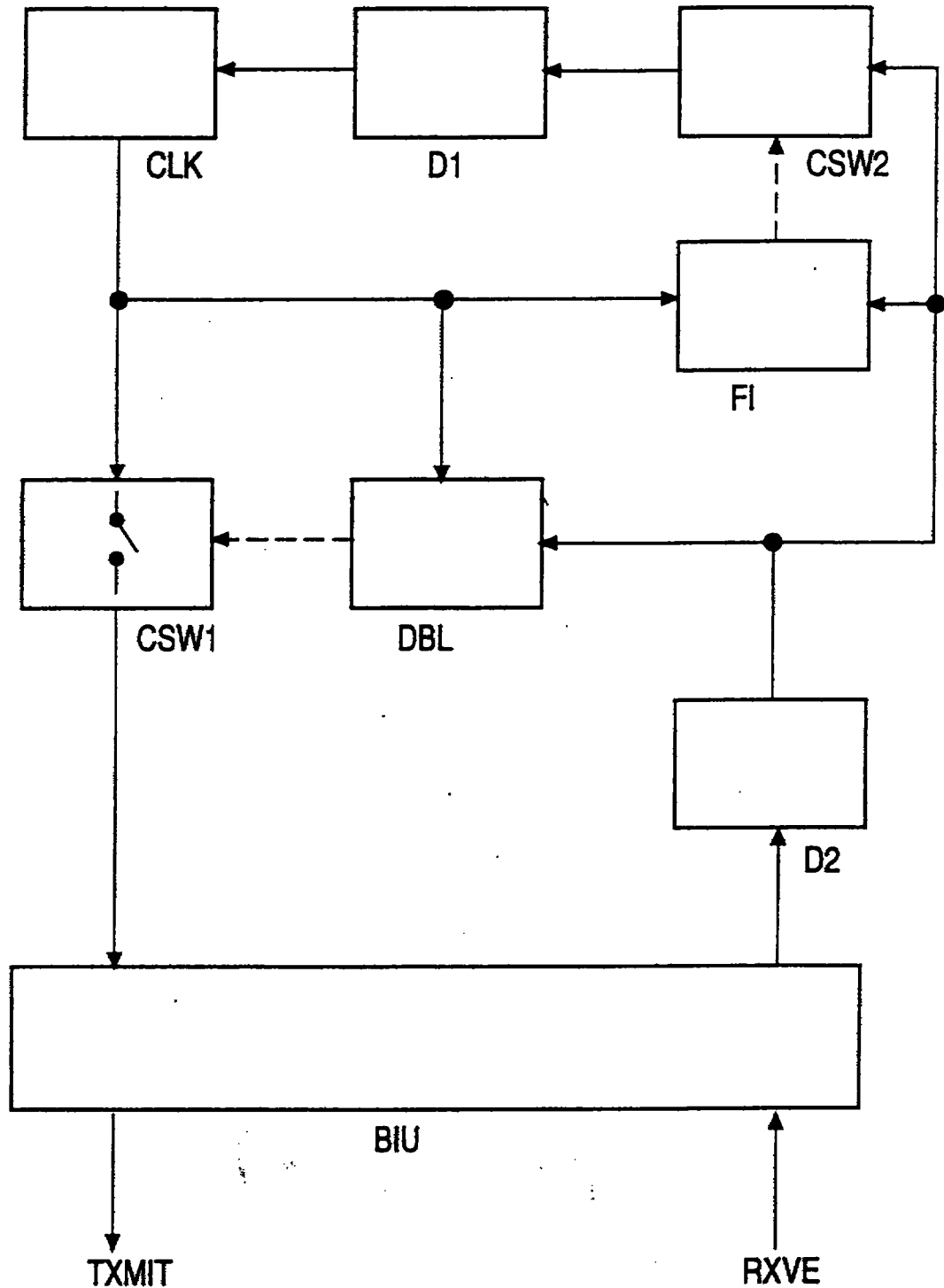


Fig.1

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Method and Apparatus for synchronising clocks being connected to a network system

The present invention relates to a method and to an apparatus for synchronising clocks being connected to a network system.

Background

Many devices (in particular white goods or brown goods) in a household may contain a clock. Some systems allow to connect all these devices and the related clocks to a common bus or network. The commands for controlling the clocks are in general limited to reading or writing a given time or to broadcasting the time of a given clock to one dedicated device or to the entire system or to a part of the system. An example home bus system is described in Esprit Home Systems Specification 1.1, ESPRIT project 6782.

In such known systems it is not specified in which manner a clock should react if it receives the time broadcast by another clock. So, it is possible to initialise all clocks to a given time (e.g. by a user action, which creates a 'write time' broadcast to the entire system), but due to tolerances in the different clocks, so achieved synchronisation will not be maintained. Regular broadcasting by a special device 'master clock' has the disadvantage of introducing one device with different capabilities. In case there are several master clocks, conflicts may occur and the advantages of a high precision clock will fade away if a lower precision master clock overrides it.

From EP-A-0 548 381 a method for synchronising clocks in hierarchically subdivided computer networks is known.

There is one high precision clock provided in a computer which is positioned at the highest hierarchical level. This clock is the master clock of the system and synchronises all clocks at the next lower hierarchical level by sending

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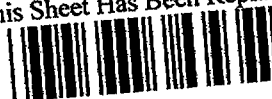
timestamps. The clocks at the second lower hierarchical level are synchronised by timestamps which are broadcast by a sub-master clock of the next higher level. Therefore, not all clocks in the system are synchronised by identical time stamp messages.

In GB-A-2 022 881 a programmed digital secondary clock is disclosed, which is arranged to function as a master clock, a sub-master clock or a slave clock. It is revealed, that the programmed digital secondary clock will be used in a system where identical units are connected in daisy chain to provide a continuously updated real time count at remote locations such as in an airport, hospital, school, etc.. Each unit sends its updated real time count in serial data format to the next unit of the daisy chain. Each unit acting as a slave clock checks whether there is a malfunction at the previous master clock and starts operating as a master clock when a malfunction is detected.

Invention

It is one object of the invention to guarantee initial synchronisation and keeping of synchronisation between real time clocks in a bus connecting distributed devices. This object is reached by the methods disclosed in claims 1 and 3.

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It is a further object of the invention to disclose an apparatus which utilises the inventive method. This object is reached by the apparatus disclosed in claims 11 and 12.

A good synchronising system should care about the precision of different clock types:

- non initialised
- display only, no timer included
- battery driven low precision
- 50Hz driven
- quartz driven
- official time distributed via radio (for a specific time zone)
- user intervention

This list can be interpreted as a list of priorities, user intervention having the highest. Higher priority clocks should set the time of lower priority clocks (in case there are tuners in the system which receive the time from different time zones, it is supposed that only the time of one time zone will be transmitted to the rest of the system).

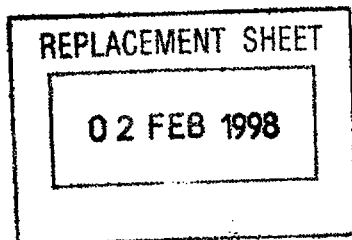
The first proposal for solving the problem is as follows:

- every clock broadcasts (datagram distribution) its time periodically
- the broadcast period is dependent on the precision (higher precision leads to a shorter period)
- every clock which receives a broadcast updates its time
- every clock which receives a broadcast resets its counter of the broadcast period
- user intervention initiates an immediate broadcast

In this manner only the clock with the highest precision broadcasts its time to the system, but whenever it fails the next lower precision clock takes over the broadcasting automatically. The broadcast periods are defined as factorial periods of a preselected time period, e.g. a minute (e.g. 5, 6, 12, 15, 20, 30, 60 seconds), and are synchronised to the preselected time unit.

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Then, all clocks displaying hours (hh) and minutes (mm) only will receive their time with no extra cost.

Another proposal is, that all devices will broadcast the time with an equal period (say one minute), but with a different phase (in seconds, e.g. highest precision clock at hh:mm:50, next lower precision clock at hh:mm:52, etc.; or highest precision clock at hh:mm:00, next lower precision clock at hh:mm:02, etc.), but only if no broadcast was received in the preceding time period. In the latter case, traffic on the network is independent of the precision of the different clocks. The displays are either slightly out of time or will need internal second counting capability.

In both proposals, time broadcasting may be done to the entire system or to a group, or subgroup, of clocks only.

A disadvantage of the both above described kinds of synchronising is that the risk of collisions between two devices of equal precision is enhanced (causing higher traffic on the network), at least on media without collision avoidance (e.g. current carrier transmission on power lines), or if repetition is handled in the lower protocol layers only.

According to the invention, there are two proposals:

Phase of transmission depends on precision

- every clock receiving a time broadcast of the same or higher precision class does not broadcast for a certain amount of time (e.g. N minutes). The precision class of the broadcaster can be easily derived from the phase of the time broadcast (e.g. seconds count).
- this amount of time (e.g. N minutes) is a random or pseudo-random value, depending on some internal state of the instance of this device (and not only on the present time). Two possibilities: these values may be changed periodically or after each transmission.

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Frequency of transmission depends on precision

- every clock receiving a time broadcast of any precision class does not broadcast for a certain amount of time (e.g. N minutes).
- this amount of time (e.g. N minutes) is a random or pseudo-random value, it depends a.o. on the precision of this clock, so that higher precision clocks will wait (in average) for a shorter time.

In principle, the inventive method is suited for synchronising clocks being connected to a network system, whereby:

- said clocks may belong to different precision classes;
- the time of every clock is broadcast within said network system after expiry of a pre-selected time period, whereby a higher of said precision classes is associated with a shorter time period and time period counting means are related to each of said clocks;
- every clock which receives said broadcast updates its time and the related time period counting means are reset,

or whereby:

- said clocks may belong to different precision classes;
- the time of every clock is broadcast within said network system having a pre-selected phase, which is related to said precision class in such a way that the broadcast time related to a higher of said precision classes is earlier, and having a pre-selected broadcast time period, which is independent of said precision class;
- the time of a specific clock is broadcast only, when the clock has received no related time from a clock belonging to a higher precision class;
- every clock which receives said broadcast updates its time.

Advantageous additional embodiments of the inventive method are resulting from the respective dependent claims.

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In principle the inventive apparatus for synchronising clocks being connected to a network system is related to a method according to any of claims 1 to 10 and includes:

- a clock which may belong to different precision classes;
- bus interface means which broadcast the time of said clock within said network system after expiry of a pre-selected time period, which is related to said precision class in such a way that a higher of said precision classes is associated with a shorter time period, whereby time period counting means are related to said clock;
- interrupt means which interrupt time transmission from said clock to said bus interface means during a certain time period after each reception of time information by said bus interface means, whereby the time of said clock is broadcast only, when the bus interface means have received no related time from a clock belonging to a higher precision class and whereby the time of said clock is updated when receiving said broadcast time information and said time period counting means are reset,

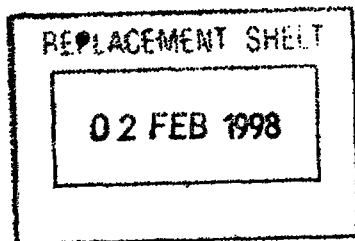
or includes:

- a clock which may belong to different precision classes;
- bus interface means which broadcast the time of said clock within said network system having a pre-selected phase, which is related to said precision class in such a way that the broadcast time related to a higher of said precision classes is earlier, and having a pre-selected broadcast time period, which is independent of said precision class;
- interrupt means which interrupt time transmission from said clock to said bus interface means during a certain time period after each reception of time information by said bus interface means, whereby the time of said clock is broadcast only, when the bus interface means have received no related time from a clock belonging to a higher precision class and whereby the time of said clock is updated when receiving said broadcast time information.

Advantageous additional embodiments of the inventive apparatus are resulting from the respective dependent claim.

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Drawing

Preferred embodiments of the invention are described with reference to the accompanying drawing, which shows in:

Fig. 1

Preferred embodiments

In a real system there is some delay in datagram distribution (routers, time for medium access). This delay may vary considerably over the time. For this reason every clock should reset its internal time only in case of major and/or repeated differences to the time received. But this can be left to the designer of the clock - nevertheless the choice should be made keeping in mind the time difference between broadcasts of different precision classes, so that it is guaranteed that every clock will be overwritten, at least on the long term, by broadcasts of higher precision classes.

The distribution of time in the described manner is not limited to the time of day. E.g. the date may be distributed with the time in every time period, or could be distributed only on longer periods, but only by the device which succeeded to distribute its time.

A internal clock CLK continuously distributes the local time inside a device (coffee machine, cooker, dish washer, washing machine, heating system, air conditioner, FM receiver, TV set, VCR). A bus interface unit BIU receives time information RXVE from a bus. Time information TXMIT is sent to the bus only when the controlled switch CSW1 is closed. This switch is controlled by a delaying block DBL which interrupts time transmission during a certain time period after each reception of time information (and possibly allows transmission only at fixed intervals corresponding to the internal time).

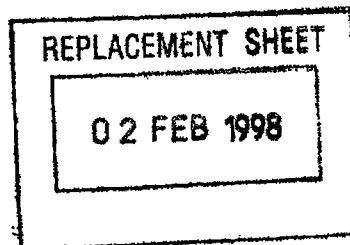
Incoming time information RXVE is allowed to set the internal clock CLK only when a second controlled switch CSW2 is closed. This switch may be closed continuously in a simple embodiment,



or can be controlled by a digital filter circuit FI which compares the internal (output of CLK) and the received time and allows updating only when a significant difference over a certain period is detected.

Supplementary blocks D1, D2 compensating the delay of time distribution within the network may be included.

Advantageously, in a bus system with more than one real time clock initial synchronisation will be achieved without user intervention (if at least one of the clocks is initialised). Synchronisation will be kept, while highest precision clocks take priority over lower precision ones. Even if the controlling clock fails, the next lower priority clock will automatically take over the task of controlling the system. Updating is still possible by manual intervention from any point of the system. Bus traffic is kept low.



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CLAIMS :

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1. Method for synchronising clocks (CLK) being connected to a network system, characterised by the steps of:
choosing said clocks to belong to different precision classes;
broadcasting the time of every clock (TXMIT) within said network system after expiry of a pre-selected time period, whereby a higher of said precision classes is associated with a shorter time period and time period counting means are related to each of said clocks, whereby within these steps every clock which receives said broadcast (RXCE) updates its time and the related time period counting means are reset.
2. Method according to claim 1, characterised in that every clock (CLK) receiving a time broadcast of any precision class does not broadcast its time within a further time period which is higher than said pre-selected time period.
3. Method for synchronising clocks (CLK) being connected to a network system, characterised by the steps of:
choosing said clocks to belong to different precision classes;
broadcasting the time of every clock (TXMIT) within said network system having a pre-selected phase, which is related to said precision class in such a way that the broadcast time related to a higher of said precision classes is earlier, and having a pre-selected broadcast time period, which is independent of said precision class;
broadcasting the time of a specific clock only, when the clock has received no related time from a clock belonging to a higher precision class;
whereby within these steps every clock which receives said broadcast (RXVE) updates its time.
4. Method according to claim 3, characterised in that every clock (CLK) receiving a time broadcast of the same or higher precision class does not broadcast its time within a further time period which is higher than said pre-selected time period.



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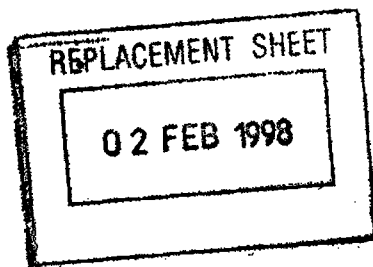


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5. Method according to any of claims 1 to 4, characterised in that said further time period is a random or pseudo-random value, depending on some internal state of a device to which the clock (CLK) belongs and depending not only on the present time, whereby these values are changed periodically or after each time broadcast.
6. Method according to any of claims 1 to 5, characterised in that said time is broadcast (TXMIT) only to a part of the clocks belonging to said network system.
7. Method according to any of claims 1 to 6, characterised in that said pre-selected time period is a factorial period of a minute.
8. Method according to any of claims 1 to 7, characterised in that in case tuners related to said clocks (CLK) receive the time of different time zones, one of said zone times is selected for broadcasting within said network system.
9. Method according to any of claims 1 to 8, characterised in that when evaluating the internal time of a clock (CLK) and the time broadcast within said network system the delay of time distribution within said network system is compensated using appropriate delay means (D1, D2).
- 10 Method according to any of claims 1 to 9, characterised in that digital filter means (FI) compare the internal time of a clock (CLK) and the time (RXVE) broadcast within said network system and allow (CSW2) updating only when a difference exceeding a pre-selected threshold over a pre-selected observation period is detected.
11. Apparatus for synchronising clocks being connected to a network system, according to the method of any of claims 1, 2 and 5 to 10 and including:
a clock (CLK) which belongs to one precision class out of a plurality of different precision classes;

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bus interface means (BUI) which are capable to broadcast (TXMIT) the time of said clock within said network system after expiry of a pre-selected time period, which is related to said one precision classe in such a way that a higher of said precision classes is associated with a shorter time period, whereby time period counting means are related to said clock;

interrupt means (DBL, CSWI) which are capable to interrupt time transmission from said clock to said bus interface means during a certain time period after each reception of time information (RXVE) by said bus interface means, whereby the time of said clock is broadcast only, when the bus interface means have received no related time from a clock belonging to a higher precision class and whereby the time of said clock is updated when receiving said broadcast time information (RXVE) and said time period counting means are reset.

12. Apparatus for synchronising clocks being connected to a network system, according to the method of any of claims 3 to 10 and including:

a clock (CLK) which belongs to one precision class out of a plurality of different precision classes;

bus interface means (BUI) which are capable to broadcast (TXMIT) the time of said clock within said network system having a pre-selected phase, which is related to said one precision class in such a way that the broadcast time related to a higher of said precision classes is earlier, and having a pre-selected broadcast time period, which is independent of said precision class;

interrupt means (DBL, CSWI) which are capable to interrupt time transmission from said clock to said bus interface means during a certain time period after each reception of time information (RXVE) by said bus interface means, whereby the time of said clock is broadcast only, when the bus interface means have received no related time from a clock belonging to a higher precision class and

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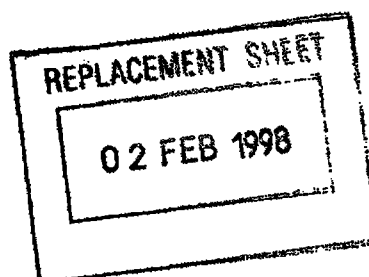




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whereby the time of said clock is updated when receiving said broadcast time information (RXVE).

- 13 Apparatus according to claim 11 or 12, characterised in that digital filter means (FI) compare the internal time of said clock (CLK) and the time (RXVE) broadcast within said network system and allow updating of the clock time only when a difference exceeding a pre-selected threshold over a pre-selected observation period is detected.



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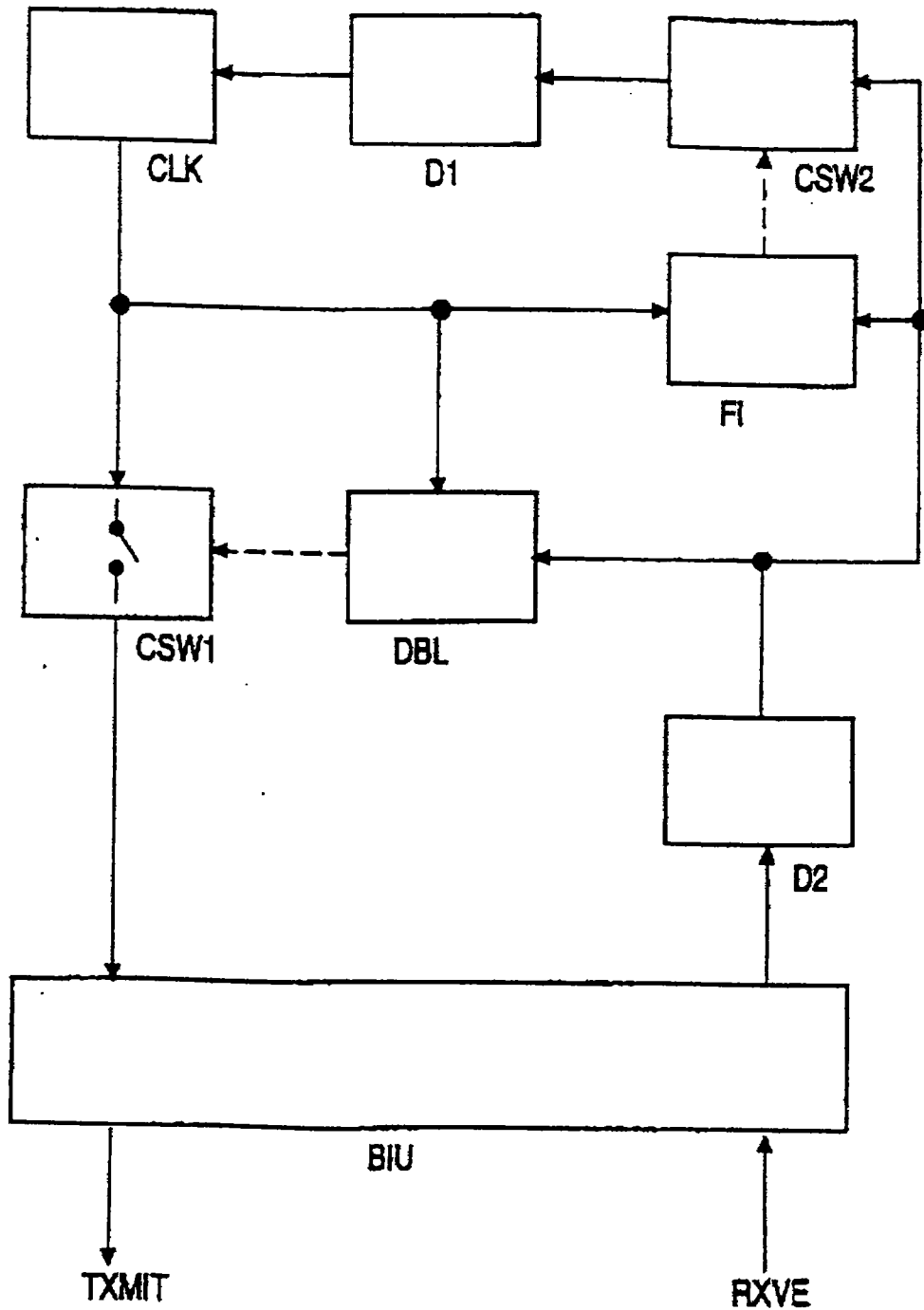


Fig.1

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METHOD AND APPARATUS FOR SYNCHRONISING CLOCKS BEING
CONNECTED TO A NETWORK

Description

The present invention relates to a method and to an apparatus for synchronising clocks being connected to a network system.

Background

Many devices (in particular white goods or brown goods) in a household may contain a clock. Some systems allow to connect all these devices and the related clocks to a common bus or network. The commands for controlling the clocks are in general limited to reading or writing a given time or to broadcasting the time of a given clock to one dedicated device or to the entire system or to a part of the system. An example home bus system is described in Esprit Home Systems Specification 1.1, ESPRIT project 6782. In such known systems it is not specified in which manner a clock should react if it receives the time broadcast by another clock. So, it is possible to initialise all clocks to a given time (e.g. by a user action, which creates a 'write time' broadcast to the entire system), but due to tolerances in the different clocks, so achieved synchronisation will not be maintained. Regular broadcasting by a special device 'master clock' has the disadvantage of introducing one device with different capabilities. In case there are several master clocks, conflicts may occur and the advantages of a high precision clock will fade away if a lower precision master clock overrides it.

From EP-A-0 548 381 a method for synchronising clocks in hierarchically subdivided computer networks is known. There is one high precision clock provided in a computer which is positioned at the highest hierarchical level. This clock is the master clock of the system and synchronises all clocks at the next lower hierarchical level by sending timestamps. The clocks at the second lower hierarchical level are synchronised by times-

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tamps which are broadcast by a sub-master clock of the next higher level. Therefore, not all clocks in the system are synchronised by identical time stamp messages.

In GB-A-2 022 881 a programmed digital secondary clock is disclosed, which is arranged to function as a master clock, a sub-master clock or a slave clock. It is revealed, that the programmed digital secondary clock will be used in a system where identical units are connected in daisy chain to provide a continuously updated real time count at remote locations such as in an airport, hospital, school, etc.. Each unit sends its updated real time count in serial data format to the next unit of the daisy chain. Each unit acting as a slave clock checks whether there is a malfunction at the previous master clock and starts operating as a master clock when a malfunction is detected.

Invention

It is one object of the invention to guarantee initial synchronisation and keeping of synchronisation between real time clocks in a bus connecting distributed devices. This object is reached by the methods disclosed in claims 1 and 3.

It is a further object of the invention to disclose an apparatus which utilises the inventive method. This object is reached by the apparatus disclosed in claims 11 and 12.

A good synchronising system should care about the precision of different clock types:

- non initialisec
- display only, no timer included
- battery driven low precision
- 50Hz driven
- quartz driven
- official time distributed via radio (for a specific time zone)

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- user intervention

This list can be interpreted as a list of priorities, user intervention having the highest. Higher priority clocks should set the time of lower priority clocks (in case there are tuners in the system which receive the time from different time zones, it is supposed that only the time of one time zone will be transmitted to the rest of the system).

The first proposal for solving the problem is as follows:

- every clock broadcasts (datagram distribution) its time periodically
- the broadcast period is dependent on the precision (higher precision leads to a shorter period)
- every clock which receives a broadcast updates its time
- every clock which receives a broadcast resets its counter of the broadcast period
- user intervention initiates an immediate broadcast

In this manner only the clock with the highest precision broadcasts its time to the system, but whenever it fails the next lower precision clock takes over the broadcasting automatically. The broadcast periods are defined as factorial periods of a preselected time period, e.g. a minute (e.g. 5, 6, 12, 15, 20, 30, 60 seconds), and are synchronised to the preselected time unit.

Then, all clocks displaying hours (hh) and minutes (mm) only will receive their time with no extra cost.

Another proposal is, that all devices will broadcast the time with an equal period (say one minute), but with a different phase (in seconds, e.g. highest precision clock at hh:mm:50, next lower precision clock at hh:mm:52, etc.; or highest precision clock at hh:mm:00, next lower precision clock at hh:mm:02, etc.), but only if no broadcast was received in the preceding time period. In the latter case, traffic on the network is independent of the precision of the different clocks. The displays are

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either slightly out of time or will need internal second counting capability.

In both proposals, time broadcasting may be done to the entire system or to a group, or subgroup, of clocks only.

A disadvantage of the both above described kinds of synchronising is that the risk of collisions between two devices of equal precision is enhanced (causing higher traffic on the network), at least on media without collision avoidance (e.g. current carrier transmission on power lines), or if repetition is handled in the lower protocol layers only.

According to the invention, there are two proposals:

Phase of transmission depends on precision

- every clock receiving a time broadcast of the same or higher precision class does not broadcast for a certain amount of time (e.g. N minutes). The precision class of the broadcaster can be easily derived from the phase of the time broadcast (e.g. seconds count).
- this amount of time (e.g. N minutes) is a random or pseudo-random value, depending on some internal state of the instance of this device (and not only on the present time). Two possibilities: these values may be changed periodically or after each transmission.

Frequency of transmission depends on precision

- every clock receiving a time broadcast of any precision class does not broadcast for a certain amount of time (e.g. N minutes).
- this amount of time (e.g. N minutes) is a random or pseudo-random value, it depends a.o. on the precision of this clock, so that higher precision clocks will wait (in average) for a shorter time.

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In principle, the inventive method is suited for synchronising clocks being connected to a network system, whereby:

- said clocks may belong to different precision classes;
- the time of every clock is broadcast within said network system after expiry of a pre-selected time period, whereby a higher of said precision classes is associated with a shorter time period and time period counting means are related to each of said clocks;
- every clock which receives said broadcast updates its time and the related time period counting means are reset,

or whereby:

- said clocks may belong to different precision classes;
- the time of every clock is broadcast within said network system having a pre-selected phase, which is related to said precision class in such a way that the broadcast time related to a higher of said precision classes is earlier, and having a pre-selected broadcast time period, which is independent of said precision class;
- the time of a specific clock is broadcast only, when the clock has received no related time from a clock belonging to a higher precision class;
- every clock which receives said broadcast updates its time.

Advantageous additional embodiments of the inventive method are resulting from the respective dependent claims.

In principle the inventive apparatus for synchronising clocks being connected to a network system is related to a method according to any of claims 1 to 10 and

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or includes:

- a clock which may belong to different precision classes;
- bus interface means which broadcast the time of said clock within said network system having a pre-selected phase, which is related to said precision class in such a way that the broadcast time related to a higher of said precision classes is earlier, and having a pre-selected broadcast time period, which is independent of said precision class;
- interrupt means which interrupt time transmission from said clock to said bus interface means during a certain time period after each reception of time information by said bus interface means, whereby the time of said clock is broadcast only, when the bus interface means have received no related time from a clock belonging to a higher precision class and whereby the time of said clock is updated when receiving said broadcast time information.

Advantageous additional embodiments of the inventive apparatus are resulting from the respective dependent claim.

Drawing

Preferred embodiments of the invention are described with reference to the accompanying drawing, which shows in:

Fig. 1 .

Preferred embodiments

In a real system there is some delay in datagram distribution (routers, time for medium access). This delay may vary considerably over the time. For this reason every clock should reset its internal time only in case of major and/or repeated differences to the time received. But this can be left to the designer of the clock - never-

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theless the choice should be made keeping in mind the time difference between broadcasts of different precision classes, so that it is guaranteed that every clock will be overwritten, at least on the long term, by broadcasts of higher precision classes.

The distribution of time in the described manner is not limited to the time of day. E.g. the date may be distributed with the time in every time period, or could be distributed only on longer periods, but only by the device which succeeded to distribute its time.

A internal clock CLK continuously distributes the local time inside a device (coffee machine, cooker, dish washer, washing machine, heating system, air conditioner, FM receiver, TV set, VCR). A bus interface unit BIU receives time information RXVE from a bus. Time information TXMIT is sent to the bus only when the controlled switch CSW1 is closed. This switch is controlled by a delaying block DBL which interrupts time transmission during a certain time period after each reception of time information (and possibly allows transmission only at fixed intervals corresponding to the internal time). Incoming time information RXVE is allowed to set the internal clock CLK only when a second controlled switch CSW2 is closed. This switch may be closed continuously in a simple embodiment, or can be controlled by a digital filter circuit FI which compares the internal (output of CLK) and the received time and allows updating only when a significant difference over a certain period is detected.

Supplementary blocks D1, D2 compensating the delay of time distribution within the network may be included.

Advantageously, in a bus system with more than one real time clock initial synchronisation will be achieved without user intervention (if at least one of the clocks is initialised). Synchronisation will be kept, while highest precision clocks take priority over lower precision ones. Even if the controlling clock fails, the next lower priority clock will automatically take over the task of controlling the system. Updating is still possible by

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manual intervention from any point of the system. Bus traffic is kept low.

Claims

1. Method for synchronising clocks (CLK) being connected to a network system, characterised by the steps of:

choosing said clocks to belong to different precision classes;

broadcasting the time of every clock (TXMIT) within said network system after expiry of a pre-selected time period, whereby a higher of said precision classes is associated with a shorter time period and time period counting means are related to each of said clocks, whereby within these steps every clock which receives said broadcast (RXCE) updates its time and the related time period counting means are reset.

2. Method according to claim 1, characterised in that every clock (CLK) receiving a time broadcast of any precision class does not broadcast its time within a further time period which is higher than said pre-selected time period.

3. Method for synchronising clocks (CLK) being connected to a network system, characterised by the steps of:

choosing said clocks to belong to different precision classes;

broadcasting the time of every clock (TXMIT) within said network system having a pre-selected phase, which is related to said precision class in such a way that the broadcast time related to a higher of said precision classes is earlier, and having a pre-selected broadcast time

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manual intervention from any point of the system. Bus traffic is kept low.

Claims

1. Method for synchronising clocks (CLK) being connected to a network system, characterised by the steps of:

choosing said clocks to belong to different precision classes;

broadcasting the time of every clock (TXMIT) within said network system after expiry of a pre-selected time period, whereby a higher of said precision classes is associated with a shorter time period and time period counting means are related to each of said clocks, whereby within these steps every clock which receives said broadcast (RXCE) updates its time and the related time period counting means are reset.

2. Method according to claim 1, characterised in that every clock (CLK) receiving a time broadcast of any precision class does not broadcast its time within a further time period which is higher than said pre-selected time period.

3. Method for synchronising clocks (CLK) being connected to a network system, characterised by the steps of:

choosing said clocks to belong to different precision classes;

broadcasting the time of every clock (TXMIT) within said network system having a pre-selected phase, which is related to said precision class in such a way that the broadcast time related to a higher of said precision classes is earlier, and having a pre-selected broadcast time

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period, which is independent of said precision class;

broadcasting the time of a specific clock only, when the clock has received no related time from a clock belonging to a higher precision class;

whereby within these steps every clock which receives said broadcast (RXVE) updates its time.

4. Method according to claim 3, characterised in that every clock (CLK) receiving a time broadcast of the same or higher precision class does not broadcast its time within a further time period which is higher than said pre-selected time period.
5. Method according to any of claims 1 to 4, characterised in that said further time period is a random or pseudo-random value, depending on some internal state of a device to which the clock (CLK) belongs and depending not only on the present time, whereby these values are changed periodically or after each time broadcast.
6. Method according to any of claims 1 to 5, characterised in that said time is broadcast (TXMIT) only to a part of the clocks belonging to said network system.
7. Method according to any of claims 1 to 6, characterised in that said pre-selected time period is a factorial period of a minute.
8. Method according to any of claims 1 to 7, characterised in that in case tuners related to said clocks (CLK) receive the time of different time zones, one of said zone times is selected for broadcasting within said network system.

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9. Method according to any of claims 1 to 8, characterised in that when evaluating the internal time of a clock (CLK) and the time broadcast within said network system the delay of time distribution within said network system is compensated using appropriate delay means (D1, D2).
10. Method according to any of claims 1 to 9, characterised in that digital filter means (FI) compare the internal time of a clock (CLK) and the time (RXVE) broadcast within said network system and allow (CSW2) updating only when a difference exceeding a pre-selected threshold over a pre-selected observation period is detected.
11. Apparatus for synchronising clocks being connected to a network system, according to the method of any of claims 1, 2 and 5 to 10 and including:

a clock (CLK) which belongs to one precision class out of a plurality of different precision classes;

bus interface means (BUI) which are capable to broadcast (TXMIT) the time of said clock within said network system after expiry of a pre-selected time period, which is related to said one precision class in such a way that a higher of said precision classes is associated with a shorter time period, whereby time period counting means are related to said clock;

interrupt means (DBL, CSW1) which are capable to interrupt time transmission from said clock to said bus interface means during a certain time period after each reception of time information (RXVE) by said bus interface means, whereby the time of said clock is broadcast only, when the bus interface means have received no related time from a clock belonging to a higher precision class and whereby the time of said

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clock is updated when receiving said broadcast time information (RXVE) and said time period counting means are reset.

12. Apparatus for synchronising clocks being connected to a network system, according to the method of any of claims 3 to 10 and including:

a clock (CLK) which belongs to one precision class out of a plurality of different precision classes;

bus interface means (BUI) which are capable to broadcast (TXMIT) the time of said clock within said network system having a pre-selected phase, which is related to said one precision class in such a way that the broadcast time related to a higher of said precision classes is earlier, and having a pre-selected broadcast time period, which is independent of said precision class;

interrupt means (DBL, CSW1) which are capable to interrupt time transmission from said clock to said bus interface means during a certain time period after each reception of time information (RXVE) by said bus interface means, whereby the time of said clock is broadcast only, when the bus interface means have received no related time from a clock belonging to a higher precision class and whereby the time of said clock is updated when receiving said broadcast time information (RXVE).

13. Apparatus according to claim 11 or 12, characterised in that digital filter means (FI) compare the internal time of said clock (CLK) and the time (RXVE) broadcast within said network system and allow updating of the clock time only when a difference exceeding a pre-selected threshold over a pre-selected observation period is detected.

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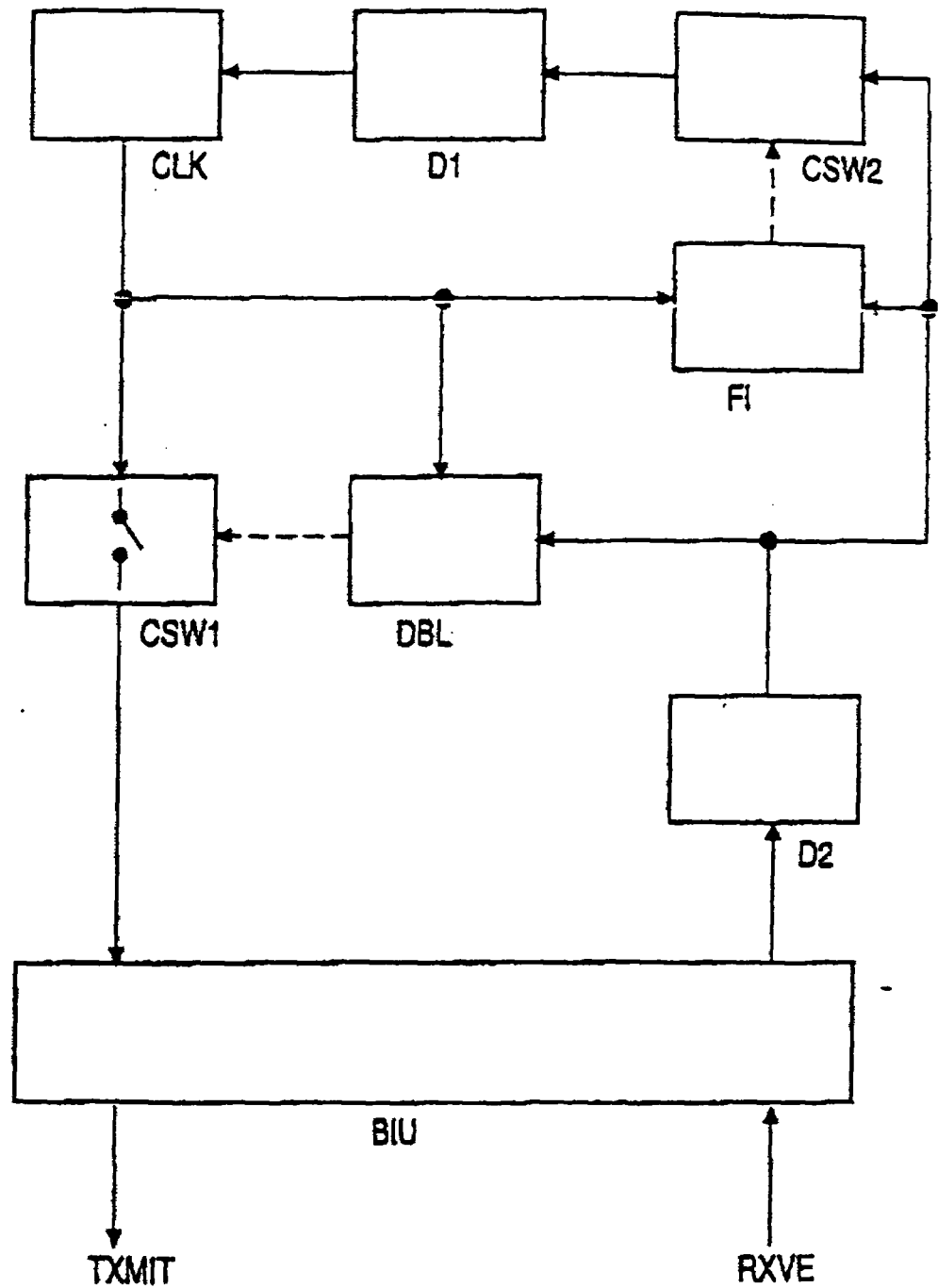


Fig.1

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- ☒ Description : paged 117 to paged 118
☒ Claim(s) : paged 119 to paged 120
☐ Drawing(s) : paged 121 to paged 122
☒ Abstract : paged 123 to paged 124

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DATE OF RECEIPT 5/2/99

METHOD AND APPARATUS FOR SYNCHRONISING
CLOCKS BEING CONNECTED TO A NETWORK SYSTEM

Description

The present invention relates to a method and to an apparatus for synchronising clocks being connected to a network system.

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Background

Many devices (in particular white goods or brown goods) in a household may contain a clock. Some systems allow to connect all these devices and the related clocks to a common bus or network. The commands for controlling the clocks are in general limited to reading or writing a given time or to broadcasting the time of a given clock to one dedicated device or to the entire system or to a part of the system. An example home bus system is described in Esprit Home Systems Specification 1.1, ESPRIT project 6782. In such known systems it is not specified in which manner a clock should react if it receives the time broadcast by another clock. So, it is possible to initialise all clocks to a given time (e.g. by a user action, which creates a 'write time' broadcast to the entire system), but due to tolerances in the different clocks, so achieved synchronisation will not be maintained. Regular broadcasting by a special device 'master clock' has the disadvantage of introducing one device with different capabilities. In case there are several master clocks, conflicts may occur and the advantages of a high precision clock will fade away if a lower precision master clock overrides it.

From EP-A-0 548 381 a method for synchronising clocks in hierarchically subdivided computer networks is known. There is one high precision clock provided in a computer which is positioned at the highest hierarchical level. This clock is the master clock of the system and synchronises all clocks at the next lower hierarchical level by sending timestamps. The clocks at the second and lower hierarchical level are synchronised by times-

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includes:

- a clock which may belong to different precision classes;
- bus interface means which broadcast the time of said clock within said network system after expiry of a pre-selected time period, which is related to said precision class in such a way that a higher of said precision classes is associated with a shorter time period, whereby time period counting means are related to said clock;

interrupt means which interrupt time transmission from said clock to said bus interface means during a certain time period after each reception of time information by said bus interface means, whereby the time of said clock is broadcast only, when the bus interface means have received no related time from a clock belonging to a higher precision class and whereby the time of said clock is updated when receiving said broadcast time information and said time period counting means are reset,

or includes:

- a clock which may belong to different precision classes;
- bus interface means which broadcast the time of said clock within said network system having a pre-selected phase, which is related to said precision class in such a way that the broadcast time related to a higher of said precision classes is earlier, and having a pre-selected broadcast time period, which is independent of said precision class;
- interrupt means which interrupt time transmission from said clock to said bus interface means during a certain time period after each reception of time information by said bus interface means, whereby the time of said clock is broadcast only, when the

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bus interface means have received no related time from a clock belonging to a higher precision class and whereby the time of said clock is updated when receiving said broadcast time information.

Advantageous additional embodiments of the inventive apparatus are resulting from the respective dependent claim.

Drawing

Preferred embodiments of the invention are described with reference to the accompanying drawing, which shows in:

Fig. 1 .

Preferred embodiments

In a real system there is some delay in datagram distribution (routers, time for medium access). This delay may vary considerably over the time. For this reason every clock should reset its internal time only in case of major and/or repeated differences to the time received. But this can be left to the designer of the clock - nevertheless the choice should be made keeping in mind the time difference between broadcasts of different precision classes, so that it is guaranteed that every clock will be overwritten, at least on the long term, by broadcasts of higher precision classes.

The distribution of time in the described manner is not limited to the time of day. E.g. the date may be distributed with the time in every time period, or could be distributed only on longer periods, but only by the device which succeeded to distribute its time.

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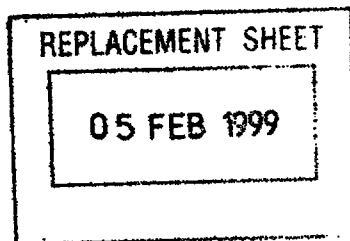
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A internal clock CLK continuously distributes the local time inside a device (coffee machine, cooker, dish washer, washing machine, heating system, air conditioner, FM receiver, TV set, VCR). A bus interface unit BIU receives time information RXVE from a bus. Time information TXMIT is sent to the bus only when the controlled switch CSW1 is closed. This switch is controlled by a delaying block DBL which interrupts time transmission during a certain time period after each reception of time information (and possibly allows transmission only at fixed intervals corresponding to the internal time). Incoming time information RXVE is allowed to set the internal clock CLK only when a second controlled switch CSW2 is closed. This switch may be closed continuously in a simple embodiment, or can be controlled by a digital filter circuit FI which compares the internal (output of CLK) and the received time and allows updating only when a significant difference over a certain period is detected.

Supplementary blocks D1, D2 compensating the delay of time distribution within the network may be included.

Advantageously, in a bus system with more than one real time clock initial synchronisation will be achieved without user intervention (if at least one of the clocks is initialised). Synchronisation will be kept, while highest precision clocks take priority over lower precision ones. Even if the controlling clock fails, the next lower priority clock will automatically take over the task of controlling the system. Updating is still possible by manual intervention from any point of the system. Bus traffic is kept low.



Claims

1. Method for synchronising clocks (CLK) being connected to a network system, characterised by the steps of:

choosing said clocks to belong to different precision classes;

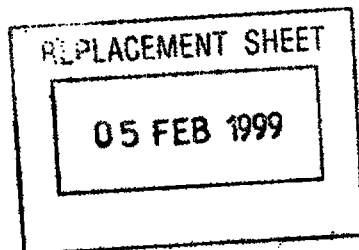
broadcasting the time of every clock (TXMIT) within said network system after expiry of a pre-selected time period, whereby a higher of said precision classes is associated with a shorter time period and time period counting means are related to each of said clocks, whereby within these steps every clock which receives said broadcast (RXCE) updates its time and the related time period counting means are reset.

2. Method according to claim 1, characterised in that every clock (CLK) receiving a time broadcast of any precision class does not broadcast its time within a further time period which is higher than said pre-selected time period.

3. Method for synchronising clocks (CLK) being connected to a network system, characterised by the steps of

choosing said clocks to belong to different precision classes;

broadcasting the time of every clock (TXMIT) within said network system having a pre-selected phase, which is related to said precision class in such a way that the broadcast time related to a higher of said precision classes is earlier, and having a pre-selected broadcast time period, which is independent of said precision class;



broadcasting the time of a specific clock only, when the clock has received no related time from a clock belonging to a higher precision class;

whereby within these steps every clock which receives said broadcast (RXVE) updates its time.

4. Method according to claim 3, characterised in that every clock (CLK) receiving a time broadcast of the same or higher precision class does not broadcast its time within a further time period which is higher than said pre-selected time period.
5. Method according to any of claims 1 to 4, characterised in that said further time period is a random or pseudo-random value, depending on some internal state of a device to which the clock (CLK) belongs and depending not only on the present time, whereby these values are changed periodically or after each time broadcast.
6. Method according to any of claims 1 to 5, characterised in that said time is broadcast (TXMIT) only to a part of the clocks belonging to said network system.
7. Method according to any of claims 1 to 6, characterised in that said pre-selected time period is a factorial period of a minute.
8. Method according to any of claims 1 to 7, characterised in that in case tuners related to said clocks (CLK) receive the time of different time zones, one of said zone times is selected for broadcasting within said network system.

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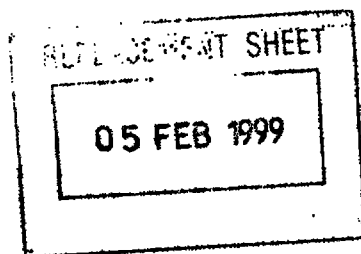


9. Method according to any of claims 1 to 8, characterised in that when evaluating the internal time of a clock (CLK) and the time broadcast within said network system the delay of time distribution within said network system is compensated using appropriate delay means (D1, D2).
10. Method according to any of claims 1 to 9, characterised in that digital filter means (FI) compare the internal time of a clock (CLK) and the time (RXVE) broadcast within said network system and allow (CSW2) updating only when a difference exceeding a pre-selected threshold over a pre-selected observation period is detected.
11. Apparatus for synchronising clocks being connected to a network system, according to the method of any of claims 1,2 and 5 to 10 and including:

a clock (CLK) which belongs to one precision class out of a plurality of different precision classes;

bus interface means (BUI) which are capable to broadcast (TXMIT) the time of said clock within said network system after expiry of a pre-selected time period, which is related to said one precision classe in such a way that a higher of said precision classes is associated with a shorter time period, whereby time period counting means are related to said clock;

interrupt means (DBL, CSW1) which are capable to interrupt time transmission from said clock to said bus interface means during a certain time period after each reception of time information (RXVE) by said bus interface means, whereby the time of said clock is broadcast only, when the bus interface means have received no related time from a clock belonging to a higher precision class and whereby the time of said



clock is updated when receiving said broadcast time information (RXVE) and said time period counting means are reset.

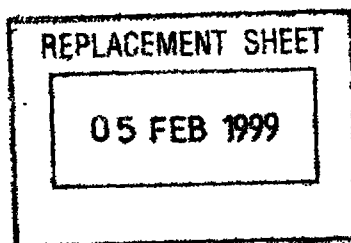
- 12. Apparatus for synchronising clocks being connected to a network system, according to the method of any of claims 3 to 10 and including:**

a clock (CLK) which belongs to one precision class out of a plurality of different precision classes;

bus interface means (BUI) which are capable to broadcast (TXMIT) the time of said clock within said network system having a pre-selected phase, which is related to said one precision class in such a way that the broadcast time related to a higher of said precision classes is earlier, and having a pre-selected broadcast time period, which is independent of said precision class;

interrupt means (DBL, CSW1) which are capable to interrupt time transmission from said clock to said bus interface means during a certain time period after each reception of time information (RXVE) by said bus interface means, whereby the time of said clock is broadcast only, when the bus interface means have received no related time from a clock belonging to a higher precision class and whereby the time of said clock is updated when receiving said broadcast time information (RXVE).

- 13. Apparatus according to claim 11 or 12, characterised in that digital filter means (FI) compare the internal time of said clock (CLK) and the time (RXVE) broadcast within said network system and allow updating of the clock time only when a difference exceeding a pre-selected threshold over a pre-selected observation period is detected.**



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ABSTRACT OF THE DISCLOSURE

METHOD AND APPARATUS FOR SYNCHRONISING CLOCKS BEING CONNECTED
TO A NETWORK SYSTEM

Many devices (in particular white goods or brown goods) in a household may contain a clock. Some systems allow to connect all these devices and the related clocks to a common bus or network. The commands for controlling the clocks are in general limited to reading or writing a given time or to broadcasting the time of a given clock to one dedicated device or to the entire system or to a part of the system. In such known systems it is not specified in which manner a clock should react if it receives the time broadcast by another clock. It is possible to initialise all clocks to a given time but due to tolerances in the different clocks, so achieved synchronisation will not be maintained. Regular broadcasting by a special device 'master clock' has the disadvantage of introducing one device with different capabilities. In case there are several master clocks, conflicts may occur and the advantages of a high precision clock will fade away if a lower precision master clock overrides it.

One solution is, that only the clock with the highest precision broadcasts its time to the system, but whenever it fails the next lower precision clock takes over the broadcasting automatically. The broadcast periods are defined as factorial periods of a preselected time period.

Another possibility is, that all devices will broadcast the time with an equal period but with a different phase and only if no broadcast was received in the preceding time period.

Fig.1