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(54) **A lighting controller**

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Description

FIELD OF THE INVENTION

[0001] The invention relates to control of operation of one or more light sources. In particular, embodiments of the invention relate to a lighting controller in which a master processor is able to convey both operating commands and timing information to one or more slave processors that control the delivery of operating power to devices coupled to outputs of the lighting controller. Embodiments of the invention also relate to a method and to a computer program for conveying operating commands and timing information from the master processor to the slave processor(s).

BACKGROUND

[0002] Lighting controllers frequently include processor-controlled multichannel dimmers. A channel means an individual AC output: for example a four-channel dimmer can dim four luminaires or luminaire groups independently of each other. A multichannel dimmer typically comprises a main processor or master, which receives all dimming commands and other commands concerning all channels from for example a human-operated control device, and conveys them further to auxiliary processors or slaves, each of which controls an individual channel. One or more channels may be equipped with on/off switching relays or other means that enable using the lighting controller also for other purposes than just dimming.

[0003] Sometimes one wants to use a channel to dim old-fashioned incandescent lamps or so-called retrofit LED lamps, which are mechanically and electrically compatible with incandescent lamps. For this purpose the output of a channel in the dimmer must comprise suitable switching components that the dimmer can use to phase-cut the output AC, i.e. to cut off a predetermined portion from each AC half-wave. For the phase-cutting to take place appropriately, the slave processor controlling that channel must have at its disposal information about the timing of the AC half-waves. It would naturally be possible to equip each slave processor with its own AC zero crossing detection means, but in order to avoid redundant components in the lighting controller it is common that the master processor (or an indicator circuit associated therewith) finds out the timing of the AC half-waves and conveys this information to the slaves.

[0004] Fig. 1 illustrates a structure of the kind described above in a four-channel dimmer. AC mains come to the MAINS input, from which it is lead to the channel-specific switching components 101, 102, 103, and 104 of all four channels. The lamps to be dimmed are coupled to the outputs of the channels. The master processor 105 receives, through a data connection (CTRL IN), control commands, which it conveys further to the slave processors 111, 112, 113, and 114 according to need. It is pos-

sible, although not mandatory, that the control commands go to the slave processors through optoisolators 121, 122, 123, and 124. An example of a control command is a command for a certain channel to dim the produced illumination to a certain percentage of full brightness. After a slave processor has received such a command, it controls the switching components of that channel so that they cut the required portion out of every AC half-wave.

[0005] All processors are able to listen to all commands transmitted in the control bus, but the commands are specified to each slave processor through the use of a suitable communications protocol.

[0006] The exact timing of zero voltage points between AC half-waves is important for the slave processors in driving the switching components correctly. The master processor 105 has a zero voltage detection (ZVD) circuit 106 at its disposal. This circuit measures, when the zero voltage point between half-waves occurs. This timing information should find its way to the slave processors.

[0007] In prior art multichannel dimmers, such as the one in fig. 1, it has been customary to draw a dedicated timing line from the zero voltage detection circuit 106 to the slave processors 111, 112, 113, and 114. If galvanic isolation between channels is desired, dedicated optoisolators 131, 132, 133, and 134 are needed also for the timing line(s). This adds manufacturing costs and may increase the possibilities of malfunctioning.

[0008] Another drawback of prior art lighting controllers of the kind shown in fig. 1 is the jitter that occurs in zero voltage detection. The AC mains voltage that the ZVD circuit 106 monitors contains small-scale interference, which introduces error into finding the exact moment of time when the voltage crosses zero. The jitter in ZVD becomes particularly annoying if the outputs of the lighting controller drive LED lights, because these may analyze the length of each half-wave in the AC they receive from the controller and control the brightness of the LEDs accordingly. Jitter in ZVD timing ultimately causes variation in the lighting intensity of the LEDs, which a human observer may consider annoying.

[0009] A prior art document JP 2014 003600 A (Yoshikawa RF Semicon Co Ltd) discloses using a small, frequency-modulated, high-frequency control signal overlaid with the AC half-waves and transmitting a number of such control signals at various phases of the half-wave period.

[0010] A prior art document WO 2013/061206 A2 (Koninkl Philips Electronic NV) discloses making small changes to the peak voltage levels of AC half-waves in order to convey simple digital messages.

[0011] A prior art document EP 0 390 035 A2 (Toshiba Lighting & Technology) discloses transmitting addressed information during the half-wave period of the AC mains.

[0012] A prior art document US 5,825,135 A (Chang Chin-Hsiung) discloses chaining triac dimmers so that the chopped half-wave output from one triac dimmer goes as a control signal to the next one.

SUMMARY

[0013] Consequently, it is an object of the present invention to provide an internal structure and operating technique of a multichannel lighting controller that is suitable for accurately controlling the switching of AC half-waves in channels of the lighting controller while simultaneously providing reliability and enabling a simple structure that is advantageous to manufacture.

[0014] The objects of the invention are reached by a lighting controller, by a method, and by a computer program as defined by the respective independent claims.

[0015] According to an example embodiment, a lighting controller for driving one or more luminaires is provided. The lighting controller comprises an operating power input for receiving alternating current, a master processor, one or more slave processors, each said slave processor configured to use respective switching components to manipulate half-waves of said alternating current for outputting a phase-cut alternating current at a respective output of the lighting controller, and an internal control bus for conveying control commands indicative of desired extent of said manipulating from said master processor to said one or more slave processors. Said master processor is configured to time transmissions of said control commands on said internal control bus in a predetermined relationship with zero crossing points between said half-waves of said alternating current.

[0016] According to another example embodiment, a method for producing phase-cut alternating current in a lighting controller is provided. The method comprises:

observing zero crossing points in incoming alternating current,

transmitting control commands from a master processor to a slave processor on an internal control bus of said lighting controller in a predetermined relationship with zero crossing points between half-waves of said alternating current, and

manipulating half-waves of said alternating current under control of said slave processor to produce said phase-cut alternating current, using content of said control commands to determine the extent of said manipulating and using timing of said control commands on said internal bus to determine the timing of said manipulating.

[0017] According to another example embodiment, a computer program is provided for transmitting control commands from a master processor to a slave processor on an internal control bus of a lighting controller. The computer program includes one or more sequences of one or more instructions which, when executed by one or more master processors, cause said one or more master processors to transmit to said slave processor a con-

trol command, the content of which determines the extent to which said slave processor should manipulate half-waves of an alternating current to produce a phase-cut alternating current, and the timing of which determines the timing of said manipulating.

[0018] According to another example embodiment, a computer program is provided for manipulating half-waves of alternating current under control of one or more slave processors to produce phase-cut alternating current in a lighting controller. The computer program includes one or more sequences of one or more instructions which, when executed by said one or more slave processors, cause said one or more slave processors to use content of control commands received on an internal control bus of said lighting controller to determine the extent of said manipulating and to use timing of said control commands on said internal bus to determine the timing of said manipulating.

[0019] The computer programs may be embodied on a volatile or a non-volatile computer-readable record medium, for example as a computer program product comprising at least one computer readable non-transitory medium having program code stored thereon, the program code, which when executed by an apparatus, causes the apparatus at least to perform the operations described hereinbefore for the computer program in accordance with an example embodiment.

[0020] There are exemplifying embodiments of the invention presented in this patent application. The verb "to comprise" and its derivatives are used in this patent application as an open limitation that does not exclude the existence of also unrecited features. The features described hereinafter are mutually freely combinable unless explicitly stated otherwise.

[0021] The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following detailed description of specific embodiments when read in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022]

Figure 1 schematically illustrates a lighting controller according to prior art.

Figure 2 schematically illustrates a lighting controller in accordance with an example embodiment.

Figure 3 illustrates an exemplifying way to time transmissions on a control bus.

Figure 4 illustrates another exemplifying way to time transmissions on a control bus.

Figure 5 illustrates yet another exemplifying way to time transmissions on a control bus.

Figure 6 illustrates an example of details in a master processor.

Figure 7 illustrates an example of details in a slave processor.

Figure 8 illustrates an example of a method.

Figure 9 illustrates an example of details of a method.

Figure 10 illustrates another example of details of a method.

DESCRIPTION OF SOME EMBODIMENTS

[0023] Figure 2 schematically illustrates an exemplifying lighting controller 200 suitable for example for providing controlled operating power to four dimmable luminaires or luminaire groups. Also other kinds of loads can be coupled to the outputs of the four channels of the lighting controller 200. Displaying four outputs in the example embodiment is not a limiting feature; the same structural and functional solutions are easily generalized to any number of output channels.

[0024] For receiving alternating current the lighting controller 200 comprises an operating power input, which in fig. 2 appears with a reference designator MAINS IN. Switching components 101, 102, 103, 104 are provided at each channel for outputting manipulated half-waves of the alternating current, for example phase-cut alternating current. At each channel a slave processor 211, 212, 213, 214 is configured to control and use the respective switching components.

[0025] The lighting controller 200 comprises a master processor 205 and an internal control bus 206 for conveying, from the master processor 205 to the slave processors 211, 212, 213, 214, control commands indicative of desired type and extent of manipulating that the slave processors should do to the half-waves output from their respective channels. In other words, for example if trailing edge type phase-cut AC should be obtained from channel 1, with 60% of the length of each half-wave remaining, the master processor 205 uses the internal control channel 206 to send to the slave processor 211 of the first channel a control command, which the slave processor 211 interprets as an instruction to implement phase cutting of said kind.

[0026] Optoisolators 121, 122, 123, 124 may be provided to galvanically isolate the slave processors 211, 212, 213, 214 from the internal control bus 206, but these are not necessary, if galvanic isolation between channels is not needed in the lighting controller 200.

[0027] As a difference to the lighting controller according to prior art that was explained previously with reference to fig. 1, the lighting controller 200 does not com-

prise a separate timing line to the slave processors 211, 212, 213, 214. The master processor 205 is configured to time transmissions of control commands on the internal control bus 206 in a predetermined relationship with zero crossing points between half-waves of the alternating current. The master processor 205 may become aware of the timing of said zero crossing points for example through a zero voltage detection (ZVD) circuit 207 that is coupled between the AC lines and the master processor 205 within the lighting controller 200. As an alternative, there could be a ZVD circuit external to the lighting controller, with a coupling from such an external ZVD circuit to the master processor 205.

[0028] Fig. 3 illustrates an example embodiment of timing transmissions of control commands in the internal control bus 206 in a predetermined relationship with zero crossing points between half-waves in the alternating current 300. In particular, in the example illustrated in fig. 3, the master processor is configured to transmit the control commands on the internal control bus in frames, of which frame 301 is an example. Three vertical lines illustrate the location of zero crossing points on the time axis in fig. 3. A predetermined part, here the beginning, of each transmitted frame coincides in time with a zero crossing point between half-waves in the alternating current 300. The part of each frame that coincides in time with a zero crossing point could also be the end of the frame, or some reference point between the beginning and the end of the frame.

[0029] Another example of a feature that is schematically illustrated in fig. 3 is the use of slave-processor-specific time slots. In the example of fig. 2 the lighting controller has four slave processors, so in a corresponding way each frame in fig. 3 has four slave-processor-specific time slots, of which slot 302 of frame 301 is shown as an example. In this example the master processor is configured to transmit control commands to a particular slave processor in a slave-processor-specific time slot of the frames. Each slave processor has been programmed to handle a received frame appropriately, so that the slave processor knows to read control commands destined to itself from the correct time slot in the frame, while simultaneously using the predetermined part of the frame - e.g. the beginning - as an indication of the timing of a zero crossing point in the alternating current.

[0030] Fig. 4 illustrates another example embodiment of timing transmissions of control commands in the internal control bus 206 in a predetermined relationship with zero crossing points between half-waves in the alternating current 300. In particular, in the example illustrated in fig. 4, the master processor is configured to transmit the control commands on the internal control bus one at a time, so that a predetermined part of each transmitted individual control command coincides in time with a zero crossing point between half-waves in the alternating current. An individual control command 401 is shown as an example. It consists of a header part 402 and a payload

part 403. In the header part 402 the master processor inserts a recipient identifier, which tells, to which slave processor the control command is meant. In the payload part 403 the master processor inserts the actual content of the control command.

[0031] A common feature to the examples shown in figs. 3 and 4 is that the master processor is configured to transmit each frame (in the embodiment of fig. 3) or each individual control command (in the embodiment of fig. 4) in a time that is shorter than a half-wave in the alternating current 300. In particular, the embodiment of fig. 3 involves the advantage that a new control command can be transmitted to each slave processor once during each half-wave period. Taken that the slave processors will use their respective switching components to manipulate the alternating current on a half-wave-wise basis, it is not likely that more frequent delivery of control commands to slave processors than once per half-wave length would be necessary. It is, however, possible to make the transmission of control commands even more frequent, for example so that the master processor transmits a whole frame - with a dedicated time slot for each slave processor - two times, three times or even more frequently during each half-wave period.

[0032] Fig. 5 illustrates an example embodiment that goes towards the other extreme, i.e. transmitting a frame 501 that is longer than a half-wave period in the alternating current. A slave-processor-specific time slot 502 is shown as an example. The embodiment of fig. 5 involves the advantage of particularly large capacity for transmitting even very long and complicated control commands to the slave processors without requiring the control command transmission and reception arrangements to be capable of very fast signal processing. However, the embodiment of fig. 5 requires programming the slave processors so that they know, how many zero crossing points will occur between the beginnings (or other predetermined parts) of two consecutive frames, so that they can maintain an appropriate time base for switching.

[0033] Fig. 6 illustrates details of an example embodiment in which the master processor 205 digitally filters the ZVD signals. The lighting controller comprises a zero voltage detector (ZVD) 207 that is configured to produce an indication signal, like a transition between two digital states, indicating when a zero crossing point occurs between half-waves in the alternating current. The master processor 205 is configured to digitally filter a sequence of indication signals produced by the ZVD 207 to produce a digitally filtered zero crossing time base.

[0034] The reason for applying digital filtering is the possible occurrence of jitter in the output of the ZVD 207. The alternating current, the zero crossing points of which should be detected, should ideally be a smooth, clean sine wave, the zero crossing points of which occur at exactly constant time intervals. In reality, imperfections in the generation and delivery of mains AC cause the indications of zero crossing points to be generated at more or less irregular intervals. Switching in a lighting

controller should follow possible slow, long-term variations in the timing of zero-crossing points, so that it does not develop any significant timing bias but remains synchronized with the general rhythm of the half-waves in the alternating current. However, rapid variations in the timing of zero-crossing points (and hence also in the sequence of indication signals output by the ZVD 207) are typically caused by random interference, the effect of which should cancel out in the long term.

[0035] The digital filtering applied by the master processor 205 has the nature of lowpass filtering, and it serves to remove the effect of rapid random variations in the time intervals between consecutive indication signals output by the ZVD 207. A digital filtering block 601 is schematically shown in fig. 6. It takes the sequence of indication signals received from the ZVD 207, performs low pass filtering, and outputs a digitally filtered zero crossing time base.

[0036] Other parts or functionalities of the master processor 205 that are shown in fig. 6 are the control command receiver 602 for receiving control commands through an auxiliary bus, a processing part 603 for interpreting the auxiliary control commands, a command forming part 604 for forming the control commands to be sent to the slave processors, and a control command transmitter 605 for transmitting control commands on the internal bus 206. Corresponding functionalities were known in prior art master processors, and do not need to be described here further. As a difference to prior art solutions, the control command transmitter 605 is configured to time transmissions of the control commands on said internal control bus in a predetermined relationship with the digitally filtered zero crossing time base that is available at the output of the digital filtering block 601.

[0037] The invention does not require digitally filtering the zero crossing point indications, if it can be otherwise ensured that these indications are sufficiently free of short-term interference. Even if filtering is performed, it is not necessary to do it in the master processor. Fig. 7 illustrates schematically some parts of an example of a slave processor 211. A control command receiver 701 is configured to receive control commands on the internal control bus 206 of the lighting controller. An optoisolator may be employed at the input of the control command receiver 701, but is not separately shown in fig. 7. The handling of received control commands takes place in two branches. In fig. 7 it is assumed that the master processor did not perform digital filtering of the indication signals produced by the ZVD circuit, for which reason a digital filtering block 703 exists in the slave processor 211. If the master processor already included digital filtering, block 703 can be omitted and the timing of the received control commands is directly taken to block 704, which uses it to maintain the time base for switching in the slave processor 211.

[0038] The content of the received control commands is interpreted in a part of the slave processor 211 that is schematically illustrated as the processing block 702.

Switching signals are formed correspondingly in block 706, with their timing synchronized to the time base maintained in block 704, and given to one or more switch driver circuits 707 that perform the actual driving of the MOSFETs or other switches through which the alternating current flows to the output of the corresponding channel.

[0039] Block 703 in fig. 7 and block 601 are basically alternatives to each other, although it is not excluded to divide the digital filtering of the zero crossing indications into two. In that case the master processor would perform coarse filtering and the slave processor would finalize the effect of filtering, including the removal of possible additional jitter that could have been caused by imperfections in timing the transmission of control commands on the internal control bus.

[0040] Fig. 8 illustrates a method for producing phase-cut alternating current in a lighting controller according to an example embodiment. Step 801 represents receiving alternating current in the lighting controller. Step 802 represents observing zero crossing points in the incoming alternating current, and step 803 represents transmitting control commands from a master processor to a slave processor on an internal control bus of the lighting controller in a predetermined relationship with zero crossing points between half-waves of said alternating current. Here the predetermined relationship means particularly a relationship in time, so that the timing of control commands transmitted on the internal control bus serves as an indication of the timing of detected zero crossing points.

[0041] Step 804 in fig. 8 represents receiving the control commands in a slave processor of the lighting controller. Step 805 represents manipulating half-waves of the alternating current under control of the slave processor to produce phase-cut alternating current. The slave processor uses content of the control commands to determine the extent of said manipulating, and timing of the control commands on said internal bus to determine the timing of said manipulating. Step 806 represents outputting the resulting phase-cut alternating current from the lighting controller.

[0042] The transmission of control commands at step 803 may take place in frames, so that a predetermined part of each transmitted frame coincides in time with a zero crossing point between half-waves in the alternating current. In such an embodiment control commands to a particular slave processor may be transmitted in a slave-processor-specific time slot of the frames. As an alternative, the transmission of control commands at step 803 may take place one at a time, so that a predetermined part of each transmitted individual control command coincides in time with a zero crossing point between half-waves in the alternating current. Irrespective of which of these alternatives is used, each transmission on the internal control bus may be shorter than a half-wave in the alternating current.

[0043] Figs. 9 and 10 show how the method may com-

prise digitally filtering a sequence of indication signals indicating when zero crossing points occur between half-waves of said alternating current, thus producing a digitally filtered zero crossing time base, and using the digitally filtered zero crossing time base to determine the timing of said manipulating. In the embodiment illustrated in fig. 9 digital filtering 902 takes place in the master processor, between the steps of observing 901 zero crossing points in the incoming alternating current and transmitting 903 control commands from the master processor to the slave processor on the internal control bus. These are shown with different reference designators than in fig. 8 because the digital filtering at step 902 may imply changes to the other steps; for example, the detection of zero crossing points at step 901 may be originally accomplished at a lower level of accuracy (i.e. with cheaper components) if the filtering at step 902 can be relied upon to remove any resulting jitter.

[0044] In the embodiment illustrated in fig. 10 digital filtering 1002 takes place in the slave processor between the steps of receiving 1001 control commands from the master processor and manipulating 1003 half-waves of the alternating current under control of the slave processor to produce phase-cut alternating current.

[0045] Computer programs according to various embodiments can be classified into computer programs of the master processor and computer programs of the slave processor. Computer programs of the first kind include one or more sequences of one or more instructions which, when executed by one or more master processors, cause said one or more master processors to transmit to a slave processor a control command, the content of which determines the extent to which said slave processor should manipulate half-waves of an alternating current to produce a phase-cut alternating current, and the timing of which determines the timing of said manipulating. They may also comprise one or more sequences of one or more instructions which, when executed by said one or more master processors, cause said one or more master processors to digitally filter a received sequence of indications indicating when zero crossing points occur between half-waves in said alternating current, thus producing a digitally filtered zero crossing time base, and to time transmissions of control commands on said internal control bus in a predetermined relationship with said digitally filtered zero crossing time base.

[0046] Computer programs of the slave processor include one or more sequences of one or more instructions which, when executed by one or more slave processors, cause said one or more slave processors to use content of control commands received on an internal control bus of the lighting controller to determine the extent of manipulating half-waves of an alternating current to produce a phase-cut alternating current, and to use timing of said control commands on said internal bus to determine the timing of said manipulating.

[0047] Reference to a processor should not be understood to encompass only programmable processors, but

also dedicated circuits such as field-programmable gate arrays (FPGA), application specific circuits (ASIC), signal processors, etc.

Claims

1. A lighting controller (200) for controlling one or more light sources coupled to respective outputs of the lighting controller, the lighting controller comprising:
 - an operating power input for receiving alternating current,
 - a master processor (205),
 - one or more slave processors (211, 212, 213, 214), each said slave processor configured to use respective switching components (101, 102, 103, 104) to manipulate half-waves of said alternating current for outputting a phase-cut alternating current at a respective one of said respective outputs of the lighting controller (200), and
 - an internal control bus (206) for conveying control commands indicative of a desired extent of said manipulating from said master processor to said one or more slave processors;

characterized in that said master processor (205) is configured to further convey timing information to said one or more slave processors (211, 212, 213, 214) by timing transmissions (301, 401, 501) of said control commands on said internal control bus (206) in a predetermined relationship with zero crossing points between said half-waves of said alternating current (300).
2. A lighting controller according to claim 1, wherein said master processor (205) is configured to transmit said control commands on said internal control bus in frames (301, 501), so that a predetermined part of each transmitted frame coincides in time with a zero crossing point between half-waves in said alternating current (300).
3. A lighting controller according to claim 2, wherein said master processor (205) is configured to transmit control commands to a particular slave processor (211, 212, 213, 214) in a slave-processor-specific time slot (302, 502) of the frames (301, 501).
4. A lighting controller according to claim 1, wherein said master processor (205) is configured to transmit said control commands on said internal control bus one at a time, so that a predetermined part of each transmitted individual control command (401) coincides in time with a zero crossing point between half-waves in said alternating current (300).
5. A lighting controller according to any of claims 1 to 4, wherein:
 - said master processor (205) is configured to transmit each frame (301) or each individual control command (401) in a time that is shorter than a half-wave in said alternating current (300).
6. A lighting controller according to any of claims 1 to 5, wherein:
 - the lighting controller comprises a zero voltage detector (207) configured to produce an indication signal indicating when a zero crossing point occurs between half-waves in said alternating current (300),
 - said master processor (205) is configured to digitally filter (601) a sequence of indication signals produced by said zero-voltage detector (207) to produce a digitally filtered zero crossing time base, and
 - said master processor (205) is configured to time transmissions (301, 401, 501) of said control commands on said internal control bus (206) in a predetermined relationship with said digitally filtered zero crossing time base.
7. A method for producing phase-cut alternating current in a lighting controller, comprising:
 - observing (802, 901) zero crossing points in incoming alternating current, **characterized in that** the method comprises:
 - transmitting (802, 901) control commands from a master processor (205) to a slave processor (211, 212, 213, 214) on an internal control bus (206) of said lighting controller (200) in a predetermined relationship with zero crossing points between half-waves of said alternating current (300), and
 - manipulating (805) half-waves of said alternating current under control of said slave processor (211, 212, 213, 214) to produce said phase-cut alternating current, using content of said control commands to determine the extent of said manipulating and using timing of said control commands on said internal bus (206) to determine the timing of said manipulating.
8. A method according to claim 7, wherein said control commands are transmitted on said internal control bus (206) in frames (301, 501), so that a predetermined part of each transmitted frame coincides in time with a zero crossing point between half-waves in said alternating current (300).
9. A method according to claim 8, wherein control commands to a particular slave processor (211, 212, 213, 214) are transmitted in a slave-processor-specific

time slot (302, 502) of the frames.

10. A method according to claim 7, wherein said control commands are transmitted on said internal control bus (206) one at a time, so that a predetermined part of each transmitted individual control command (401) coincides in time with a zero crossing point between half-waves in said alternating current (300).

11. A method according to any of claims 7 to 10, wherein each transmission (301, 401) on said internal control bus (206) is shorter than a half-wave in said alternating current (300).

12. A method according to any of claims 7 to 11, comprising:

digitally filtering (902, 1002) a sequence of indication signals indicating when zero crossing points occur between half-waves of said alternating current (300), thus producing a digitally filtered zero crossing time base, and using the digitally filtered zero crossing time base to determine the timing of said manipulating.

13. A computer program for transmitting control commands from a master processor (205) to a slave processor (211, 212, 213, 214) on an internal control bus (206) of a lighting controller (200), the computer program including one or more sequences of one or more instructions which, when executed by the master processor (205), cause said master processor (205) to transmit to said slave processor (211, 212, 213, 214) a control command, the content of which determines the extent to which said slave processor (211, 212, 213, 214) should manipulate half-waves of an alternating current to produce a phase-cut alternating current, and the timing of which in relation to zero crossing points between said half-waves of said alternating current (300) determines the timing of said manipulating.

14. A computer program according to claim 13, comprising one or more sequences of one or more instructions which, when executed by said master processor (205), cause said master processor (205) to:

digitally filter (902) a received sequence of indications indicating when zero crossing points occur between half-waves in said alternating current, thus producing a digitally filtered zero crossing time base, and time transmissions (301, 401, 501) of said control command on said internal control bus (206) in a predetermined relationship with said digitally filtered zero crossing time base.

15. A computer program for manipulating half-waves of alternating current under control of one or more slave processors (211, 212, 213, 214) to produce phase-cut alternating current in a lighting controller (200), the computer program including one or more sequences of one or more instructions which, when executed by said one or more slave processors (211, 212, 213, 214), cause said one or more slave processors to use content of control commands received on an internal control bus (206) of said lighting controller (200) to determine the extent of said manipulating and to use timing of said control commands on said internal bus in relation to zero crossing points between half-waves of said alternating current (300) to determine the timing of said manipulating.

Patentansprüche

1. Beleuchtungssteuerungseinheit (200) zum Steuern einer oder mehrerer Lichtquellen, die mit entsprechenden Ausgängen der Beleuchtungssteuerungseinheit gekoppelt sind, wobei die Beleuchtungssteuerungseinheit umfasst:

einen Betriebsenergieeingang zum Aufnehmen von Wechselstrom,

einen Master-Prozessor (205),

einen oder mehrere Slave-Prozessoren (211, 212, 213, 214), wobei jeder Slave-Prozessor eingerichtet ist, entsprechende Schaltkomponenten (101, 102, 103, 104) zu verwenden, um Halbwellen des Wechselstroms zu manipulieren, einen phasengeschnittenen Wechselstrom an einem entsprechenden der jeweiligen Ausgänge der Beleuchtungssteuerungseinheit (200) auszugeben, und

einen internen Steuerungsbus (206) zum Weiterleiten von Steuerungsbefehlen, die ein gewünschtes Ausmaß des Manipulierens anzeigen, von dem Master-Prozessor zu dem einen oder den mehreren Slave-Prozessoren;

dadurch gekennzeichnet, dass der Master-Prozessor (205) eingerichtet ist, ferner Timing-Informationen an den einen oder die mehreren Slave-Prozessoren (211, 212, 213, 214) weiterzuleiten durch Timen von Übertragungen (301, 401, 501) der Steuerungsbefehle auf dem internen Steuerungsbus (206) in einer vorherbestimmten Beziehung mit Nulldurchgangspunkten zwischen Halbwellen des Wechselstroms (300).

2. Beleuchtungssteuerungseinheit nach Anspruch 1, wobei der Master-Prozessor (205) eingerichtet ist, die Steuerungsbefehle auf dem internen Steuerungsbus in Frames (301, 501) zu übertragen, so dass ein vorherbestimmter Teil jedes übertragenen

- Frames mit einem Nulldurchgangspunkt zwischen Halbwellen im Wechselstrom (300) zeitlich zusammenfällt.
3. Beleuchtungssteuerungseinheit nach Anspruch 2, wobei der Master-Prozessor (205) eingerichtet ist, Steuerungsbefehle an einen bestimmten Slave-Prozessor (211, 212, 213, 214) in einem Slave-Prozessor-spezifischen Zeitschlitz (302, 502) der Frames (301, 501) zu übertragen.
4. Beleuchtungssteuerungseinheit nach Anspruch 1, wobei der Master-Prozessor (205) eingerichtet ist, die Steuerungsbefehle auf dem internen Steuerbus nacheinander zu übertragen, so dass ein vorherbestimmter Teil jedes übertragenen einzelnen Steuerungsbefehls (401) mit einem Nulldurchgangspunkt zwischen Halbwellen im Wechselstrom (300) zeitlich zusammenfällt.
5. Beleuchtungssteuerungseinheit nach einem der Ansprüche 1 bis 4, wobei:
der Master-Prozessor (205) eingerichtet ist, jeden Frame (301) oder jeden einzelnen Steuerungsbefehl (401) in einer Zeit zu übertragen, die kürzer ist als eine Halbwelle in dem Wechselstrom (300).
6. Beleuchtungssteuerungseinheit nach einem der Ansprüche 1 bis 5, wobei:
die Beleuchtungssteuerungseinheit einen Nullspannungsdetektor (207) umfasst, der eingerichtet ist, ein Anzeigesignal zu erzeugen, das anzeigt, wann ein Nulldurchgangspunkt zwischen Halbwellen in dem Wechselstrom (300) auftritt,
der Master-Prozessor (205) eingerichtet ist, eine Folge von Anzeigesignalen, die von dem Nullspannungsdetektor (207) erzeugt werden, digital zu filtern (601), um eine digital gefilterte Nulldurchgang-Zeitbasis zu erzeugen, und
der Master-Prozessor (205) eingerichtet ist, Übertragungen (301, 401, 501) der Steuerungsbefehle auf dem internen Steuerbus (206) in einer vorherbestimmten Beziehung mit der digital gefilterten Nulldurchgang-Zeitbasis zu timen.
7. Verfahren zum Erzeugen von phasengeschnittenem Wechselstrom in einer Beleuchtungssteuerungseinheit, umfassend:
Beobachten (802, 901) von Nulldurchgangspunkten in ankommendem Wechselstrom, **dadurch gekennzeichnet, dass** das Verfahren umfasst:
Übertragen (802, 901) von Steuerungsbe-
- fehlen von einem Master-Prozessor (205) zu einem Slave-Prozessor (211, 212, 213, 214) auf einem internen Steuerbus (206) der Beleuchtungssteuerungseinheit (200) in einer vorherbestimmten Beziehung zu Nulldurchgangspunkten zwischen Halbwellen des Wechselstroms (300), und Manipulieren (805) von Halbwellen des Wechselstroms unter Steuerung des Slave-Prozessors (211, 212, 213, 214), um den phasengeschnittenen Wechselstrom zu erzeugen, mit Verwenden des Inhalts der Steuerungsbefehle, um das Ausmaß des Manipulierens zu bestimmen, und mit Verwenden des Timings der Steuerungsbefehle auf dem internen Bus (206), um das Timing des Manipulierens zu bestimmen.
8. Verfahren nach Anspruch 7, wobei die Steuerungsbefehle auf dem internen Steuerbus (206) in Frames (301, 501) übertragen werden, so dass ein vorherbestimmter Teil jedes übertragenen Frames mit einem Nulldurchgangspunkt zwischen Halbwellen in dem Wechselstrom (300) zeitlich zusammenfällt.
9. Verfahren nach Anspruch 8, wobei Steuerungsbefehle an einen bestimmten Slave-Prozessor (211, 212, 213, 214) in einem Slave-Prozessor-spezifischen Zeitschlitz (302, 502) der Frames übertragen werden.
10. Verfahren nach Anspruch 7, wobei die Steuerungsbefehle auf dem internen Steuerbus (206) nacheinander übertragen werden, so dass ein vorherbestimmter Teil jedes übertragenen einzelnen Steuerungsbefehls (401) mit einem Nulldurchgangspunkt zwischen Halbwellen in dem Wechselstrom (300) zeitlich zusammenfällt.
11. Verfahren nach einem der Ansprüche 7 bis 10, wobei jede Übertragung (301, 401) auf dem internen Steuerbus (206) kürzer ist als eine Halbwelle in dem Wechselstrom (300).
12. Beleuchtungssteuerungseinheit nach einem der Ansprüche 7 bis 11, umfassend:
digitales Filtern (902, 1002) einer Folge von Anzeigesignalen, die anzeigen, wann Nulldurchgangspunkte zwischen Halbwellen des Wechselstroms (300) auftreten, dadurch Erzeugen einer digital gefilterte Nulldurchgang-Zeitbasis, und
Verwenden der digital gefilterten Nulldurchgang-Zeitbasis, um das Timing des Manipulierens zu bestimmen.

13. Computerprogramm zum Übertragen von Steuerungsbefehlen von einem Master-Prozessor (205) zu einem Slave-Prozessor (211, 212, 213, 214) auf einem internen Steuerungsbus (206) einer Beleuchtungssteuerungseinheit (200), wobei das Computerprogramm eine oder mehrere Folgen von einer oder mehreren Anweisungen enthält, die, bei Ausführung durch den Master-Prozessor (205), den Master-Prozessor (205) veranlassen, an den Slave-Prozessor (211, 212, 213, 214) einen Steuerungsbefehl zu übertragen, dessen Inhalt das Ausmaß bestimmt, in dem der Slave-Prozessor (211, 212, 213, 214) Halbwellen eines Wechselstroms manipulieren sollte, um einen phasengeschnittenen Wechselstrom zu erzeugen, und dessen Timing in Bezug auf Nulldurchgangspunkte zwischen den Halbwellen des Wechselstroms (300) das Timing des Manipulierens bestimmt.
14. Computerprogramm nach Anspruch 13, umfassend eine oder mehrere Folgen von einer oder mehreren Anweisungen, die, bei Ausführung durch den Master-Prozessor (205), den Hauptprozessor (205) veranlassen:
- eine empfangene Folge von Anzeigen, die anzeigen, wann Nulldurchgangspunkte zwischen Halbwellen in dem Wechselstrom auftreten, digital zu filtern (902), wodurch eine digital gefilterte Nulldurchgang-Zeitbasis erzeugt wird, und Übertragungen (301, 401, 501) des Steuerungsbefehls auf dem internen Steuerungsbus (206) in einer vorbestimmten Beziehung mit der digital gefilterten Nulldurchgang-Zeitbasis zu timen.
15. Computerprogramm zum Manipulieren von Halbwellen von Wechselstrom unter Steuerung eines oder mehrerer Slave-Prozessoren (211, 212, 213, 214), um phasengeschnittenen Wechselstrom in einer Beleuchtungssteuerungseinheit (200) zu erzeugen, wobei das Computerprogramm eine oder mehrere Folgen von einer oder mehreren Anweisungen enthält, die, bei Ausführung durch den einen oder die mehreren Slave-Prozessoren (211, 212, 213, 214), den einen oder die mehreren Slave-Prozessoren veranlassen, den Inhalt von Steuerungsbefehlen zu verwenden, die auf einem internen Steuerungsbus (206) der Beleuchtungssteuerungseinheit (200) empfangen werden, um das Ausmaß des Manipulierens zu bestimmen und ein Timing der Steuerungsbefehle auf dem internen Bus in Bezug auf Nulldurchgangspunkte zwischen Halbwellen des Wechselstroms (300) zu verwenden, um das Timing des Manipulierens zu bestimmen.

Revendications

- Moyen de commande d'éclairage (200) pour commander une ou plusieurs sources de lumière couplées à des sorties respectives du moyen de commande d'éclairage, le moyen de commande d'éclairage comprenant:
 - une entrée de puissance de fonctionnement pour recevoir un courant alternatif, un processeur maître (205), un ou plusieurs processeurs esclaves (211, 212, 213, 214), chaque dit processeur esclave étant configuré pour utiliser des composants de commutation respectifs (101, 102, 103, 104) pour manipuler les demi-ondes dudit courant alternatif pour sortir un courant alternatif à coupure de phase à l'une respective desdites sorties respectives du moyen de commande d'éclairage (200), et un bus de commande interne (206) destiné à transmettre les ordres de commande indiquant une étendue souhaitée de ladite manipulation dudit processeur maître auxdits un ou plusieurs processeurs esclaves;
 - caractérisé par le fait que** ledit processeur maître (205) est configuré pour transmettre par ailleurs les informations de synchronisation auxdits un ou plusieurs processeurs esclaves (211, 212, 213, 214) par des transmissions de moments (301, 401, 501) desdits ordres de commande sur ledit bus de commande interne (206) selon un rapport prédéterminé avec les points de passage par zéro entre lesdites demi-ondes dans ledit courant alternatif (300).
- Moyen de commande d'éclairage selon la revendication 1, dans lequel ledit processeur maître (205) est configuré pour transmettre lesdits ordres de commande sur ledit bus de commande interne dans des trames (301, 501), de sorte qu'une partie prédéterminée de chaque trame transmise coïncide dans le temps avec un point de passage par zéro entre les demi-ondes dans ledit courant alternatif (300).
- Moyen de commande d'éclairage selon la revendication 2, dans lequel ledit processeur maître (205) est configuré pour transmettre des ordres de commande à un processeur esclave particulier (211, 212, 213, 214) dans un intervalle de temps spécifique au processeur esclave (302, 502) des trames (301, 501).
- Moyen de commande d'éclairage selon la revendication 1, dans lequel ledit processeur maître (205) est configuré pour transmettre un à la fois lesdits ordres de commande sur ledit bus de commande interne, de sorte qu'une partie prédéterminée de

chaque ordre de commande individuel transmis (401) coïncide dans temps avec un point de passage par zéro entre les demi-ondes dans ledit courant alternatif (300).

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5. Moyen de commande d'éclairage selon l'une quelconque des revendications 1 à 4, dans lequel: ledit processeur maître (205) est configuré pour transmettre chaque trame (301) ou chaque ordre de commande individuel (401) dans un laps de temps qui est plus court qu'une demi-onde dans ledit courant alternatif (300).

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6. Moyen de commande d'éclairage selon l'une quelconque des revendications 1 à 5, dans lequel:

le moyen de commande d'éclairage comprend un détecteur de tension nulle (207) configuré pour produire un signal d'indication indiquant le moment où se produit un point de passage par zéro entre les demi-ondes dans ledit courant alternatif (300),

ledit processeur maître (205) est configuré pour filtrer numériquement (601) une séquence de signaux d'indication produite par ledit détecteur de tension nulle (207) pour produire une base de temps de passage par zéro filtrée numériquement, et

ledit processeur maître (205) est configuré pour déterminer le moment des transmissions (301, 401, 501) desdits ordres de commande sur ledit bus de commande interne (206) selon un rapport prédéterminé avec ladite base de temps de passage par zéro filtrée numériquement.

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7. Procédé de production de courant alternatif à coupure de phase dans un moyen de commande d'éclairage, comprenant le fait de:

observer (802, 901) les points de passage par zéro dans le courant alternatif entrant, **caractérisé en ce que** le procédé comprend le fait de:

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transmettre (802, 901) des ordres de commande d'un processeur maître (205) à un processeur esclave (211, 212, 213, 214) sur un bus de commande interne (206) dudit moyen de commande d'éclairage (200) selon un rapport prédéterminé avec les points de passage par zéro entre les demi-ondes dudit courant alternatif (300), et manipuler (805) les demi-ondes dudit courant alternatif sous la commande dudit processeur esclave (211, 212, 213, 214) pour produire ledit courant alternatif à coupure de phase, à l'aide du contenu desdits ordres de commande pour déterminer l'étendue de

ladite manipulation et à l'aide du moment desdits ordres de commande sur ledit bus interne (206) pour déterminer le temps de ladite manipulation.

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8. Procédé selon la revendication 7, dans lequel lesdits ordres de commande sont transmis sur ledit bus de commande interne (206) en trames (301, 501), de sorte qu'une partie prédéterminée de chaque trame transmise coïncide dans le temps avec un point de passage par zéro entre les demi-ondes dans ledit courant alternatif (300).

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9. Procédé selon la revendication 8, dans lequel les ordres de commande à un processeur esclave particulier (211, 212, 213, 214) sont transmis dans un intervalle de temps spécifique au processeur esclave (302, 502) des trames.

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10. Procédé selon la revendication 7, dans lequel lesdits ordres de commande sont transmis un à la fois sur ledit bus de commande interne (206), de sorte qu'une partie prédéterminée de chaque ordre de commande individuel transmis (401) coïncide dans le temps avec un point de passage par zéro entre les demi-ondes dans ledit courant alternatif (300).

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11. Procédé selon l'une quelconque des revendications 7 à 10, dans lequel chaque transmission (301, 401) sur ledit bus de commande interne (206) est plus courte qu'une demi-onde dans ledit courant alternatif (300).

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12. Procédé selon l'une quelconque des revendications 7 à 11, comprenant le fait de:

filtrer numériquement (902, 1002) une séquence de signaux d'indication indiquant le moment où se produisent les points de passage par zéro entre les demi-ondes dudit courant alternatif (300), produisant ainsi une base de temps de passage par zéro filtrée numériquement, et utiliser la base de temps de passage par zéro filtrée numériquement pour déterminer le temps de ladite manipulation.

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13. Programme d'ordinateur pour transmettre des ordres de commande d'un processeur maître (205) à un processeur esclave (211, 212, 213, 214) sur un bus de commande interne (206) d'un moyen de commande d'éclairage (200), le programme d'ordinateur comportant une ou plusieurs séquences d'une ou plusieurs instructions qui, lorsqu'elles sont exécutées par le processeur maître (205), font que ledit processeur maître (205) transmette audit processeur esclave (211, 212, 213, 214) un ordre de commande dont le contenu détermine la mesure dans laquelle ledit processeur esclave (211, 212, 213,

214) doit manipuler les demi-ondes d'un courant alternatif pour produire un courant alternatif à coupure de phase, et dont le temps par rapport aux points de passage par zéro entre lesdites demi-ondes dudit courant alternatif (300) détermine le temps de ladite manipulation. 5

14. Programme d'ordinateur selon la revendication 13, comprenant une ou plusieurs séquences d'une ou plusieurs instructions qui, lorsqu'elles sont exécutées par ledit processeur maître (205), font que ledit processeur maître (205): 10

 filtre numériquement (902) une séquence d'indications reçue indiquant le moment où se produisent les points de passage par zéro entre des demi-ondes dans ledit courant alternatif, produisant ainsi une base de temps de passage par zéro filtrée numériquement, et 15
 détermine le temps des transmissions (301, 401, 501) dudit ordre de commande sur ledit bus de commande interne (206) selon un rapport prédéterminé avec ladite base de temps de passage par zéro filtrée numériquement. 20

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15. Programme d'ordinateur pour manipuler des demi-ondes du courant alternatif sous la commande d'un ou plusieurs processeurs esclaves (211, 212, 213, 214) pour produire un courant alternatif à coupure de phase dans un moyen de commande d'éclairage (200), le programme d'ordinateur comportant une ou plusieurs séquences d'une ou plusieurs instructions qui, lorsqu'elles sont exécutées par lesdits un ou plusieurs processeurs esclaves (211, 212, 213, 214), font que lesdits un ou plusieurs processeurs esclaves utilisent le contenu des ordres de commande reçus sur un bus de commande interne (206) dudit moyen de commande d'éclairage (200) pour déterminer l'étendue de ladite manipulation et pour utiliser le moment desdits ordres de commande sur ledit bus interne par rapport aux points de passage par zéro entre les demi-ondes dans ledit courant alternatif (300) pour déterminer le temps de ladite manipulation. 30
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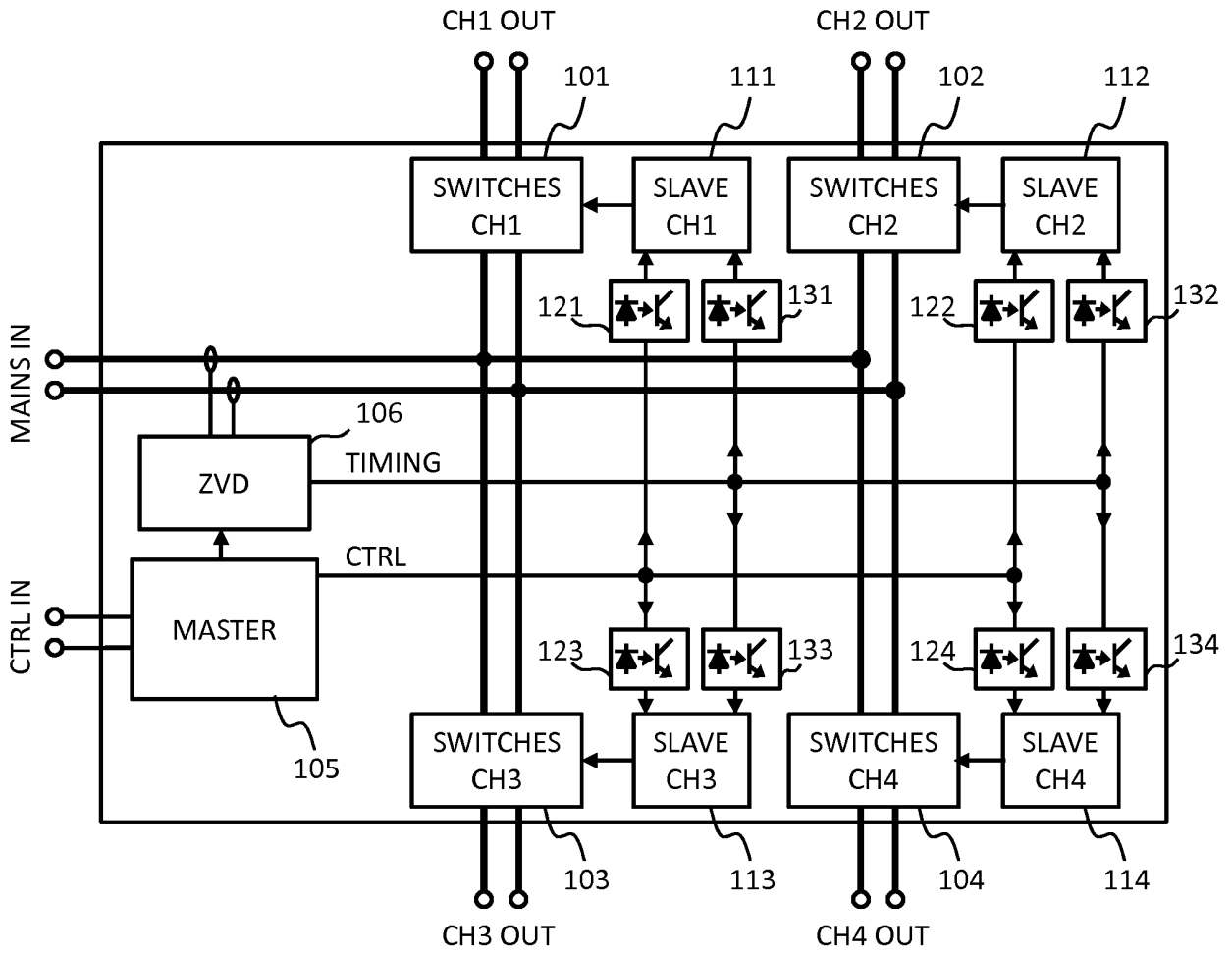


Figure 1

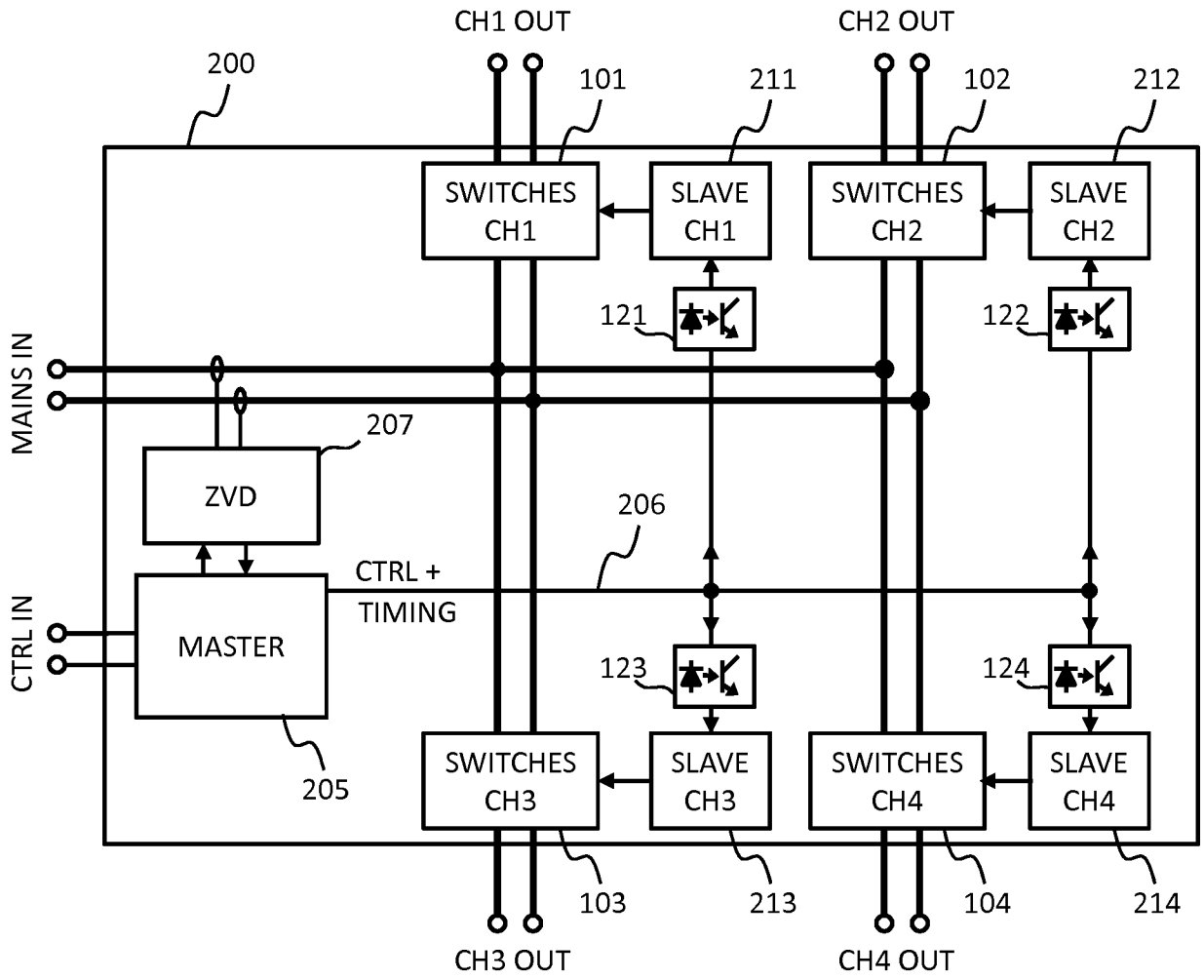


Figure 2

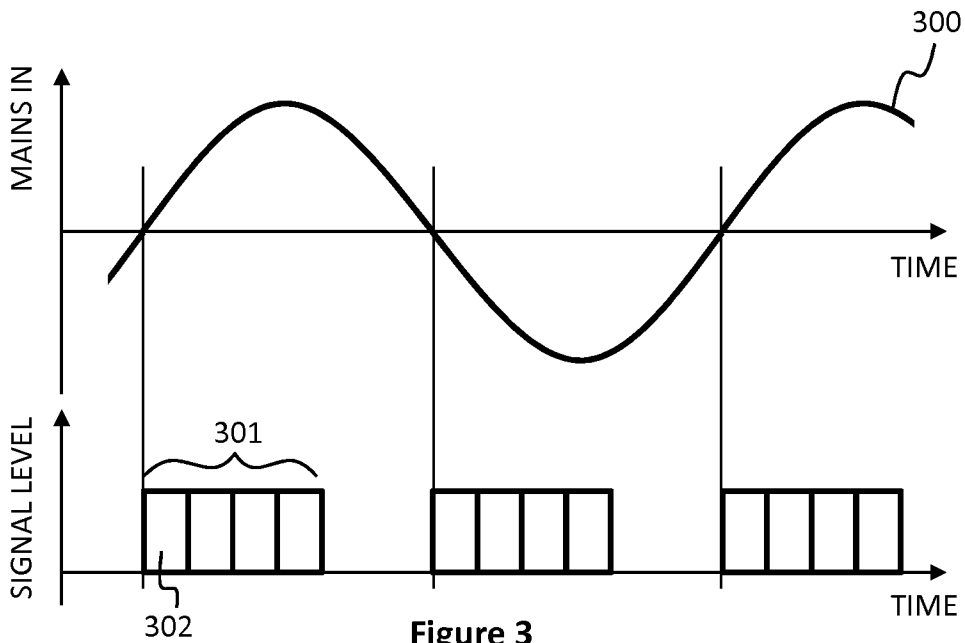


Figure 3

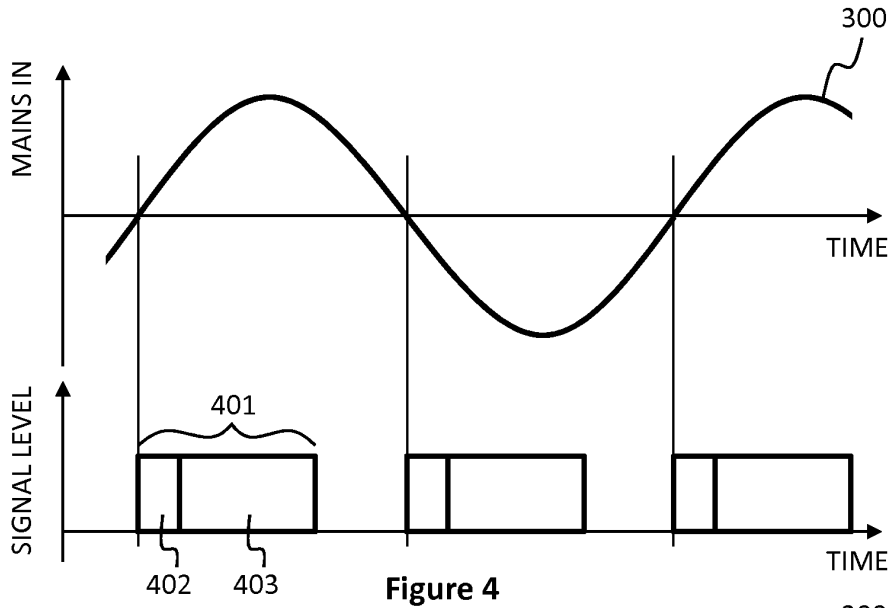


Figure 4

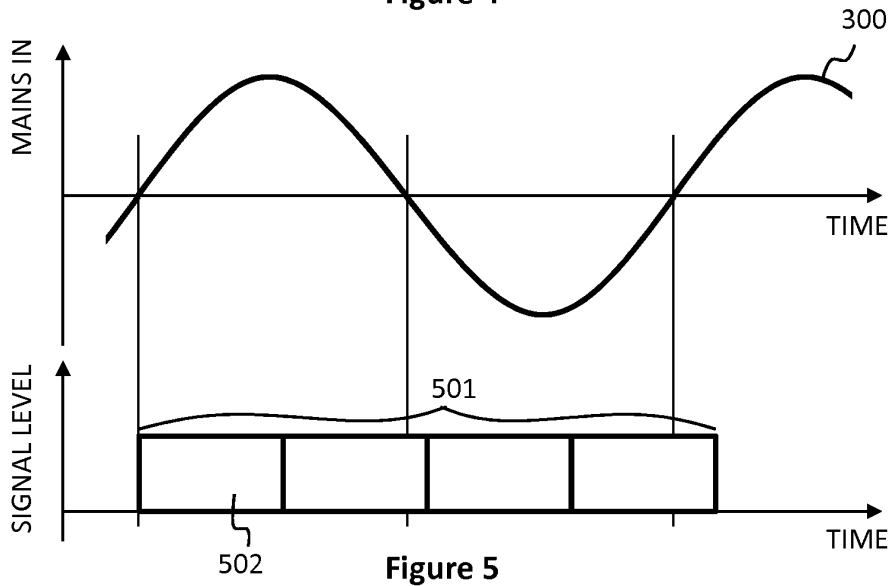


Figure 5

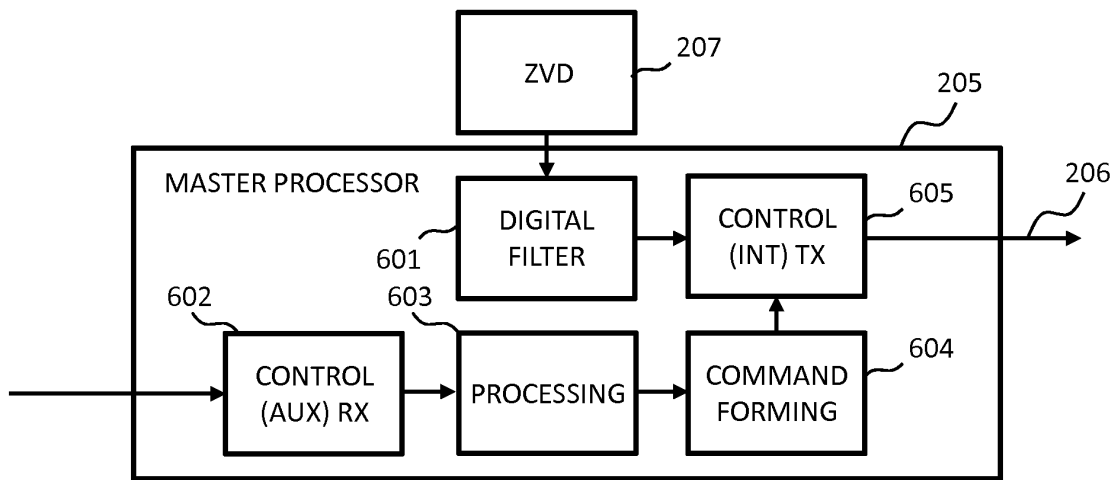


Figure 6

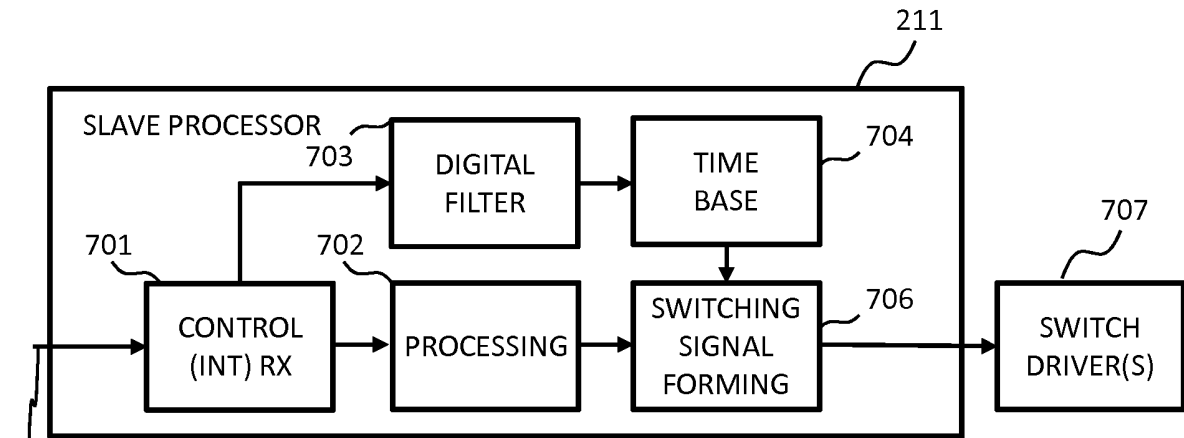


Figure 7

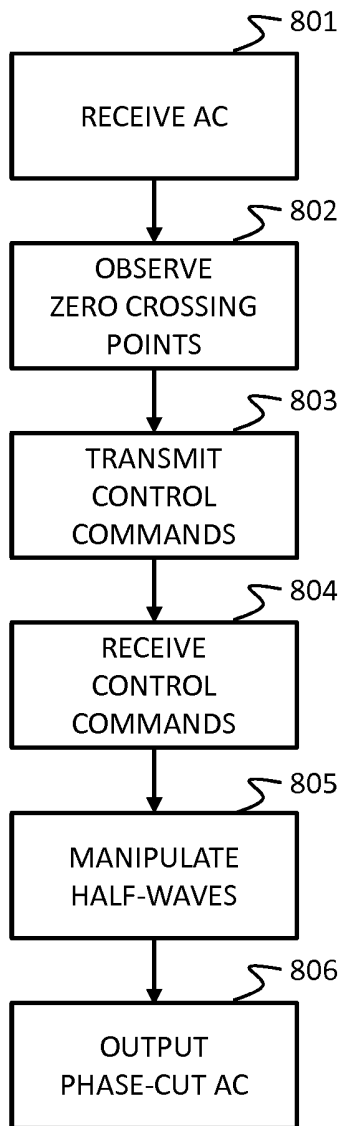


Figure 8

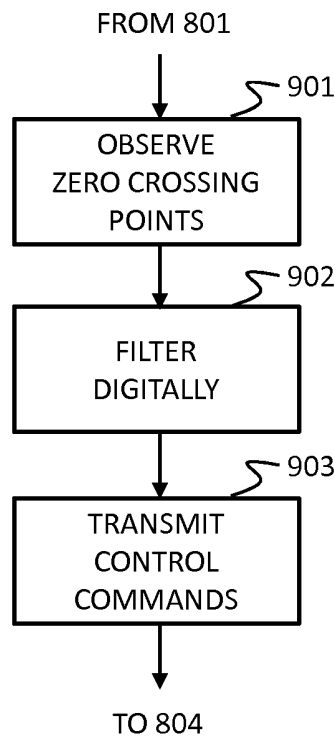


Figure 9

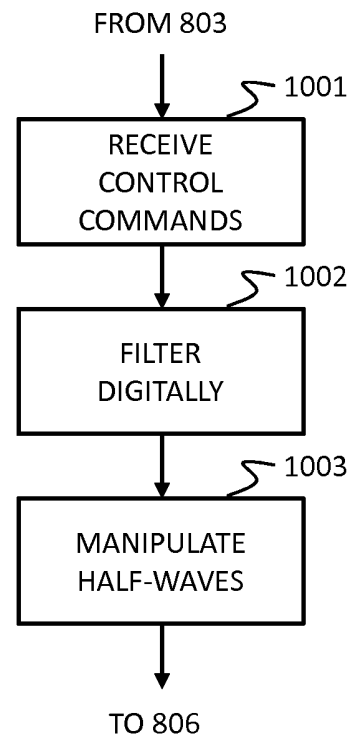


Figure 10

REFERENCES CITED IN THE DESCRIPTION

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