

Segmented control arrangement

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The present invention relates to a system arrangement for error-tolerant actuation of a plurality of execution units. In this context, the present invention advantageously makes it possible to actuate execution units in such a way
10 that, among other things, both a high common mode stability and a high failure safety are achieved even if there are a large number of execution units. Moreover, the present invention relates to a method which serves to operate or produce the proposed system arrangement. Moreover, a computer program product is proposed comprising control commands which carry out the
15 method or operate the device.

WO 2017/162 323 A1 discloses an efficient control arrangement and a control method in which sequentially arranged execution units are actuated by means of a command unit.

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WO 2018/103 880 A1 discloses a compact LED arrangement, which can be used generically but, as a result of the compact construction, is advantageous in particular for use in a vehicle.

25 WO 2017/153 026 A1 discloses a method for brightness compensation in at least one LED.

DE 20 2013 103146 U1 discloses an appliance system comprising a plurality of appliances for distributed arrangement along escape routes or traffic
30 routes.

US 2014/333 207 A1 shows a protocol for exchanging status messages in a lighting system.

US 8,492,983 B1 discloses methods and systems for actuating lighting units.

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DE 10 2016 125 290 A1 discloses methods and a device for chained control and/or programming of a plurality of integrated circuits.

US 2010/0188972 A1 shows a communication system with a ring topology.

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EP 2 663 028 A1 shows a communication system which increases an error tolerance due to a fault line.

US 2011/0309746 A1 shows a system arrangement with light-emitting diodes for use in an automobile.

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DE 20 2016 008 325 U1 shows a communication system with a command unit and several control units.

20 In conventional methods, a plurality of options are known for addressing control units connected in series. Generic approaches exist, which may be disadvantageous in specific application scenarios, as well as highly specialised approaches, which are no longer usable generically. For example, the CAN bus is known, which was developed in relation to cable harnesses and
25 is intended to implement networking of control devices in particular.

In general, the complexity of the CAN protocol is much greater than for ISELED (registered trade mark) and thus more expensive. However, the greatest drawback of CAN and LIN is that because of the bus architecture

they do not offer a natural (automatic) addressing option. In these cases, the address has to be configured. For ISELED (execution units), and also for segmented ISELED (line driver unit and execution units), there is a physically predetermined string, resulting in one option for allocating addresses automatically.

From the prior art, various execution units are known, which typically work as a slave or as a client and thus receive commands from a superordinate entity, typically referred to as a master. The execution units subsequently implement these commands. In this regard, the prior art discloses various architectures or topologies for how corresponding execution units, along with the control units thereof, are to be arranged.

However, in this context the prior art has the problem that different requirements are set depending on the application scenario, and thus overall it has to be weighed up whether an energy-efficient method having high error susceptibility is to be provided, or a method which takes up more energy but is more error-proof as a result. Moreover, the dimensions of the provided place of use of an architecture of this type are to be taken into account. Some arrangements are not suitable for large-area use, and can therefore only be implemented on individual circuit boards. By contrast, other architectures can be installed over a large area over several metres, and thus have to meet completely different requirements from system arrangements on individual circuit boards.

The prior art also deals with the problem of electromagnetic acceptability. Thus, faults can occur which either are suppressed from the start or else are eliminated in retrospect. In addition, faults can occur in that individual components fail under the effect of force or heat and thus bring about resultant

failures. This is a problem in particular if units are connected in series and each unit receives commands from its predecessor. Thus, in the case of daisy-chaining, problems may occur if individual components are not connected through in the event of a failure. Thus, the upstream sub-chain is cut off from the flow of communication and therefore fails. Very specific requirements also occur in a system arrangement which is to be installed in an automobile. An automobile is generally an expensive product on which the customer is constantly reliant. As a result, high error susceptibility will not be tolerated by the customer, and in addition components to be actuated are often safety-related. In this context, error susceptibility plays a major role, since the customer only wants to make use of customer service in exceptional situations, and in addition the functionality of safety-critical units has to be ensured.

Therefore, an object of the present invention is to provide a system arrangement for actuating execution units which is error-tolerant in the broadest sense and in addition can be provided at a low technical complexity. Error tolerance is based in particular on electromagnetic acceptability and failure safety. In addition, an object of the present invention is to propose a method for providing or operating the proposed system arrangement. In addition, a computer program product comprising control commands which carries out the method or operates the system arrangement is to be proposed.

The object is achieved by the features of the independent claims. Further advantageous embodiments are specified in the dependent claims.

Accordingly, a system arrangement for error-tolerant actuation of a plurality of execution units of the system arrangement is proposed, comprising a command unit and a plurality of line driver units, the plurality of execution units being segmented into a plurality of sub-chains which are each in series, each

- sub-chain comprising at least one execution unit along a first data line, and a line driver unit being connected upstream from each sub-chain, and the line driver units being communicatively coupled to one another in series by means of a second data line, and the first line driver unit connected in series
- 5 being communicatively coupled to the command unit by means of the second data line, wherein the system arrangement is arranged such that signals on the second data line are modulated with 10 times greater an amplitude than signals on the first data line.
- 10 Among other things, the proposed invention provides the advantage that, to increase the system-wide error-tolerance, the proposed segmentation further makes automatic address allocation possible. Neither CAN nor LIN provides this advantage. According to the invention, the plurality of execution units, upstream from each of which only one line driver unit is connected, results
- 15 in a positive relationship between the number of execution units and the number of line driver units. This makes automatic addressability possible, by contrast with CAN/LIN, along with a maximal error tolerance and minimal complexity as a result of the simple protocol. The series arrangement makes automatic addressability or address allocation possible, in such a way that
- 20 the execution units can each be addressed using a dedicated address.

As a master, the command unit transmits orders. An order contains for example a command, in other words what is to be done (for example "set pulse width modulation PWM of red channel"), and optionally a parameter (for example = 255) and preferably an address. This address addresses one or more

25 execution units. The execution units have a unique address which is derived automatically from the position thereof.

There is thus the option of providing a method step which implements automatic assignment of an associated address to each of the execution units as a function of the physical arrangement of the execution units in question within the proposed system arrangement. The physical arrangement may
5 take into account in which sub-chain the execution unit in question is arranged. This may take into account which line driver unit is upstream from the execution unit in question.

The orders are typically distributed via all line driver units to all execution
10 units. Filtering or processing in the line driver units can thus be dispensed with. The execution units subsequently decide, on the basis of their own addresses and the address contained in the order, whether or not to carry out the command. Typically, they carry out the command if they themselves were addressed by the address.

15 In this context, the present invention advantageously makes it possible to actuate execution units in such a way that both a high common mode stability and a high failure safety are achieved even if there are a large number of execution units. The option is also provided of using line drivers which are optimal for example for optical or differentially electrical physical media. As a result of the segmentation, a small number of line driver units is required by
20 comparison with the total number of execution units, and so it is possible to work with higher current/power consumption and a higher complexity of the chips here than in the execution units.

25 An alternative is thus proposed to bus solutions such as CAN/LIN, and among other things solves the described problem of a lack of automatic addressing. The segmentation using line driver units, the option of passively connecting through, and the optimisation of the physical layer (common

mode and electrically differential or optical) now solve the problem of fault susceptibility.

Among other things, the proposed system arrangement is error-tolerant,
5 since the execution units are segmented and therefore arranged in sub-chains. This results in series sub-chains, the individual execution units being connected in succession. Thus, if one of the execution units fails, adverse effects only occur within the sub-chain in which the failing execution unit is arranged. This has the advantage over the prior art that, instead of a plurality
10 of further execution units connected in series failing, merely execution units in the same segment fail. This can also be dealt with in that in the event of a failure the execution units are merely connected through.

The execution units are coupled in series, preferably bidirectionally. It is thus
15 possible for the execution units to receive commands conveyed from the line driver unit and subsequently to implement them. A command may involve an instruction or else reading out or setting a parameter. Thus, the execution units may be provided as LED units which actuate individual LEDs. LEDs typically take the form of red, green and blue LEDs, it also being possible
20 that a white LED is to be provided. The execution units therefore implement the commands of the line driver unit and are additionally able to provide a return value. It is thus possible for the line driver unit to instruct the execution unit to read out a sensor, and by means of the bidirectional communication the execution unit can return a read-out temperature value of the sensor.

25 Since according to the invention there are a plurality of sub-chains or segments, an error does not adversely affect the entire sub-chain as is disclosed in the prior art, and also according to the invention not all sub-chains but only one (the relevant) sub-chain, but rather the failure safety is increased in

- that separate sub-chains are formed which are to be actuated individually. Non-exclusively, the sub-chains include at least one execution unit, a line driver unit being connected upstream from each sub-chain. The error tolerance is also ensured in that the line driver units pass signals through in the event of an inactive state. Passing through generally describes passing signals on without processing them. As a result, no logic is implemented and no processing steps are carried out within the failed element. Rather, a signal present at an input is outputted again at the output without any processing.
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- 10 Electromagnetic acceptability when a plurality of execution units are actuated can be brought about in that, among other things, a differential modulation is always provided, in other words the line is actively driven even when no order is being transmitted. As a result, a steep flank which occurs when the line driver is switched on and off is dispensed with. According to the invention, it is possible to implement the proposed topology in such a way that
- 15 a wired connection (optical or electrically differential) is produced at least between the line driver units. As a result, the data line is not implemented on a circuit board in the conventional manner, but rather the individual sub-chains are merely arranged on a circuit board, and the resulting circuit
- 20 boards can be communicatively coupled via the associated line driver unit by means of a wired connection (optical or electrically differential). It is thus particularly advantageous that the number of sub-chains scales because any desired number of line driver units can be connected in series and a sub-chain of execution units is communicatively arranged or coupled at each line
- 25 driver unit.

In general, the number of execution units to be operated or of line driver units is limited by the address space, in other words the number of units

which can be addressed. Since the address space can be selected as desired, the number of units to be installed thus also scales.

The proposed system arrangement also provides, among other things, a command unit which ultimately controls the individual execution unit. This typically does not take place directly, but rather via the line driver units. The command unit thus generates commands and conveys them to the execution units via the associated line driver units, or receives parameters and values from the execution units via the line driver units. The command unit thus represents a superordinate instance with respect to the line driver units, and can thus be referred to as a master unit. In this case, the line driver units behave as slave units or client units. Since the line driver units are connected upstream from the sub-chains, in other words the execution units, and the line driver units convey the commands to the associated sub-chains, in this regard the line driver units behave like master units with respect to the execution units. The execution units thus take on the role of the slave unit or client unit.

For example, the proposed system arrangement takes the form of an LED chain. For this purpose, the command unit outputs a particular pattern which is to be implemented by means of the individual LEDs. For this purpose, the command unit actuates the individual line driver units, which subsequently pass on the command to the associated sub-chain. The line driver units can not only pass on the command, but also independently adapt the command. The individual execution units implement the command and actuate for example individual LEDs. Again, these may be the LEDs red, green and blue, it also optionally being possible to provide a white LED. The execution units may also take the form of other actuators, such as motors, matrix LEDs, sensors, temperature sensors, light sensors or scanners.

The first data line is the data line formed by sub-chains. The first data line thus connects the individual execution units and connects this chain of execution units to exactly one line driver unit. The data line thus initially comprises a line driver unit to which an execution units is connected. Optionally, further execution units are connected to this execution unit in series. Again, there is no restriction on the number of execution units, but rather the underlying address space is merely selected accordingly. In this context, the address space need not be fully exhausted, but rather the address space merely represents an upper limit on the number of execution units to be installed.

The second data line interconnects the line driver units in series and preferably bidirectionally. As a first unit, the command unit is connected to the second data line, and subsequently at least one line driver unit follows.

Since the individual sub-chains each have a dedicated data line, the first data line may be referred to as a data line of a first type. In general, there are as many data lines as sub-chains. For example, if there are three sub-chains, exactly three line driver units are installed and three sub-chains are formed, a data line of the first type being present within each sub-chain. As a result, in this case there are thus exactly three first data lines. The difference between the first and second data line makes it possible for each first data line to be configured differently from the second data line, which is typically only provided once. Thus, the first data line may be arranged on a circuit board in each case, and the second data line may for example take the form of a cable. This results, in a particularly advantageous manner, in a flexible construction which is based in particular on the application scenario in an automobile.

In one aspect of the present invention, the line driver unit upstream from a sub-chain acts as a master unit for the at least one execution unit of this sub-chain, and the at least one execution unit acts as a slave unit with respect to this line driver unit. This has the advantage that the execution units can receive commands from the line driver unit and the commands are subsequently passed through or executed by the execution units. The line driver unit thus provides a command which is passed through the sub-chain and carried out and passed on by each execution unit. Moreover, it is also possible to address an individual execution unit using an address, in such a way that the corresponding command from the line driver unit is addressed to this one specific execution unit through the chain. If the command has been carried out, it is also possible to convey a result from the associated execution unit back to the preceding execution unit and subsequently to provide the end result to the line driver unit. Bidirectional communication within the sub-chain is advantageous for this scenario. The command is advantageously outputted by the command unit and passed on, typically unchanged, via the line driver units to the associated execution units.

In a further aspect of the present invention, the command unit acts as a master unit for the line driver units, and the line driver units act as slave units with respect to the command unit. This has the advantage that an individual command or a sequence of commands can be created by the command unit and conveyed to the line driver units. The line driver units thus receive this command or these commands and pass them on, unchanged or adapted, to the execution units. In this case too, it is possible for the line driver units to be addressed individually using an address and optionally also to output return values to the command unit.

In a further aspect of the present invention, the first data line and/or the second data line are configured bidirectionally. This has the advantage that commands or signals are conveyed in both directions, and as a result it is also possible both for the execution units to transmit return values to the line driver units and for the line driver units to transmit signals to the command unit. In particular, the individual units can communicate with one another. Preferably, both data lines are configured bidirectionally, it also being possible for only the first data line or the second data line to be bidirectional. Since there are a plurality of data lines of the first type, it is also possible for the individual first data lines to be configured differently. Typically, however, all first data lines are configured identically.

In a further aspect of the present invention, signals on the second data line are modulated with a greater amplitude than signals on the first data line. This has the advantage that by means of the second data line greater distances can be overcome without error. A higher amplitude is based on the difference between zero and one being greater, and the signal modulation thus being less error-susceptible. It is thus possible to implement the first data line on a circuit board and to implement the second data line using a wired line, which is subsequently also accordingly modulated with a greater amplitude as a result of the greater distance.

In a further aspect of the present invention, signals on the second data line are modulated with 10 times greater an amplitude than signals on the first data line. This has the advantage that, surprisingly, this value is particularly advantageous, and the signals can be modulated particularly efficiently on the first data line, and although the signals on the second data line are modulated less efficiently they are much more robust against errors. Surprisingly, it has been found according to the invention that precisely the proposed

value is particularly well-suited for setting the ratio of the amplitude of the second data line to that of the first data line.

5 In a further aspect of the present invention, the first data line and/or the second data line are optical or electrical data lines. This has the advantage that a plurality of options can be offered, which can in turn be selected as a function of the application scenario. According to the invention, an electric data line is preferably implemented.

10 In a further aspect of the present invention, the first data line and/or the second data line are electrical data lines which always carry current. This has the advantage that differential transmission is always possible, and as a result there are also no drawbacks of a particularly steep flank while the current is being applied. Rather, there is always a current, and transient oscillation is prevented. The proposed method is thus also insensitive to electro-
15 magnetic disturbance. Moreover, it is advantageous to select a configuration of this type because a wired connection can be implemented which has to cover distances of several metres.

20 In a further aspect of the present invention, each line driver unit is arranged on a dedicated circuit board along with a sub-chain. This has the advantage that the line driver units, along with the execution units and the associated first data line, can be optimised for short distances, and as a result can simply also be arranged on an individual circuit board. This also reduces error sus-
25 ceptibility, since the execution units are segmented, and individual sub-chains are separated by means of circuit boards.

In a further aspect of the present invention, the line driver units are each configured in such a way that signals on the second data line are passed through

the associated line driver unit when this line driver unit is in an inactive state. This has the advantage that if one line driver unit fails the further line driver units connected in series still receive commands and can also send signals back. The defective line driver unit is thus merely masked out, and corresponding signals are passed through passively. As a result, there is no processing of signals in the defective line driver unit, but this line driver unit also does not interrupt the rest of the chain. It is thus advantageous that in the event of a defective line driver unit merely one sub-chain of a plurality of sub-chains fails.

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In a further aspect of the present invention, the execution units are each configured as an LED, motor, sensor, temperature sensor, light sensor, scanner or switch. This has the advantage that different execution units can be provided, an LED being particularly preferred according to the invention. The LED may in turn have individual units which emit red, green or blue. In general, however, it is also possible to mix the individual execution units, in such a way that for example LEDs and also sensors are present within the same chain. In addition, one sub-chain may be formed from LEDs, and another sub-chain from sensors. Preferably, however, all execution units are configured identically.

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In a further aspect of the present invention, the execution units are set up to provide at least one piece of status information to the line driver unit. This has the advantage that the line driver unit can instruct that a particular value should be read out, and subsequently this command is passed through the sub-chain to the addressed execution unit, and this execution unit returns the requested value again via the other execution units. In this context, bidirectional communication is particularly advantageous.

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The object is also achieved by a method for error-tolerant actuation of a plurality of execution units, comprising providing a command unit and a plurality of line driver units, the plurality of execution units being segmented into a plurality of sub-chains which are each in series, each sub-chain comprising
5 at least one execution unit along a first data line, and a line driver unit being connected upstream from each sub-chain, and the line driver units being communicatively coupled to one another in series by means of a second data line, and the first line driver unit connected in series being communicatively coupled to the command unit by means of the second data line, wherein sig-
10 nals on the second data line are modulated with 10 times greater an amplitude than signals on the first data line.

The object is also achieved by a computer program product comprising control commands which carry out the method or operate the proposed system
15 arrangement.

According to the invention, it is particularly advantageous that the system arrangement provides structural features which functionally correspond to the method steps. Further, method steps are proposed which can also be
20 structurally reflected by the system arrangement in terms of the corresponding functionality. The method thus serves to operate the system arrangement, and the system arrangement can carry out the proposed method.

Further advantageous configurations are described in greater detail with reference to the accompanying drawings, in which:
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Fig. 1 shows a sub-chain comprising a microcontroller and a plurality of LED units connected in series according to the prior art;

Fig. 2A, 2B shows a modulation of data as an example application of the present invention;

5 Fig. 3 shows the proposed system arrangement in a block diagram for an aspect of the present invention; and

Fig. 4 is a flow chart in accordance with the proposed method for error-tolerant actuation of a plurality of execution units according to one aspect of the present invention.

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The left side of Fig. 1 shows a microcontroller which acts for example as a command unit. Moreover, a plurality of execution units, in this case implemented as LED controllers, are arranged with bidirectional communication. This is indicated by reference sign MLED CTRL. For some application scenarios, the prior art has the drawback that, if a controller fails, all further controllers connected in series also fail, since communication is suppressed.

Fig. 1 shows a possible configuration of a system or communication arrangement according to the prior art. Thus, in this case, the command unit BE, which is connected to three control units, can be seen on the left side. Since the three control units are connected in series, the command unit is directly connected to a control unit and indirectly connected to the further control units. The control units may be multi-LED controllers. This is denoted in Fig. 1 as MLED CTRL. The unitary reference sign is intended to illustrate in particular that the control units are typically configured identically. As can be seen here, the LEDs are RGB (red, green, blue) LEDs. These are set up to set a particular colour value by means of a mixing ratio of the individual LED units. Further, it can be seen in this drawing that further components are to be provided as required. For example, it may be necessary to provide a

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power supply. In this context, it is also possible, however, to provide these components, for example the power supply, externally and merely to connect them.

- 5 The data line is in this case in the form of a plurality of data line segments, which are indicated as bidirectional arrows SIO1, SIO2. Control units may also be referred to as execution units. The MLED controller may also be referred to as an ISELED controller, such as may according to the invention be used as an execution unit.

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Fig. 2A shows data modulation, the data lines being differentially modulated only in the active phase when orders are being transmitted. In the inactive phase, in other words when no orders are being transmitted, the current is switched off on both lines and both lines “fall” to a non-differential potential, which is typically specified by a termination. During the transition from the active phase (differential with high current consumption) to the inactive phase (non-differential, no current consumption), a steep flank occurs. In addition, clocking is indicated by means of the vertical lines, and serves to read out a semantic analysis from the signal. Preferably, the signal is read out within the clocking when the amplitude is fully exhausted so as to achieve error robustness. The data shown may be synchronisation data on the left side and an order on the right side.

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In general, the dimensions and contents of Fig. 2A and 2B are merely to be understood as exemplary and schematic. There may thus also be other modifications.

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Fig. 2A shows a drawback of the prior art, specifically the steep flank on the left side, which is not electromagnetically acceptable. Thus, this type of modulation is ill-suited to a wired connection. This modulation is suitable for a circuit board, and therefore according to the invention it is only possible to
5 transmit in this manner on the first data line. This is because the connection here is short and shielding is possible.

Fig. 2B shows a superposed signal, and therefore shows two characteristics. By contrast with figure 2A, the data line is always actively driven. The orders
10 are conveyed using a sequence of bits, which are differentially modulated as in Fig. 2A. By contrast with Fig. 2A, the data lines are not switched off after the orders are transmitted, and continue to transmit a differential idle pattern. This is an aspect of data modulation which can also be used according to the invention. It is particularly advantageous that according to the inven-
15 tion, without adapting the transmitter, not only is sampling of these disadvantageous times avoided at the receiver, in other words when a signal is close to the threshold, but sampling also actually takes place at a maximum amplitude. This guarantees a sufficient interval of the signal strength from the threshold to a measurement time, in other words the sampling time. The
20 sampling time is arranged temporally within a bit width which determines in which time period the associated bit for transmission is coded. Thus, the sampling time is to be selected within this bit width in each case, and reads out a bit occupancy in each case. The individual bit widths, which subdivide the serial bit dataflow into individual bits, and typically equidistant in time.
25 An idle pattern is also referred to as a dormant pattern.

In the samplings which are typically carried out, the sampling time may be the temporal centre of a bit width. The signal strength thus increases for example upon a change from a coded zero to a coded one towards the start of

the bit width, reaches a maximum approximately at the centre of the bit width, and then falls until a zero is subsequently to be coded. Thus, the centre of a bit width may be selected as a reference point for a suitable sampling time.

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Fig. 3 shows the proposed construction of a system arrangement, the command unit BE taking the form of a microcontroller. This control unit BE is communicatively coupled to a plurality of line driver units LTE. The line driver unit BE is connected via the second data line to the line driver unit LTE connected in series. For this purpose, each line driver unit LTE has three interfaces, namely interfaces A, B and C. As is illustrated here, a line driver unit LTE communicates with a sub-chain of execution units AE. These execution units AE are likewise connected in series, and communicated by means of the first data line.

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As is also shown, there are a plurality of sub-chains, each sub-chain comprising a line driver unit LTE and at least one execution unit AE. There are thus also a plurality of data lines of the first type, merely three sub-chains, in other words three first data lines, being illustrated.

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The proposed system scales, this being marked by drawing in dots between the second sub-chain and the third sub-chain. These dots clarify that there may be a plurality of an indeterminate number of sub-chains. The number is merely limited by the address space. The bottom right of Fig. 3 shows that a different number of execution units AE may be provided, this likewise being indicated by dots. In this case too, the address space is decisive as to the number of execution units AE.

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In Fig. 3, in each case the first data line is illustrated horizontally and the second data line is illustrated vertically. The second data line also refers to the connection between the command units BE and the plurality of line driver units LTE. As a whole, the horizontal sub-chains may in each case be arranged on a circuit board, while a wired connection can be implemented between the vertical connection. Thus, vertically, larger distances of several metres can still be overcome. Herein, vertically and horizontally merely refer to the drawing, as a person skilled in the art will appreciate that the actual implementation will be in accordance with the requirements.

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Fig. 4 is a schematic implementation chart of a method for error-tolerant actuation of a plurality of execution units AE, comprising providing 100 a command unit BE and a plurality of line driver units LTE, the plurality of execution units AE being segmented 101 into a plurality of sub-chains which are each in series, each sub-chain comprising at least one execution unit AE along a first data line, and a line driver unit LTE being connected 102 upstream from each sub-chain, and the line driver units LTE being communicatively coupled 103 to one another in series by means of a second data line, and the first line driver unit LTE connected in series being communicatively coupled 104 to the command unit BE by means of the second data line, wherein signals on the second data line are modulated with 10 times greater an amplitude than signals on the first data line.

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Claims

1. System arrangement for error-tolerant actuation of a plurality of execution units (AE), comprising:
 - 5 - a command unit (BE) and a plurality of line driver units (LTE),
 wherein
 - the plurality of execution units (AE) being segmented into a plurality of sub-chains which are each in series, each sub-chain comprising at least one execution unit (AE) along a first data line, and a line driver unit (LTE) being connected upstream from each sub-chain; and
 - 10 - the line driver units (LTE) being communicatively coupled to one another in series by means of a second data line, and the first line driver unit (LTE) connected in series being communicatively coupled to the command unit (BE) by means of the second data line, wherein the system arrangement is arranged such that signals on the second data line are modulated with 10 times greater an amplitude than signals on the first data line.
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2. System arrangement according to claim 1, characterised in that the line driver unit (LTE) upstream from a sub-chain is arranged to act as a master unit for the at least one execution unit (AE) of this sub-chain, and the at least one execution unit (AE) is arranged to act as a slave unit with respect to this line driver unit (LTE).
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- 25 3. System arrangement according to either claim 1 or claim 2, characterised in that the command unit (BE) is arranged to act as a master unit for the line driver units (LTE), and the line driver units (LTE) are arranged to act as slave units with respect to the command unit (BE).

4. System arrangement according to any of the preceding claims, characterised in that the first data line and the second data line are bidirectional.
- 5 5. System arrangement according to any of the preceding claims, characterised in that the first data line and/or the second data line are optical or electrical data lines.
- 10 6. System arrangement according to any of claims 1 to 6, characterised in that the first data line and/or the second data line are electrical data lines which are arranged to always carry current.
- 15 7. System arrangement according to any of the preceding claims, characterised in that each line driver unit (LTE) is arranged on a dedicated circuit board along with a sub-chain.
- 20 8. System arrangement according to any of the preceding claims, characterised in that the execution units (AE) are each configured as an LED, motor, sensor, temperature sensor, light sensor, scanner or switch.
- 25 9. System arrangement according to any of the preceding claims, characterised in that the execution units (AE) are set up to provide at least one piece of status information to the line driver unit (LTE).
10. Method for error-tolerant actuation of a plurality of execution units (AE), comprising:
 - providing (100) a command unit (BE) and a plurality of line driver units (LTE),

- the plurality of execution units (AE) being segmented into a plurality of sub-chains which are each in series, each sub-chain comprising at least one execution units (AE) along a first data line, and a line driver unit (LTE) being connected (102) upstream from each sub-chain; and
- 5 - the line driver units (LTE) being communicatively coupled to one another in series by means of a second data line, and the first line driver unit (LTE) connected in series being communicatively coupled to the command unit (BE) by means of the second data line, wherein
- 10 signals on the second data line are modulated with 10 times greater an amplitude than signals on the first data line.

11. Computer program product comprising control commands which carry out the method according to claim 10 when they are executed on a computer.