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(54) **Earmarked display with intelligent light points**

(57) Innovation object is an earmarked display with intelligent light points, where the positions of light points are optional and predefined, so not necessarily positioned in the raster. The set of mutually logically connected light points with elements like (bulb, LED, LCD, oLED, mechanic display or any element that submits or reflects the light) forms a light field that presents the changing light traffic lights, information panels, advertising inscriptions, etc, and is controlled over PCBUS (Power Communication Bus) of supply communication guide, which connects the light elements with the controller and needs only two guides for that.

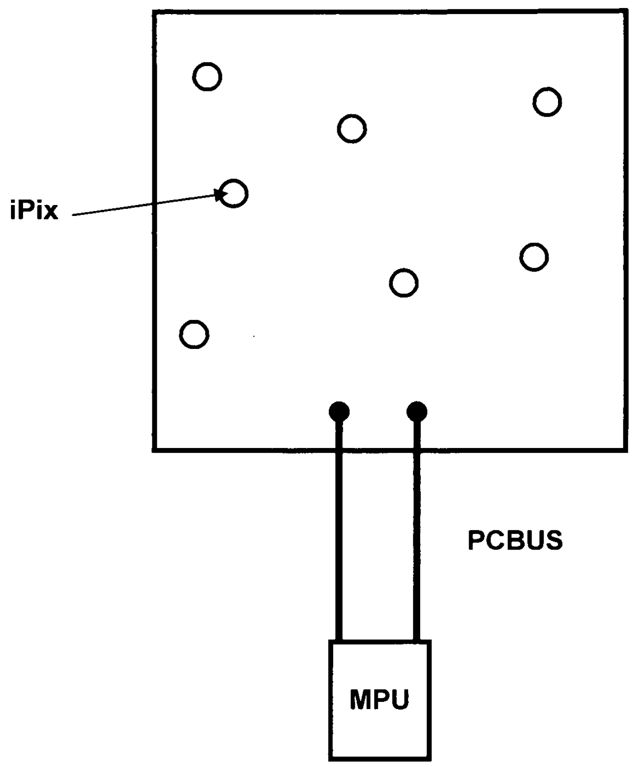

Fig. 1

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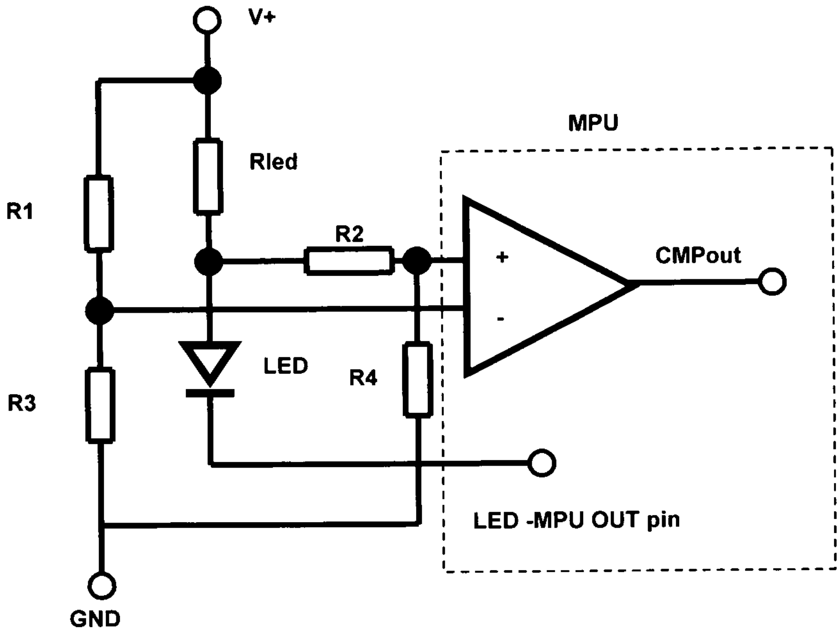

Fig. 11

Description

[0001] Innovation object is earmarked display with intelligent light points, where the positions of light points are optional and predefined, so not necessarily positioned in the raster. The set of mutually logically connected light points with elements like (bulb, LED, LCD, oLED, mechanic display or any elements that submit or reflect the light) forms a light field, that presents variable light traffic signs, information tables, information panels, advertising inscriptions, etc, and is controlled through PCBUS (Power Communication BUS) supplying communication guide that connects individual light points with the controller and needs only two guides for that. The innovation belongs to class G09G 03/32 of international patent classification.

[0002] Technical problem, successfully solved by this innovation, is to enable the development of series production of unique earmarked displays, that should, in spite of significantly more complex solution (in comparison to LED chains), ensure lower price of unique displays, as per option of simple and quick, automatized series production, where the installation of light points on each individual display can be different.

[0003] Solution of the set technical problem is therefore the fundamental paradox of series production of unique specimen. Existing solutions base on connecting the individual light points with cables. The other solution is the manufacture of dedicated printed circuit, where the light points are mounted on the required spots and the controller as well.

[0004] Both existing solutions are not most appropriate for small series production and prototype solution. They demand a lot of manual work from the person that is assembling the device or knowledge and professional development. This demands a lot of time and many times, high costs. The automatization of the production would be very complex, expensive and maybe unreliable.

[0005] With the earmarked display with intelligent light points after the invention, the positions of the light points are optional and predefined, so they are not necessarily positioned in the raster (as with e.g. with matrix display), where the solution is used, that PCBUS has also the function of carrying construction, so the installation of individual light points iPix to the carrying board with two conductive layers.

[0006] The invention will be explained in details based on implementation case and respective pictures that show possible applications and implementations, where there will be three basic types of solutions described further, namely: simplified system for displaying only two pictures, simplified system for displaying up to 2**N pictures and complex system with the possibility of controlling individual light point iPix:

- **picture 1** basic implementation idea of earmarked display with intelligent light elements with complex system with the possibility of controlling individual light point after the innovation;
- **picture 2** circuit of the basic unit of the light point to display only two pictures;
- **picture 3** code diagram of controlling the basic unit of the light point for display of four pictures;
- **picture 4** light point basic unit circuit for displaying only 2**N pictures, hereinafter N = 4;
- **picture 5** schematic display of alternative solution with cable connections;
- **picture 6** schematic display of alternative solution on carrying board with two conductive layers;
- **picture 7** light point basic unit circuit;
- **picture 8** diagram of communication impulses;
- **picture 9** controller connection with light point basic unit;
- **picture 10** communication packages in one communication cycle;
- **picture 11** circuit for light point basic unit error detection.

[0007] Basic implementation idea of earmarked display with intelligent light points with complex system with the possibility of controlling individual iPix light point is shown on picture 1. Each light point iPix contains light element LED and microcontroller MPU that communicates with main controller over the supplying communication guide PCBUS. The supply can be implemented over the two conductive layers that are isolated between themselves. With this solution, all cables are removed and the implementation of automated process is significantly simplified. MPU that is contained by each iPix light point, enables, besides the communication, also a direct controlling of iPix light point and controls that it is working correctly. In the case when iPix light point is not working correctly, it notifies the main controller.

[0008] Picture 2 shows the circuit of basic unit of the iPix light point for displaying only two pictures. It consists from the parallel connection of two successive connections of diode D, resistor and LED 1 and diode D, resistor and LED 2 diode. Such an implementation enables the implementation of earmarked display, adjusted for typical application for displaying only two pictures (e.g. traffic sign cross - arrow). In such case the iPix light point basic unit does not need any intelligence, as the terminals A and B are supplied with AC voltage. In each case, there is only one light element on (diode LED 1 or LED 2) Diodes D are necessary only when there is LED $\mathbf{V}_{Fmax} < \mathbf{V}_{AB}$. Physical implementation of iPix' light point is simple, driver for field of light points can be easily implemented with H-Bridge FET power rate, the price of individual iPix' light points is minimal.

[0009] With the alternative solution, where the earmarked display needs to show up to 2**N pictures (possibility of individual control N groups of iPix points), the implementation case is shown on pictures 3 and 4. With this solution, the iPix" light point can be presented in more pictures. Information with light point supply is coded in a way, as shown by code diagram on picture 3. With the exchange period of picture Tpicture, that is usually time of the level of a second, the modulation appears in time Tdata, that is substantially shorter from the time of picture exchange, therefore LED supply is not bothered and is not affecting the luminosity. In Tdata time, N data pulses are sent, the total of which defines the code that starts the adequate base unit of iPix" light point. Simplified circuit, that enables decoding and submitting of the iPix" light point base unit, is shown on picture 4.

[0010] Supply reserves during the data transfer are again implemented with diode D and C2. Deletion of the meter (data detection start) is implemented with differentiator C1 and R1. The code that turns the LED on is chosen by switching the adequate pin Qx. The logic of the acceptance code can be implemented with a simple 4 byt meter of series 74, e.g. 74HC163 (for example N*4). There are three main advantages in favour of the decision to use the submitted circuit, namely, the price for circuit 74 is, and for a factor 3-5, lower than the cheapest CPU; there is no software to develop for the light point and that both the driver and the generator of the data pulses are very simple.

[0011] Picture 5 shows the schematic display of alternative solution of earmarked display with intelligent light points iPix in the housing O with complex system with the possibility of controlling individual iPix light point with cable connections; picture 6 shows the schematic display of the same alternative solution on the carrying board in housing O with conductive layers P1, P2 and insulation in between; while picture 7 shows the iPix light point basic unit circuit.

[0012] The characteristic of the chosen PIC controllers is low consumption, under 200μA and supply from 2 to 5V. Both is appropriate for this project as the supply of the basic cycle of MPU will be provided only from the condenser C in both phases. The capacitance C and times of individual cycle phases are therefore mutually connected. The design of complete process ensures that it is feasible.

[0013] Current limitation of MCU exit is 20mA through LED, which is enough in this case. The current can be additionally limited with the choice of Rled resistor. Diode luminosity will be balanced by MPU with pulse-wide modulation in the phase READ. The diagram of communication impulse is shown on picture 8. Hence, there is no problem in achieving at least 16 levels of luminosity. Because of the communication and synchronization, 100% duty cycle is not possible, but in reality, it will approach 90%. The communication is always performed in cycle and in sync. The cycle period is constant. As the supply and the communication are joint in the same guide, the problem of communication and supply should be taken care of in a way, that it ensures constant luminosity, regardless the communication. Hence we use the solution with communication pulses, that are always present regardless the transferred information and modulation of these pulses with useful information. One cycle of communication is divided to three phases, namely (picture 7) READ - transfer from the controller to iPix light point. The controls of iPix light point and data: status, luminosity, working mode.... all go in this direction; WRITE - transfer from iPix light point back to the controller. Minimum quantity of information is transferred in this direction, mainly it is the status »error LED« ; SYNC - start synchronization.

[0014] Mentioned three cycles are enabled by a connection that is given on picture 9, and shows the connection of the controller with the iPix light point basic unit.

[0015] In phase READ, the supply voltage *Un* = *UR* is bigger than *Uf* (LED diode voltage), therefore it can light. The resistor *Rled* defines the current through the diode. In this case, *Un* defines also the MPU supply over D diode. With that, the condenser C reaches UR. In this phase, short negative communication supply pulses that carry the information of READ communication (see detail) are present, The length of these pulses *Tpulz* is significantly lower than the period of the appearance of the *Tbit* pulses. This prevents them to visibly impact the LED luminosity. Coding (modulation) of these pulses must be such, that the number of the communication pulses and the width are not changed, which ensures steady luminosity regardless the communication. As all iPix light points can light in this phase, the supplying current is big.

[0016] In the phase WRITE the supply voltage *Un* is lowered to *Uw* - under the *Uf* LED. Therefore the current through the diode is automatically cancelled. The voltage *Un* is also lower than the voltage of the condenser C, that is now the supply for MCU. Condenser current can only go to MCU and not backwards, this is prevented by diode D. The current in this phase falls practically to zero which enables the supply through relatively high impendance in this phase. Actually, the supply goes through the resistor Rfw. All this enables the iPix light point to force GND to *Un* through IN/OUT MPU pin that enables the communication back to the controller.

[0017] At the end of the cycle there is SYNC phase, where the controller of the iPix field sets the voltage *Un* to GND, which is a sign to all light points, that a new cycle is about to start. The length of SYNC phase must be longer than the communication pulse, but not too long in order not to use the whole reserve in C.

[0018] Picture 10 shows the coding - communication protocol of controller connection to the iPix light point base unit.

[0019] In the READ phase (main communication - direction controller -> iPix), two problems have to be solved when preparing the communication protocol, namely: whether the coding is appropriate (as the signal and the supply are together, only such coding is appropriate, where the level is high most of the time) and the constancy of the number of communication pulses, so that the luminosity won't change according to the communication.

[0020] First line on picture 10 shows the information, which we want to code. For coding, we use known and tested Manchester code (second row on the picture), which has the main characteristic, that carries, besides the information, also the information CLK. The second characteristic is, that the number of transitions is always the same regardless the information. The problem of Manchester code in our case is, that the duty cycle is 50%, and that is not allowed due to the supply. Therefore we modify the Manchester code in a way, that each transition generates a short pulse of low level, which is shown by the third row on picture 10. Decoding is done by a simple algorithm, where the time between two pulses is measured. If the time is short, there is no change in the information signal; but if a long time is measured, the level of exit signal is inverted. As we don't know what will be the starting bit of the information, there have to be some »1 « sent at the beginning so that the decoder synchronizes and then one »0« to mark the start of the package.

[0021] Each negative impulse as a disturbance can cause desynchronization of the communication package. We can significantly avoid the problems, if we do not react to the edge of communication pulse, but detect the pulse with level scanning. The second hint is, that because of well defined times we know, when we can expect the next pulse and scan it only then.

[0022] This way, a lot of disturbances can be filtered.

[0023] As the MPU has no option to process IRQ, the whole program will run in one loop and we can use the following program principle:

- Waiting for the communication impulse;
- In the time *Tpulz* tiping at least 2x;
- If there is no pulse, we foresee twice the length;
- Exit decoding from the measured time;
- Now we have Tbit of time to process all, that is necessary;
- Repetition of the loop.

  Mentioned principle is good, as we don't need IRQ processing, we need a bit of time to scan the entry and we have relatively long time to process the rest of the functions. Of course, the times Tpulz and Tbit have to be appropriately chosen, so that the MPU load will be optimal.

  In the WRITE phase (direction light point -> controller) we can use the coding of standard series communication. The relationship of ones and zeros is not relevant, as the LEDs are switched off. Only a minimal number of bytes is transferred, therefore this phase is short enough in the sense that the supply condenser C lasts till the end.

  Any parametrizing (setting of processing, colour luminosity ...) cannot be, due to the poor MPU resources, performed in a permanent memory, but only in RAM of MPU. This is in the phase of initialization after the light point field is switched on or while it is on. For the most of the settings, this is not a problem. But there is a problem of iPix light point addressing.

  It is obvious, that all the iPix light points are, in the sense of communication, on the same bus. So, all the units accept the same communication. As we want an individual control of individual iPix light point, it is clear that there has to exist some way of addressing. A question, how to make each iPix light point different to others, needs to be solved. We have to somehow insert unique code or address into each unit and that information has to be permanently stored. As we want the minimal possible price for MPU, the alternatives with EEROM are not applicable. The code can be written only as a program constant, entered together with firmware. Luckily, there are two options in PIC family MPU.
- Program (firmware) can be stored into MCU's flash memory before the installation into the light element. A couple of locations in flash can be designated for the appliance address.
- In a mass production, where programming on the go is not wanted, MICROCHIP offers the possibility of entering unique code and fixed firmware in the phase of chip production.

[0024] So we have a certain ID in both cases, that is different for each light element in the field and can be used for appliance address, that has to have the following characteristics: as we are extremely limited with resources, only two bytes should be intended for this purpose, that is 65536 of different Ids, which is enough, as we are targeting a system that will have the size level of approximately 1000 elements. That is substantially less then there are possible codes. Further on, the addresses have to follow continuously without any spaces one after the other throughout all the field of the light elements, as in some transportable communication packages we can use the addressing with positioning the byte in the set, which will be explained later. This request enables simultaneous activation of all light elements on the display or simply said, the current picture change with the transfer of one communication package. In the case of pre-programmed addresses in the area 0 - FFFF, provided by the MPO manufacturer, the problem appears iwth activation package, where the light point unit has to know the first unit's offset, so that the address is adjusted to the position of the byte in activation package. This can be avoided if we fix the DATA length in activation package to 2 ** N bytes. In our case the optimum is 1024. Now the offset is no more needed. Hence follows also the Tcyc value.

[0025] As already mentioned, there is a fixed number of communication bytes sent in one communication cycle, but it is not necessary, that they all transfer useful information. The same it is possible, that there are more communication packages transferred in one cycle. One package is designed as follows:

Št. bitov				
8	16 HEADER	16	0 - 1024	16
SYNC		ADDRESS	DATA	CHK

Maximum length is 1080 bytes. And hence the connection:

$$T_R = 1080 * T_{bit}$$

SYNC

7	6	5	4	3	2	1	0
1	1	1	1	1	1	1	0

It is a constant set of 8 bytes, where 7 numbers 1 at the beginning take care of decoder synchronization. Last 0 presents the start of the information that has to be processed.

HEADER

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
			N bytes: ADDRESS + DATA + CHK												
0	Always 0														
	0	0	Package with control												
	0	1	Activation package												
	1	0	Reserve												
	1	1	Reserve												

ADDRESS

15	14	13	12	11	9	8	7	6	5	4	3	2	1	0
0	0	0	Goal address 0 - 1 FFF (8191)											
0	0	1	AND Mask for unit group											
rest			Undefined - reserve											

CHK

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
The total of all numbers 1 in the package of the segments HEADER, ADDRESS, DATA															

DATA

[0026] The data are assembled in two ways:

PACKAGE WITH CONTROL

N - bytes	M bytes
CONTROL	PARAMETERS

ACTIVATION PACKAGE

1024 bytes
»1« at the designated position (index) triggers designated action to iPix" unit with the address »index«

[0027] The size of controls and parameters as the controls and parameters themselves, are in this phase still undefined and will be defined at the implementation of final solution. The important thing is, that part of the DATA information is treated as a control that is performed on the light element, where parameters, located in the field PARAMETERS are used. The packages with control are suitable for controlling individual light point or a group of iPix light points.

[0028] While the earmarked display with intelligent light elements is working, the processor can run into a loop due to a disturbance and iPix light point stops working. The problem can be solved with integrated WDOG function. Although iPix light point in a loop is not good, it is not critical in the sense of another problem. MPU can run into a loop or gets out of order in a way that forces the pin for communication to GND. In READ phase that is not a big problem, as there is only the maximum I/O current of approx 20mA running through the pin, which is not a problem. Problem is, that it will prevent feedback information to all other iPix light points in the WRITE phase.

[0029] This problem can be solved with MPU WDOG function installed, that will, in this case, reset MPU, which will normalize the process. In the case of hardware error, when one bad pin would prevent the communication to all other units, there is no other help than to monitor such status at the controller side and submit main system error. The error will be detected when there will be no feedback information possible. Of course, the display will continue to correctly show the information, only the error detection will not offer the information on iPix individual light point. Picture 12 shows the circuit for iPix light point base unit error detection. Although the experience show that the most LED errors is stopped status, the following solution detects also the status - short circuit. As the PIC family has MPU alternative with integrated comparator of voltage, it can be used for the purpose of detecting LED errors. Picture 12 shows the circuit that exploits the integrated comparator for error detection in LED.

[0030] Detection is performed in the time, when LED is switched on (LED MPU OUT exit), gives low level, therefore the current runs through the resistor Rled and LED.

[0031] According to LED status we have 3 voltage options at the entry of comparator C+:

C +	LED status
Close to value Uf (fall on LED)	OK
Close GND	Short circuit
Close V+	stopped

[0032] If we want to set, in which of three areas the measured voltage is located and have only one comparator, we need to have a possibility to set the reference at the comparator C- to two values RefHi and RefLow. With two trials we can set the area, into which the measured voltage falls. For a lower reference, we take the internal reference that is already present in MPU. Unfortunately, this reference is approximately 0.6 V as the LED Uf is significantly larger; we would need a bit higher reference. The problem can be solved in a way, that the voltage is lowered with the divider R2 and R4. For the second measure, when we need the reference higher than *Uf*, we use entry C- and divider R1 and R3.

[0033] Status LED is set according to the table:

Um is on a joint point of R2 and R4.

Uref (C -)	condition	CMPout	LED status
RefHi	Um > RefHi	1	stopped
RefHi	Um < RefHi	0	OK
RefLow - internal	Um > RefLow	1	OK

(continued)

Uref (C -)	condition	CMPout	LED status
RefLo - internal	Um < RefLow	0	Short circuit

[0034] If we get the answer OK in both trials, the LED is ok, otherwise we have a sort of a mistake.

[0035] Earmarked display with intelligent light points after the invention that successfully solves the set technical problem can be performed with the newest technology, namely with processors that fulfil two essential conditions: low consumption (which is necessary for the multiplex of supply and communication through the same guide) and extremely low price of MPU.

[0036] Both is required condition for the submitted solution to get economic purpose. Due to the technology that enables the MPU price even lower than the price of light point (LED) means a significant saving in the appliance production.

Claims

1. Earmarked display with intelligent light points,
characterized in that,
the positions of light points (iPix), are optional and predefined, where each light point (iPix) contains microcontroller (MPU) that communicates with the main controller over the supply communication guide (PCBUS) and the supply communication guide (PCBUS) also has the function of carrying construction i a way, that the assembly of individual light points (iPix) is enabled to the carrying plate with two conductive layers and enables direct control of the light point (iPix) and simultaneously controls whether it is working correctly.

2. Earmarked display with intelligent light points is, as per requirement 1,
characterized in that,
the base unit of the light point (iPix') for the display of only two pictures consists from the parallel connection of two successive connections of the diode (D), resistor and diode (LED 1) and diode (D), resistor and din diode (LED 2), connected to AC voltage and by that enables the implementation of earmarked display, adjusted for a typical application with a purpose of showing only two pictures (e.g. traffic sign cross - arrow).

3. Earmarked display with intelligent light points is, as per requirement 1,
characterized in that,
that with the alternative solution, where earmarked display should show up to 2** N pictures, the light point (iPix") can appear in more pictures and the (iPix") light point supply information is coded in a way, where in a period of *Tpicture* picture change, which usually happens in a time of a second, there appears modulation in the time *Tdata*, that is substantially shorter than the time of picture exchange, while there are N data pulses sent, the total of which defines the code that switches the appropriate light point (iPix") base unit.

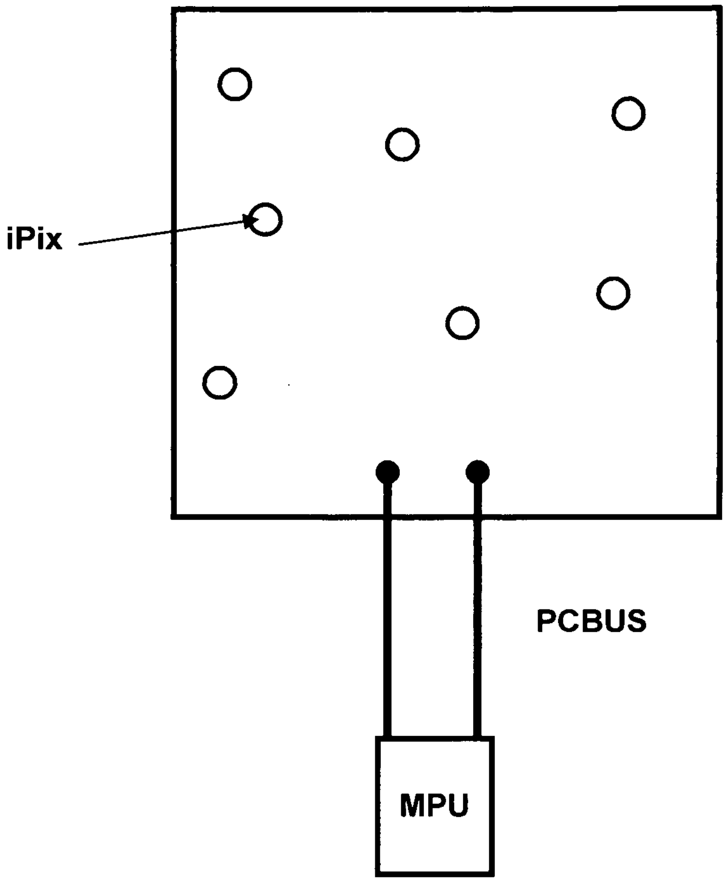

Fig. 1

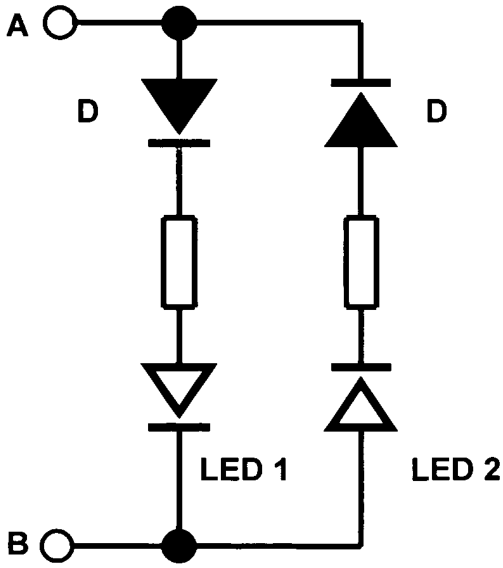

Fig. 2

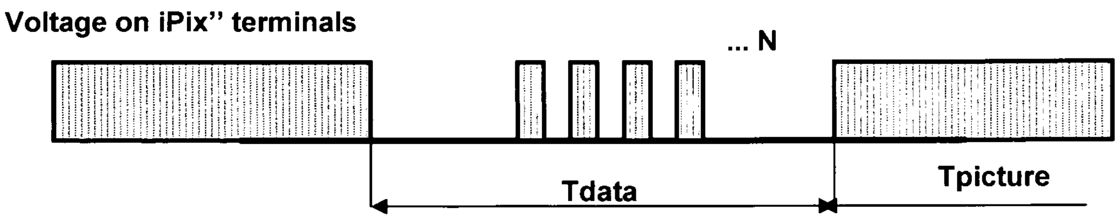
Voltage on iPix" terminals
... N
Tdata
Tpicture

Fig. 3

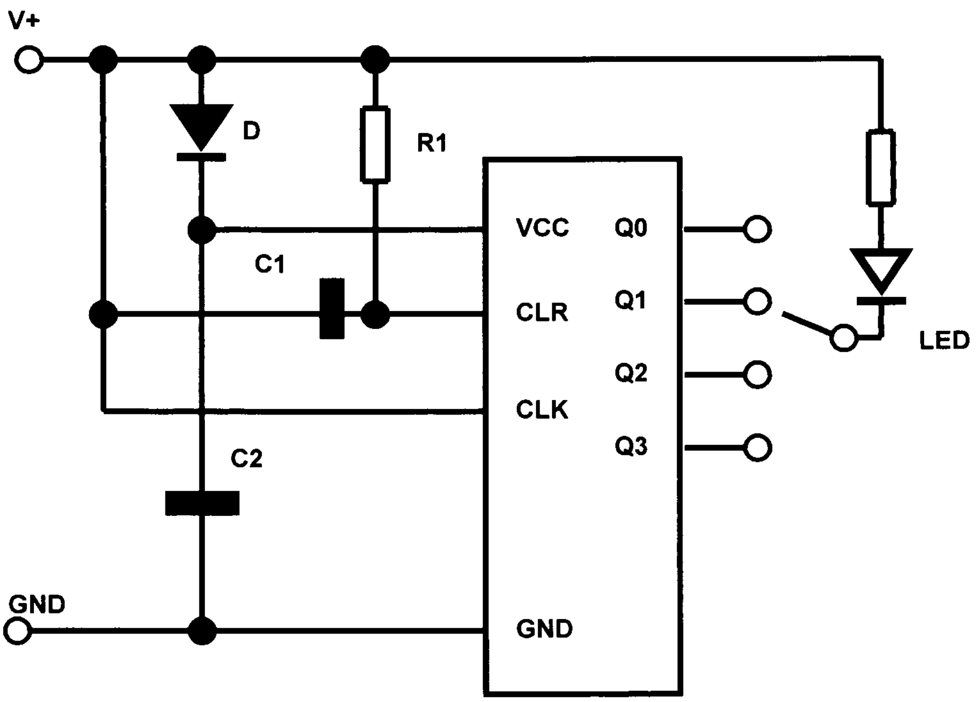
V+
D
R1
VCC
Q0
C1
CLR
Q1
LED
Q2
CLK
Q3
C2
GND
GND

Fig. 4

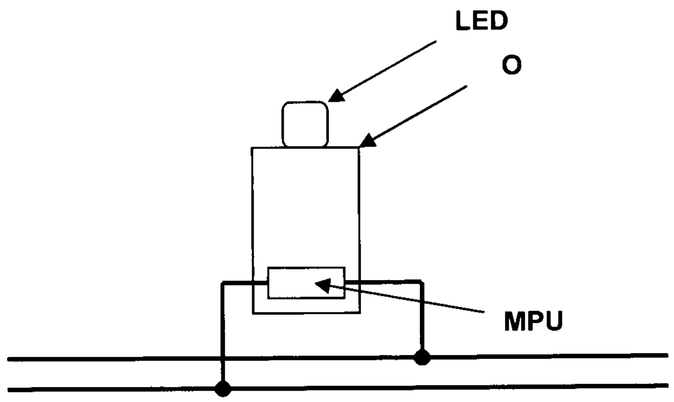

Fig. 5

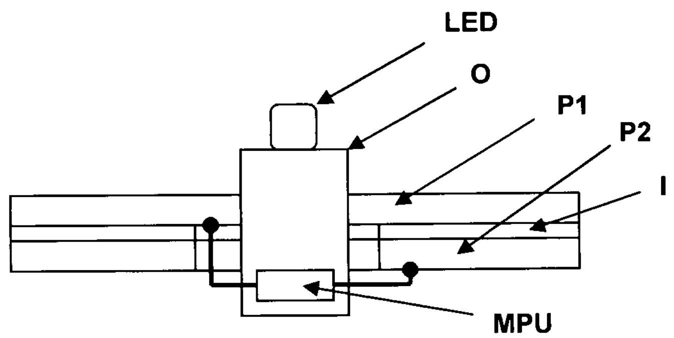

Fig. 6

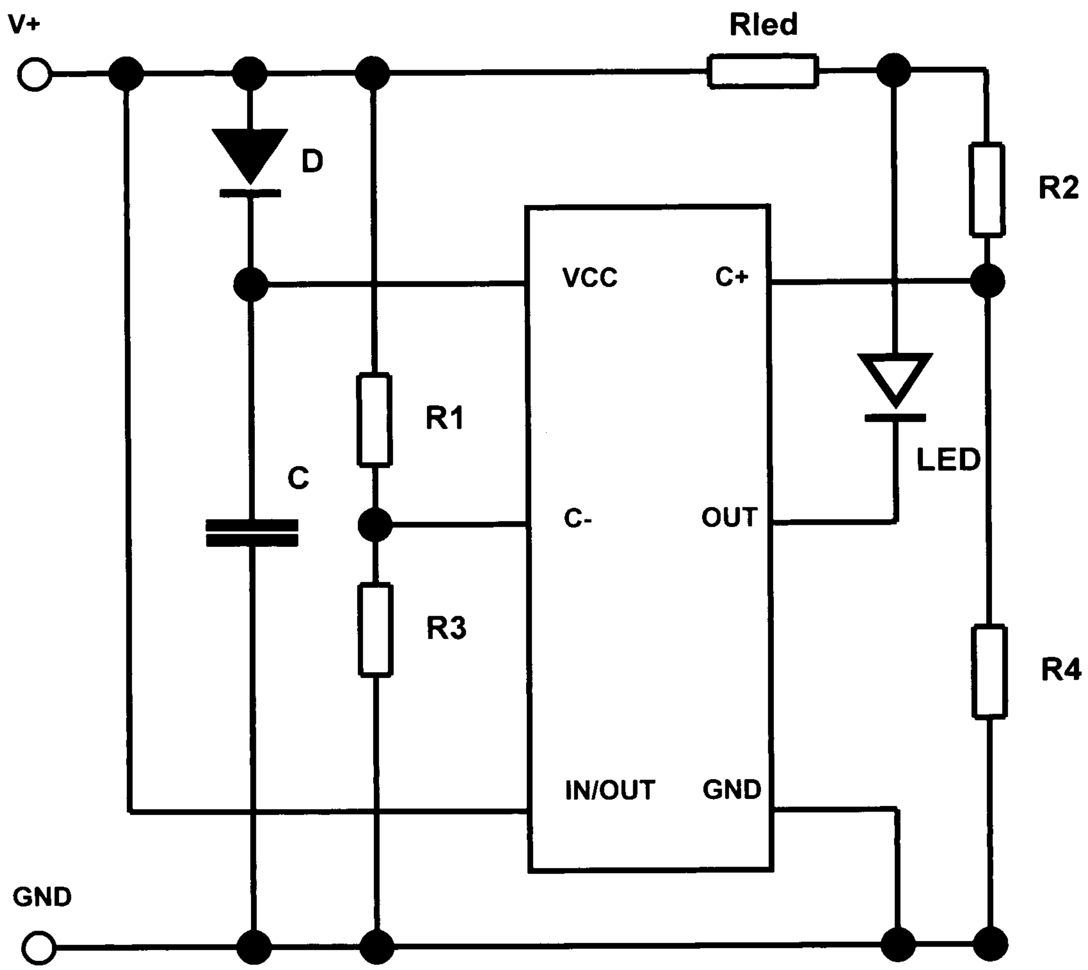
V+
Rled
D
R2
VCC
C+
R1
C
LED
C-
OUT
R3
R4
IN/OUT
GND
GND

Fig. 7

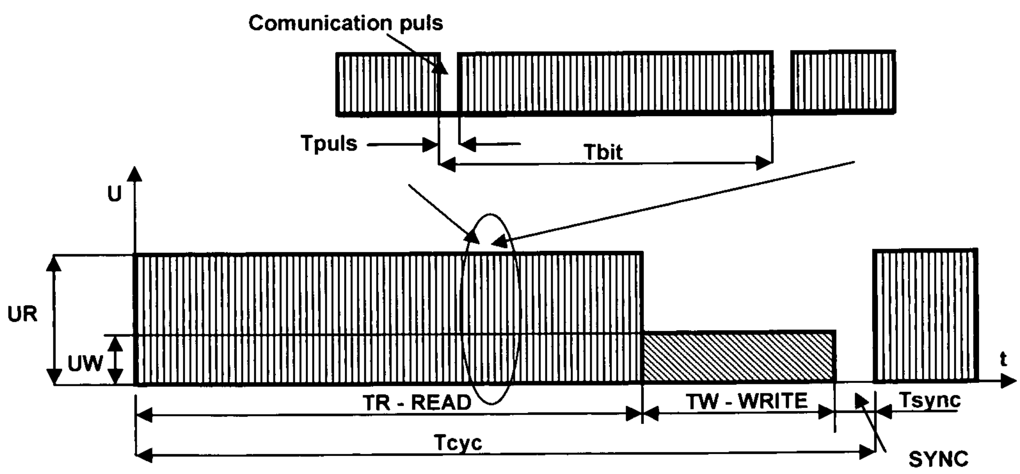
Comunication puls
Tpuls
Tbit
U
UR
UW
t
TR - READ
TW - WRITE
Tsync
Tcyc
SYNC

Fig. 8

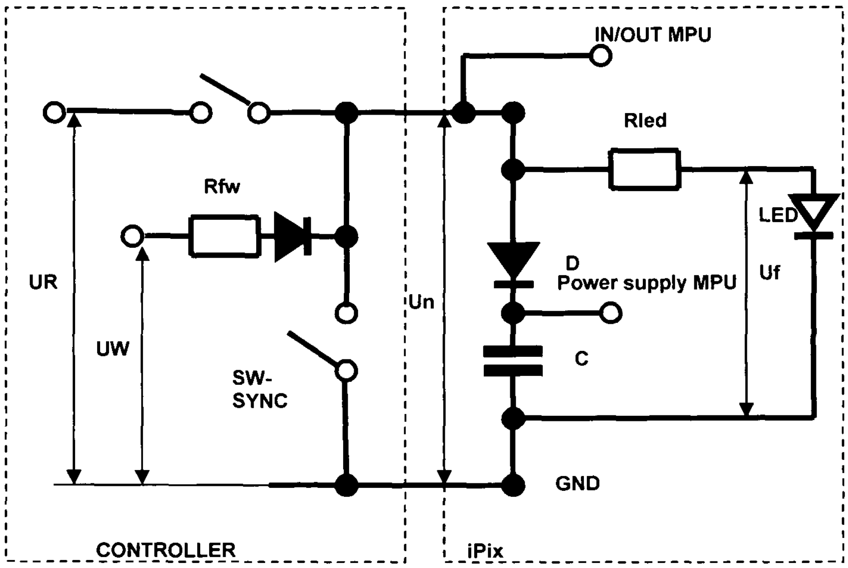
IN/OUT MPU
Rled
Rfw
LED
D
Power supply MPU
UR
Uf
Un
UW
SW-
SYNC
C
GND
CONTROLLER
iPix

Fig. 9

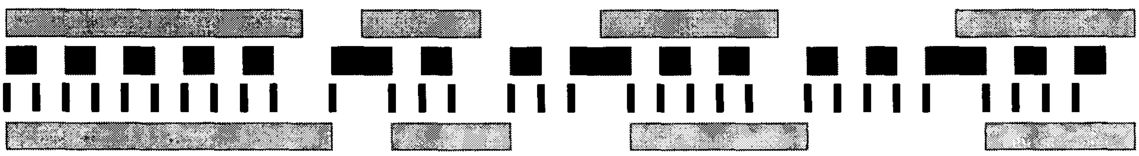

Fig. 10

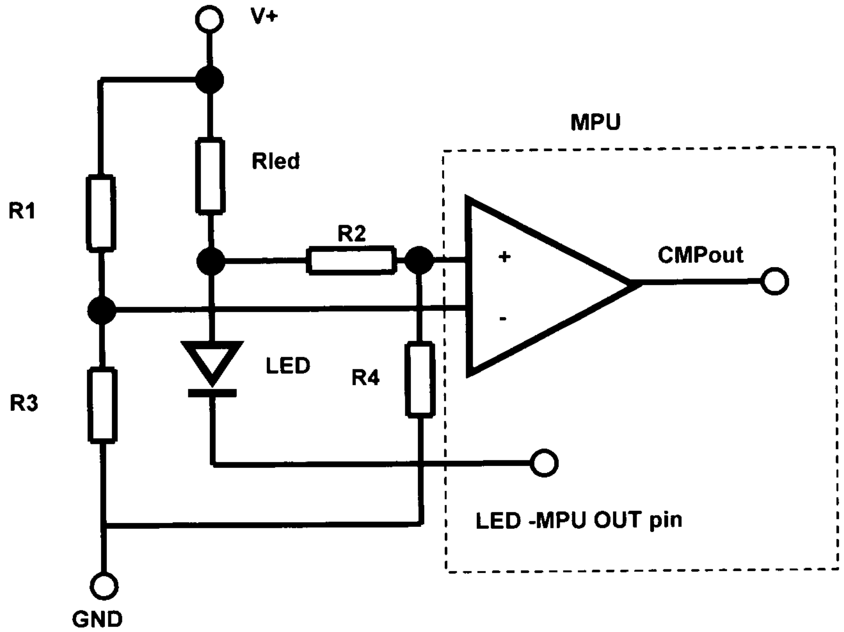

Fig. 11