(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 445 990 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
11.08.2004 Bulletin 2004/33

(51) Int Cl.[7]: **H05B 37/02**

(21) Application number: **04250598.2**

(22) Date of filing: **04.02.2004**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IT LI LU MC NL PT RO SE SI SK TR
Designated Extension States:
AL LT LV MK

(30) Priority: **28.03.2003 GB 0302976**
10.02.2003 GB 0307217

(71) Applicants:
- **Sim, Quan Yee**
  Worcester Park, Surrey KT4 8SR (GB)
- **Sim, See Lip**
  Worcester Park, Surrey KT4 8SR (GB)

(72) Inventors:
- **Sim, Quan Yee**
  Worcester Park, Surrey KT4 8SR (GB)
- **Sim, See Lip**
  Worcester Park, Surrey KT4 8SR (GB)

(74) Representative: **Weitzel, David Stanley**
Brookes Batchellor
102-108 Clerkenwell Road
London EC1M 5SA (GB)

(54) Multiple location switching of an AC load

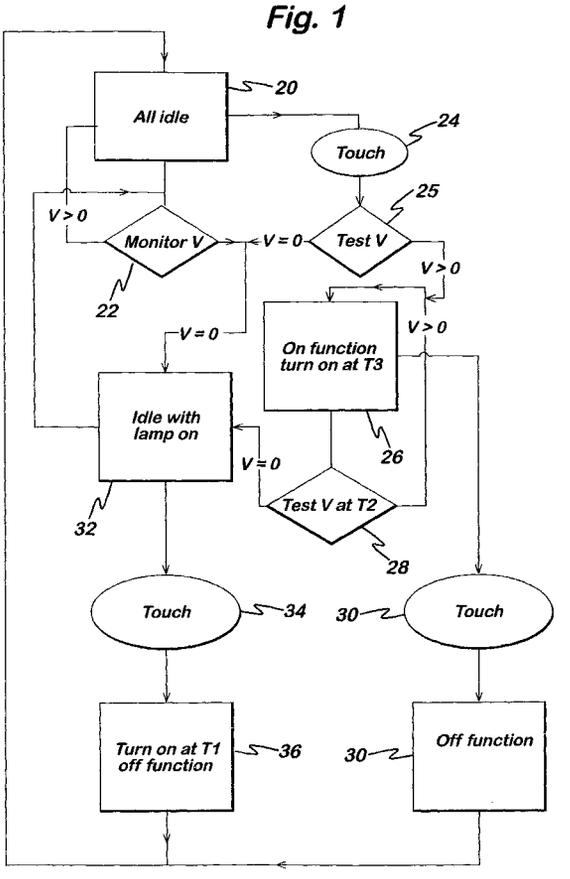
(57) It is common for lamps to be controlled from two switches so that, for example, a hall light can be turned on and off by either of two switches. There are occasions when it would be desirable for the lamp to be controlled by more switches, for example a switch at both ends of the hall and another on the landing above.

An electrical switch for AC is disclosed, for connection in parallel with others of the same kind. The switch has an operating member, a controlled switching device and a controller for controlling the time in a cycle from which the switching device conducts. The controller is responsive to the voltage across the switching device to detect a time in a cycle from which the switching device in one of the parallel switches conducts so as to determine whether all parallel switches are idle, that another switch is on, or when it is itself on that another switch has been operated.

When all parallel switches are idle the controller is responsive to an operating signal produced by operation of the operating member to perform an on function causing the switching device to conduct from a first set time within the cycle. The controller is being responsive to a subsequent operating signal to cause the switching device not to conduct, or to the determination that another switch has been operated to cause the switching device not to conduct. When another parallel switch is on, the controller is responsive to the operating signal to cause the switching device to conduct from a second set time in advance of the first and to perform an off function.

Installation of the switches is simple since they need only to be connected in parallel at the switch or the light fitting. Each switch can then both turn on the light or turn it off independently.

Fig. 1



EP 1 445 990 A1

Description

[0001] This invention relates to electrical switches.

[0002] The background to the invention will be described in relation to switches for the control of AC mains lamps. It will be readily understood, however, that the invention is applicable in other fields.

[0003] It is common for lamps to be controlled from two switches so that, for example, a hall light can be turned on and off by either of two switches, one in the hall, the other on a landing on the floor above. The switches operate co-operatively so that either can switch the light on and either can switch it off.

[0004] There are occasions when it would be desirable for the lamp to be controlled by more switches, for example a switch at both ends of the hall and another on the landing above. To achieve that using conventional switches involves complicated wiring and the use of two two-way switches and one or more intermediate switches.

[0005] Some electronic switches provides switching at more than one location by connecting a number of switches to a "controller" which takes the inputs from the various switches and provides the output to control the light. This is expensive and involves more wiring.

[0006] Other electronic switches provide switching at more than one location by providing a 'Master' switch and 'Slave' switches. The Master switch provides the output to control the light and takes inputs from the various slave switches. This is also expensive and involves more wiring.

[0007] Against this background, in accordance with the invention there is provided an electrical switch for AC, for connection in parallel with others of the same kind, comprising: an operating member, a controlled switching device and a controller for controlling the time in a cycle from which the switching device conducts, the controller being responsive to the voltage across the switching device to detect a time in a cycle from which the switching device in one of the parallel switches conducts so as to determine whether all parallel switches are idle, that another switch is on, or when it is itself on that another switch has been operated;

and when all parallel switches are idle being responsive to an operating signal produced by operation of the operating member to perform an on function causing the switching device to conduct from a first set time within the cycle then being responsive to a subsequent operating signal to cause the switching device not to conduct, or to the determination that another switch has been operated to cause the switching device not to conduct; when another parallel switch is on, being responsive to the operating signal to cause the switching device to conduct from a second set time in advance of the first and to perform an off function. Installation of the switches is simple since they need only to be connected in parallel at the switch or the light fitting. Each switch can then both turn on the light or turn it off independently.

[0008] Preferably, during the on function and/or the off function, the switching device is controlled to gradually increase the conduction period during the cycle.

[0009] In order to provide a dimmer function, the increase or decrease is provided for a time corresponding to the time for which the operating member is operated.

[0010] In another form, the operating member is a movement sensitive switch which produces a operating signal when movement is detected, the controller acting to operate the off function when movement has not been detected for a predetermined period.

[0011] Preferably, the operating member is a touch pad. In other arrangements the operating member is a passive infra red movement sensor, light level sensor, infra red communication link (i.e. as in infra red remote control), wireless, e.g. radio or optical receiver etc.

[0012] The first and second set times are preferably defined by a phase locked loop.

[0013] The phase locked loop preferably has a digital oscillator and a digital phase detector.

[0014] Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a state diagram of a switch embodying the invention;
Figure 2 is an exploded pictorial view of the switch of Figure 1;
Figure 3 is a circuit diagram of a control module and switching device of the switch of Figure 1;
Figure 4 is a circuit diagram of an operating member of the switch of Figure 1; and
Figure 5 is a detail of the waveform across the switching device of the embodiment of Figure 1.

[0015] Referring to the drawings and in particular Figure 3, AC mains supply to a lamp (not shown) is switched by a switching device in the form of pair of back to back thyristors 2 in series with a choke 3 between a live terminal 4 and a load terminal 6. The point at which the thyristors fire in the cycle is controlled by a controller in the form of a micro controller 8 and associated circuitry. A half wave rectifier 10 supplies power to the controller 8 on lines 12 and 14. When power is first applied, a transistor Q1 is off and input to the master reset pin 4 of the controller 8 is logically low. This prevents the micro controller from starting up when the supply voltage is low. As the voltage rises above the

breakdown voltage of zener diode D3, The transistor Q1 conducts pulling the voltage at pin 4 to VDD allowing the micro controller to start functioning. This happens when the supply voltage is about 5 V. As a part of the start up routine pin 3 is programmed as an output and logical low. The values of resistors R6 and R8 are chosen so that transistor Q1 remains on until the supply voltage falls to about 2.5 V. If the voltage falls below this threshold transistor Q1 stops conducting, so that the input at pin 4 becomes low and the micro controller shuts down. Temperature sensing is provided by a thermistor 15 in series with a resistor R5. The node between the thermistor and resistor R5 is connected to pin 7 of the controller 8 which switches off when the temperature exceeds a value set by the thermistor and resistor R5

[0016] During operation an AC reference signal is applied to pin 5 of the controller via resistors R1, R2 and R3. A signal emitted by an operating member, e.g. a touch pad is fed from a connector 16 to pin 2 of the controller 8. Pin 6 of the controller supplies a signal correctly phased to trigger the thyristors 2.

[0017] One of the functions of the controller 8 is to provide a digital phase locked loop, phase locked to the AC mains, and by which four points T0 to T6, are set (see Figure 2).

[0018] In the following phase lock loop routine, the variable TMRO is a number stored by a counter which is incremented by an oscillator; FILL is a number which determines the number of times a FILL or dummy subroutine executes; OSCCAL is a number which sets the frequency of the oscillator; and HALFTIME is a number which is a constant corresponding closely to a half cycle.

1	INITIALISE	
2	SET TMRO = 0	
3	SET FILL = Y	
4	SET OSCCAL = 0	
5	SET HALFTIME = X	
6	FIRST STEP LOCK	
7	Has a 0-1 transition of the mains taken place?	
8	If yes goto 9, if not goto 7	
9	IS TMRO = HALFTIME?	
10	IF YES goto 11, if no goto 9	
11	RUN FILL SUBROUNTINE	
12	SET TMRO = 0	
13	Has a 0-1 transition of the mains taken place?	
14	If yes goto 15, if not goto 13	
15	IS TMRO > HALFTIME	
16	If yes goto SECOND STEP LOCK, if no goto 17	
17	Increment OSCCAL	
18	RUN FILL SUBROUNTINE	
19	SET TMRO = 0	
20	Goto 9	
21	SECOND STEP LOCK	
22	RUN FILL SUBROUNTINE	
23	SET TMRO = 0	
24	IS TMRO = HALFTIME?	
25	IF YES goto 26, if no goto 24	
26	RUN FILL SUBROUNTINE	
27	SET TMRO = 0	
28	Has a 0-1 transition of the mains taken place?	

(continued)

29	If yes goto 30, if not goto 28	
30	Is TMRO > HALFTIME?	
31	If yes goto 32, if no goto 33	
32	Increment FILL, goto 34	
33	Decrement FILL, goto 35	
34	If FILL > FILLmax goto 36, if not goto 22	
35	If FILL < FILLmin goto 39, if not goto 22	
36	Let FILL = Y	
37	Decrement OSCCAL	
38	Goto 22	
39	Let FILL = Y	
40	Increment OSCAL	
41	Goto 22	

[0019] Starting from an all idle state 20 in which all switches are off, in step 22 the controller continuously monitors the voltage on pin 5 during each positive half cycle. As long as all switches are off, or idle, the voltage V across the switching device is normal mains voltage, i.e. V > 0, and towards the end of the positive half the controller returns to the all idle state 20. In the event that another switch becomes active, the voltage across the switching device is zero, i.e. V = 0, and the controller keeps a record of the time, i.e. T5, and passes to step 32.

[0020] When in the all idle state the switch's own touch pad is operated (touched) in step 24, the controller passes to test state 25 on function state 26 and prepares to turn on at T5 in the next cycle. Immediately before turning on the switching device at T5, i.e. at T4, the controller will monitor the voltage on pin 5 and will proceed to on function 26 to turn on the switching device only if the voltage is not zero, i.e. V > 0, indicating no other device is on. If the voltage is zero, then the controller passes to step 32. The time in the on function when the switching device 2 conducts in the cycle is T5. T5 is a variable determined by the on function or by a dimmer function and lies between T2 and T6, in Fig. 5. T2 and T6 are fixed positions within the positive cycle. The on function could be a gradual increase or decrease in the value of T5 in one alternative, or T5 could remain in one fixed time in another. In either eventuality this turn on time in the positive half cycle is reflected in the negative half cycle.

[0021] In each positive half cycle, the controller 8 now tests the voltage on pin 5 at T2. If the voltage were zero, this would be a signal that another switch had been operated. If V > 0 the controller returns to state 26. This cycle continues, unless interrupted, completing the on function, when the following half cycles will all fire at T5 = T3.

[0022] If the touch pad is operated again at step 30 when the controller is in the state 26, the controller passes to an off function state 32 in which the conducting time in a cycle of the switching device is reduced to zero, either immediately or over a time period. The controller then returns to the all idle state 20.

[0023] If the voltage in step 22 or step 28 is found to be equal to zero, V = 0, the controller passes to an idle with lamp on state. Thus, from step 22 the controller which is idle notices that another switch is on. From step 28, the switch which turned the lamp on notices that another switch has been operated and itself stops controlling the lamp, leaving it under the control of the newly operated switch.

[0024] If when in the idle with lamp on state 32 the switch's touch pad is operated at step 34, the controller passes to state 36 in which the switching device is turned on at T4 which comes before T5 in a positive half cycle, to let the switch which is controlling the lamp know, operates the turn off function and the controller returns to the all idle state.

[0025] A connector 40 mates with the connector 16 in Figure 3 to receive power on pins 2 and 4. Power on pin 2 is fed back to Figure 3 on pin 1 via the series connected LEDs D1, D2 and D3. The LEDs are used to illuminate the switch so that it can be located in the dark. R5 is connected between pins 2 and 3 and a series of high value resistors R1, R2, R3 is connected between a touch pad 42 and pin 3. When there is no touch on the touch pad, pin 3 of the connector 16 and 40, and thus pin 2 of the controller 8 are at -5V due to the effect of R5. Touching the touch pad 42 pulls the voltage to OV at the time when the controller 8 samples the input at pin 2.

[0026] Referring to Figure 2 the physical realisation of the embodiment is illustrated. An insulating box 50 contains two printed circuit boards 52 and 54. The board 52 constitutes the circuit shown schematically in Figure 3 and incorporates wire terminals 4 and 6 accessible through slots 56 in an end wall 58 of the box. The board 52 is contained in

one side of the box 50 and closed by a cover not shown. The board 54 constitutes the circuit shown schematically in Figure 4 and is accommodated by a recess 60 in the other side of the box 50. The connectors 16 and 40 communicate through a slot 62. This side of the box is closed by an insulating cover 64 which supports a metallic touch pad 66 connected by a conducting spring 68 to a conducting area 70 on the board 54.

[0027] In another embodiment the controller has an on function which gradually increases the brightness of the lamp as long as the touch pad is touched. If the touch pad ceases to be touched before the lamp is fully bright, the controller maintains the level of brightness at which touch ceased. Similarly the off function gradually decreases the brightness of the lamp as long as the touch pad is touched. When the touch pad ceases to be touched before the lamp is fully off, the controller maintains the level of brightness at which touch ceased.

[0028] In yet another embodiment, the operating member is a passive infra red movement detector (PIR). Each movement produces an operating signal to pin 2 of the controller 8 which acts to maintain the lamp on as long as movement is detected within a predetermined period from the last detected movement.

[0029] Generally, there are a number of different functions which may be performed by the operating number. Examples are:

Touch ON Touch OFF

[0030] If the switch, or another switch, is active, activating the touch pad will turn it off. The switch will perform this function by "grabbing" control of the circuit, perform a blink (to indicate it has started to turn it off) and then starts ramping down the light towards switch off.

[0031] If the circuit is inactive, i.e. all switches are off, then activating the touch pad will turn it on. The switch will simply ramp up the light level from a minimum level to the maximum level gradually.

Time Lag

[0032] If the switch, or another switch, is active, by activating the touch pad the switch will immediately "grab" control of the circuit, ramp up the light level gradually from what ever level it was to a maximum level and starts the count for the timer. When the timer has reached a preset time, the light will blink to indicate that the end of the timed period and then starts ramping down the light towards switch off.

[0033] If the circuit in inactive, i.e. all switches are off, then activating the touch pad will turn it on. The switch will simply ramp up the light level from a minimum level to the maximum level gradually and starts the count for the timer. When the timer has reached a preset time, the light will blink to indicate that the end of the timed period and then starts ramping down the light towards switch off.

[0034] When the switch is already active when the touch pad is activated, the count for the timer will be re-started. Should the touch pad be operated again within 1 second, then the light will blink to indicate that the timed period is doubled.

Touch Dimmer

[0035] If the switch, or another switch, is active, activating the touch pad momentarily will turn it off. The switch will perform this function by "grabbing" control of the circuit, perform a blink (to indicate it has started to turn it off) and then starts ramping down the light from its present level (i.e. whatever level it was at) towards switch off.

[0036] If the circuit is inactive, i.e. all switches are off, then activating the touch pad momentarily will turn it on. The switch will simply ramp up the light level from a minimum level to the preset light level gradually.

[0037] If the touch pad is activated for longer than one second then the light will ramp up (or down) gradually toward maximum, stays there for one second and starts to ramp down towards minimum, stays there for one second and starts to ramp up towards maximum and the sequence is repeated until such a time the touch pad is de-activated (i. e. not touched). Whatever the light level was becomes the preset light level for that switch.

PIR Sensor

[0038] In this implementation, the touch pad is replaced by a PIR sensor with daylight sensing facility. When the ambient light level is above a set level, the output is maintained at a high level and when the ambient light level is below that of a set level, the output is maintained at a low level. When a movement is detected, the output changes between levels and settles eventually to the level determined by the ambient light level. The microcontroller will determine when to react to the input signal from the PIR sensor, a "movement" is deemed to be detected if there are more than two transitions within a given period (to cut out false triggering), will turn on the light when the ambient light level is below a given threshold, once turned on, it will remain on until a timed period has expired, the timed period will be

re-started if triggered again while active, it will dimmed gradually down to idle at the end of the timed period, it will ramps up slowly to full power when activated.

Claims

1. An electrical switch for AC, for connection in parallel with others of the same kind, comprising: an operating member, a controlled switching device and a controller for controlling the time in a cycle from which the switching device conducts, the controller being responsive to the voltage across the switching device to detect a time in a cycle from which the switching device in one of the parallel switches conducts so as to determine whether all parallel switches are idle, that another switch is on, or when it is itself on that another switch has been operated;
   and when all parallel switches are idle being responsive to an operating signal produced by operation of the operating member to perform an on function causing the switching device to conduct from a first set time within the cycle then being responsive to a subsequent operating signal to cause the switching device not to conduct, or to the determination that another switch has been operated to cause the switching device not to conduct; when another parallel switch is on, being responsive to the operating signal to cause the switching device to conduct from a second set time in advance of the first and to perform an off function.

2. A switch as claimed in claim 1, in which during the on function and/or the off function, the switching device is controlled to gradually increase/decrease the conduction period during the cycle.

3. A switch as claimed in claim 2, in which the increase or decrease is provided for a time corresponding to the time for which the operating member is operated.

4. A switch as claimed in claim 2, in which the operating member is a movement sensitive switch which produces a operating signal when movement is detected, and the controller acting to operate the off function when movement has not been detected for a predetermined period.

5. A switch as claimed in any of claims 1 to 3, wherein the operating member is a touch pad.

6. A switch as claimed in any preceding claim, wherein the first and second set times are defined by a phase locked loop.

7. A switch as claimed in claim 6, wherein the phase locked loop has a digital oscillator and a digital phase detector.

Fig. 1

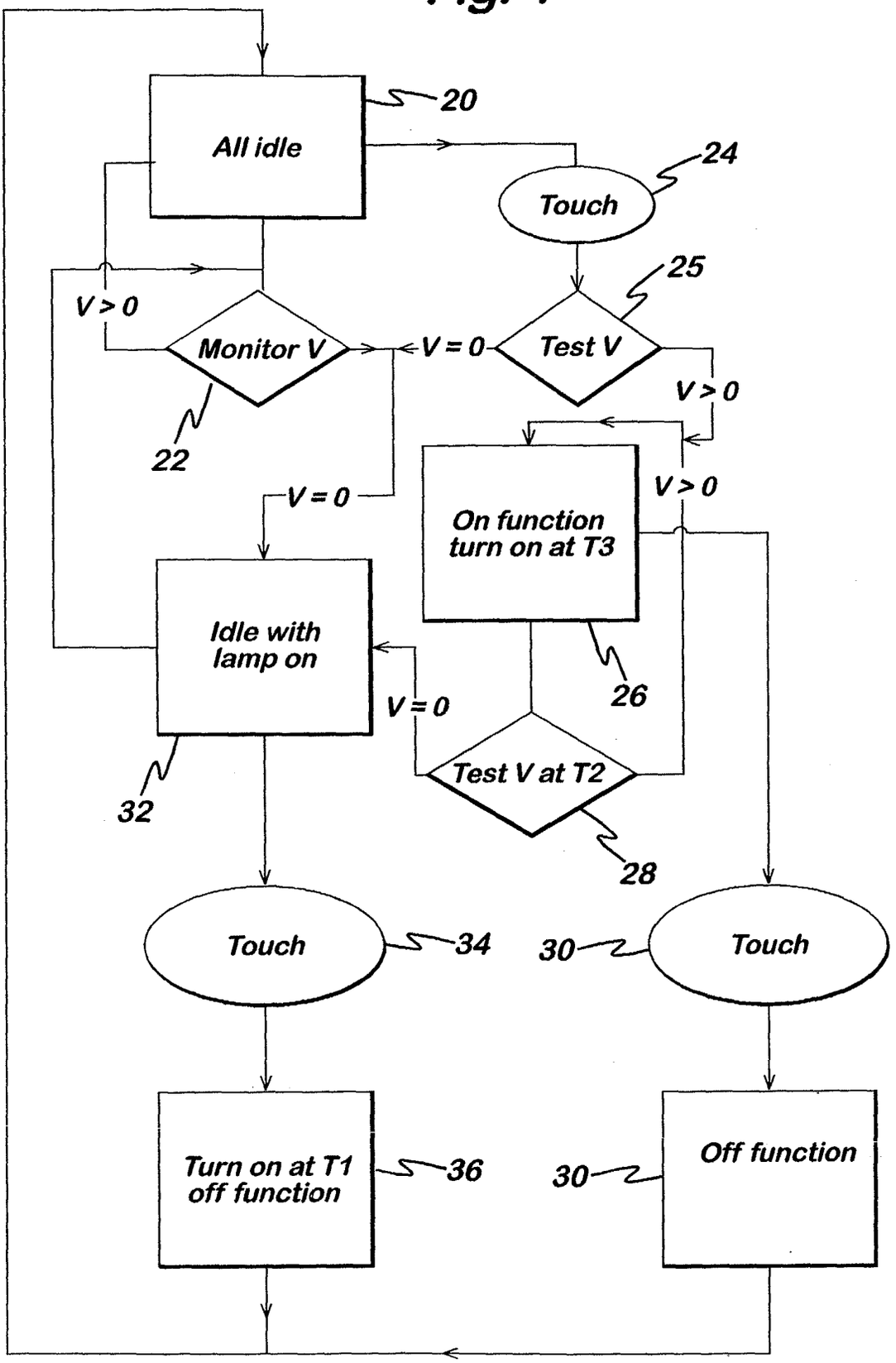

All idle
20
Touch
24
25
V > 0
Monitor V
V = 0
Test V
V > 0
22
V = 0
V > 0
On function turn on at T3
Idle with lamp on
26
V = 0
Test V at T2
32
28
Touch
34
30
Touch
Turn on at T1 off function
36
30
Off function

Fig. 2

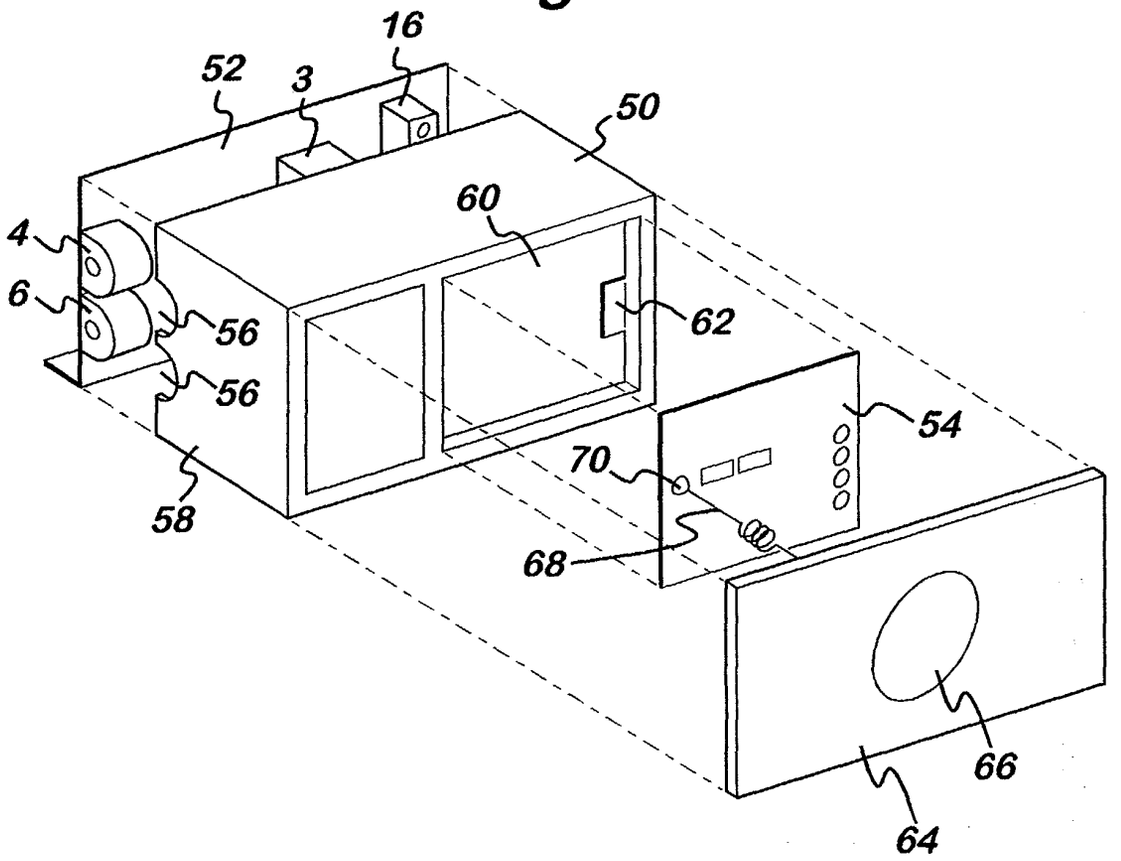


Fig. 5

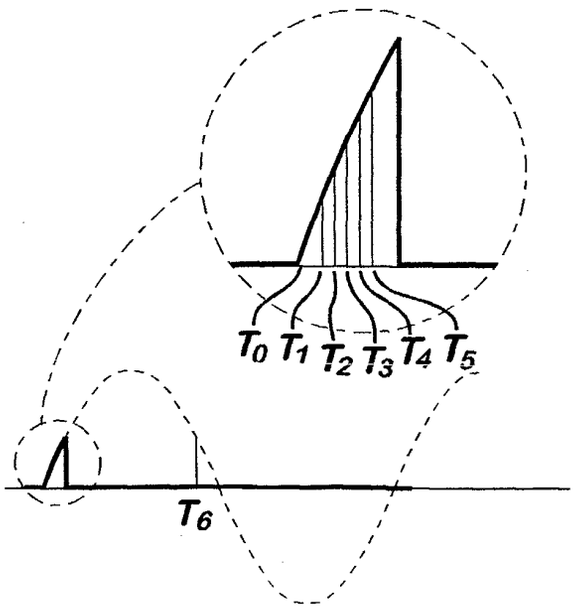


Fig. 3

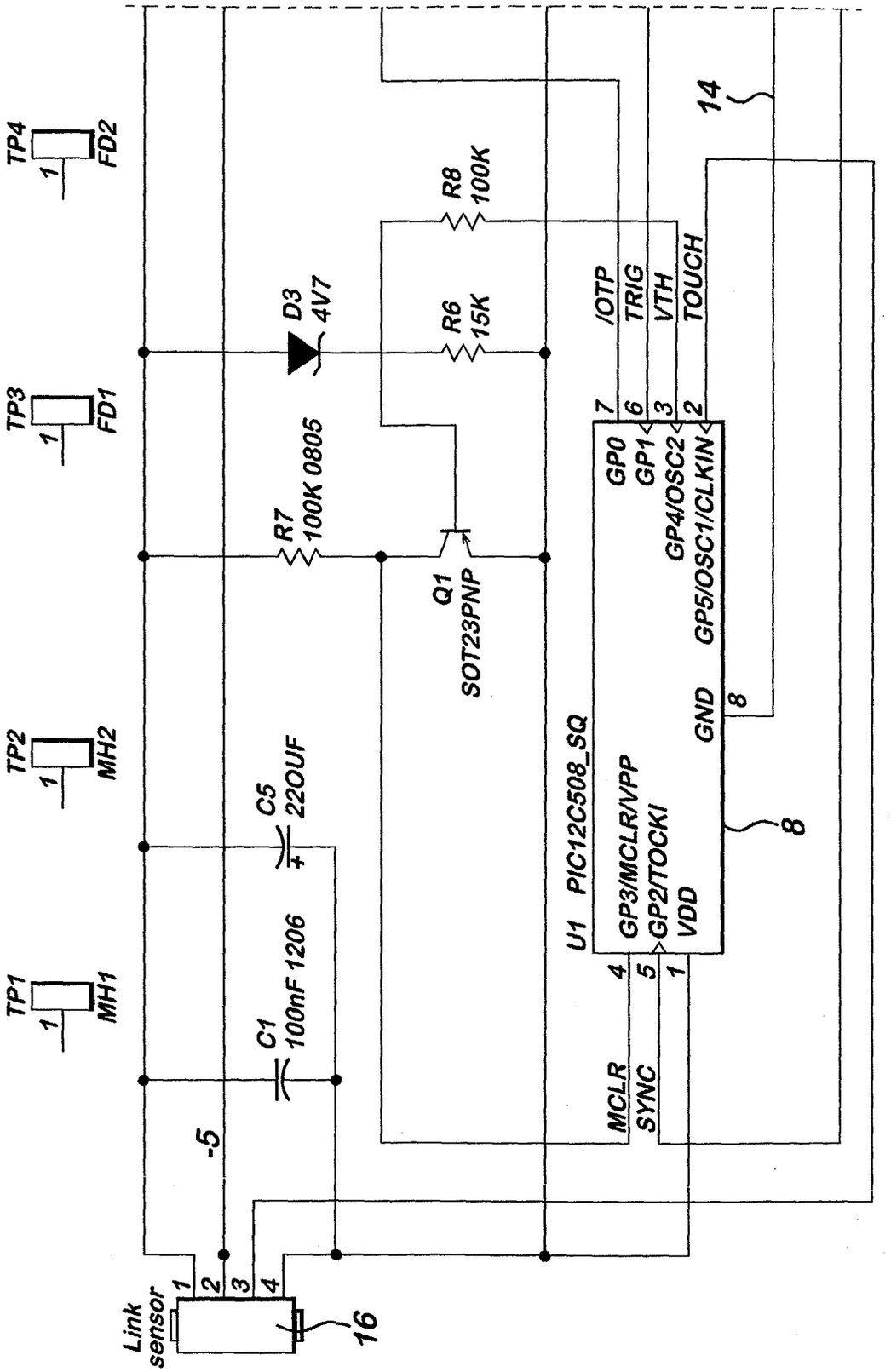

TP4
1
FD2
TP3
1
FD1
TP2
1
MH2
TP1
1
MH1
R8
100K
D3
4V7
R6
15K
R7
100K 0805
Q1
SOT23PNP
C5
22OUF
C1
100nF 1206
-5
Link
sensor
1
2
3
4
16
14
8
U1 PIC12C508_SQ
GP0
GP1
GP4/OSC2
GP5/OSC1/CLKIN
GND
GP3/MCLR/VPP
GP2/TOCKI
VDD
/OTP
TRIG
VTH
TOUCH
7
6
3
2
8
4
5
1
MCLR
SYNC

Fig. 3(Contd.)

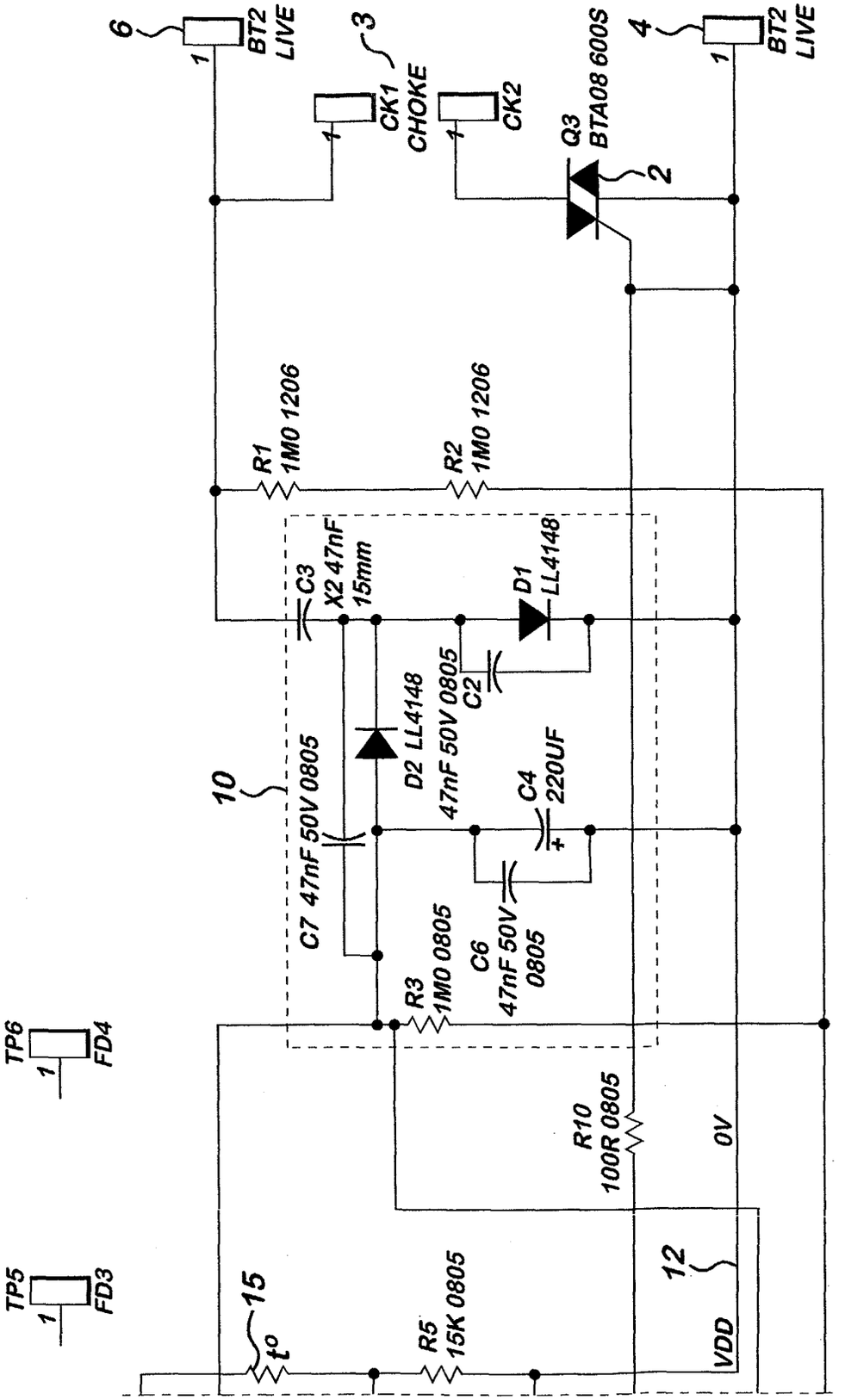
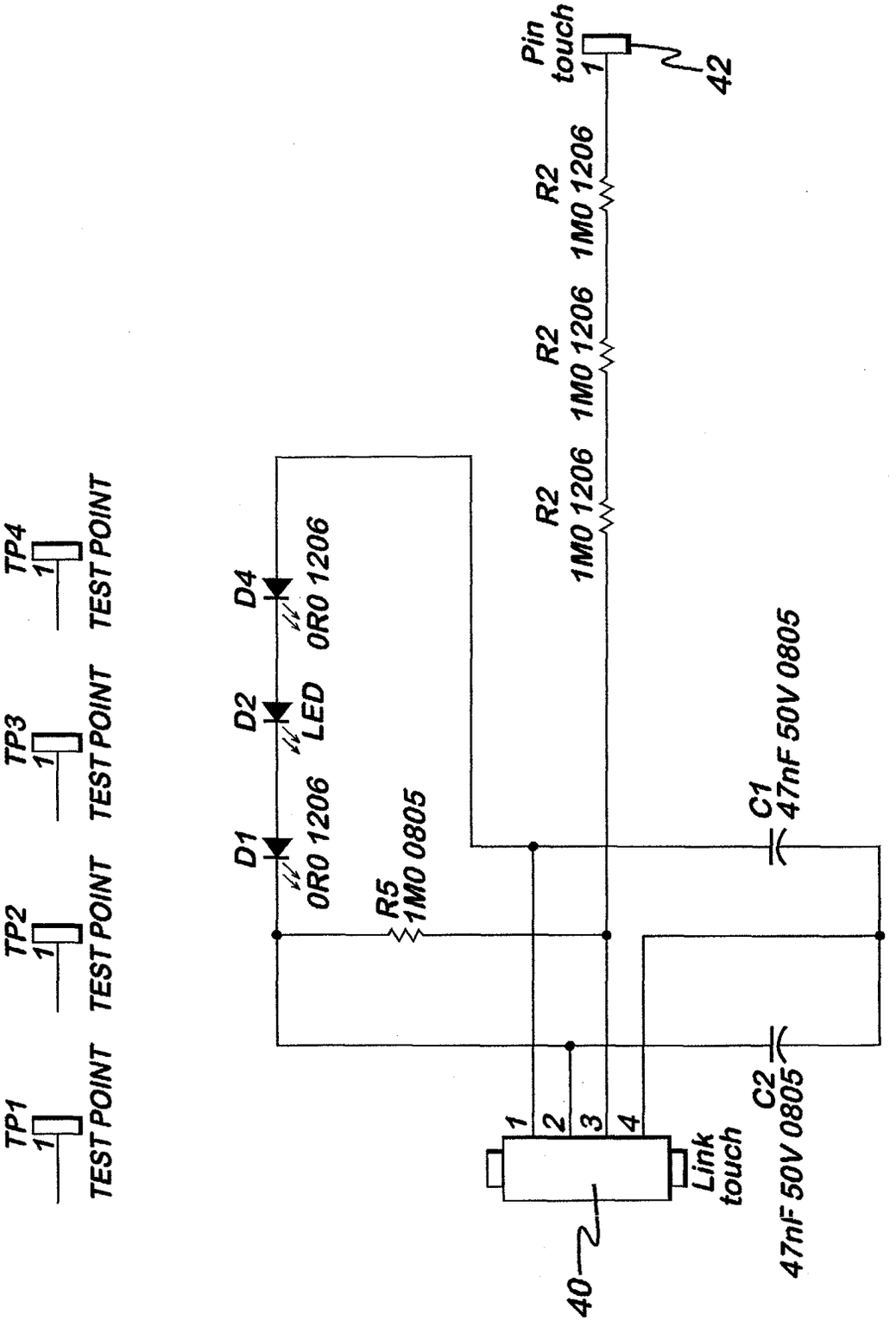

6
BT2
LIVE
1
3
CK1
CHOKE
CK2
Q3
BTA08 600S
2
4
BT2
LIVE
R1
1M0 1206
R2
1M0 1206
C3
X2 47nF
15mm
D1
LL4148
C2
47nF 50V 0805
D2 LL4148
10
C7 47nF 50V 0805
C4
220UF
C6
47nF 50V
0805
R3
1M0 0805
TP6
FD4
R10
100R 0805
0V
TP5
FD3
15
t°
R5
15K 0805
12
VDD

Fig. 4


TP1
1
TEST POINT
TP2
1
TEST POINT
TP3
1
TEST POINT
TP4
1
TEST POINT
D1
0R0 1206
D2
LED
D4
0R0 1206
R5
1M0 0805
R2
1M0 1206
R2
1M0 1206
R2
1M0 1206
Pin
touch
1
42
C1
47nF 50V 0805
C2
47nF 50V 0805
1
2
3
4
Link
touch
40

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 04 25 0598

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	FR 2 774 528 A (FRISTOT PIERRE) 6 August 1999 (1999-08-06) * the whole document *	1-7	H05B37/02
A	US 4 745 351 A (LONGENDERFER JOHN E ET AL) 17 May 1988 (1988-05-17) * column 3, line 50 - column 4, line 55; figures 1,2 *	1-7	
A	US 4 525 634 A (SOUTHARD JAMES S) 25 June 1985 (1985-06-25) * abstract; figure 1 *	1-7	
A	US 4 746 809 A (COLEMAN CHARLES E ET AL) 24 May 1988 (1988-05-24) * abstract; figure 4 *	1-7	
A	US 2002/011808 A1 (CARMEN LAWRENCE R ET AL) 31 January 2002 (2002-01-31) * paragraph [0049] - paragraph [0052]; figures 8A,8B *	1-7	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
			H05B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	11 May 2004	Boudet, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 04 25 0598

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

11-05-2004

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
FR 2774528 A	06-08-1999	FR 2774528 A1	06-08-1999
US 4745351 A	17-05-1988	US 4689547 A	25-08-1987
		AU 617558 B2	28-11-1991
		AU 4544189 A	08-03-1990
		AU 588667 B2	21-09-1989
		AU 6877487 A	05-11-1987
		CA 1337702 C	05-12-1995
		DE 3705531 A1	05-11-1987
		FR 2598054 A1	30-10-1987
		GB 2190804 A ,B	25-11-1987
		GB 2232834 A ,B	19-12-1990
		JP 2057849 C	10-06-1996
		JP 7089294 B	27-09-1995
		JP 62269208 A	21-11-1987
		KR 9513267 B1	26-10-1995
US 4525634 A	25-06-1985	NONE	
US 4746809 A	24-05-1988	GB 2197568 A	18-05-1988
US 2002011808 A1	31-01-2002	US 6313588 B1	06-11-2001
		AU 7707500 A	24-04-2001
		CA 2385466 A1	29-03-2001
		DE 60002102 D1	15-05-2003
		DE 60002102 T2	05-02-2004
		EP 1219145 A1	03-07-2002
		ES 2197116 T3	01-01-2004
		JP 2003510771 T	18-03-2003
		WO 0122781 A1	29-03-2001

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82