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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :		(11) International Publication Number:
G01R 31/28, G01D 3/08, F16D 66/02	A1	WO 98/14790
		(43) International Publication Date: 9 April 1998 (09.04.98)

(21) International Application Number: PCT/GB97/02683

(22) International Filing Date: 29 September 1997 (29.09.97)

(30) Priority Data:
9620417.7 1 October 1996 (01.10.96) GB

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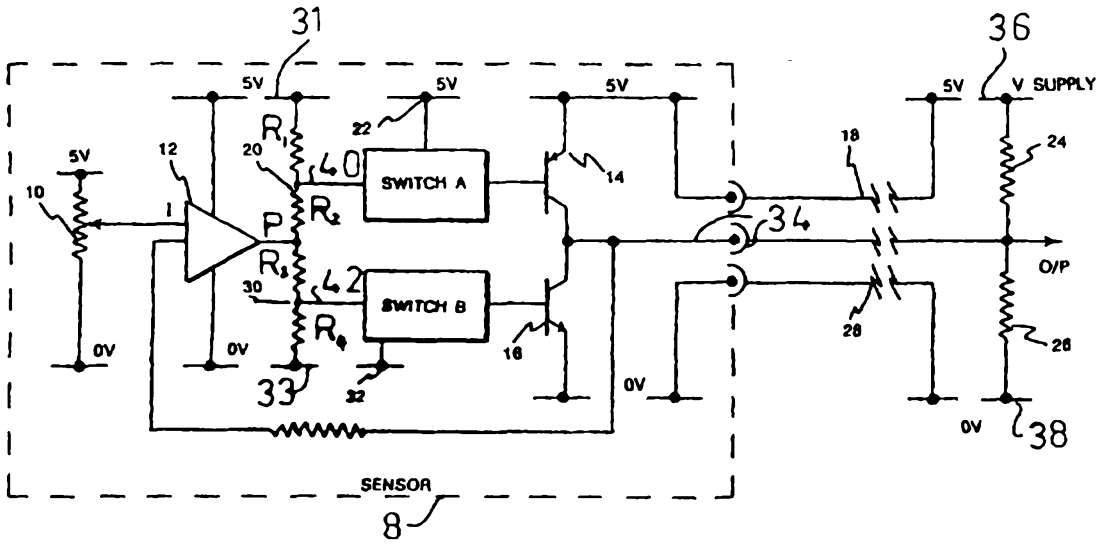
(81) Designated States: BR, JP, KR, US, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: FAULT WARNING IN ELECTRONIC SENSORS



(57) Abstract

An output stage for an electronic sensor comprising two transistors (14, 16) connected in series to form a push/pull arrangement between a pair of current supply lines (31, 33), operating with a fixed supply voltage therebetween, and a sensor output line (34) connected to the junction of these two transistors (14, 16). Each transistor (14, 16) is adapted to be driven via a respective drive line (40, 42) from an amplified sensor input signal (I). A detecting means (A, B) detects an open circuit condition in either of the two supply lines (31, 33) and disables the signal drive to that one of the two transistors (14, 16) which is connected to the supply line, in a manner so as to prevent back feed from powering the sensor via the sensor output line (34).

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DESCRIPTION

FAULT WARNING IN ELECTRONIC SENSORS

The present invention relates to electronic sensors and is concerned in particular with sensor fault error generation.

With the integration of electronics within vehicle control, more and more electronic sensors are required that have a high signal integrity. For this reason, manufacturers have insisted on a minimum quiescent current flowing through all of the sensor connections, even the output pin. It is well known that with low voltage signal connections, a high quiescent current of several milliamperes improves connection reliability. To guarantee this current, the output pin will have either a pull-up or pull-down resistor connected within the monitoring ECU. This output loading resistor has the advantage that if the output connection at the sensor goes open circuit, the monitored signal will be pulled into an error band (ie a voltage level outside the normal sensor operating range), enabling the fault to be detected. In order to supply this increased output current while maintaining a wide voltage swing on the output, it is common for push-pull output stages to be used, consisting of two transistors. Figs 1a and 1b of the accompanying drawings show two typical configurations well known in this field.

The aforegoing load resistor, while solving the output open circuit fault, causes other failure detection problems. If, for example, either supply pin is open circuit, it is possible for enough current to flow back into

the sensor, via the output pin, to produce an output signal within the normal operating range, therefore making the failure difficult to detect.

It is an object of the present invention to overcome or mitigate this problem.

In accordance with the present invention, there is provided an output stage for an electronic sensor comprising two transistors connected in series to form a push/pull arrangement between a pair of current supply lines, operating with a fixed supply voltage therebetween, and a sensor output line connected to the junction of these two transistors, each transistor being adapted to be driven via a respective drive line from an amplified sensor input signal, and further comprising a detecting means for detecting an open circuit condition in either of the two supply lines and disabling the signal drive to that one of said two transistors which is connected to that supply line, in a manner so as to prevent back feed from powering the sensor via said sensor output line.

Thus, an output stage in accordance with this invention is provided with a detecting means for detecting an open circuit condition in either supply and disabling the output drive in a manner such as to prevent any back feed from powering the sensor.

A system in accordance with the invention has the advantage that any open circuit connector failure can be detected by the output signal moving into an error band voltage range.

When applied to the particular context of a brake pad wear

sensor, the present invention can be used to detect the failure of either of the supply lines into the sensor and disable the output drive stage to inhibit any reverse current flow from the output pin, causing the output voltage to stay within its normal operating band.

Advantageously, the detecting means comprises a switch which is responsive to a voltage difference between two circuit points arising in the presence of an open circuit supply condition.

In some embodiments, the detecting means can comprise two switches, each of which is responsive to a voltage difference between two circuit points arising in the presence of an open circuit condition in a respective one of said two supply lines.

Advantageously, said sensor output line is coupled via respective resistors to opposite terminals of a second voltage supply source.

The invention is described further hereinafter, by way of example only, with reference to the accompanying drawings, in which:-

Figs. 1a and 1b illustrate known circuits; and

Fig. 2 illustrates one embodiment of a circuit in accordance with the present invention, applied to a pad wear sensor of a vehicle brake control system.

The operation will be described with reference to Fig. 2 although it could be applied to either circuit of Fig. 1 and to many other output stage configurations.

Fig. 2 shows a sensor 8 in which an input signal I from a variable resistor 10 connected across a voltage supply is buffered by an amplifier 12, the output signal P from the amplifier 12 driving an output stage, comprising two output transistors 14,16, via a series resistor network R_1, R_2, R_3, R_4 connected between first voltage supply rails 31, 33. These parts together form a buffer that can provide the output current required for the sensor on a line 34 and will allow the output to swing quite close to the supply rails. The output line/pin 34 of the sensor is connected to the junction of pull-up and pull-down resistors 24, 26 connected in series between second voltage supply lines 36, 38 externally of the sensor 8.

Under an open circuit supply connection 18 in the line 31, a first switching element A detects a voltage reduction between points 20 and 22 via an input line 40. This voltage reduction is arranged to open the switching element A by means of conventional switching circuitry, known per se, to stop any back feed via the output line/pin 34 from powering the circuit, therefore reducing current drawn from the pull-up resistor 24. This action will hold the output signal outside its normal operating range.

The sensor 8 is required to operate with the pull-down resistor 26 as part of the output load. Under these conditions, a failure of the 0_V connection 28 (line 33) is arranged to be detected by a second switching element B via an input line 42. A reduction in voltage between points 30 and 32 is arranged to be detected and switching element B to be opened. This action, as with switching element A, will stop any back feed from the pull-

down resistor 26 providing a return path for the sensor power, thereby maintaining the output signal outside its operating band.

CLAIMS

1. An output stage for an electronic sensor comprising two transistors (14,16) connected in series to form a push/pull arrangement between a pair of current supply lines(31,33), operating with a fixed supply voltage therebetween, and a sensor output line (34) connected to the junction of these two transistors (14,16), each transistor (14,16) being adapted to be driven via a respective drive line (40,42) from an amplified sensor input signal (I), and further comprising a detecting means (A,B) for detecting an open circuit condition in either of the two supply lines (31,33) and disabling the signal drive to that one of said two transistors (14,16) which is connected to that supply line, in a manner so as to prevent back feed from powering the sensor via said sensor output line (34).

2. An output stage as claimed in claim 1 wherein the detecting means comprises a first switching element (A) which is responsive to a voltage difference between two circuit points (20,22) arising in the presence of an open circuit supply condition.

3. An output stage as claimed in claim 1, wherein the detecting means comprises two switching elements (A,B), each of which is responsive to a voltage difference between two circuit points (20,22;30,32) arising in the presence of an open circuit condition in a respective one of said two supply lines.

4. An output stage as claimed in claim 1, 2 or 3, wherein the sensor is a brake pad wear sensor, and whose said amplified sensor input

signal is obtained from a buffer amplifier (12) which receives an input signal (I) derived from a variable resistor (10).

5. An output stage as claimed in any of claims 1 to 4, wherein said sensor output line (34) is coupled via respective resistors (24,26) to opposite terminals of a second voltage supply source (36,38).

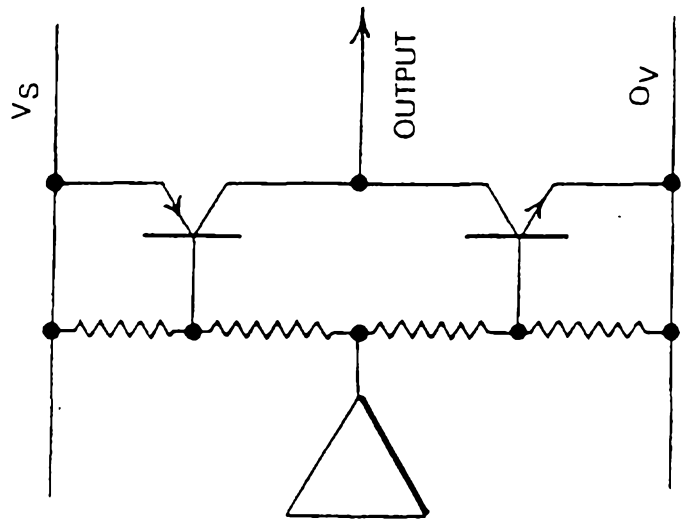

FIG. 1B

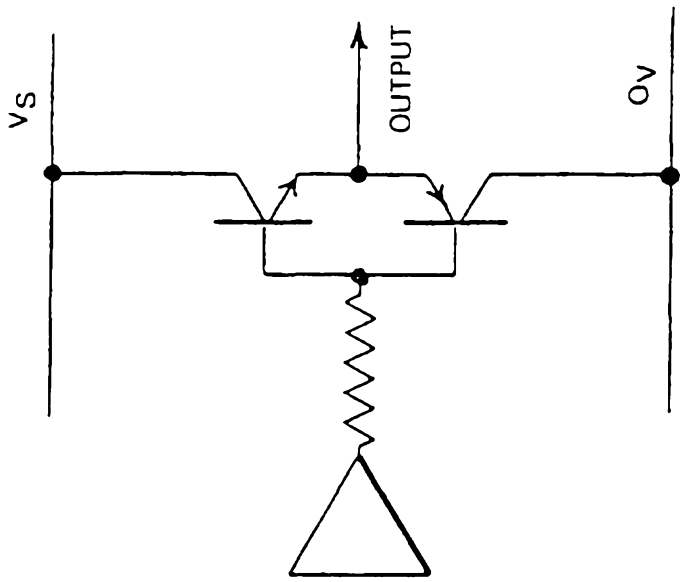

FIG. 1A

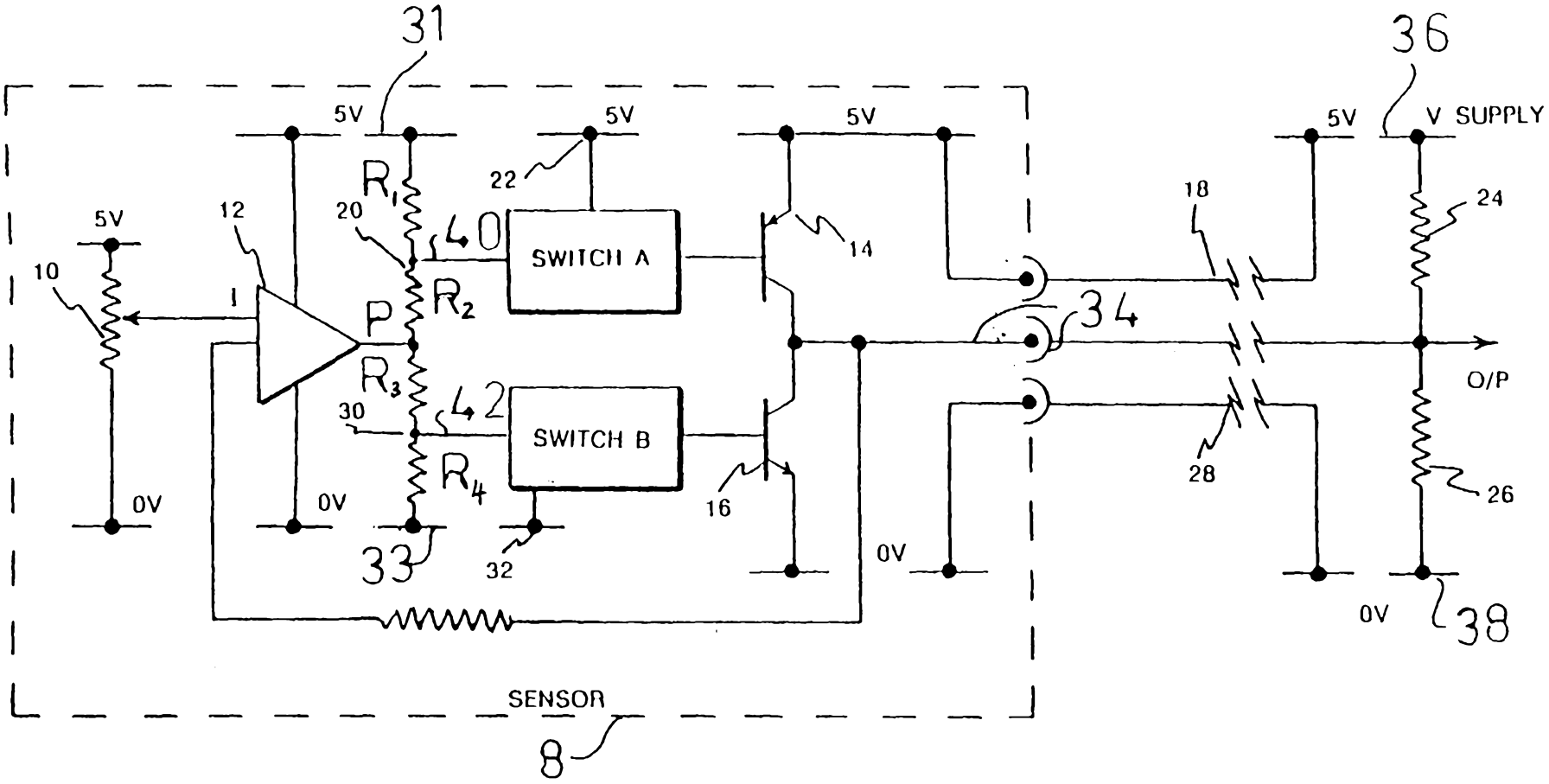
31
36
5V
5V
5V
5V
V SUPPLY
R1
22
18
24
5V
12
20
40
SWITCH A
14
10
I
P
R2
34
R3
30
42
SWITCH B
O/P
28
R4
16
26
0V
0V
0V
0V
33
32
38
SENSOR
8

FIG. 2

INTERNATIONAL SEARCH REPORT

Intr. ional Application No
PCT/GB 97/02683

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G01R31/28 G01D3/08 F16D66/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G01D G01R F16D

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Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 891 973 A (BOLLWEBER LOTHAR ET AL) 9 January 1990 see column 3, line 55 - column 4, line 12; figure 2	1
A	DE 44 43 941 A (KNORR BREMSE SYSTEME) 27 June 1996 see column 2, line 58 - column 4, line 6; figures 2,3	1-4
A	US 4 839 633 A (KRENIK WILLIAM R) 13 June 1989 see column 4, line 7 - column 7, line 26; figure 2	1-3

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
18 December 1997	08/01/1998

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category `	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No
A	US 4 293 902 A (WHITE JOHN E) 6 October 1981 see column 3, line 23 - column 5, line 20; figures 1-4	1-3
A	FR 2 574 508 A (RENAULT) 13 June 1986 see claim 1; figures 2A,2B	4

INTERNATIONAL SEARCH REPORT

Information on patent family members

Ir. .tional Application No
PCT/GB 97/02683

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