(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
31 January 2008 (31.01.2008)

PCT

(10) International Publication Number
WO 2008/011894 A1

(51) International Patent Classification:
H04L 12/40 (2006.01) *H04B 3/44* (2006.01)

(21) International Application Number:
PCT/EP2006/007320

(22) International Filing Date: 25 July 2006 (25.07.2006)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant *(for all designated States except US)*: **SIEMENS AKTIENGESELLSCHAFT** [DE/DE]; Wittelsbacherplatz 2, 80333 München (DE).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **ZIMMERMANN, Rudolf** [DE/DE]; Hammerphilippsburg 3, 92237 Sulzbach-Rosenberg (DE).

(74) Common Representative: **SIEMENS AKTIENGESELLSCHAFT**; Postfach 22 16 34, 80506 München (DE).

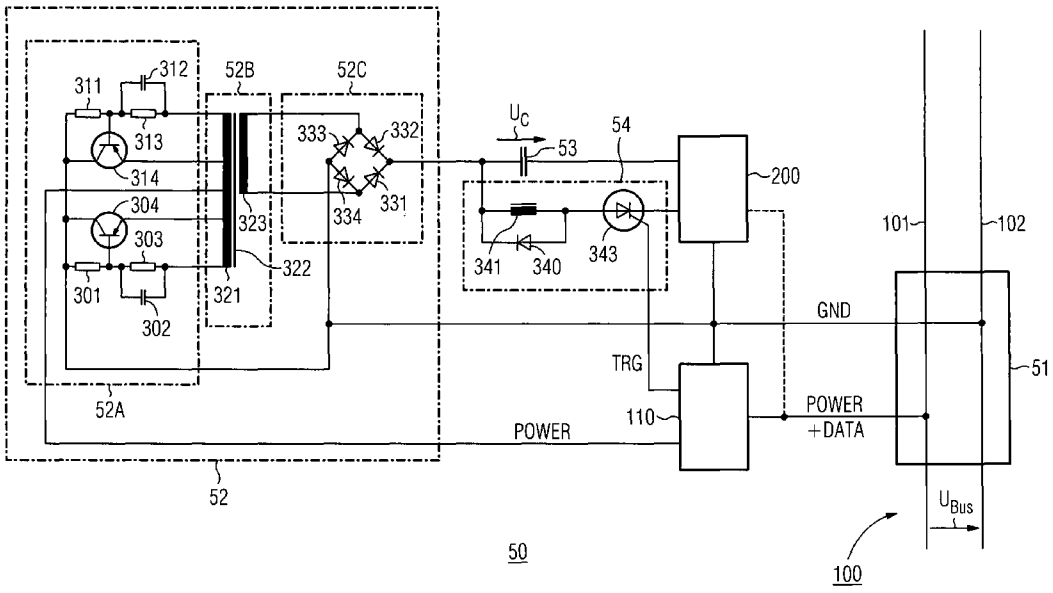
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) **Title:** A DEVICE AND A METHOD FOR PROVIDING ELECTRICAL ENERGY TO AN ACTUATOR, AND AN ACTUATOR SYSTEM



(57) **Abstract:** A method for providing electrical energy to an actuator (200) comprises the steps of: i) receiving an electric current having a first voltage (UBUS) from a data bus (100, 101, 102); ii) converting said electric current to a current having a second voltage (Uc) that is higher than said first voltage (U_{Bus}); iii) storing electrical energy of said second electric current; and discharging said stored electrical energy to an actuator (200). Independent claims also for a device (50) for providing electrical energy to an actuator (200), and for an actuator system.

WO 2008/011894 A1

A device and a method for providing electrical energy to an actuator, and an actuator system

Field of the invention

The invention relates to devices and methods for providing electrical energy to an actuator, and further to actuator systems.

Background art

In different applications for automation engineering, the use of sensors or actuators via data buses for monitoring and controlling of processes has become very popular. Related cost advantages may be remarkable, in particular, because the complexity of the wiring and cabling may be reduced, at the same time improving the reliability of operation.

Indeed, the advantages of reducing the need for cabling and wiring have been considered to be so important that in some applications employing system components requiring an electrical power supply, in addition to the primary function of data transfer, a secondary function of providing electrical power through the data bus has been implemented too. This is the case with the AS-Interface bus, for example.

For actuators, such as valve sets, with relatively high power consumption, the "black power cable" next to the "yellow cable" of the AS-Interface bus provides a 24V floating DC supply which is fully isolated from the data signals. The "black power cable" in an AS-Interface bus is typically rated up to 8A though the cable itself could handle more. With an improved design, currents higher than 8A can be drawn, still complying with the AS-Interface specification regarding the amount of voltage drops in the network.

Unfortunately, part of the advantages gained by the reduced need for cabling or wiring are lost if a separate power cable is needed.

Summary of the invention

An objective of the invention is to improve devices and methods for providing electrical energy to an actuator so that a separate power cabling becomes redundant.

This objective can be achieved with a device for providing electrical energy to an actuator according to claim 1, with a system according to claim 7, and with a method according to claim 9.

The dependent claims describe advantageous aspects of the invention.

Advantages of the invention

If a device for providing electrical energy to an actuator comprises i) a connection means for receiving a first electric current from a data bus, the first electric current having a first voltage, ii) transformer means for converting said first electric current to a second electric current having a second voltage that is higher than said first voltage, iii) a storing means adapted to store electrical energy of said second electric current; and iv) discharging means adapted to discharge electrical energy stored in said storing means to an actuator, the separate power cabling so far required to operate an actuator requiring an operating voltage higher than that available via a data bus is no more needed.

If the device for providing electrical energy to an actuator further comprises a control means adapted to discharge said discharging means, the moment at which the actuator is used can be better selected. In this manner, also actuators requiring more instantaneous power than the data bus can instantaneously supply can be used, since the smaller continuously available power that can be taken from the data bus can be stored.

A particularly efficient way to store electrical energy is to store it in capacitive storing means.

If the connection unit comprises an AS-Interface connector, the device for providing electrical energy to an actuator can be adapted to receive energy from the AS-Interface and also the discharging of the actuator may be carried out in response to a command over the AS-Interface.

Detailed description

In the following, the preferred embodiment of the invention is described in more detail with reference to the accompanying drawing in the Figure.

The Figure shows a device 50 for providing electrical energy to an actuator 200. The device comprises a connection unit 51, a transformer unit 52, a storage unit 53 and a discharging unit 54. Even though it is possible that the device 50 comprises an actuator 200, it is nevertheless not necessary. It suffices that the device 50 is connectable to an actuator 200, preferably via an actuator connector.

The actuator 200 may be any kind of actuator. In the preferred embodiment, it nevertheless comprises a step motor, a magnet valve, an interlocking or interlocking-releasing electromagnet, or a piezoelectric force transducer.

The connection unit 51 is adapted to receive a first electric current from a data bus 100, the first electric current thus having a first voltage u_{BUS} which may be less or equal to the data bus voltage. The connection unit 51 may be carried out using a connector connected to a cable, or with a separate wiring. It provides the first electric current to the transformer unit 52, likewise it provides the ground potential GND for the other units.

A non-limiting example of a data bus 100 suitable for carrying out the invention is the AS-Interface (ASI), in

which case the connection unit 51 comprises an AS-Interface connector. The data bus of an AS-Interface comprises two wires 101, 102, one of which is the ground line 102 and the other of which is the data line 101, between of which the voltage U_{BUS} = 30 Volt.

The transformer unit 52 is adapted to convert the first electric current to a second electric current having a second voltage U_C that is higher than the first voltage u_{BUS}.

If the direction of the first electric current changes, i.e. that the first electric current is an A.C. current and not an D.C. current, the transformer unit 52 preferably consists of a transformer 52B comprising a primary coil 321 and a secondary coil 323 and preferably also a ferritic core 322, and optionally also an A.C. to D.C. converter 52C, depending on the kind of the storage unit 53, i.e. depending on whether the storage unit 53 is adapted to store electrical energy of an A.C. current or of a D.C. current. The A.C. to D.C. converter 52C converts, preferably by using four diodes 331, 332, 333 and 334 an A.C. current to a D.C. current and ensures that electrical energy that will be released from the storage unit 53 will not be led back to other parts of the transformer unit 50 and to the data bus 100.

If the direction of the first electric current does not change, i.e. that the first electric current is a D.C. current and not an A.C. current, the transformer unit 52 may additionally comprise a D.C. to A.C. converter 52A between the connection unit 51 and the transformer 52B. A possible circuit for an D.C. to A.C. converter 52A comprises two switches - such as transistors 304, 314 - that can be switched in a predetermined manner - preferably with the help of timing components 301, 302, 303, 311, 312, 313 - to form an A.C. current, for example, by feeding the a D.C. voltage different ends of the primary coil 321 of the transformer 52C.

Since suitable D.C. to A.C. converters are available on the market at the time of filing of the patent application, it is to be understood that the manner in which the skilled person can carry out the invention does not require an in-depth knowledge of the working principle of an D.C. to A.C. converter.

In the AS-Interface, the voltage between the lines 101, 102 is a D.C. voltage and therefore the first electrical current is a D.C. current.

The storage unit 53 is adapted to store electrical energy of the second electric current. The storage unit 53 is preferably a capacitive storing unit which is extremely well suitable for storing electrical energy contained in a D.C. current. A capacitive storing unit may consist of one or more capacitors 53 that are connected in series or in parallel.

Also other kinds of systems for storing electrical energy can be used in the storage unit 53, depending whether storage of electrical energy contained in an A.C or in a D.C current is desired. As a particular example, at least one rechargeable battery where energy is stored chemically, can be used as the storing unit 53 as well.

The discharging unit 54 is adapted to discharge electrical energy stored in the storage unit 53 to an actuator 200. The discharging unit 54 may comprise a switch 343, such as a transistor or a thyristor, a resistor 341 and a diode 340. Upon receiving a discharge command, e.g. in the form of a control voltage TRG, the switch is activated and electrical energy stored in the storage unit 53 is released to the actuator 200.

The circuitry of the device 50 is preferably connected to both the data line 101 and the ground line 102. The data line 101 is preferably connected to a control unit 110 that is adapted to discharge the discharging unit 54 preferably by

setting a control voltage TRG. The control unit 110 may be adapted to discharge the discharging unit 54 in response to a command (DATA) received via the data bus 100, or upon meeting predefined criteria, such as passing of enough current to the transformer unit 52 indicating that the charge status of the energy storing unit 53 is enough to actuate the actuator 200.

To this end, the control unit 110 may comprise a protocol stack adapted to communicate over the AS-Interface, i.e. to receive or send 4-bits of user data or as in the "Combined Transaction Type 1", to receive or send 16-bit analog values.

Even though the invention was described using a non-limiting embodiment, the true scope of the invention can be studied from the scope of the attached patent claims.

Claims:

1. A device (50) for providing electrical energy to an actuator (200), **comprising:**
   i) a connection means (51) for receiving a first electric current from a data bus (100), the first electric current having a first voltage (U_{BUS}); and
   ii) a transformer means (52) for converting said first electric current to a second electric current having a second voltage (U_C) that is higher than said first voltage (U_{BUS});
   iii) a storing means (53) adapted to store electrical energy of said second electric current; and
   iv) a discharging means (54) adapted to discharge electrical energy stored in said storing means (53) to an actuator (200).

2. A device (50) according to claim 1, further **comprising:** a control means (110) adapted to discharge (TRG) said discharging means (54).

3. A device (50) according to claim 2, **wherein:** said control means (110) is responsive to a command (DATA) received from the data bus (100).

4. A device (50) according to claim 3, **wherein:** said control means (110) comprises a protocol stack adapted to communicate over the AS-Interface.

5. A device (50) according to any one of the preceding claims, **wherein:** the storing means (53) is a capacitive storing means.

6. A device (50) according to any one of the preceding claims, **wherein:** said connection unit (51) comprises an AS-Interface connector.

7. A actuator system, comprising: an actuator (200) and a device (50) for providing electrical energy to said actuator (200), **characterized in that** said device (50) for providing electrical energy is a device according to any one of claims 1 to 6.

8. An actuator system according to claim 7, **wherein**: said actuator (200) comprises a step motor, a magnet valve, an interlocking or interlocking-releasing electromagnet, or a piezoelectric force transducer.

9. A method for providing electrical energy to an actuator (200), **comprising the steps of**:

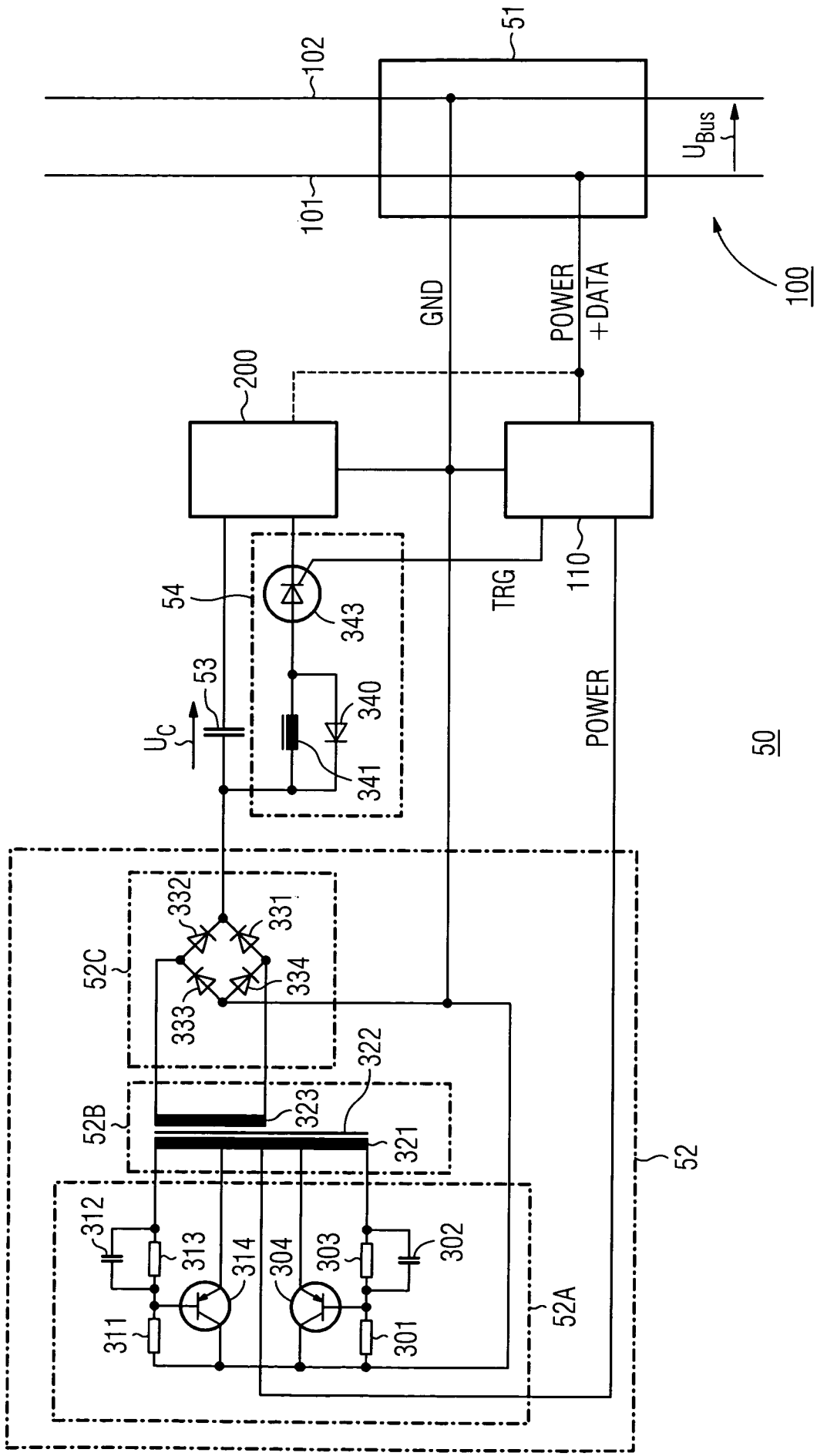
i) receiving an electric current having a first voltage (U_{BUS}) from a data bus (100, 101, 102);

ii) converting said electric current to a current having a second voltage (U_C) that is higher than said first voltage (U_{BUS});

iii) storing electrical energy of said second electric current; and

iv) discharging said stored electrical energy to an actuator (200).

10. A method according to claim 9, **wherein**: said step of storing electrical energy is performed using a capacitive storing means.


51
102
101
U_{Bus}
100
GND
POWER
+DATA
200
54
343
53
U_C
340
341
TRG
110
POWER
50
52C
332
331
334
333
322
52B
323
321
52
312
313
314
304
303
302
311
301
52A

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2006/007320

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L12/40 H04B3/44

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)
H04B H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 153 448 A (ZIERHUT HERMANN [DE]) 6 October 1992 (1992-10-06) abstract figures 1,2 column 1, line 6 - line 12 column 1, line 21 - line 34 column 2, line 35 - line 68	1-10
Y	US 6 163 578 A (SEIBOLD JOCHEN [DE] ET AL) 19 December 2000 (2000-12-19) abstract figure 1 column 1, line 4 - line 7 column 2, line 19 - line 22 column 2, line 28 - line 30 column 2, line 56 - column 3, line 28 column 4, line 29 - line 35 column 5, line 41 - line 46	1-10

-/--

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
3 May 2007	11/05/2007

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Oliveira, Joel

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2006/007320

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	DE 199 47 501 A1 (IFM ELECTRONIC GMBH [DE]) 23 May 2001 (2001-05-23) abstract figure 1 column 1, line 3 - line 9 column 2, line 29 - line 48 column 3, line 24 - line 33	1-10
Y	GB 2 123 589 A (HONEYWELL INC) 1 February 1984 (1984-02-01) abstract figures 2,3 column 1, line 42 - line 57 column 2, line 90 - line 93 column 3, line 13 - line 43 column 4, line 87 - line 107	1-10

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2006/007320

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5153448 A	06-10-1992	AT 111273 T	15-09-1994
		AU 623972 B2	28-05-1992
		AU 4882990 A	02-08-1990
		BR 9000339 A	27-11-1990
		CA 2008552 A1	27-07-1990
		DE 59007006 D1	13-10-1994
		DK 379902 T3	13-02-1995
		EP 0379902 A1	01-08-1990
		ES 2062108 T3	16-12-1994
		FI 100071 B1	15-09-1997
		JP 2235444 A	18-09-1990
		JP 3056500 B2	26-06-2000
		NO 900388 A	30-07-1990
		PT 92958 A	30-09-1991
		ZA 9000589 A	31-10-1990
US 6163578 A	19-12-2000	DE 19744099 A1	08-04-1999
		EP 0911740 A2	28-04-1999
		JP 11243649 A	07-09-1999
DE 19947501 A1	23-05-2001	NONE	
GB 2123589 A	01-02-1984	CA 1194175 A1	24-09-1985
		US 4463352 A	31-07-1984