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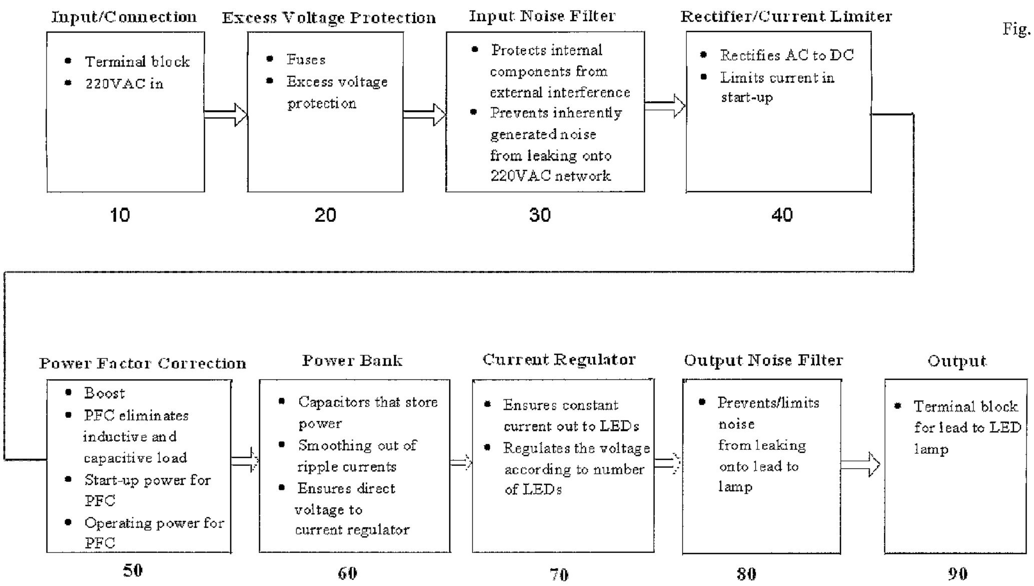

Fig. 1

(57) Abstract: A high power LED driver with rectified high voltage at the output, low inherent noise generation and a soft start-up, where the use of PFC constitutes an essential part of the invention.

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CONTROL ELECTRONICS FOR HIGH POWER LEDS

Introduction

The present invention relates to a driver device for high power LEDs. More specifically, an optimal solution is described for driving a large number of LEDs with a stable and adapted high-voltage power supply.

Prior art

Today there are many different types of LED (light-emitting diode) drivers. None of them are designed to supply an output voltage that exceeds 48 volts and they have typically a maximum power output of about 22 watts. Therefore, they cannot drive more than about 14 high power LEDs with a supply voltage of about 3.2 volts which is what is required per LED in order to reach 50 to 80 lumens, a necessity if the LED as a light source is to be competitive in relation to conventional lighting, for example, halogen/sodium vapour lamps etc.

US-7116294 describes a LED driver, the main object of which is to deliver constant current strength to series-connected LEDs. This is an important feature of an LED driver and will help to increase the lifetime of the LED lamps.

High power LED lighting is now in the process of taking over from traditional lighting in, for example, streets and tunnels. The use of LEDs can result in a power saving of as much as 70%.

As mentioned, known LED drivers are low voltage devices. To be able to drive, for example, street lighting, six such drivers are required, and when they are to be connected a great deal of work with wiring etc. is called for, and, moreover, a lot of heat will be generated (when heat is measured for six LED drivers, the temperature is just above 100 C°, which means that the lifetime is greatly reduced in that semi-conductors dry out).

In other words, when using the prior art, the problem is transferred from the actual light bulb, which today is typically a halogen light bulb with a lifetime of up to 16 000 light burning hours, to LED drivers which today have a light burning time of 150 000 light burning hours, i.e., that drivers must perhaps be changed more often than every 20 000 hours. Thus, with the prior art related to LED lighting, it will be necessary to change LED drivers instead of light bulbs as in the case of ordinary lighting.

The present invention is a high voltage driver for LEDs. By using high voltage, it will be possible to drive at least 100 LEDs on one driver, which is very many more than has previously been possible. But the use of high voltage also introduces a number of challenges which, inter alia, are associated with the generation of noise.

These problems are solved in the inventive high power LED driver which will be described in more detail below.

Summary of the invention

The object of the present invention is to provide a high power LED driver with rectified high voltage and constant current at the output, low inherent noise generation and a soft start-up.

This is achieved with a driver which at least comprises an input, a rectifying circuit, a PFC (Power Factor Correction) circuit comprising means to provide a soft start-up, a current regulator for providing constant current to LEDs, and where the voltage is regulated according to the number of LEDs, and an output that delivers constant current and high voltage to LEDs.

The driver further comprises excess voltage protection at the said input, an input noise filter, a power bank comprising capacitors to smooth out ripple currents exiting the said PFC circuit, and to provide smooth voltage to the current regulator, and an output noise filter in the form of a L/C filter which removes ripple and noise spikes at the output of the LED driver.

Additional features of the LED driver are described in the attached dependent claims.

Detailed description

The invention will now be described in more detail with reference to Figure 1 which shows the different parts that form the LED driver from input to output according to the present invention.

As mentioned, the object of the LED driver is to supply rectified high voltage and constant current at the output, and where the LED driver has low inherent noise generation and soft start-up.

This is achieved in that the input 10 of the driver is connected to excess voltage protection 20 which in turn is connected to an input noise filter 30 ahead of a rectifier 40. The last-mentioned is further connected to a PFC 50 which in turn is connected to a power bank 60. A current regulator 70 and output noise filter 80 ensure that constant current with a minimum of noise is given out to an output 90 to which LEDs are connected.

All the modules mentioned above comprise components that are connected to each other via a dedicated printed circuit board.

Each of the modules will be explained in more detail below.

The input 10 of the driver is connected to a terminal that has intakes for large cables having a cross-section designed for high voltage from the supply mains, which is 220V alternating current. The terminal is soldered directly onto the circuit board to which the driver components are also soldered. Cables can be connected on both sides of the terminal so that several LED drivers can thus be connected in parallel without having to mount an extra connection box to reduce the cross-section of the supply cable to the driver.

The excess voltage protection 20 comprises fuses in both phases to improve safety. This protects against short circuits to earth on both phases, and short-circuiting between the phases. Usually, there is protection on only one phase in known drivers.

Furthermore, in a preferred embodiment, there is also excess voltage protection at the input that consists of transient protection. It is known that transients from the supply mains can damage components if they are allowed to penetrate into sensitive electronics. The transient protection consists of three voltage-dependent resistors, i.e., varistors. Two of them are coupled between each phase and earth, and one is coupled between the phases. The components begin to conduct current when the voltage over them exceeds a set limit. This means that transients are short-circuited between the phases or to earth. These components will efficiently protect against transients from the supply mains.

The input noise filter 30 has two functions. First, it is to prevent inherently generated noise from the LED driver from getting into the power supply network. There are special stringent requirements with regard to how much noise is allowed from an electronic product. Secondly, the filter is to prevent noise from the power supply network from passing into the LED driver. The filter is of the second order with characteristics which mean that noise over a certain frequency is short-circuited between the phases (differential mode noise), or to earth (common mode noise). The filter has components on both the alternating current side and the direct current side of the rectifier 40.

The rectifier 40 must be present in the LED driver since light-emitting diodes are driven by direct current (DC). The power supply found on the supply mains is alternating current (AC) which enters on one side of the rectifying bridge, and direct current exits on the other side. Therefore there is DC high voltage on the output of the rectifier 40. Through this process, some heat is generated which, in a preferred embodiment of the LED driver, is conducted away via the soldering points on the printed circuit board of the LED driver. All components of the LED driver are fastened to a printed circuit board in a layout that is optimised to cool down the heat-generating components. Components which generate heat are soldered to points on the circuit board which have heat-conducting surfaces on one or both sides of the circuit board, and where the surfaces on each side may be connected to each other. This provides an efficient heat distribution and cooling thereby eliminating the need for separate cooling jackets for components that produce a lot of heat.

In a preferred embodiment, the rectifying circuit 40 also has means for giving the LED driver a soft start-up by limiting the current in the start-up phase. This is done by using a resistor with negative temperature coefficient (NTC) that is coupled to the DC side of the rectifying circuit. An NTC resistor has a relatively high resistance before it becomes hot. Therefore, in a brief start-up phase not as much current will pass through such a resistor as when it becomes hot. Limitation of current in the start-up phase (inrush-current) is important for dimensioning cables, fuses and other components. Giving the driver electronics a so-called soft start-up will prolong the lifetime of sensitive components.

The PFC circuit 50 is considered to be the core of the present invention. A PFC (Power Factor Correction) is a well-known component, but not in connection with LED drivers. The object of a PFC is to force the current to take the form of a smooth sine in phase with the voltage. It lessens the inductive and capacitive load on the power grid, which results in a gain by giving smaller losses in wiring, thereby reducing the energy consumption of the LED driver.

The PFC circuit 50 also provides a boost in that it gives out 390-395V DC, which is an important function to be able to drive many LEDs on one driver. A typical set-up of components around a PFC circuit 50 comprises a MOSFET which switches on and off extremely quickly, coupled to an inductance (hereafter called primary coil) and a capacitor which counters the said inductive and capacitive load of the LED driver. The load then becomes apparently resistive.

In a preferred embodiment, the PFC circuit 50 is driven at the start-up by a start-up current via components that supply this current, and during operation the PFC circuit 50 is driven by an operating current which takes over once the PFC circuit 50 has started up. This solution has been chosen to reduce power consumption during operation. This will be explained in more detail below.

The start-up current is taken out before the previously mentioned resistor with negative temperature coefficient (NTC), i.e., on the DC side of the rectifier 40 which has high voltage. The operating current is taken out after the NTC resistor from a circuit comprising a secondary coil wound on the same core as the said primary coil that constitutes a part of a typical set-up around the PFC circuit 50. Since the said MOSFET that is coupled to the primary coil switches on and off quickly, a voltage will be induced in said secondary coil on the same core as the primary coil of the PFC circuit 50.

A PFC circuit is driven by a low voltage and since the start-up current that is taken out is high voltage, the voltage must be reduced over resistors. This means a heat loss which results in increased power consumption. The operating current is, as mentioned, taken out of the induced voltage on the secondary coil where the number of windings helps to determine what voltage is taken out. The heat loss here is then insignificant on taking out low voltage.

By putting the voltage of the operating current slightly higher than the voltage of the start-up current, the operating current will take over for the start-up current when the PFC circuit 50 has started up and become stable. In practice, it takes from 0.5 – 1 second before the operating current is established.

A power bank 60 is also connected to the output of the PFC circuit 50. This comprises capacitors that are large enough to absorb and thus smooth out ripple currents exiting the PFC circuit 50, and to provide direct voltage to the current regulator 70 that comes after the PFC circuit 50, which is a precondition for the current regulator 70 to function in a stable and optimal manner.

The current regulator 70 ensures a constant current out to the LEDs, and delivers a voltage that is dependent on the number of connected LEDs. It is well known that light-emitting diodes are dependent upon a constant and correct current in order to maintain the right light intensity and lifetime. Unduly high current will give excessively high temperature in the light-emitting diode and shorter lifetime, and unduly low current will result in excessively low light intensity. There is thus a balance between lifetime and light intensity of a light-emitting diode. It is therefore important to have good cooling where the light-emitting diodes are mounted, i.e., in connection with the actual printed circuit board on which they are mounted and/or the holder inside which they are mounted.

There are separate circuits for driving light-emitting diodes, and which are suitable for regulating the output voltage of the LED driver according to the present invention. The current regulator 70 measures the current which at any given time goes out to the LEDs that are coupled to the LED driver, and will from this regulate a MOSFET so that the voltage out to the LEDs at all times is such that the right current is put out. The current regulator will ensure correct supply current even though the number of connected LEDs varies.

The output noise filter 80 is an L/C filter which removes ripple and noise spikes at the output of the LED driver. Since the light-emitting diodes need stable voltage in order not to be overloaded by high ripple voltages, this filter will ensure that the wire-bound and radiated noise on the cable to the lamp is dampened.

The output 90 of the LED driver will supply constant current and a voltage that is in accordance with the number of connected LEDs. Preferably, the connection points on the LED driver are a terminal block that is coupled so that both one and two LED lamps, each consisting of a plurality of LEDs and each having its cable, can be connected without having to have two wires in the same terminal, which ensures better contact and less danger of waver and contact breaks.

The present invention is capable of driving many more high power LEDs than has to date been possible. With the present LED driver it is possible to drive more than 100 LEDs. This is possible inasmuch as the LED driver uses high voltage, which introduces problems of noise that are solved in the different modules mentioned above. The LED driver produces less noise than the European standards as defined in:

EN 55015 (2000) + A1 (2001) + A2 (2002), EN 61000-3-2 (2000) + A2 (2005), EN 61000-6-4 (2001), EN 61547 (1995) + A1 (2000), and EN 61000-6-2 (2005).

Patent claims

1. A high power LED driver with rectified high voltage and constant current at the output, low inherent noise generation and a soft start-up, characterised in that the driver at least comprises:
- input (10);
- rectifying circuit (40);
- PFC circuit (50) comprising means for giving a soft start-up and low power consumption;
- current regulator (70) for providing constant current to LEDs, and where the voltage is regulated according to the number of LEDs; and
- output (90) which delivers constant current and high voltage to LEDs.

2. A high power LED driver according to claim 1, characterised in that the driver further comprises:
- excess voltage protection (20) at the said input (10);
- input noise filter (30);
- power bank (60) comprising capacitors for smoothing out ripple currents exiting the said PFC circuit (50), and to provide smooth voltage to the current regulator (70); and
- output noise filter (80) in the form of an L/C filter that removes ripple and noise spikes at the output of the LED driver.

3. A high power LED driver according to claim 1, characterised in that the input (10) is connected to a terminal which has intakes for large wires designed for high voltage, on both sides so that several LED drivers can be coupled in parallel without having to mount an extra connection box to reduce the cross-section of the supply cable to the driver.

4. A high power LED driver according to claim 2, characterised in that the input excess voltage protection (20) comprises fuses in both phases, and also transient protection between the phases and to earth from both phases.

5. A high power LED driver according to claim 2, characterised in that the input noise filter (30) has two functions, one of which is to prevent inherently generated noise from the LED driver from getting into the power supply network, and the other of which is to prevent noise from the power grid from passing into the LED driver, wherein this is achieved by using a second order filter for short-circuiting noise signals over a certain frequency

between the two phases and/or to earth.

6. A high power LED driver according to claim 1, characterised in that the rectifying circuit (40) rectifies the current from AC to DC, and has means for giving the LED driver a soft start-up by limiting the current in the start-up phase through the use of a resistor with negative temperature coefficient.

7. A high power LED driver according to claims 1 and 6, characterised in that the PFC circuit (50) provides a boost, and converts capacitive and inductive loads into resistive loads, and where the PFC circuit (50) is driven on start-up by a start-up current, and during operation by an operating current which ensures lower power consumption, and which takes over once the PFC circuit (50) has started, and where the start-up current is taken out before said resistor with negative temperature coefficient, the operating current being taken out thereafter.

8. A high power LED driver according to claim 7, characterised in that the operating current is taken out from a secondary coil that is wound on the same core as a primary coil that constitutes a part of the PFC circuit.

9. A high power LED driver according to claim 7, characterised in that the operating current takes over the power supply of the PFC circuit 50 when the voltage of the operating current is higher than the voltage of the start-up current.

10. A high power LED driver according to claim 1, characterised in that the output noise filter (80) is an L/C filter that removes ripples and noise spikes at the output of the LED driver.

11. A high power LED driver according to the preceding claims, characterised in that the components which constitute the LED driver are fastened to a printed circuit board in a layout that is optimised to cool down the heat-generating components, the layout, where it is necessary to cool components, having heat conducting surfaces on one or both sides of the circuit board, and where the surfaces on each side may be connected to each other.

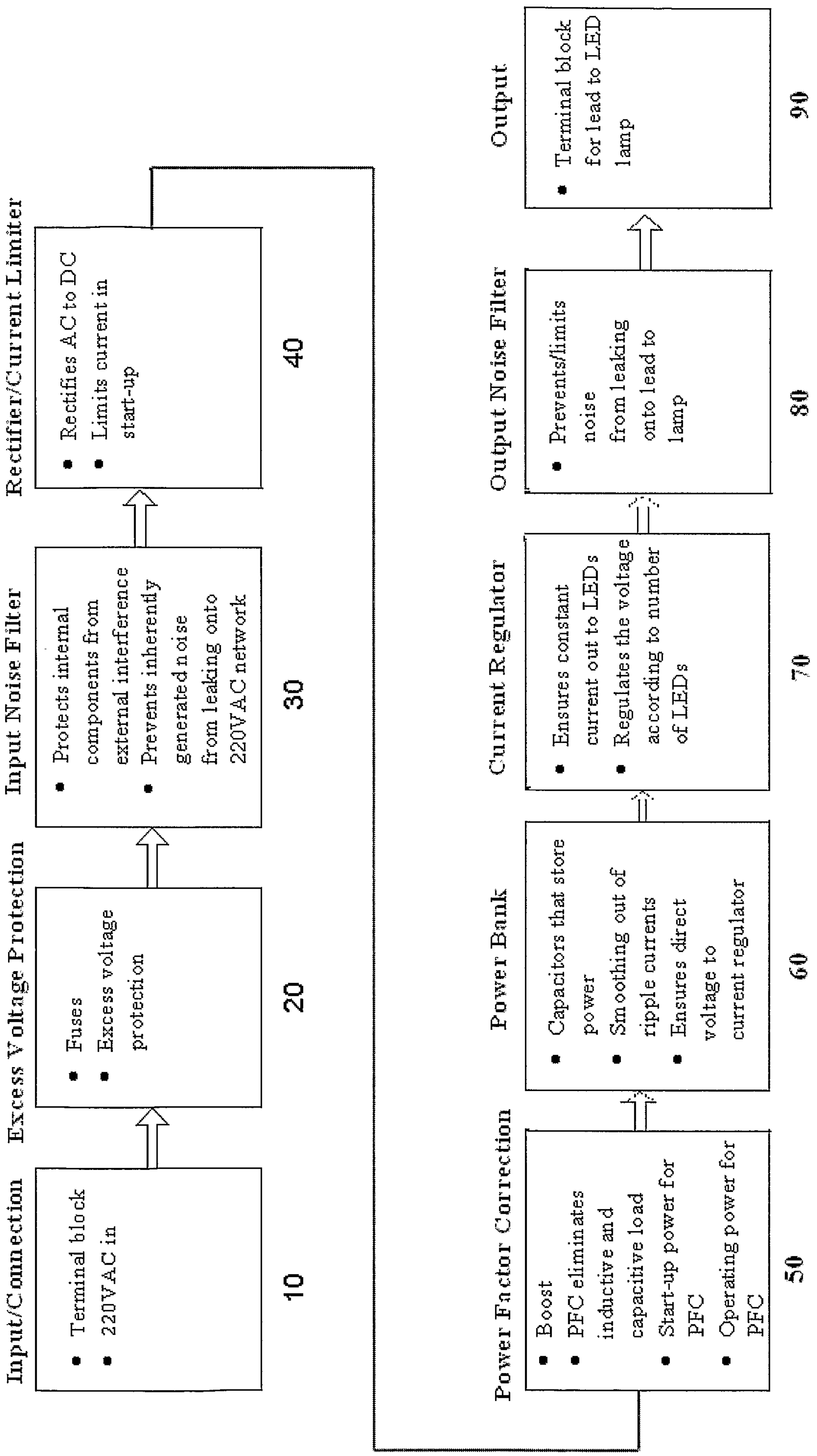
Input/Connection
Terminal block
220VAC in
10
Excess Voltage Protection
Fuses
Excess voltage protection
20
Input Noise Filter
Protects internal components from external interference
Prevents inherently generated noise from leaking onto 220VAC network
30
Rectifier/Current Limiter
Rectifies AC to DC
Limits current in start-up
40
Power Factor Correction
Boost
PFC eliminates inductive and capacitive load
Start-up power for PFC
Operating power for PFC
50
Power Bank
Capacitors that store power
Smoothing out of ripple currents
Ensures direct voltage to current regulator
60
Current Regulator
Ensures constant current out to LEDs
Regulates the voltage according to number of LEDs
70
Output Noise Filter
Prevents/limits noise from leaking onto lead to lamp
80
Output
Terminal block for lead to LED lamp
90

Fig. 1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO2008/000158

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

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: H05B, G09G

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

SE,DK,FI,NO classes as above

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

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	US 20080018261 A1 (KASTNER, M A), 24 January 2008 (24.01.2008), see whole document --	1-11
Y	US 20050128751 A1 (ROBERGE, B ET AL), 16 June 2005 (16.06.2005), figure 15, paragraph [0202] --	1-11
Y	US 20060071614 A1 (TRIPATHI, A ET AL), 6 April 2006 (06.04.2006), paragraph [0005] --	1-11
P,A	US 20070182347 A1 (SCHTEYNBERG, A ET AL), 9 August 2007 (09.08.2007), paragraph [0013] -- --------	1-11

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
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Cited literature, if any, will be enclosed in paper form.

INTERNATIONAL SEARCH REPORT

Information on patent family members

28/06/2008

International application No.

PCT/NO2008/000158

US	20080018261	A1	24/01/2008	NONE			
US	20050128751	A1	16/06/2005	US	D518218	S	28/03/2006
				US	7178941	B	20/02/2007
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US	20060071614	A1	06/04/2006	AU	2003303130	A	14/07/2004
				EP	1579735	A	28/09/2005
				JP	2006511082	T	30/03/2006
				CN	1745603	A	08/03/2006
				KR	20050089841	A	08/09/2005
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