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MULTIPLE INDIVIDUAL KELVIN EMITTER CONNECTIONS
TO REDUCE CURRENT FLOW THROUGH PARASITIC DIODE

BACKGROUND OF THE INVENTION

The present invention relates to an inverter circuit for driving a load such as a motor and, more particularly, to an improved inverter circuit which reduces current flow through a parasitic diode.

Fig. 1 shows the layout of a portion of a typical integrated circuit for a motor controller, in which reference letters A, B, and C identify the drivers that drive IGBT/MOSFET switching transistors Q_2 , Q_4 , Q_6 at the bottom rail.

Since this type of integrated circuit ordinarily has only one terminal or output pin to the common point (the COM pin), the usual practice is to connect all the emitters of the devices to a common point and connect that point to the COM terminal. This causes a problem, however, as described below.

When a switching transistor on the "top" rail (e.g. Q_8 in Fig. 1) turns off, it causes the output current to be diverted to the diode coupled across the corresponding LOW SIDE switching transistor, i.e. diode D_2 in Fig. 1. In practice, due to the finite trace

lengths of the connection on the circuit board, stray inductances are present, such as those identified by reference letters L_2 , L_4 , L_6 , L_{14} , L_{16} , etc. in Fig. 1. These stray inductances are on the order of a few 10's of nanoHenries. These stray inductances, coupled with the high turn off di/dt s (which are over $1000A/\mu s$) caused by the switching of the IGBT/MOSFETs, produces voltages at the V_s pin that can be tens of volts of a -ve polarity with respect to COM.

This causes a parasitic diode D_{s1} present between V_B and COM to become forward biased, resulting in the flow of current through parasitic diode D_{s1} from COM to V_B . This current can flow in an uncontrolled fashion and may cause malfunction of the logic of the integrated circuit or even "latch up" of the integrated circuit chip due to thyristor action.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide an improved driver circuit for switching transistors which helps protect uncontrolled current flow in the integrated circuit which would destroy the switching transistors.

It is a further object of the invention to provide a circuit of the above type which can be fabricated in a simple manner.

The foregoing and other objects of the invention are realized by an inverter circuit comprising an integrated driver circuit and a plurality of switching transistors which are laid out along a top rail and a

bottom rail. The bottom rail switching transistors are provided with individual Kelvin emitter connections to the common terminal of the integrated circuit to reduce the parasitic inductances. Further, individual traces are provided on the printed circuit board from the COM terminal to the Kelvin emitters. Still further, a small resistance (a few ohms) is provided in series with each Kelvin emitter connection.

Other features and advantages of the present invention will become apparent from the following description of the invention which refers to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows the circuit diagram of a portion of a typical integrated circuit for a motor controller.

Fig. 2 shows the circuit diagram of the present invention with multiple individual Kelvin emitter connections for the switching transistors at the bottom rail.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The problem described above, i.e. conduction of current through the parasitic diode D_{S1} of the integrated circuit (IC) driver 12, can be reduced by utilizing the following circuit and layout criteria:

1. The switching transistors Q_2 , Q_4 , Q_6 at the bottom rail are provided with individual Kelvin emitter connections to the COM terminal of the integrated circuit, as shown in Fig. 2. This reduces the parasitic inductance L_2 , L_4 , L_6 of the emitter leads to a large



extent (typically to sub nanoHenries). In practice, this is achieved by a separate connection from the common point or from the anode of the diode. Thus, the first criteria refers to the connection to each of the three IGBTs on the low side. Connecting the traces as close to the device as possible reduces the parasitic inductance as seen by the driver in the high current path.

2. Individual traces 14, 16, 18 are provided on the printed circuit board from the COM terminal 20 to the Kelvin emitters, rather than a single, joined trace as shown schematically in Fig. 1. The second criteria refers to the location in which to join the three traces. Keeping these traces separate on the printed circuit board, right up to the driver IC separates the impedances of each gate drive.

3. A small resistance (a few ohms, e.g., 1-10 Ω) R_2 , R_4 , R_6 is provided in series with each Kelvin emitter connection. This adds increased resistance in series with the parasitic diodes and hence reduces the current flowing in the parasitic diodes, thereby increasing the malfunction threshold.

Fig. 2 illustrates a top rail transistor Q_3 and bottom rail transistors Q_2 , Q_4 , Q_6 . Note that the aforementioned attributes and benefits of the invention are applicable to a circuit in which only top rail and/or bottom rail transistors are driven.

Although the present invention has been described in relation to particular embodiments thereof, many other variations and modifications and other uses will become apparent to those skilled in the art. It is

preferred, therefore, that the present invention be limited not by the specific disclosure herein, but only by the appended claims.



WHAT IS CLAIMED IS:

1. A driving circuit for driving a load, comprising:
 - a top rail and a bottom rail and at least one transistor arranged along the bottom rail;
 - an integrated circuit driver coupled to and serving for turning the at least one switching transistor at the bottom rail on and off, wherein the integrated circuit driver comprises at least one parasitic diode and is connected to the bottom rail bus;
 - and wherein each of the bottom rail at least one switching transistor has associated therewith a respective parasitic inductance; and
 - wherein the at least one switching transistor at the bottom rail is provided with an individual Kelvin emitter connection to reduce the parasitic inductances associated with the at least one bottom rail switching transistor.
2. The driving circuit of Claim 1, comprising a plurality of switching transistors including the at least one transistor arranged along the bottom rail and including at least one transistor arranged along the top rail.
3. The driving circuit of Claim 2, in which the integrated circuit driver is also coupled to and serve to turn the at least one switching transistor arranged at the top rail.



4. The driving circuit of Claim 3, further comprising a printed circuit board on which the integrated circuit and the switching transistors are mounted, the integrated circuit driver comprising a COM terminal and including individual circuit board traces from the COM terminal to the Kelvin emitter connection.

5. The driving circuit of Claim 1, further comprising a respective small resistance of a few ohms connected in series with each Kelvin emitter connection.

6. The driving circuit of Claim 4, further comprising a respective small resistance of a few ohms connected in series with each Kelvin emitter connection.

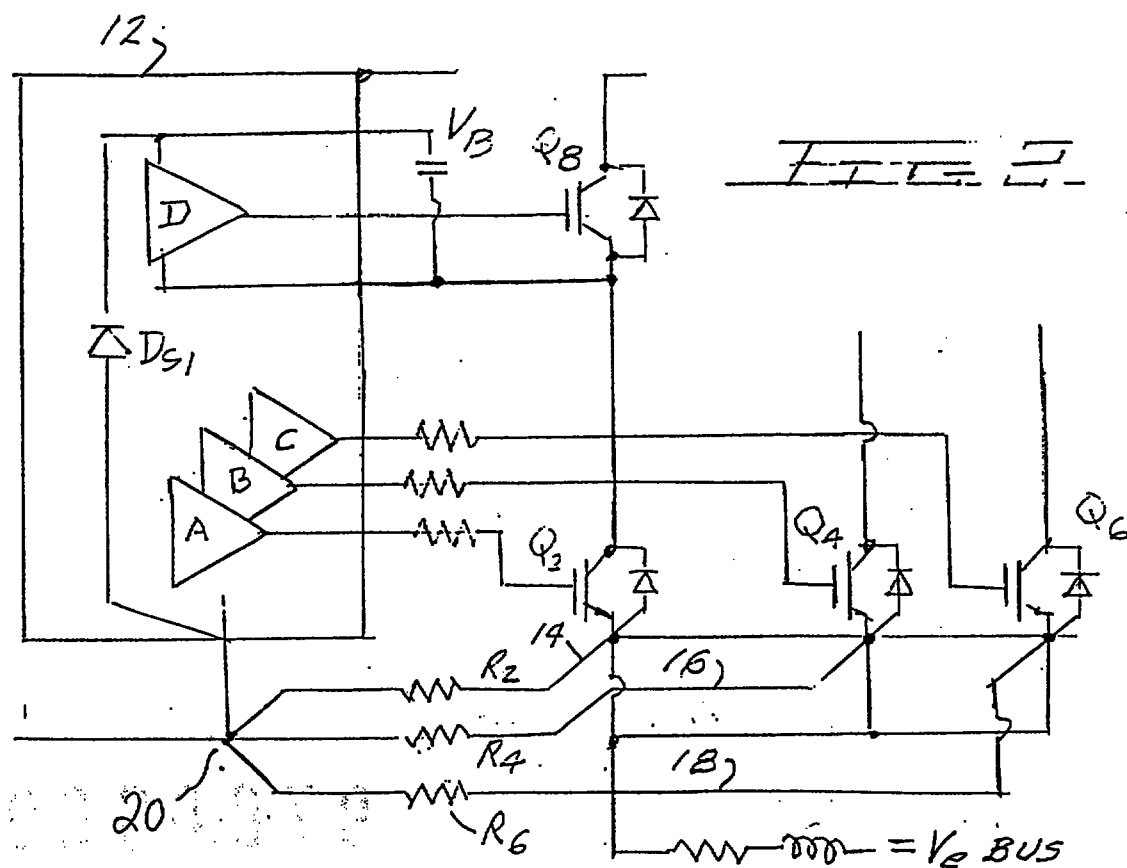
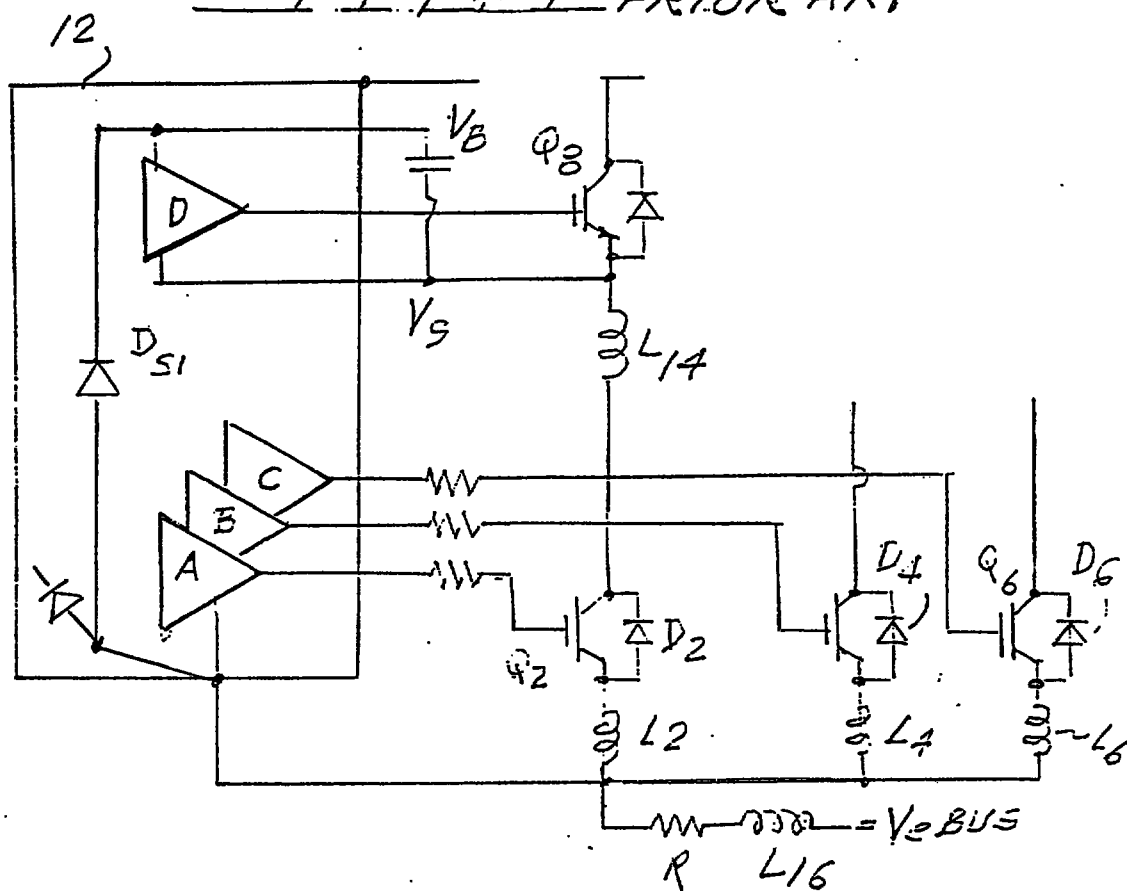


**MULTIPLE INDIVIDUAL KELVIN EMITTER CONNECTIONS
TO REDUCE CURRENT FLOW THROUGH PARASITIC DIODE**

ABSTRACT OF THE DISCLOSURE

In a motor controller circuit, an integrated circuit driver drives a plurality of switching transistors which are organized along a top rail and a bottom rail. To reduce the conduction of current through the parasitic diode D_{SI} of the integrated circuit, the switching transistors at the bottom rail are provided with individual Kelvin emitter connections, which reduce the parasitic internal inductances, which otherwise produce highly negative voltages when the top rail transistors are turned off. Further, individual traces are provided on the printed circuit board from the COM terminal to the Kelvin emitters. Finally, a small resistance is provided in series with each Kelvin emitter connection which increases the resistance in series with the parasitic diodes and hence reduces the current flowing in the parasitic diodes.

Fig. 2

FIG. 1 PRIOR ART

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bottom rail. The bottom rail switching transistors are provided with individual Kelvin emitter connections to the common terminal of the integrated circuit to reduce the parasitic inductances. Further, individual traces are provided on the printed circuit board from the COM terminal to the Kelvin emitters. Still further, a small resistance (a few ohms) is provided in series with each Kelvin emitter connection.

Thus, the invention provides

a driving circuit for driving a load, comprising:

a top rail and a bottom rail;

a plurality of switching transistors arranged along the top rail and a plurality of switching transistors arranged along the bottom rail;

an integrated circuit driver coupled to and serving for turning the plurality of switching transistors at the top rail and bottom rail on and off, wherein the integrated circuit driver has a COM pin and includes at least one parasitic diode;

and wherein each of the plurality of switching transistors at the bottom rail has an emitter connected to the bottom rail by a trace and has associated therewith a respective parasitic inductance relating to the length of the trace; and

wherein the plurality of switching transistors at the bottom rail are each provided with an individual Kelvin emitter connection from the COM pin of the integrated circuit driver to the emitter of the transistor to reduce the parasitic inductance, as seen by the integrated circuit driver, which is associated with each of the plurality of bottom rail switching transistors and which relates to the length of the trace of the connection between the emitter and the bottom rail.

Other features and advantages of the present invention will become apparent from the following description of the invention which refers to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows the circuit diagram of a portion of a typical integrated circuit for a motor controller.

Fig. 2 shows the circuit diagram of the present invention with multiple individual Kelvin emitter connections for the switching transistors at the bottom rail.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The problem described above, i.e. conduction of current through the parasitic diode D_{S1} of the integrated circuit (IC) driver 12, can be reduced by utilizing the following circuit and layout criteria:

1. The switching transistors Q_2 , Q_4 , Q_6 at the bottom rail are provided with individual Kelvin emitter connections to the COM terminal of the integrated circuit, as shown in Fig. 2. This reduces the parasitic inductance L_2 , L_4 , L_6 of the emitter leads to a large

Claims

1. A driving circuit for driving a load, comprising:
 - a top rail and a bottom rail;
 - a plurality of switching transistors arranged along the top rail and a plurality of switching transistors arranged along the bottom rail;
 - an integrated circuit driver coupled to and serving for turning the plurality of switching transistors at the top rail and bottom rail on and off, wherein the integrated circuit driver has a COM pin and includes at least one parasitic diode;
 - and wherein each of the plurality of switching transistors at the bottom rail has an emitter connected to the bottom rail by a trace and has associated therewith a respective parasitic inductance relating to the length of the trace; and
 - wherein the plurality of switching transistors at the bottom rail are each provided with an individual Kelvin emitter connection from the COM pin of the integrated circuit driver to the emitter of the transistor to reduce the parasitic inductance, as seen by the integrated circuit driver, which is associated with each of the plurality of bottom rail switching transistors and which relates to the length of the trace of the connection between the emitter and the bottom rail.
2. The driving circuit of claim 1, further comprising a printed circuit board on which the integrated circuit and the switching transistors are mounted, the integrated circuit driver comprising a COM terminal and including individual circuit board traces from the COM terminal to the Kelvin emitter connection.
3. The driving circuit of claim 1, further comprising a respective small resistance of a few ohms connected in series with each Kelvin emitter connection.
4. The driving circuit of claim 2, further comprising a respective small resistance of a few ohms connected in series with each Kelvin emitter connection.

