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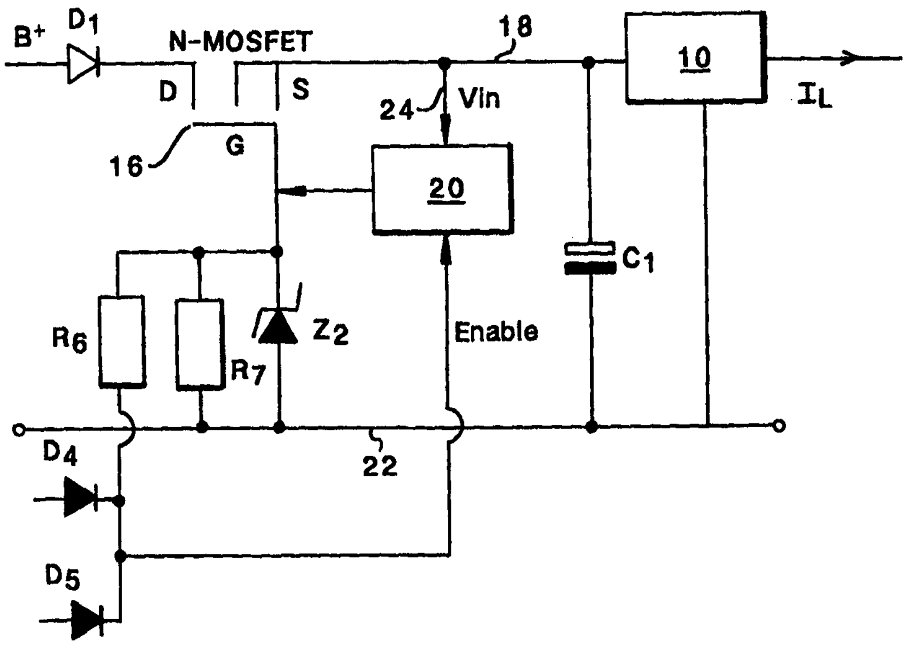

(57) Abstract

A voltage supply circuit for an ECU of the type in which a supply voltage is connected to a voltage regulator via an N–MOSFET control device (16), wherein, at least above a predetermined lower operating value, the control device (16) is adapted to introduce resistance of progressively higher value between the voltage supply and the voltage regulator in dependence upon increasing values of supply voltage.

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DESCRIPTION

POWER SUPPLIES FOR ECUs

The present invention relates to power supplies for microprocessors acting as electronic control units/controllers (ECUs) in vehicles and is concerned principally with "Load Dump" protection and on/off control of such devices.

Automotive controllers must be able to withstand without damage, high energy transients on the controllers B^+ supply, referred to as "Load Dump". It is often desired to have the controller fully functional during a "Load Dump". Most voltage regulators have some form of built-in "Load Dump" protection which may involve having the voltage regular shut down during such a "Load Dump". Thus, it is a requirement that the controller must not be damaged by a "Load Dump". Also, the controller may have to operate and be fully functional, during a "Load Dump".

The voltage regulator in the controller may have to operate up to an ambient temperature of +125°C. The power dissipated in the regulator is equal to (Supply Voltage - Output Voltage) Pass Current. When the vehicle has a defective alternator, or during a heavy charging, the B^+ voltage could be as high as 18V. During boost starting, the battery voltage may be as high as 25V for 5 minutes. The controller may have to be fully functional during high battery voltages and boost starting. Furthermore, the controller may have to operate down to a low battery voltage during engine cranking. To achieve the lowest operating voltage, any component prior to the voltage regulator must impose as small a voltage drop as possible, in order to extend the controllers operating voltage, as much as possible.

The controller may be connected to the vehicle's B^+ supply at all times but be enabled remotely. When the device is enabled remotely, the controller may then hold on after the remote enable control signal becomes non active. The controller must have a very low quiescent when not active.

Conventional circuitry for providing the aforegoing "Load Dump" function comprises a series resistor in the B^+ line upstream of the regulator and a zener diode in parallel with the regulator input. An example of such a circuit is shown in Fig. 1 of the attached drawings. Fig. 1 shows a voltage regulator 10 coupled to a voltage supply B^+ by way of a diode D_1 and resistor R_1, with a zener diode Z_1 and an electrolyte capacitor C_2 both connected between the regulator input and the other supply line 12.

For allowing remote switching on and off of the voltage regulator, this circuit also includes a switching transistor Tr_1 in the regulator input line 14 which can be controlled by way of a second transistor Tr_2 by means of enabling signals introduced via respective diodes D_2 and D_3. The switching levels are controlled by means of resistors R_3, R_4 and R_5.

Using this known circuit, reverse voltages are blocked by the diode D_1. Over-voltage transients are absorbed by the combination of R_1 and D_1. Tr_1 and Tr_2 constitute a high side switch which enables the voltage regulator to be selectively connected to the B^+ supply. The capacitor C_1 stores charge such as to enable the voltage regulator to continue working during negative spikes and during temporary interruptions in the B^+ supply.

The value of resistor R_1 is selected to stop excessive current flowing through and damaging the zener diode Z_1. The value of resistor R_1 will give a voltage drop that will impair the low operating performance of the controller. The latter problem is typically worse when the load current is normally high. The rated voltage of the capacitor must be at least the maximum clamp voltage of the zener diode Z_1.

This known circuit has the disadvantages that:

a) R_1 impedes low voltage working operation

b) If Z_1 is damaged (open circuit), the controller's operation is impaired and the voltage regulator may shut down or be over-stressed.

c) Z_1 is a redundant operation component during normal operation.

d) The rated working voltage of C_1 should be the clamp voltage of Z_1; this can result in C_1 having a physically large component size.

e) The voltage regulator will always see the battery voltage B^+ when the circuit is on; this can cause excessive heat dissipation in the voltage regulator junction.

In accordance with the present invention, a means is provided for introducing resistance of progressively higher value between the voltage (B^+) supply and the voltage regulator in dependence upon increasing values of (B^+) supply voltage.

Thus, at least above a predetermined lower operating level, eg 7 volts, the resistance introduced between the B^+ supply and the voltage regulator increases as the value of the B^+ supply voltage increases.

Preferably, said means providing said resistance is arranged to disconnect the voltage regulator from the (B^+) supply until activated by a remote enabling signal.

Preferably, said means comprises an N-MOSFET whose gate is arranged to be held at a substantially fixed potential and whose drain and source are connected between the B^+ supply and the voltage regulator.

Preferably, the fixed potential on the gate of the N-MOSFET is achieved by means of a charge pump and a zener.

Preferably, the charge pump can be remotely enabled but is also energisable via a connection to the B^+ supply line, downstream of the N-MOSFET.

Advantageously, the enabling signal for the charge pump is also arranged to be provided to the gate of the N-MOSFET for initial powering up purposes.

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

FIG. 1 is a circuit diagram of a known arrangement providing an ON/OFF function and "Load Dump" dissipation; and

FIG. 2 is a circuit diagram of one embodiment of a circuit in accordance with the present invention.

Referring to Fig. 2, the embodiment in accordance with the present invention comprises a voltage regulator 10 which is coupled to a vehicle B^+ supply via a diode D_1, and an N-MOSFET 16 source follower, whose source S is connected to the input line 18 to the voltage regulator 10 and whose drain D is connected to the diode D_1. The gate G of the N-MOSFET 16 is connected firstly to the output of a charge pump 20, secondly to the other supply line 22 by the parallel connection of a zener diode Z_2 and a resistor R_7 and thirdly to a pair of enabling diodes D_4 and D_5 by way of a resistor R_6. The diodes D_4 and D_5 are also connected to an enable input of the charge pump 20, the latter charge pump 20 having a power supply line 24 connected to the regulator input line 18. As before, an electrolytic capacitor C_1 is placed between the rails 18,22. This circuit operates as follows.

Whenever the voltage Vs at the source of the N-MOSFET is less than the voltage V_G on its gate, the N-MOSFET will conduct. Otherwise, it is non-conductive and effectively provides a high resistance. Thus, when the N-MOSFET is non-conductive, the voltage on the line 18 is held low and the voltage regulator is OFF and supplies no current to the ECU disposed downstream (not shown).

For powering up, an enable signal (normally battery voltage B^+) is applied to one of the enable diodes D_4, D_5. This raises the voltage at the gate of the N-MOSFET to battery voltage so that it is then at a higher voltage than the source Vs. Thus enables the N-MOSFET to start conducting. The enable signal is also applied to the charge pump and this results in the charge pump rapidly increasing the gate voltage V_G up to 12v, thus switching the

MOSFET further ON so that it acts as a PRE- voltage regulator.

Once the MOSFET has begun to conduct, the voltage on line 18 rises, supplying an energising voltage for the charge pump 20 via line 24 which, in the case of enabling pulses, maintains its operation when the enabling signal pulse has ended. The gate voltage V_G is then maintained at a fixed potential by virtue of the charge pump and the zener Z_2. The voltage at the source 5 is typically 2v less than the voltage on the gate. Whenever the supply voltage is less than the gate voltage, the N-MOSFET becomes more enhanced until it is fully ON (conductive) when typically the battery voltage is about 7 volts (or below). When the MOSFET is fully on, the voltage drop prior to the voltage regulator is at a minimum. However, as the battery voltage rises (for whatever reason), the MOSFET becomes progressively more resistive since the condition that Vs is less that V_G eventually no longer applies. "Load Dump" energy, which in the conventional circuitry would be absorbed in the voltage regulator junction, is then absorbed in the MOSFET junction. The result of this operation is that as B^+ rises above its normal level, the MOSFET becomes progressively more resistive such as to hold Vs at a substantially fixed voltage, typically of the order of 10v.

The above described circuit of Fig. 2 thus provides the functions of:

a) switching the controller ON/OFF;

b) providing "Load Dump" protection upstream of the voltage regulator;

c) extending the operational voltage range of the controller; and

d) providing PRE-regulation to minimise heat dissipated in the voltage regulator.

Furthermore, the circuit of Fig. 2 enables the following advantages to be obtained, namely:

1. The rated voltage of capacitor C can be lower, significantly improving the use of available stored energy potential of capacitor C.

2. The power normally dissipated in the Voltage Regulator junction is reduced because of PRE-Voltage Regulating function absorbs energy that would be dissipated in the voltage regulator junction.

3. A wider selection of voltage regulators can be used.

4. The controller can operate down to a lower supply voltage.

5. The controller can operate up to a higher voltage.

6. The controller is fully functional during a load dump, and boost start condition.

7. The controller has significant thermal advantages.

8. The operation of the "Load Dump" protection can be tested.

9. The clamping voltage of a "Load Dump" is the same as the PRE-regulator voltage.

CLAIMS

1. A voltage supply circuit for an ECU of the type in which a supply voltage is connected to a voltage regulator via a control device, wherein, at least above a predetermined lower operating value, the control device is adapted to introduce resistance of progressively higher value between the voltage supply and the voltage regulator in dependence upon increasing values of supply voltage.

2. A voltage supply circuit as claimed in claim 1, wherein said control device is arranged to disconnect the voltage regulator from the supply until activated by a remote enabling signal.

3. A voltage supply circuit as claimed in claim 1 or 2, wherein said control device comprises an N-MOSFET whose gate is arranged to be held at a substantially fixed potential and whose drain and source are connected between the supply and the voltage regulator.

4. A voltage supply circuit as claimed in claim 3, wherein the substantially fixed potential on the gate of the N-MOSFET is achieved by means of a charge pump and a zener.

5. A voltage supply circuit as claimed in claim 4, wherein the charge pump is adapted to be remotely enabled but is also energisable via a connection to the supply line, downstream of the N-MOSFET.

6. A voltage supply circuit as claimed in claim 5, wherein the enabling signal for the charge pump is also arranged to be provided to the gate of the N-MOSFET for initial powering up purposes.

7. A voltage supply circuit for an ECU, substantially as hereinbefore described with reference to and as illustrated in Fig. 2 of the accompanying drawings.

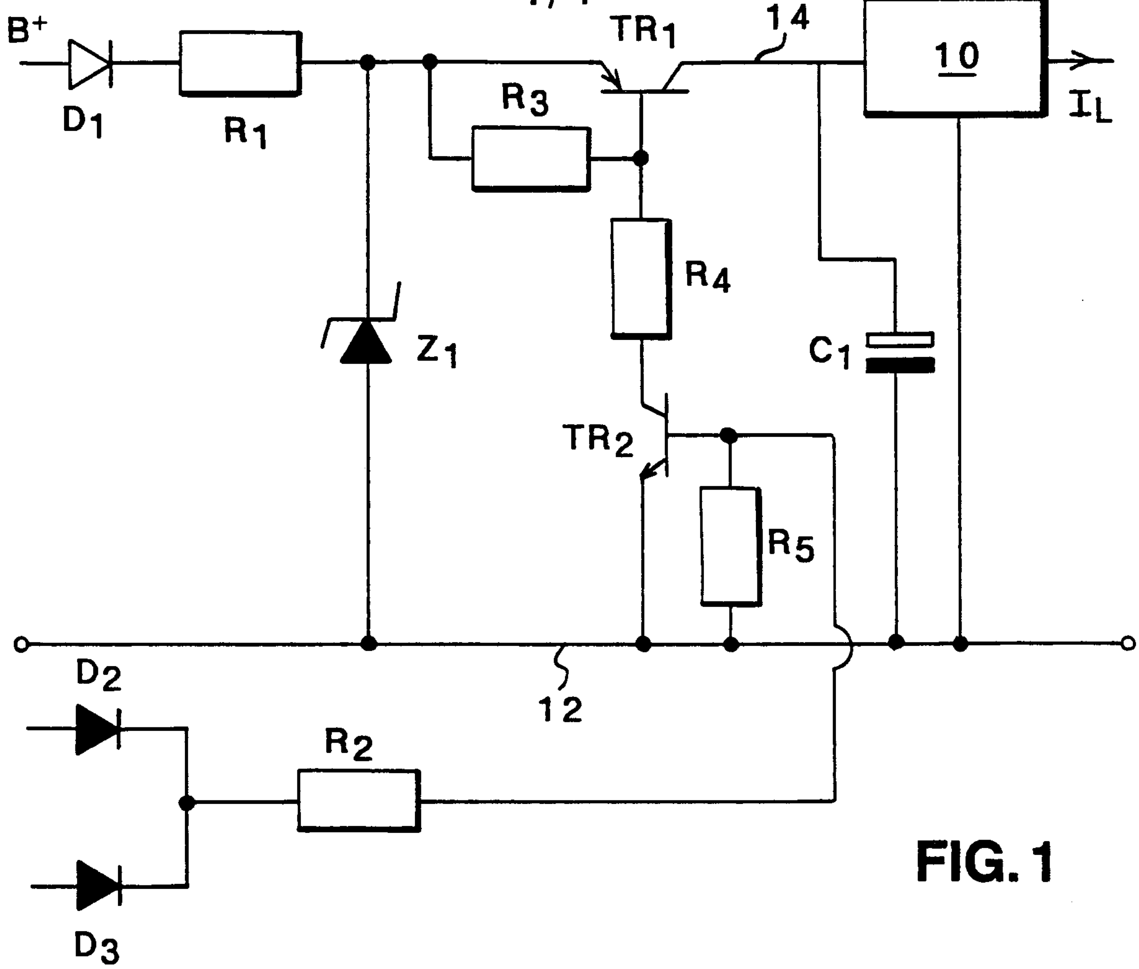
B+
D1
R1
R3
TR1
14
10
IL
R4
Z1
C1
TR2
R5
D2
12
R2
D3

FIG. 1

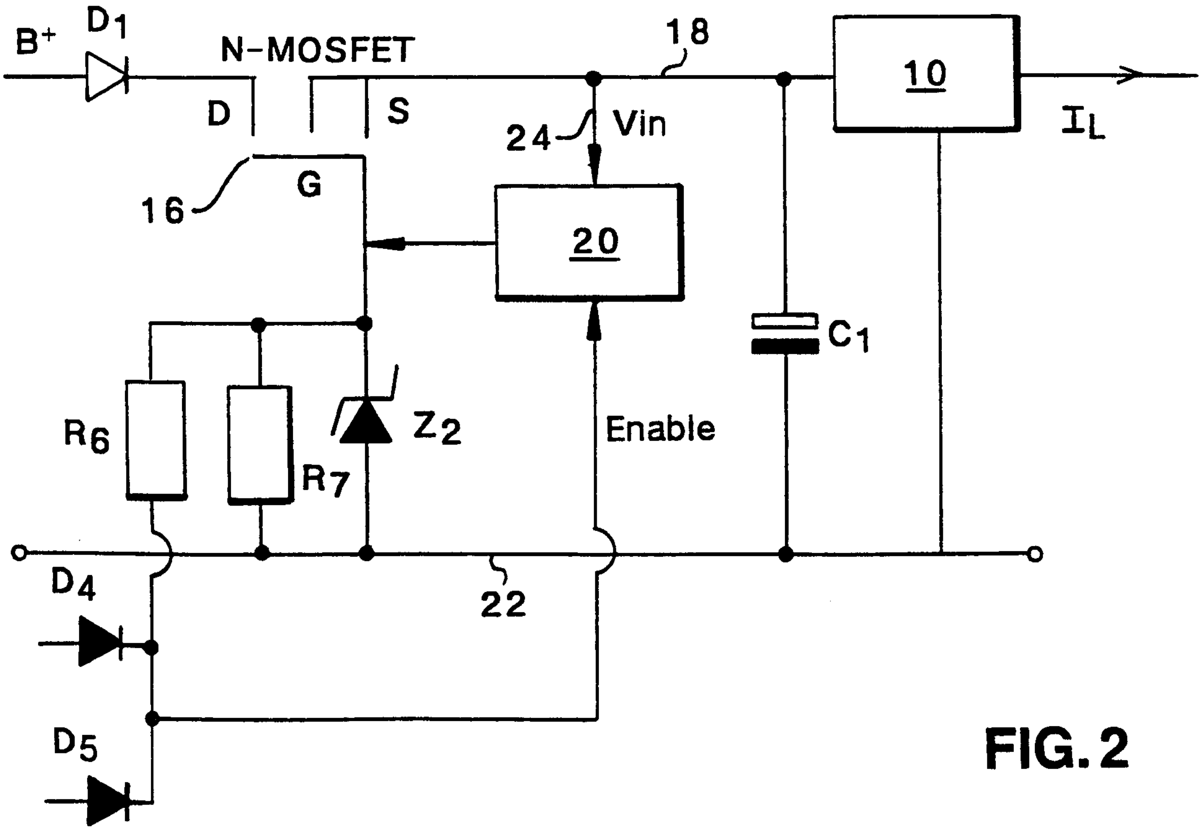
B+
D1
N-MOSFET
18
D
S
24
Vin
10
IL
16
G
20
R6
R7
Z2
Enable
C1
D4
22
D5

FIG. 2

INTERNATIONAL SEARCH REPORT

Inte. ɔnal Application No
PCT/GB 99/00322

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H02J7/00

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 H02J G05F

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)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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