

AUTOMOTIVE CIRCUIT BETWEEN ECU AND POWERTRAIN COMPONENT

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TECHNICAL FIELD

10 The invention relates to circuitry located between an automotive (e.g. powertrain) component or apparatus, a power supply such as a battery and a controller such as an Electronic Control Unit/Engine Control Unit.

BACKGROUND OF THE INVENTION

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In automotive applications, (powertrain) micro-controllers are used to control e.g. automotive components such as fuel injectors, pumps and such like. In automotive applications there are many discrete switch interfaces that need pull-up resistance to battery to indicate the “closed” or “open” state of the switch to the micro
20 controller. Such arrangements typically uses 1020/1210/1206 type of resistor packages for discrete pull-up to meet the required resistor power derating at 105°C external ambient operation.

Resistor derating starts at 70°C and the total power useful at 105°C external
25 ambient is limited to about 40 % of the component rated power rating. For example the actual power dissipation of 1K Ω resistance with a 16V battery is 256mW; maximum wattage of a 1K Ω , 1W- 1020 type resistor package can withstand at 125°C (internal ambient) is limited to 312mW after derating.

30 As per current design standard/recommendation 1K Ω , 1W, a 1020 resistor package is needed for 125°C (internal ambient) rating. Other option is to use two numbers of 2K Ω , 333mW, 1210 package resistors in parallel but need more PCB area.

Solder joint durability for larger packages are always a concern and difficult to meet the thermal cycling requirement for some customers. The use of multiple larger resistor packages increase the use of PCB area. PCB price is increasing and most customers wants to reduce product size (reduce the PCB size); further the cost of larger packages are higher. Current design guidelines recommend to use larger packages to meet the derating specification at higher operating temperature. Extended terminal resistors and wide terminal resistors are the currently available solution to address the solder joint durability problem. Both solutions do not help to improve the cost and PCB area reduction.

It is an object of the invention to overcome these problems.

SUMMARY OF THE INVENTION

In one aspect is provided a power control arrangement for providing power from a vehicle battery to an automotive powertrain component/apparatus input under control of a controller, comprising:-

a controller having,

a first output line connected to an automotive component/apparatus input via a first resistor (R2), where said automotive component/apparatus input terminal is connected to also a second resistor (R1), connect to both the vehicle battery and controller via an intermediate switching circuit;

and a second output line connected to said automotive component/apparatus via said intermediate switching circuit, wherein

said intermediate switching circuit comprises first (Q1) and second (Q2) transistors, wherein the second output line of the controller is connected to the base of said second transistor (Q2); the emitter terminal of second transistor is connected to earth, and the collector terminal is connected to the base terminal of first transistor (Q1) and where the emitter of first transistor (Q1) is connected to said battery and the collector of first transistor (Q1) is connected to the end of resistor R1.

The arrangement may include a biasing resistor R4 provided between the battery and the base of transistor Q1.

5 The arrangement may include a biasing resistor R5 between the second controller output line and the output base of transistor Q2.

The arrangement may include a biasing resistor R6 connected between the base of transistor Q2 and ground.

10 The arrangement may include a biasing resistor R3 between the base of transistor Q1 and the collector terminal of Q2.

The arrangement may include on either or both sides of the resistor R2, two capacitances C1 and C2 connected to ground.

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The arrangement may include including one or more further output terminals for automotive components connected to the collector of Q1 via respective resistors

20 BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is now described by way of example with reference to the accompanying drawings in which:

25 Figure 1 shows a typical resistor power derating chart against temperature is shown in figure 1

Figure 2 and 3 shows typical circuit diagrams which shows current designs of circuitry provided between the vehicle battery, controller (e.g. ECU), and the input to the automotive (powertrain) component for 1 discrete input;

30 Figure 4 shows an arrangement according to one example

Figure 5 compares and contrast the prior art arrangement 10 for multiple discrete interfaces and an example of the invention 11

Figure 6 shows a simulation for the arrangement of figure 4

Figure 7 shows the derating power against temperature for the arrangement of figure 4.

5 DESCRIPTION OF THE PREFERRED EMBODIMENTS

A typical resistor power derating chart against temperature is shown in figure 1.

Figure 2 and 3 show circuit diagrams which shows current designs of circuitry provided between the vehicle battery (DBATT) , controller or microcontroller (e.g. ECU) 1, and the input 2 to the automotive (powertrain) component.

Figure 2 shows a standard/recommendation 1K Ω , 1W, 1020 pull up resistor package (R1) which is needed for 125°C (internal ambient) rating. The figure shows an arrangement comprising of two capacitors C1 and C2 and two resistors R1 and R2 (30K Ω) located between the battery and the voltage input 2 to an automotive component.

Figure 3 shows another option where the pull up resistor R1 of figure 2 is replaced with resistors R1 and R3 arranged in parallel which are two 2K Ω , 333mW, 1210 package resistors are provided in parallel – however here more PCB area is required.

Conventional design methodology suggests the use of larger resistor packages for discrete pull-up circuit design to meet the design requirements at 125°C internal ambient and higher battery voltages.

In aspects of the invention is provided a novel switching circuit to switch the battery connection to the pull-up resistor to reduce the average current through the resistor without affecting the wetting current requirement. The problem of managing solder joint durability failure / high PCB real estate usage and high cost associated with larger resistor package is solved by replacing it with a smaller package.

The switching circuit is under the control of the microprocessor and has the flexibility to start switching on need basis. Example, the switching is needed only if the part is not able to handle the power due to internal temperature exceeding
 5 70°C or when the battery voltage exceeds 14.5V.

Figure 4 shows an arrangement according to one example. Here circuitry designated 3 is provided between a battery 4 and microprocessor/ECU 5 or other controller, and one or more inputs 2 to automotive components.

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The controller 5 (e.g. ECU) has a first output line 6 connected to the automotive component 2a via a resistor R2. On either or both sides of the resistor are located preferably two capacitances C1 and C2 connected to ground. A second controlling line 7 is output from the controller via an arrangement 3 to resistor R1 located in
 15 series. The other terminal of the resistor R1 is connected to the input of the automotive component.

The circuit arrangement 3 comprises a transistor pair Q1 and Q2. The output of the controller on line 7 is input/connected to the base of transistor Q2. The
 20 emitter terminal of Q2 is connected to earth and the collector terminal is connected to the base terminal of transistor Q1 preferably via resistor R3. The emitter of transistor Q1 is connected to the battery and the collector to one end of resistor R1. Resistor R4 (biasing) may be provided between the battery and the base of transistor Q1.

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A resistor R5, may be provided in output line 7 between the controller and the output base of transistor Q2. There may also be a biasing resistor R6 connected between the base of transistor Q2 and ground.

30 Further automotive components may be connected to the output from the collector of transistor Q1 via a corresponding resistor 2 for each component

Figure 5 compares and contrast the prior art arrangement 10 and an example of the invention 11. The key difference between the conventional solution and examples are the following: pull-up resistors R1 are connected to battery in conventional solution; pull-up resistors R1 are connected to a switching circuit in aspects of the invention.

In examples of the invention, power on the pull-up resistance is proportional to the battery voltage irrespective of the internal temperature in the conventional solution. Power on the pull-up resistance reduces to an acceptable limit when the temperature goes above 70 deg C. Average current can be controlled to a lower value at higher battery voltages and at higher temperature in the proposed solution. The conventional solution uses 1020 extended terminal resistors for discrete pull-up whereas in aspects of the invention as 0805 standard package is used instead of 1020 extended terminal resistors. Same methodology can be implemented to use 0603 type of resistors to replace 1210 and 1206 type resistors also.

In conventional solution the pull-up resistors are permanently connected to the battery. However, in the proposed solution based on switch configuration, the turn ON time can be reduced to ~5mS (5 times time constant) to operate at very high ambient temperature. 5mS duration is good enough for the microcontroller to read the switch status.

Where the output of the controller is to provide a duty cycle for an automotive component the voltage supply thereto provides a pulses voltage waveform having an appropriate duty cycle.

In analysis shows that the minimum ON time (duty cycle) needed to detect an OFF state of the discrete switch is ~31%. 31% ON time reduces the power requirement of the resistor drastically low and able to use an 0805 type resistor instead of 1020 type resistor package.

Figure 6 shows a simulation for the arrangements of figure 4 and shows steady state C2 voltage 12 and steady state R1 current 13 (mA) – this shows that the Vih Voltage to the microprocessor input is > 3.5V at 31% duty cycle,.

- 5 Figure 7 shows the derating power against temperature for the arrangement of figure 4. Reference numeral 20, 21, 22, 23, 24 and 25 denote plots for resistors 1020, 1210ET, 0805, 0603, R1 power without switching and R1 power with switching respectively
- 10 This is the case where DBATT voltage=16V; 2KHz Duty cycle 30% with C2 low voltage > 3.7V. It is to be noted that frequency depends on RC time constant of input. The graph indicates that there is no switching requirement up to 70°C internal ambient and worst case battery voltage. Most of the new generation microprocessors are able to report the internal temperature; this feature can be
15 used to avoid switching up to 70°C. Powertrain controllers monitor the battery voltage. A look up table if used can further fine tune the actual switching threshold. Alternator regulates the battery voltage to ~14.5 V in the vehicle. Normal operation (no switching) can be extended to even higher temperature if the internal temperature reading and operating battery voltage can be considered
20 together using a look up table. In other words, the normal operation can go up to ~90 deg C with normal battery voltage of 14.5V. Though the controller is designed for 105 deg C ambient temperature, the chances of temperature exceeding 90 deg C is rare. In this case, the switching happens only on rare occasions of temperature exceeding 90 deg C for normal operation. The invention
25 helps to optimize the design without affecting the intended operation.

The invention overcomes the problems associated with the prior art where there is no flexibility to adjust the power based on the worst case operating condition. Though the worst case operating conditions are rare, the design has to cater for it.

- 30 This results in overdesign for normal operating conditions. Based on the worst case battery voltage and maximum ambient temperature assumptions, the internal ECU temperature can be as high as 125°C. Resistor wattage capability drops

drastically at 125°C. This forces the design to select ~3 times higher power rating for the pull-up resistor.

Based on discrete pull-up configuration the proposed solution can also be used to
5 turn ON the switch min 5 times the time constant (~ 5 mS) only before the microprocessor is reading.

The invention eliminates solder joint durability concerns and allows operation at very high temperature (say 140 degrees C ambient) without increasing
10 component count. In the example the invention uses solution uses 88.6 mm² less PCB area with eight inputs, and saves overall cost by 13 cents per board. PCB size is reduced. The invention can be incorporated in future ASICs to further reduce the component count (switching) and take advantage of the temperature & battery voltage monitoring. This will further help to eliminate the microprocessor
15 SW based switching implementation.

CLAIMS

1. A power control arrangement for providing power from a vehicle battery to an automotive powertrain component/apparatus input under control of a controller, comprising:-
 5 a controller (1) having,
 a first output line (6) connected to an automotive component/apparatus input (2a) via a first resistor (R2), where said automotive component/apparatus input terminal is connected to also a second resistor (R1), connect to both the
 10 vehicle battery and controller via an intermediate switching circuit;
 and a second output line connected to said automotive component/apparatus via said intermediate switching circuit, wherein
 said intermediate switching circuit comprises first (Q1) and second (Q2) transistors, wherein the second output line of the controller is connected to the
 15 base of said second transistor (Q2); the emitter terminal of second transistor is connected to earth, and the collector terminal is connected to the base terminal of first transistor (Q1) and where the emitter of first transistor (Q1) is connected to said battery and the collector of first transistor (Q1) is connected to the end of resistor R1.
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2. An arrangement as claimed in claim 1 including a biasing resistor R4 provided between the battery and the base of transistor Q1.
3. An arrangement as claimed in claims 1 or 2 including a biasing resistor
 25 R5 between the second controller output line and the output base of transistor Q2.
4. An arrangement as claimed in claims 1 to 3 including a biasing resistor R6 connected between the base of transistor Q2 and ground.
- 30 5. An arrangement as claimed in claims 1 to 4 including a biasing resistor R3 between the base of transistor Q1 and the collector terminal of Q2.

6. An arrangement as claimed in claim 1 to 5 including, on either or both sides of the resistor R2, two capacitances C1 and C2 connected to ground.
7. An arrangement as claimed in any previous claim including one or more
5 further output terminals (2b, 2c, 2d) for automotive components connected to the collector of Q1 via respective resistors (R2b, R2c, R2d)