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POWER TRAIN PARTITIONING FOR 10 HORSEPOWER MOTOR CONTROLLER

CROSS REFERENCE TO RELATED APPLICATION

5 Under the provisions of 35 U.S.C. §120, this application claims priority to related United States Provisional Application No. 60/015,839, filed April 18, 1996 and entitled POWER TRAIN PARTITIONING FOR 10 HORSEPOWER MOTOR CONTROLLER.

BACKGROUND OF THE INVENTION

10 The present invention relates to electronic control circuitry, and more particularly to a motor controller with an improved power train partitioning layout.

15 Particularly with high volume products, the desirability of providing circuits which require less circuit board space and which can be packed in smaller and preferably modular packages that can be adapted to a diverse range of requirements is self-evident.

20 The present invention is directly concerned with power train circuits for motor controllers and the like which incorporate surface mounted power devices (SMDs) and insulated metal substrate (IMS) support boards which are more compact, more efficient to build and maintain and, importantly, have a reduced part count.

SUMMARY OF THE INVENTION

25 A key object of the present invention is to provide a power module for such applications as motor drivers which requires fewer electrical components and



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which is modularly constructed and more easily adaptable to different requirements.

5 The foregoing and other objects of the invention are realized by a power module which carefully lays out and allocates its various components between an insulated metal substrate (IMS) board and a printed circuit board (PCB). The partitioning of elements between the IMS and the PCB optimizes electrical connections, so that connections are provided as much as possible through the PCB. The partitioning of the circuit elements reduces the IMS size and therefore costs and results in a more standardized power module in which customer application-specific differences reside in the PCB.

15 The power module of the present invention, in accordance with a preferred embodiment thereof, includes only the inverter (comprising six SMD10 Copaks), an input rectifier (comprising six SMD diodes in a TO220 style package) and a thermistor on the IMS board. Also included are plural vertical connectors to the driver PCB, which is located overhead.

20 The SMD10 copak consists of an IGBT die and a fast recovery diode mounted in a common surface mount package. The overall IMS/PCB combination eliminates ten (10) large M5 terminals and four (4) current transformers from the IMS board.

25 The foregoing is combined with additional circuit optimization including a single gauge package or a dual gauge package, which reduces the IMS substrate size from about 36.5 square inches to: 1) 18.9 square inches for an IMS with single gauge packages (for a 52% saving) or 2) 14.7 square inches (40% circuit board saving) for an IMS with dual gauge packages. It also

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reduces the IMS module height from 1.000 inch to 0.320 inches. Finally, with a reduced size the invention obviates the need for conventional potting compound usually needed for such assemblies, relying instead on a thin surface coating.

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

10 BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an assembly drawing of an IMS board in accordance with a first embodiment of the invention for a single gauge surface mount device.

15 Fig. 1a shows the IMS board of Fig. 1, as seen along lines 1a-1a.

Fig. 2 is an assembly drawing of the PCB board.

Fig. 3 is an assembly of the IMS board in accordance with a second embodiment of the present invention for a dual gauge surface mount device.

20 Fig. 3a shows the IMS board of Fig. 3, as seen along lines 3a-3a thereof.

Figs. 4a-4b; 5a-5d; 6a-6e and 7a-7b are further assembly drawings for different embodiments of the invention.

25 DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

With reference to the figures, there is disclosed a printed circuit board which is intended to provide custom drivers, current sensing circuits and connections to another board which comprises the power board that houses the AC and motor terminal block and the controller connector. Figs. 1 and 2 collectively



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illustrate an SMD/IMS/PCB power-delivering assembly 10 for a 10 horsepower motor controller comprising an IMS board or assembly 12 and a PCB 14. The IMS assembly 12 comprises (Fig. 1a) a heatsink 17, an SMD/IMS substrate 18, driver and partition circuitry 20, two series linked capacitors, and an optional snubber capacitor.

With further reference to Figs. 1 and 1a, the IMS assembly 12 is a 10 horse power SMD/IMS module which provides a power inverter, a rectifier and a thermistor, realized with transistors Q1-Q6 and diodes D1-D6. The transistors Q1-Q6 may be new single gauge or dual gauge, down leads components. The diodes D1-D6 may be SMD 220 components. The area of the IMS, which measures 5.1 by 3.7 inches, is 18.9 inches square. As shown in Fig. 1a, the height of the assembly with the components 20 is about .320 inches.

With reference to Fig. 2, four current transformers are provided in conjunction with three MOVs, a softstart resistor and a softstart relay. The connector to the controller is illustrated together with a connector strip for AC lines 13 and motor lines 15. Element 17 is a heat sink. Also included is a brake module 30; IGBT, FRED (fast recovery diode) and resistor (optional).

The advantages of the component layout of the present invention derive from:

1. a smaller and less expensive IMS substrate;
2. elimination of potting compounds;
3. lower inductance;
4. standard 10HP IMS substrate; and
5. a circuit which is easily customized to customer requirements at the PCB level (including



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drivers, protection, MOV, softstart, snubber, brake, capacitor and external connectors and brake).

5 The concept of the present invention is essentially based on a novel partitioning of the power and control componentry and allocation of the same to the IMS 12 and PCB 14. The invention also provides, in novel manner, the use of vertical 100 mil center connectors to carry power and signal from the bottom IMS level to the top PCB (control) level, which is used for signal only and the power connectors. Note, all connectors are identical.

10 In Fig. 1, Q1-Q6 represent new single gauge or dual gauge with down leads transistors. D1-D6 comprise SMD 220s. Again, the overall IMS area is 18.9 square inches, as the IMS measures 5.1 by 3.7 inches. The height of the substrate is .120 inches without the components. The corresponding dimensions of the PCB 14 are 7.3 by 5.9 inches. Note the module 24, which measures 4.9 by 3.0 by 0.3 inches.

15 In the embodiment of Fig. 3, Q1-Q6 comprise dual gauge with up leads (emitters down) components. The size of the PCB is 4.9 by 3.000 inches, resulting in a smaller IMS area of only about 14.7 square inches. The height of the IMS board with its components 20 is shown in Fig. 3a.

20 The remaining Figs. 4a-7b are assembly and related drawings of various embodiments and requirements of the present invention. More specifically, Fig. 4a shows the IMS substrate assembly for a one horse power/SMD design measuring 2.750 by 4.100 inches. Further dimensional information is presented in Fig. 4b. Electrical components which can be used in connection with the embodiment of Fig. 4a are listed below.



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Element	Part No.	Identification	Description	Vendor
401	IRGBC30KD2-S	Q1 to Q6	SMD-220 IGBT	IR
402	IRGBC40K-S	Q7	SMD-220 IGBT	IR
403	LM50C	Q8	SOT-23 Single Supply Centigrade Temp- Sensor*	National Semi- Conductor
404	20ETS16S	D1 to D6	SMD-220 Diode	IR
405	10BF60	D7	SMB Diode	IR
406	6179-6	J1 to J4	Jumper, Brass with Sn/Pb	Zeirick
407	RW2RODAR050F or RW2RODAR050J	R1 & R2	SM Resistor .050 OHMS, 2 Watts 1% or 5% Tol.	Ohmite
408	50281-2-68	CN1	Connector, Surface Mount- 34 Pins Double**	Comcon
409	50281-1-30	CN2	Connector, Surface Mount- 30 Pins Single**	Comcon
410	1KS821KT	TH1	Thermistor*	Thermo Disc
411	X43-9256		Substrate, IMS	
412	SN62RM92BAS88		Solder Paste, Sn62/Pb35.7/2 Ag/0.3 Sb	Multicore

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- * Use only elements 403 or 410. In other words, these items are interchangeable.
- ** Unwanted pins must be removed prior to assembly.

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The area of the IMS board of Fig. 4a is 11.275 square inches.

Fig. 5a is a further assembly drawing of an IMS embodiment which is operable to 600 volts. Further details of the dimensional parameters of the base plate of the device of Fig. 5a are shown in Fig. 5b. Fig. 5c is the conductor pattern of the device of Fig. 5a and Fig. 5d shows the solder resist layout thereof. Further attributes of the IMS board of Fig. 5a are noted below.



1. Dimensions are shown in inches [millimeters] unless otherwise specified.
2. Controlling dimension: inches, unless otherwise specified.
- 5 3. Baseplate:
 - 3.1) Material is aluminum A5052H34.
 - 3.2) Thickness $.118 \pm .004$ [$3.00 \pm 0.11\text{mm}$]
 - 3.3) Burrs around holes $.006$ [0.15mm] maximum.
4. Insulation film:
 - 10 4.1) Dielectric strength 3KV AC for 1 minute.
 - 4.2) Thickness $.005 \pm .001$ in. [$125 \pm 25 \mu\text{M}$].
 - 4.3) Thermal conductivity 8.4×10^{-3} CAL/ $^{\circ}\text{C} \times \text{CM-SEC. MIN.}$
 - 4.4) Peel strength 1.3 KG/CM minimum at 25°C after exposure to 260°C for 60 minute.
 - 15 4.5) Dielectric constant 7.7 (100 KHZ @ 23°C).
 - 4.6) Specific resistivity 1×10^{16} OHM-CM @ 23°C .
5. Conductor metalization:
 - 5.1) Material is copper OFHC.
 - 20 5.2) Thickness $.0041 \pm .0004$ [$105 \pm 10\mu\text{M}$].
 - 5.3) Line definition $\pm .012$ in. [$\pm 300\mu\text{M}$].
 - 5.4) Flatness in solderable pads $.006$ [0.04mm].
 - 5.5) Surface must be solderable with 62Sn/36Pb/2Ag with RMA flux at 200°C .

25 Fig. 6a is the assembly of another IMS board which is designed for 10 horsepower 600 volt or 1200 volt use. It measures 5.3 by 3.7 inches for a total area of 19.61 square inches. The base plate, conductor, solder resist (600 volts) and solder resist (1200 volts) are
30 respectively shown in Figs. 6b, 6c, 6d and 6e. Other parameters of this embodiment are noted below.



1. Dimensions are shown in inches [millimeters] unless otherwise specified.
2. Controlling dimension: inches, unless otherwise specified.
- 5 3. Baseplate:
 - 3.1) Material is aluminum A5052H34.
 - 3.2) Thickness $.118 \pm .004$ [$3.00 \pm 0.11\text{mm}$].
 - 3.3) Burrs around holes $.006$ [0.15mm] maximum.
- 10 4. Insulation film: (600V)
 - 4.1) Dielectric strength 3KV AC for 1 minute.
 - 4.2) Thickness $.005 \pm .001$ in. [$125 \pm 25\mu\text{M}$].
 - 4.3) Thermal conductivity 8.4×10^{-3} CAL/°C x CM-SEC. MIN.
 - 15 4.4) Peel strength 1.3 KG/CM minimum at 25°C after exposure to 260°C for 60 minute.
 - 4.5) Dielectric constant 7.7 (100 KHZ @23°C).
 - 4.6) Specific resistivity 1×10^{16} OHM-CM @ 23°C.
- 20 5. Insulation film: (1200V)
 - 5.1) Dielectric strength 5KV AC for 1 minute.
 - 5.2) Thickness $.007 \pm .001$ in. [$170 \pm 30\mu\text{M}$].
 - 5.3) Thermal conductivity 8.4×10^{-3} CAL/°C x CM-SEC. MIN.
 - 25 5.4) Peel strength 1.3 KG/CM minimum at 25°C after exposure to 260°C for 60 minute.
 - 5.5) Dielectric constant 7.7 (100 KHZ @23°C).
 - 5.6) Specific resistivity 1×10^{16} OHM-CM @ 23°C.
- 30 6. Conductor metalization:
 - 6.1) Material is copper OFHC.
 - 6.2) Thickness $.0041 \pm .0004$ [$105 \pm 10\mu\text{M}$].
 - 6.3) Line definition $\pm .012$ in. [$\pm 300\mu\text{M}$].
 - 6.4) Flatness in solderable pads $.006$ [0.04mm].
 - 6.5) Surface should be solderable with 62Sn/36Pb/2Ag with RMA flux at 200°C.



A power train assembly for a 10 horsepower, 1200 volt application is illustrated in Fig. 7a. Production and feature criteria for this assembly are shown in Fig. 7b. Further specifications of this embodiment are indicated below.

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Element	Part No.	Identification	Description	Vendor
701	X43-9249-2		Substrate, IMS, 10HP13-	Denka/Mitsui
702		Q1 to Q6	SMD10/Mark II CoPAK IGBT-7/FRED 51	IR
703	20ETS16S	D1 to D6	SMD220 Diode .180 x .180	IR
704	50335-2-26	CN1	Connector, 24 Pins Double	Comcon
705	50335-1-18	CN2	Connector, 30 Pins Single	Comcon
706	50335-2-18	CN3	Connector, 25 Pins Double	Comcon
707	50335-2-16	CN4	Connector, 10 Pins Double	Comcon
708	1KS821KT	T1	Thermistor	MCTA
709	LM50C	Q7	Temp Sense SOT-23 (Optional to Thermistor)	National Semi-Conductor
710			Stand-off	
711	SN62RM92BAS88		Solder Paste, Sn62/Pb36/2Ag	Multicore
712	ECCOCOAT-S7013		Conformal Coating, Silicone	Grace

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The concept of the present invention makes it possible to realize an IMS board with only the inverter (6 SMD 10 copaks), input rectifiers (6 SMD 220 diodes)



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and a thermistor on the IMS substrate. A central vertical connector provides connectivity to the PCB located overhead. The invention eliminates 10 large M5 terminals and four current transformers from the IMS substrate. This combined with the use of new single gauge package or the dual gauge package reduces the IMS substrate size from the conventional 36.5 square inches to: 1) an IMS with the single gauge - 18.9 square inches (50%); or 2) an IMS with the dual gauge - 14.7 square inches (40%).

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.

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WHAT IS CLAIMED IS:

1. A power train assembly for delivering electrical power to a driven device, the assembly comprising:

5 an IMS (insulated metal substrate) board for carrying and electrically interconnecting power components and a PCB (printed circuit board) for holding control and drive components; the IMS board having mounted thereon exclusively power transistors for forming a power inverter circuit, input rectifier diodes, a
10 thermistor and a connector for providing connectivity to the PCB, thereby realizing a standardized IMS board of comparatively smaller substrate area;

the PCB comprising said control and drive components which components include drive elements, a
15 current sense, a connector to the IMS board, and terminals for effecting electrical connections to the driven device; and

the PCB being mountable directly above the IMS board, and the respective connectors of the IMS board
20 and the PCB mating with one another vertically.

2. The power train assembly of claim 1, in which the components on the IMS board are exclusively surface mounted components.

3. The power train assembly of claim 2, further comprising a heat sink for drawing heat away from the power train assembly and for dissipating the heat into the environment.



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4. The power train assembly of claim 3, in which the PCB components include two series link capacitors.

5. The power train assembly of claim 3, in which the PCB components include a snubber capacitor.

6. The power train assembly of claim 3, in which the PCB includes a plurality of current transformers.

7. The power train assembly of claim 3, in which the PCB includes a plurality of MOV's.

8. The power train assembly of claim 3, in which the PCB includes a soft-start resistor.

9. The power train assembly of claim 3, in which the PCB includes a soft-start relay.

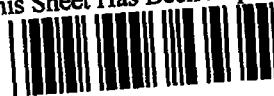
10. The power train assembly of claim 3, in which the terminals for effecting connection to the driven device comprises a connector strip for AC lines and motor lines.

11. The power train assembly of claim 3, in which the PCB includes a brake module.

12. The power train assembly of claim 3, in which the IMS board is standardized for a 10 horsepower operation.



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13. The power train assembly of claim 3, in which the IMS board is free of potting compound and instead comprises a thin surface coating on the components thereon.

14. The power train assembly of claim 3, in which the IMS board has a surface area of about 19 square inches, thereby realizing more than a 50% reduction in board surface size.

15. The power train assembly of claim 3, in which the IMS board has a surface area of about 15 square inches, thereby realizing more than a 40% reduction in board surface size.

16. The power train assembly of claim 3, in which the IMS board has height dimension on the order of about .50 inches.



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