Cost-effective Power Module Package using Leadframe and Ceramic substrate

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- **Power Module Trend and General Features**
- **SPM (Smart Power Module) ,
  Fairchild Type Power Module Package**
- **Summary**

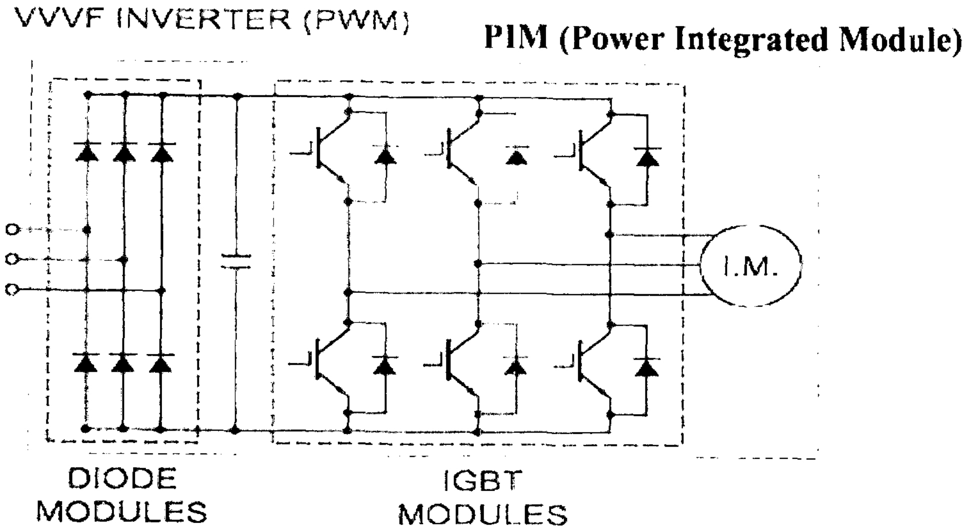
Introduction of Power Module Package

What's Power Module Package ?

- A package for the specific system and application
- Having plural power devices
- Requiring high thermal performance and reliability
- Using DBC for conduction and isolation
- Using heatsink for thermal performance
- Using plastic case and electric terminals
- Potting epoxy resin and silicone gel

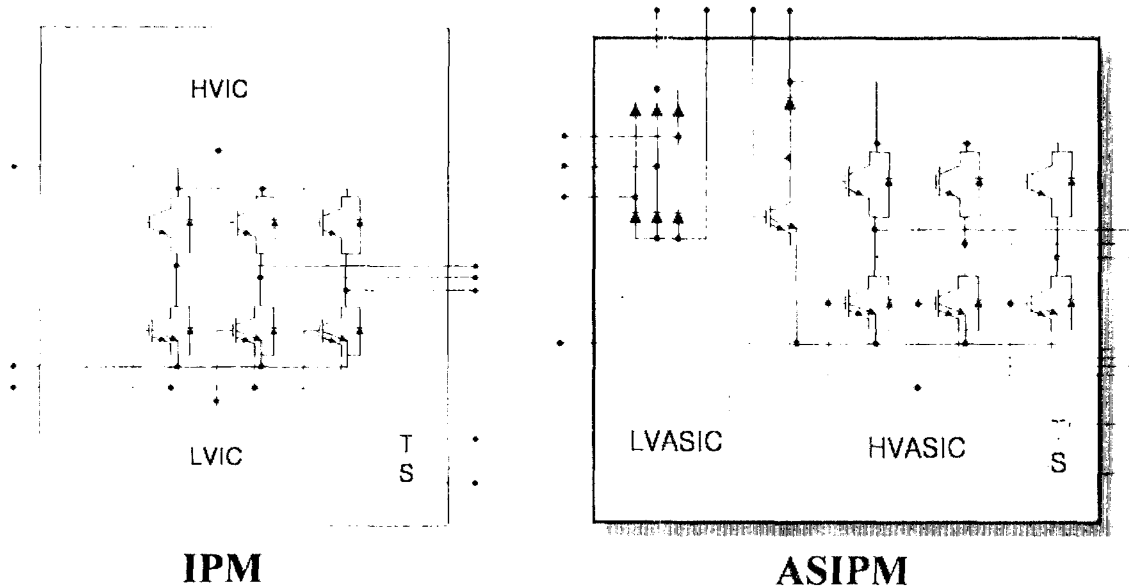
Introduction of Power Module Package

Application - Diode Module, IGBT Module, PIM



Introduction of Power Module Package

Application – IPM, ASIPM



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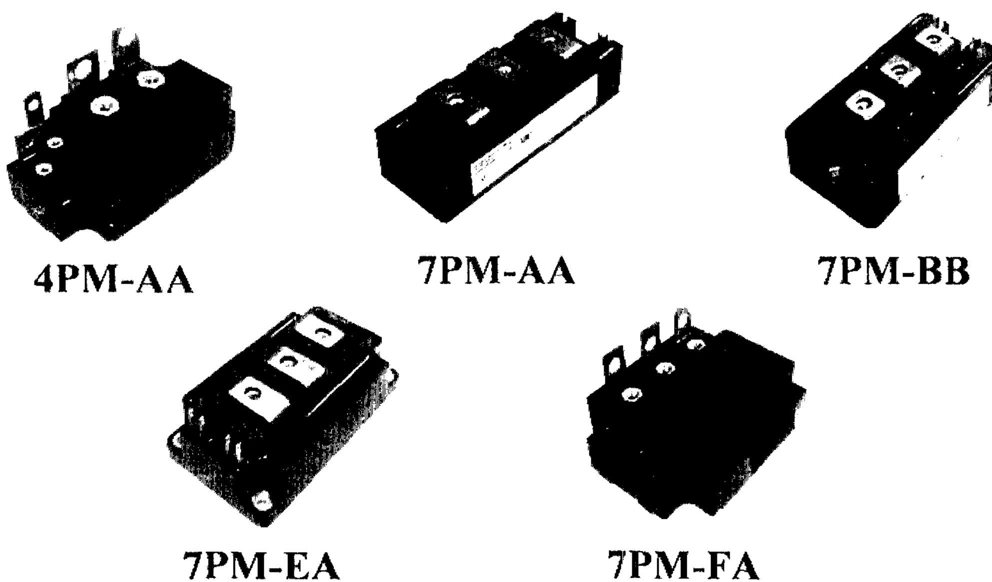
Introduction of Power Module Package

Package structure – Molding type



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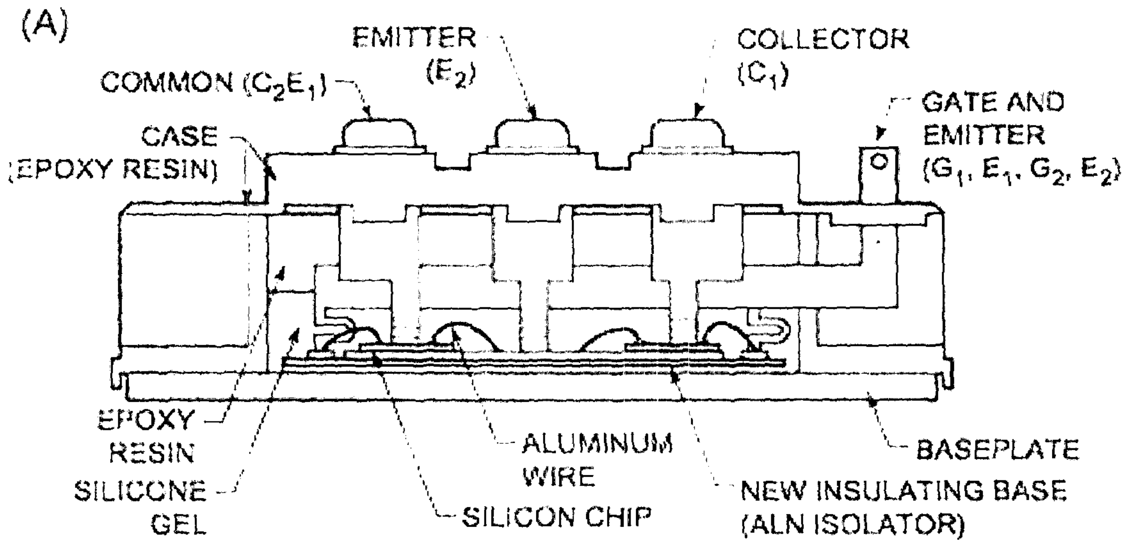
Introduction of Power Module Package

Package structure – Molding type



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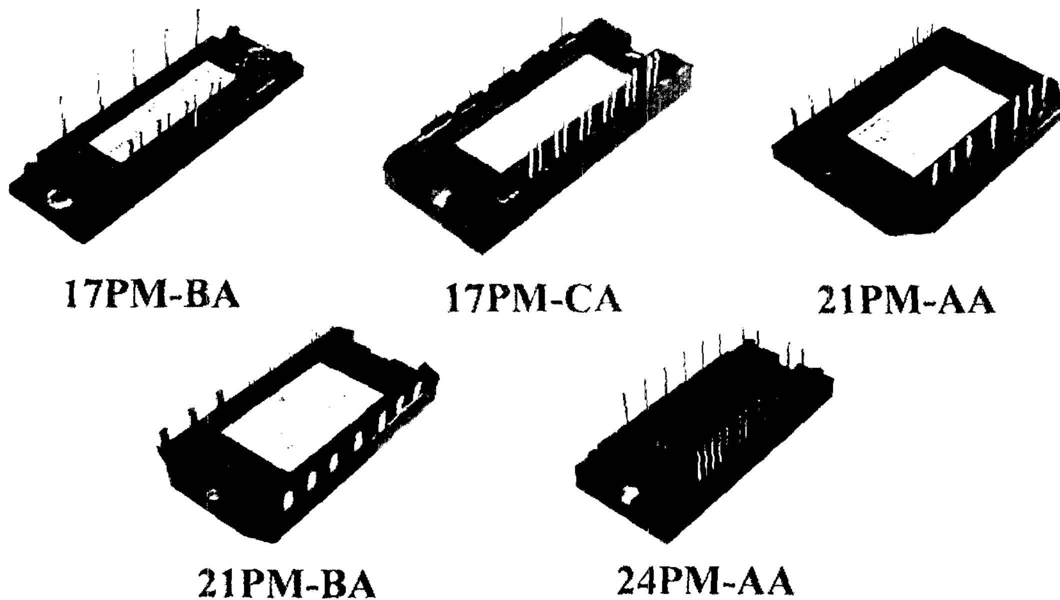
Introduction of Power Module Package

Package structure – Econo & Complex type



17PM-BA 17PM-CA 21PM-AA

21PM-BA 24PM-AA

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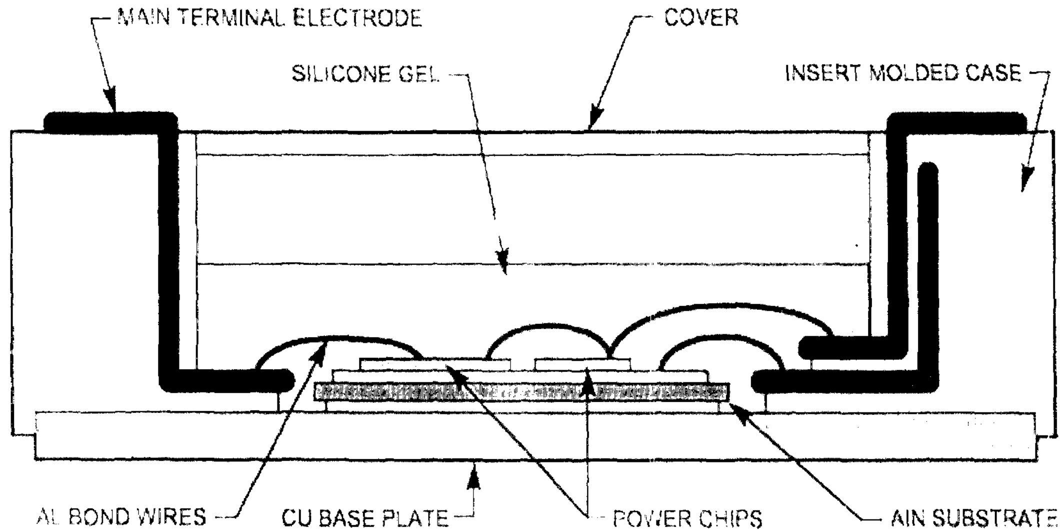
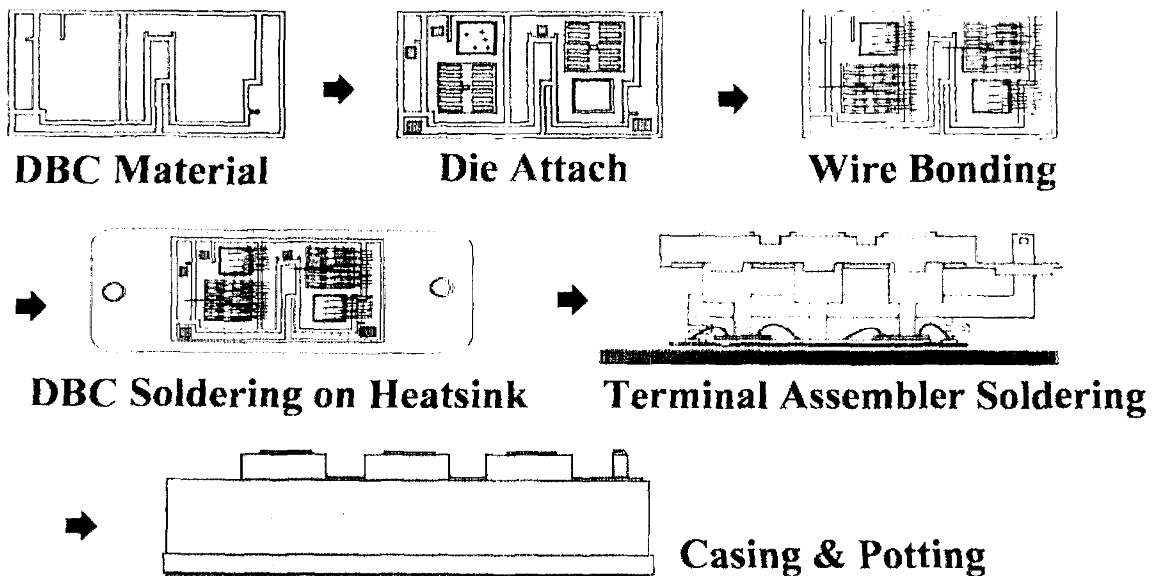
Introduction of Power Module Package

Package structure – Econo & Complex type



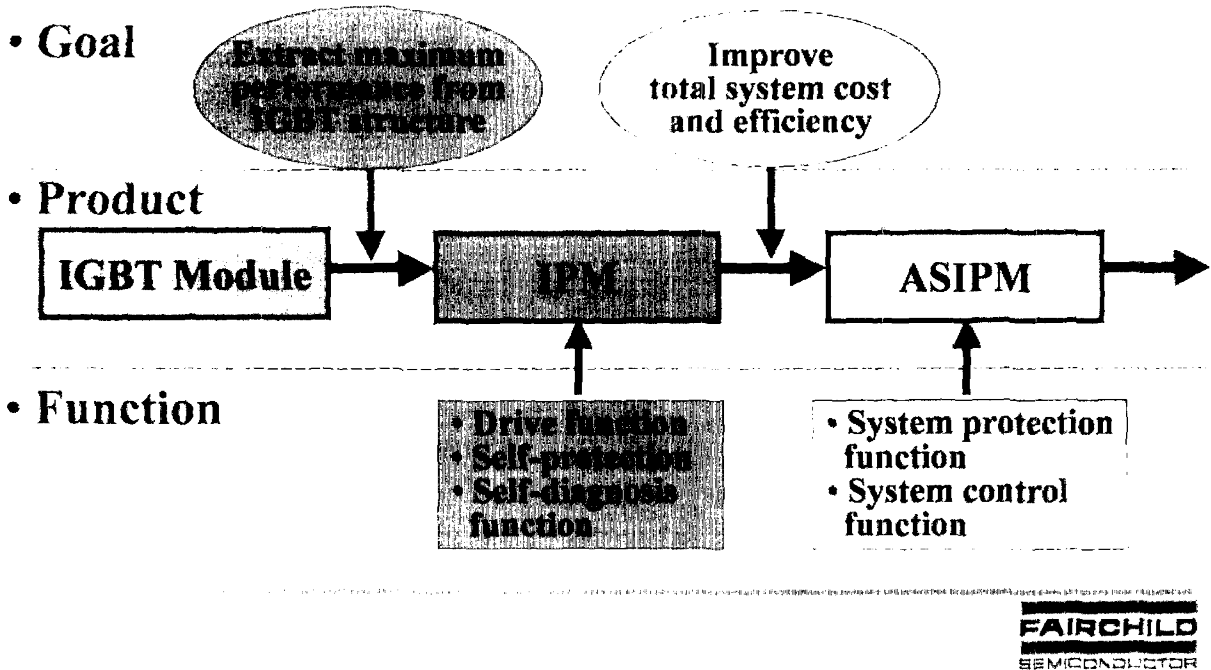
Introduction of Power Module Package

General Power Module Process



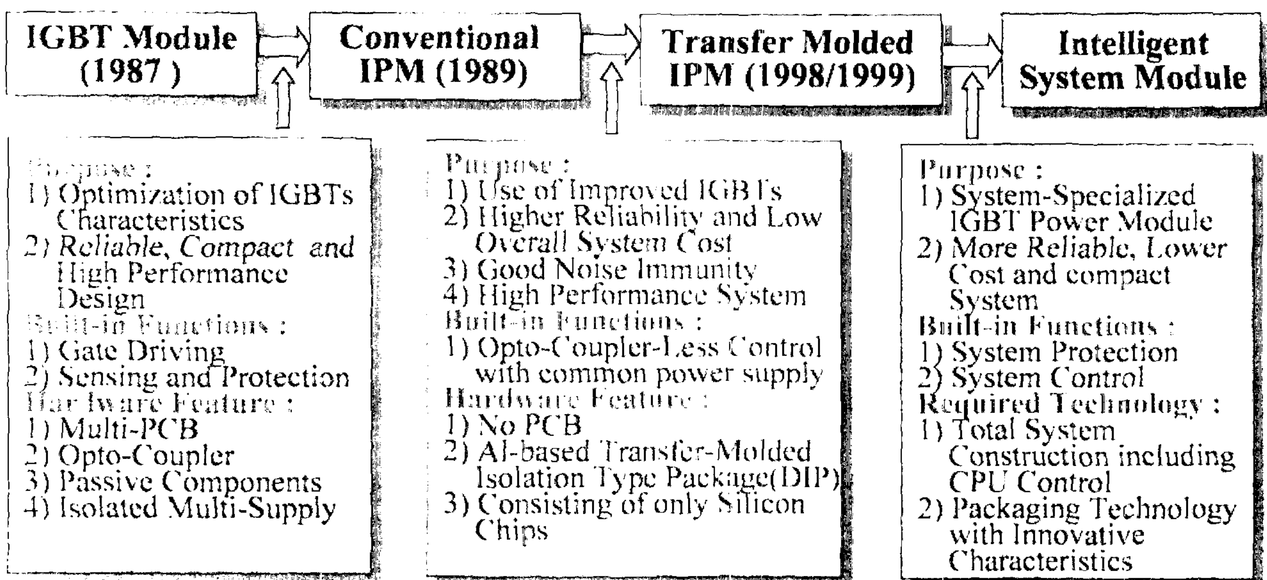
Power Module Trend and General Features

Power Module Trend



Power Module Trend and General Features

General Features



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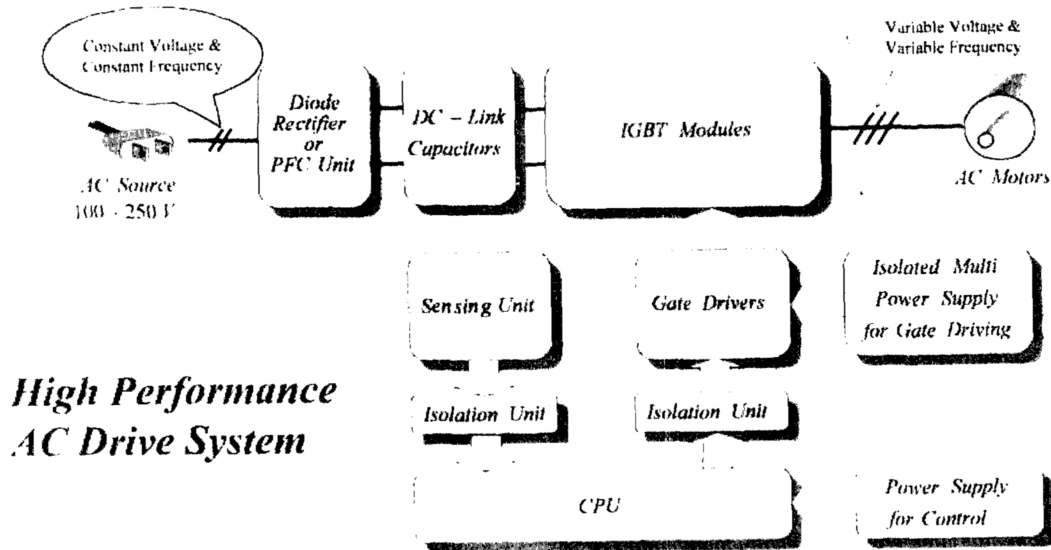
Power Module Trend and General Features

Trend of IPM Technology

Discrete or Conventional Module Solution

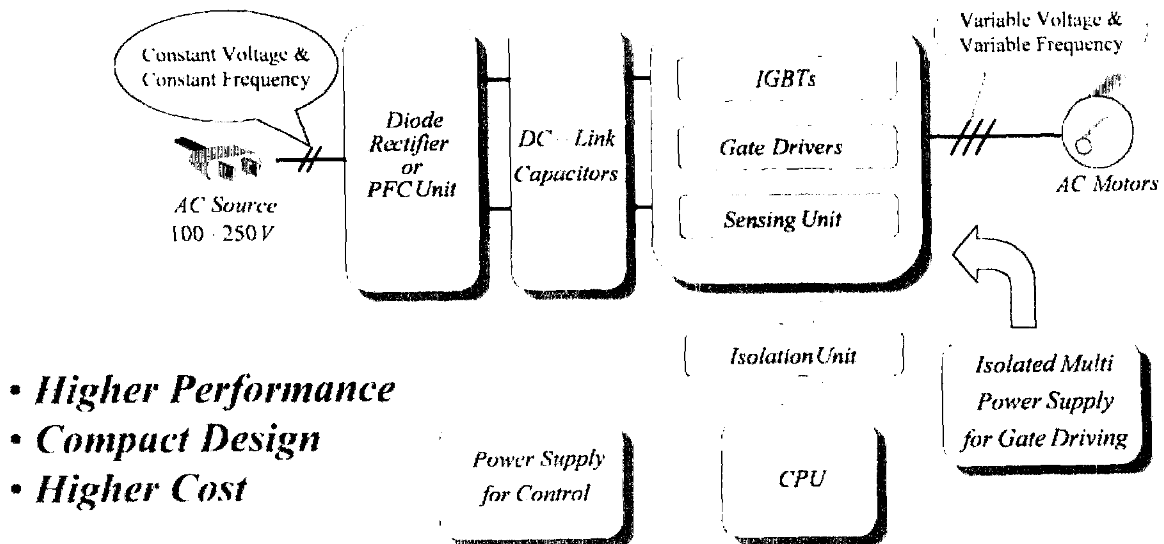


High Performance AC Drive System

Power Module Trend and General Features

Trend of IPM Technology

Conventional IPM Solution

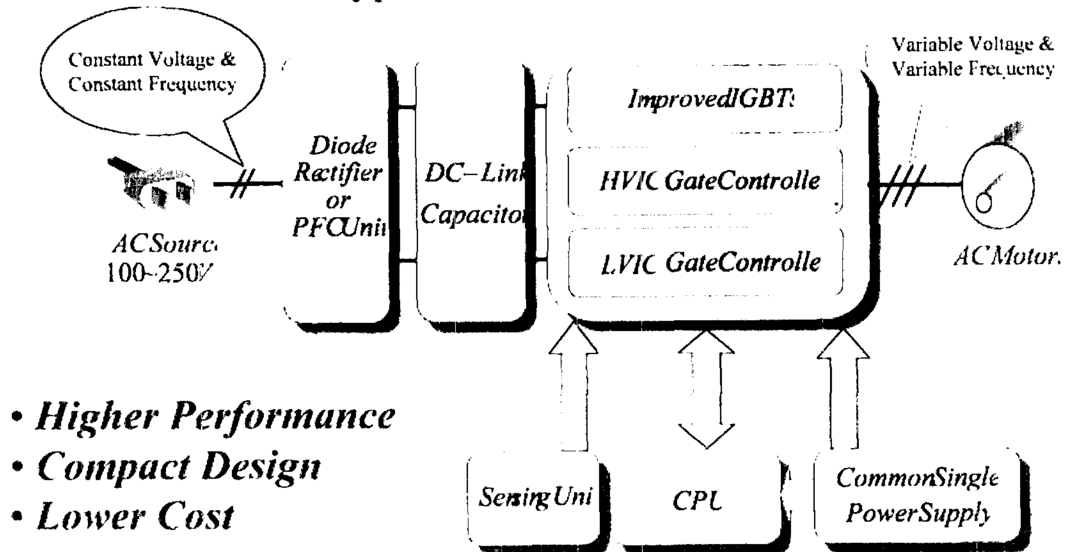


- ***Higher Performance***
- ***Compact Design***
- ***Higher Cost***

Power Module Trend and General Features

Trend of IPM Technology

Transfer-Molded Type IPM Solution (From 1999/2000)



- ***Higher Performance***
- ***Compact Design***
- ***Lower Cost***

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SPM (Smart Power Module)

What's SPM ?

- **Fairchild type IPM (Intelligent Power Module)**
- **IPM having**
  - **More functionality**
  - **Lower manufacturing cost**
  - **More flexibility targeting the next generation than conventional transfer-molded one**
- **Ceramic-based transfer-molded isolation package**

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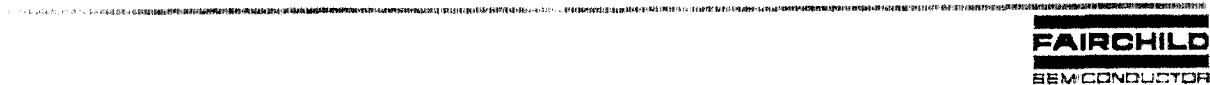
SPM (Smart Power Module)

Applications of Fairchild SPM

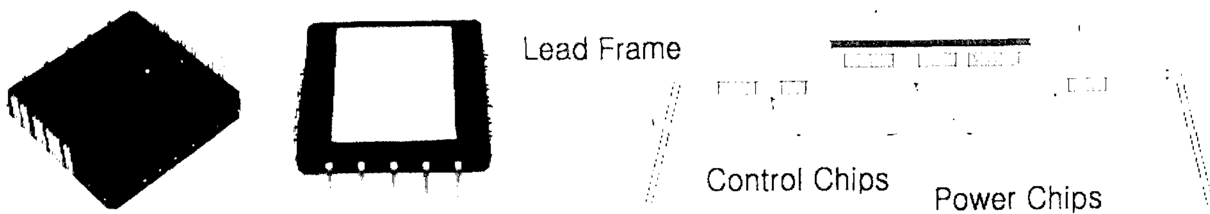
Three-phase inverter-driven low-power (up to 2hp/220-250V AC) industrial and home appliances applications using AC motors.

- **Industrial AC motor control system using inverters**
- **Washing machine control system**
- **Air-conditioner control system**
- **Refrigerator control system**

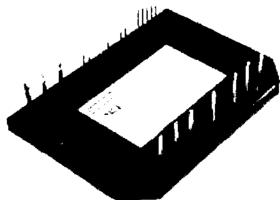


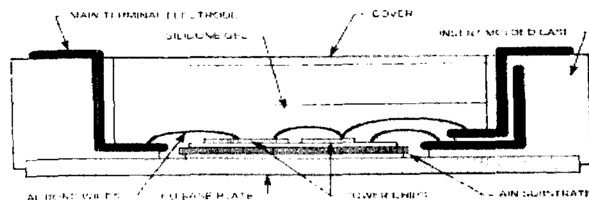
SPM (Smart Power Module)

Package Structure

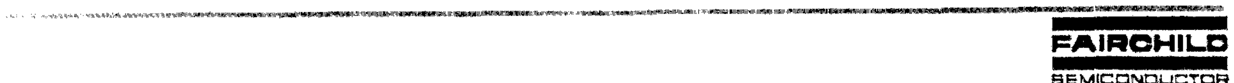


Smart Power Module





Conventional Power Module



SPM (Smart Power Module)

Material

Material	Smart Power Module	Conventional Power Module
Substrate	Leadframe	DBC
Interconnection	Al & Au wire	Al wire
Heatsink	Ceramic	Copper
Housing	EMC	Plastic case & cover Cu terminal
Adhesive (Sub & H/S)	Epoxy film	Solder preform
Filler (inside housing)	None	Silicone Gel

SPM (Smart Power Module)

Process Flow

Smart Power Module	Conventional Power Module
• Solder D/A for Power part • Ceramic Attach • Epoxy D/A for Control part • Al wire Bonding • Au wire Bonding • Molding • Deflash & Plating • Marking & Trim/Form • Electrical Test	• Solder D/A on DBC • Presoldering DBC & H/S • Heatsink Attach • Case & Terminal Attach • Al wire Bonding • Potting Si Gel • Cover Attach • Labeling • Electrical Test

SPM (Smart Power Module)

Package Size and Cost

	Smart Power Module	Conventional Power Module
Package Type	SPM30-AA	PM21-BA
Device Rating	600V/30A	600V/30A
Chips mounted	20	20
Package Size (mm)	55*57*7.2 (42%)	60*125*21 (100%)
Material Cost	40%	100%
Package cost	50%	100%

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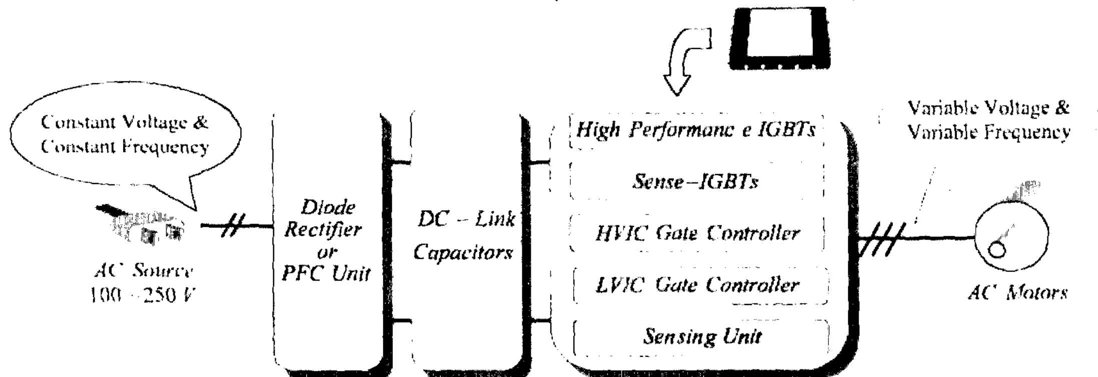
SPM (Smart Power Module)

Introduction of Fairchild IPM (SPM)

Fairchild-IPM Solution (From 2000/2001)



- *Higher Performance*
- *More Compact*
- *Lower Cost*

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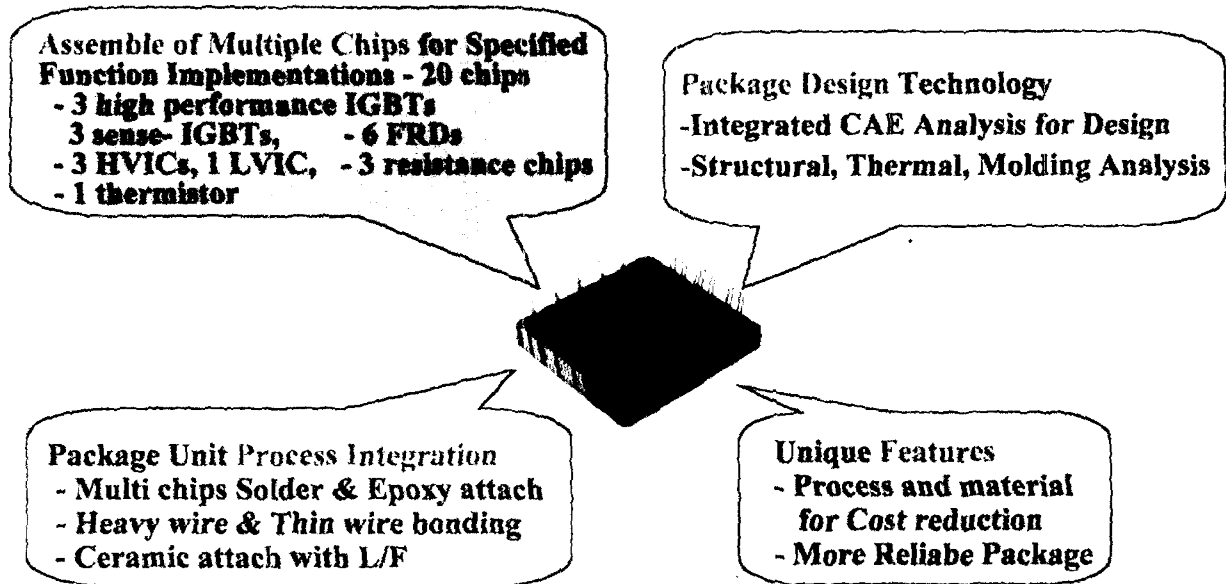
SPM (Smart Power Module)

Key Issues in Development



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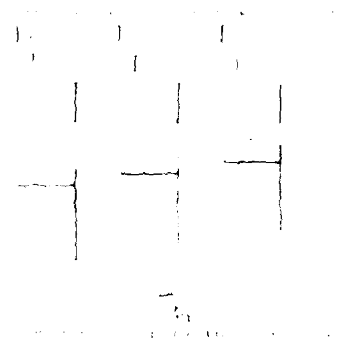
SPM (Smart Power Module)

Multi Chips Integration Using L/F

Assemble of Multiple Chips (20 Chips) into One Package for Specified Function Implementations

- 3 high performance Insulated Gate Bipolar Transistor(*IGBT*)
- 3 sense *IGBTs*
- 6 Fast Recovery Diode(*FRD*)
- 3 High Voltage IC
- 1 Low Voltage IC
- 3 resistance chips
- 1 thermistor



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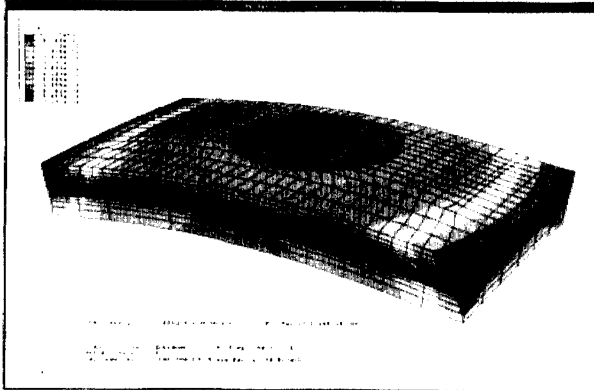
SPM (Smart Power Module)

Integrated CAE Analysis

Structural analysis for stress and deformation prediction to assure structural integrity


Typical warpage shape

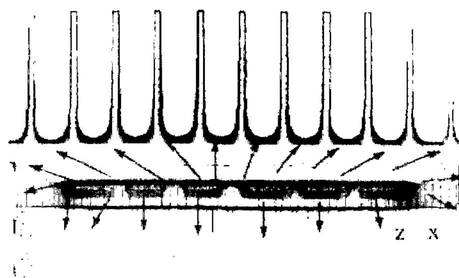
- Warpage
- Stresses acting on the dies
- Assembly stresses due to bolting between package and heatsink

SPM (Smart Power Module)

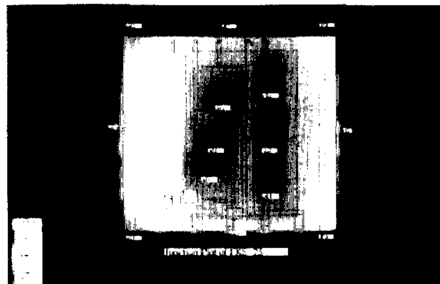
Integrated CAE Analysis

Thermal analysis for thermal performance optimization

- Thermal Resistance
- Thermal Impedance
- Optimization on the Geometry (adhesive thickness,etc.) and Material Change Effects


Typical heat flux field

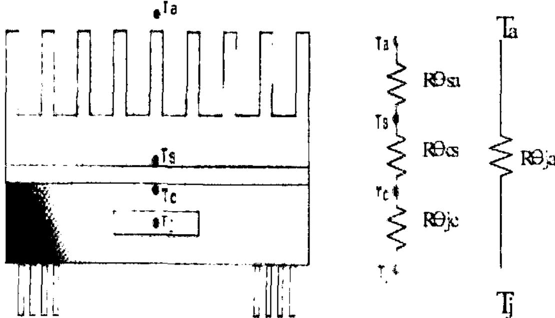
$R_{jc} = 2.6\ ^{o}C/W$


Typical temperature field

SPM (Smart Power Module)

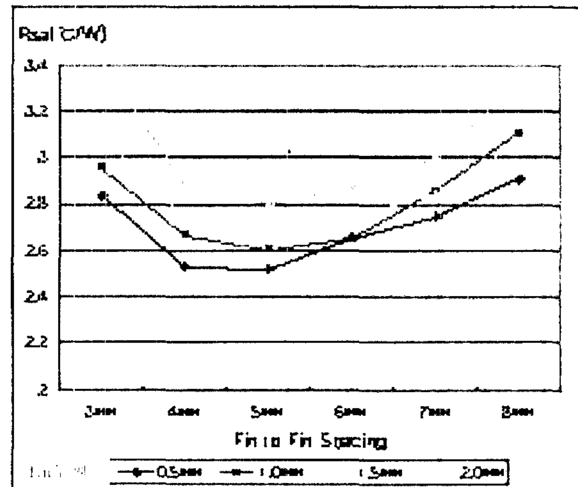
Integrated CAE Analysis

Heatsink design optimization for field application(system level)



Typical thermal network

- **Optimum heatsink selection guide build-up: Pin size, spacing, height, etc.**



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SPM (Smart Power Module)

Unit Process Development

- **Multi chips automatic solder attach process without void**
- **Clamping technology with multi-die paddle having different planarity for heavy Al wire bonding**
- **Ceramic attach process with void-free using adhesive**
- **Molding process for optimization to prevent void, flash, warpage and ceramic crack from large package size**

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SPM (Smart Power Module)

Reliability Performance

- HTRB 500 hrs (Ta=Tjmax, Vdd=0.8x Bvces, Vcc =20V)
  0/20
- THB 500 hrs (85℃/ 85% RH)
  0/20
- ACLV 168 hrs (121℃, 100% RH, 15PSIG)
  0/20
- TMCL 200cys (-65 to 150℃)
  0/20

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Summary

- Fairchild has been developing a new class IPM called SPM consisting of dramatic Packaging technology to achieve the lowest cost and better performance for low power home appliances and industrial AC drive applications.
- The first Fairchild SPM development with IGBT 600V/15A for washing machine application started in 1999 and was completed successfully. Fairchild SPMs are going to be the best solution for low power inverter-driven AC drive system after 2001.
- The new SPM Packages like SPM II and SPIM for the next generation IPM with the highest competitiveness (cost & performance) shall be continuouslly developed.

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