High Density Packaging for Mixed Signal Applications

Art of Technology

- Experts in Miniaturization of Electronic Systems
  - Follow up of the EC-Project EUROPRACTICE MCM
  - Founders are active in miniaturization since 1995
  - Demonstrated in many successful projects

- AoT supplies the practical skills needed to make HDP/MCM-technologies available
  - Consulting and contracting at detailed technical level
  - AoT is NOT a hardware manufacturer

- Company Headquarters in Zürich Switzerland
Introduction
HDP/MCM – Technologies and Applications

Agenda

• Design Challenges of Today
• What is High Density Packaging?
• HDP/MCM Advantages
• Best Practice Application Examples
• How you can benefit from HDP/MCM

Design Challenges of Today

• High SYSTEM performance
  • IC performance is only one factor in SYSTEM performance
  • System performance is strongly affected by packaging
• Small Size and Weight
  • A vast number of applications require or benefit significantly from small size and light weight of electronics
  • Can’t always put everything on one ASIC
    • Especially in the “mixed-signal” environment
• Total System Cost
  • “It’s the overall cost that counts!”
  • Minimizing the cost of each component without regard to the total system can result in a higher than necessary total cost
Today’s application areas: Mixed-Signal

- Medical
  - Pacemakers, Internal Defibrillators, Hearing Aids, Drug Dispensers, Heart Rate Monitors, Flow meters

- Consumer
  - Handhelds (Cell Phones, PDAs), Security Sensors (GPS locator in lifejacket), Toys, Remote Controls, Cameras, Sporting Gear (Body-function Monitors), GPS devices, Sensor telemetry through GSM

- Industrial/Aerospace/Automotive

Mixed Signal: Not easy to integrate...

- Low noise requirements in sensor applications
- High power needed to drive motors or heavy loads
- Optical coupling for isolation
- When only a certain volume and limited design time is available
- Incompatible technologies needed in a single device
  - Communications: GaAs for serial data, Si CMOS for parallel logic
  - RF applications: SiGe for the RF, Si CMOS for the rest
  - If you are using optical communications or interconnects
    - Lasers and LEDs are made from III-V and II-VI alloys and cannot be made from Si
    - If you need opto-isolation of some inputs

⇒ High Density Packaging (HDP/MCM) helps in solving these issues, thus achieving system objectives
What is High Density Packaging?

Mount unhoused chips ("bare dies") directly onto a highly integrated circuit board ("substrate")
- Think of this as an advanced PCB or as a high-function IC package
- Requires more precise assembly technologies than traditional PCB
- The substrate provides very efficient interconnections

An HDP/MCM-Module can be
- a complete System
- or part of a System

Very significant advantages over SMD/PCB:
- Size reduction (up to 5x)
  - Smaller than PCB/SMD, larger than ASIC
- Performance improvement over SMD/PCB approach
What is High-Density Packaging (HDP/MCM)

- **Until now** every single Chip has been packaged into a package (SCP) and was then assembled onto a PCB board (through hole, SMD)

- **Now unpackaged Chips are used. They will be assembled:**
  - either directly onto the PCB board (COB) or
  - several Chips together into a package (MCP) and then onto a board.
Module Substrate Alternatives

- Many alternative substrate technologies:
  - PCBs (e.g. Reinforced Epoxy FR4/5, BT)
    - Poor thermal dissipation
    - Line width 75-750 microns, pitch 100-1000 microns
    - Cost per cm² low
  - Ceramics (e.g. Al₂O₃, AlN)
    - High thermal dissipation
    - Line width 90-125 microns, pitch 125-375 microns
    - Cost per cm² moderate
  - Thin film on various bases (e.g. Cu/BCB on Glass)
    - Thermal dissipation high
    - Line width 15 microns, pitch 25 microns
    - Cost per cm² high

HDP/MCM is NOT a New Idea

- IBM “SLT” Technology 1963
  - Discrete components mounted without encapsulation onto a ceramic PCB ½ inch square by means of solder bumps
  - In a 1971 internal IBM study “SLT” was shown to have been significantly more cost-effective than early IC technology.
  - Since 1963 IC technology has developed a great deal... but so has packaging technology!

An IBM Internal study in 1971 concluded that SLT was:
“The major technological factor in IBM’s success in the 1960s”
Advantages of HDP/MCM over PCB/SMD

- **Small Size**
  - 20%-60% of PCB/SMD designs
  - Improved package efficiency

- **Improved Performance**
  - Short interconnection lengths
    - Reduced time of flight, Lower power supply inductance, Lower capacitance loading, Less power required
  - Lower cross talk, Low noise
    - Lower off-chip driver power, High wiring density, Less complex board

- **Cost benefits realized at system level**
  - Less complex system PCB, meeting a given form factor
Advantages of HDP/MCM cont’d.

- Better protection against EMC and EMI
  - Shorter Connections between IC’s (less “antenna” effect)
  - Smaller areas to shield

- Increased Modularity and Reusability of subsystems

- High Reliability
  - Fewer solder joints in package
  - Smaller modules are easier to protect from harsh environments
  - Smaller (lighter) modules less prone to damage from physical shock (dropping etc.)

Advantages of HDP/MCM over ASICs

- Faster time-to-market than ASIC
- Investment cost for HDP/MCM is much less
- HDP/MCM modules can include
  - RF Receivers or Transmitters
  - Sensors operating on very low currents (sensitive to noise)
  - Power control or management devices (Zeners, Diodes etc.)
  - Large Memories

- Simplify ASIC Design
  - Sometimes routing signals in substrate can substitute for long heavily RC loaded on-chip lines.
  - Memories and other cores can be added as off-the shelf components instead of integrating into a large ASIC.

- When you need very high performance...
  - Used by IBM (and others) for high-end multiprocessors
Introduction

HDP/MCM – Technologies and Applications

Application Examples

- Wearable Health Monitor
  (Size, Weight, Power consumption)
- GPS-MS1
  (Modularity, Performance)
- Antenna Switch
  (Cost, Complexity, Performance)

HDP/MCM – Best Practices
Introduction
HDP/MCM – Technologies and Applications

**Wearable Health Monitor - System**

**International Research Project AMON**
*(AoT responsible for system integration)*

- Wrist Wearable Medical Device for heart patients
- Communication interface to telemedicine center
- Need to meet certain form factor ("wrist")

**Variables Measured**
- Temperature
- Pulse
- ECG
- Blood Pressure
- Blood O2

**Special Features**
- Emergency Button

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**Health Monitor Prototype - Technologies**

- Communication
  - GSM (SMD)
- Sensors
  - Still bulky
- Data Processing / Control
  - COB w/ ASIC
  - Height reduction

HDP enables to meet wrist form factor already in prototyping phase
Introduction
HDP/MCM – Technologies and Applications

GPS Receiver Module

- Product of the ETH-Spin off Company AG
- Global Positioning Receiver “from the antenna to position output”
- HDP enabled them to gain market segment since 1997 before actually developing their own chip set

1st generation of µ-blox receiver family

DBS Satellite Multiswitch - System

2 Original PCBs with 5:4 Switch @ 2.5GHz

1 PCB with 9:4 Switch @ 2.5GHz:
Same functionality
Introduction
HDP/MCM – Technologies and Applications

DBS Satellite Multiswitch - Technology

- AoT development for Hirschmann Electronics GmbH&Co KG, Germany
- Thin film on Ceramic, Termination resistors and coupling capacitors integrated
- Switch for satellite receiver (7 Chips)

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<th>1st level interconnect</th>
<th>Number Layers</th>
<th>Designrules</th>
<th>Specialities</th>
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<td>Wire bond, cap &amp; gel</td>
<td>2</td>
<td>40/60/60</td>
<td>Integrated Passives</td>
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<table>
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<tr>
<th>2nd level interconnect</th>
<th>Size</th>
<th>Substrate</th>
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<tr>
<td>Wire bond to BGA carrier</td>
<td>17 x 17 mm²</td>
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HDP/MCM Example Advantages

- **Personal Health Monitor**
  - Standard Components for uC and Memory
  - Mixed with Analog Processing ASIC to minimize component count and minimize noise sensitivity
  - Reduced volume and power consumption

- **GPS Receiver**
  - High Performance Receiver with signal processing unit
  - Provides a complete (sub) system working @ 1.575GHz
  - Minimized volume, easy to design in

- **Antenna Switch**
  - Combined existing ASICs to a larger component (9 instead of 5 inputs)
    - Avoid new ASIC development
    - ASICs can be used for 5 to 4 and 9 to 4 switches
    - Added intelligence to the component (Analog and Digital Protocol instead of Analog only)
Introduction
HDP/MCM – Technologies and Applications

Summary

• Mixed Signal Systems
  - Often require several IC technologies
  - Are sensitive to noise
  - Often used in mobile Applications (size, weight and power)

• HDP/MCM
  - Combines technology mix without compromising performance
  - Reduces parasitic loads and therefore radiation
  - Eases shielding
  - Reduces size, weight and power consumption
  - Redesign is usually used to increase the functionality
    - Cost benefits realized at the system level
    - Comparison very difficult;
      - GPS: same price as the larger modules
      - Antenna switch: saves one PCB

⇒ New products can arise and new markets can be opened by using HDP/MCM

How you can benefit from HDP/MCM
Introduction
HDP/MCM – Technologies and Applications

Art of Technology offers a one stop service to transfer a customers idea into a product

- Development of ideas & solutions
- Feasibility studies
- Component supply
- Technology evaluation
- Design & layout
- Evaluation of manufacturers and continuously accompanying the manufacturing process
- Test & qualification

... using HDP/MCM -technologies

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