Design of Miniature Multi-Mode SiP Modules with Two Integrated Antennas

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• Insight SIP
• What is “Heterogeneous SiP”
• What & Why “Antenna in Package”
• Combo Module BLE + LoRa
• Electronic part design process for SiP
• Antenna design process for SiP
• Twin antenna design
• Overall Integration
• Performance
• Other twin antenna solutions
Insight SiP
- Established in 2005
- Ultra – miniaturization thru SiP
- Design and Fab - RF SiP Modules
- BLE, LoRa, UWB, NBloT,…
- Innovative Antenna in Package
- HQ on French Riviera near Nice
- Worldwide sales thru distribution
HETEROGENEOUS RF SiP

- Complete 3D RF System Including
  Multiple SoCs in different Tech Nodes (CMOS, GaAs, SiGe….)
- Multiple Packaging Techniques (Flip_chip, Wire-bond, Package in Package)
- Passive Integration (SMDs, Integrated Passives (glass, silicon, ceramic)…)
- Different Substrate Technologies (BT, LTCC, Si,..)
- Built In Antennas (in substrate, in/on molding, custom part,..)

- Smallest size
- More reliable
- Lowest overall cost
- Reduced Time to Market
From PCB to SiP to AiP

1990: PCB + Antenna
2000: SiP + Antenna
2010: AiP
2020: Size reduction
Antenna in Package

- Final step to put ALL system in one package
- Plug and Play
- Removes need for RF expertise at system level
- Eases Radio certification
AiP Roadmap

- 2005 – 2008 Original R&D at ISP
- 2008 world first AiP patented by ISP
- 2010 First BLE module AiP ISP191201
- 2014 2\textsuperscript{nd} gen AiP ISP1301
- 2014 Murata module uses AiP concept
- 2016 3\textsuperscript{rd} gen AiP ISP1507
- 2017 1\textsuperscript{st} gen 2 antenna AiP ISP1510 UWB + BLE
- 2018 SiLabs AIP BLE module
- 2019 1\textsuperscript{st} gen 2 antenna AiP LoRa + BLE
Complete self contained LoRa node with baseband and BLE
Includes dual band antenna and all frequency control & matching
DESIGN OF ELECTRONICS

ISP4520 BLE - LoRa

9.8 x 17.2 x 1,7 mm
Schematic to Layout

Toolsets
- Altium
- Allegro SiP
- Expedition

Capture Schematic

Place Components
- Tight spacings 200um

Route Substrate
- Best design practice
- Careful shielding
- Iterative
- Key task for quality
DESIGN OF ELECTRONICS

- Extract 3D layout of substrate
- Simulate with 3D Electromagnetic Tool
  - Ansys HFSS (or CST or ADS FEM)
- Create n port s parameter model
- Export to schematic simulator
  - Keysight ADS
- Add components and optimize
  - Keysight ADS
- Feedback to adjust substrate design

Reduce # of design spins
Improve Performance
Time to Market
DESIGN OF ELECTRONICS

RF Schematic to optimize & validate Keysight ADS

3D EM simulation in ANSYS HFSS

Results for 10RF paths
Integrated Antenna Design Constraints

- Miniaturization to fit into the package
  - Size reduction of 2 to 3 times cf discrete antennas
- Must use standard SiP technology
  - LTCC or Organic substrates
  - Structures in or on mold compound
  - IPD (silicon or glass based passive devices)
  - SMT components down to 01005

Performance Margins
- Multiple application platforms (ground plane size variations)
- Standard SiP production tolerances
  - Dimensions
  - Material properties

Technical Specifications
- Return Loss over operating band
- Radiation Efficiency over operating band
- Radiation Patterns and Gain
INTEGRATED ANTENNA DESIGN

Design Process

Assess antenna topologies

Topology 1
Mechanical Object 1
Batch EM Simulation
Schematic Model 1
Optimisation of parameters
Fine tuning of best antenna
With 3D EM tool

Topology 2
Mechanical Object 2

Design Knowledge
Design Experience

Mathematical Model
S11=f(W1,W2,X1,X2,X3,Y)
LoRa BLE Antenna

- **LoRa sub Giga Frequencies**
  - Wavelength ca 32 cm
  - $\lambda/4 = 8$ cm
  - Miniaturization complex

- **BLE 2.4 GHz ISM band**
  - Wavelength 12 cm
  - $\lambda/4 = 3$ cm

- **Design Options**
  - 2 antennas
  - 1 antenna with 2 modes and diplexer

- **Integration options (in SiP technology)**
  - Printed in substrate
  - 3D structure using vertical vias in mold compound
  - 3D structure as component in mold compound
LoRa BLE Antenna

- 3D EM simulation
- ANSYS
- Design Optimized
LoRa BLE Antenna

Donut Radiation Pattern at LoRa
LoRa BLE Fabrication

- Based on large Panel
- SMT process for all components
- Compression molding
- Metallization for shielding
- Separation
- Test

Panel for Compression Molding

Flip Chip
Xtal
Passives
TCXO
RF match & Decoupling
Switch
QFN in Package
UWB BLE Module

- Module with 2 antennas
- BLE (2.4 Ghz) and UWB (6.5 GHz)
- Based on Decawave DW1000 and nRF52832 (Nordic)
- Real Time Indoor Localization
- Social Distancing Solution
  - Accurate measure of distance (<10cm)
  - Security Bubble
https://www.youtube.com/watch?v=ItNF83il9RY
&feature=emb_logo
THANK YOU