Integration of SAW (BAW) Devices

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Outline

- Motivation
- Substrates
- SiP/SoC
- GSM Front-End Modules
- WLAN Front-End Modules
- Conclusion

Motivation - 1

Schlüsselaktivitäten eines Mobiltelefons

RF Section of a Cellular Phone
- Receiver (Antenna)
- Filters (SAW, Duplexer, Diplexer)
- Switches (ASM, FEM)
- Amplification (LNA, PA)
- Modulation (VCO, Mixer)

Basicband
- Digital Signal Processing
- Data Storage
- Power Management
- Interface to the User (Key Board, Display, Speaker, Microphone)

Motivation - 2 - Reduction of Number of Components in the RF Section

Significant Miniaturisation
- Increased Functionality
- Cost Reduction

1999
Dualband
appr. 300 Components

2002
Triband
appr. 100 Components

Motivation 3 - Miniaturisation by System on a Chip (SoC)

Several different Technologies on the PCB

Motivation 5 - Advantages of the „System in a Package“ (SiP) - Technology

Integrate Components using Different Technologies in One Package
Use the best Technology for Each Component
Simpler Design Verification Compared to SoC
Higher Flexibility and Shorter Design Cycles
Use of the Carrier Substrate for the Integration of Passive Components
Motivation 6 - RF Modules - the First Step Towards RF-Systems

Advantages by Using Modules
- Better Electric Performance
- Miniaturisation
- Component Count Reduction

Status of RF-Module at EPCOS AG
- Dual-, Triple- und Quad-Band Module for GSM, UMTS
- Multilayer Ceramics with approx. 50 integrated passive Components
- Smallest SAW Filter
- RF Switches with Diodes and GaAs-Chips

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Motivation 7 - Roadmap for the RF Section in Cellular Phones

Substrate 1 - Desirable Material Properties
- Low signal attenuation per unit length of RF tracks
- Via hole connections between metal layers for signal routing
- Support RF transmission lines of different impedances
- High reproducible manufacturing
- Mechanical stability
- Thermal expansion match to components/chips
- Sufficiently good thermal conductor for high power applications

Substrate 2 - RF Substrate Technologies
- Laminated Multilayer Substrates (MCM-L)
- Deposited Dielectrics (MCM-D)
- Ceramic Substrates (MCM-C)

LTCC 1 - LTCC: Platform for Passive Integration

High Conductivity Metal can be used (Ag), no refractory needed
Sandwiching of different materials for optimum performance

LTCC = Low Temperature Co-fired Ceramic

Low Loss (tan δ < 0.002)
Epsilon can be chosen over a wide range (ε, 5 ... 800)

LTCC 2 - Interconnect Schematic Drawing
**LTCC 5 - High-Density Passive Integration: Advanced LTCC Processes**

Co-Sintering of Different Ceramics

High-Resolution Screen Printing

**Filter 3 - Evolution of Filter Size/Packaging**

- 5x5 mm²: 3x3 mm²
- 3.8x3.8 mm²
- 2.7x2.5 mm²
- 2.1x2.1 mm²

**Filter 4 - Packaging: CSSP 1st and 2nd Generation**

- Underfiller
- SAW chip
- Hermetic coating
- Solder ball
- Ceramic carrier
- PROTEC passivation
- SMD pad
- Ceramic carrier
- Laminate

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**GSM Module 1 - Partitioning Trends**

- Single Chip Radio
- Challenges: Cost, Design Cycles, Flexibility, Technology Match, Reliability

**GSM Modules 4 - Typical Performance Requirements**

- Insertion Loss Tx EGSM: 680-915 MHz 2.9 dB (max)
- Insertion Loss Tx DCS: 1710-1755 MHz 3.4 dB (max)
- Insertion Loss Rx EGSM: 925-960 MHz 1.4 dB (max)
- Insertion Loss Rx DCS: 1805-1880 MHz 4.0 dB (max)
- Insertion Loss Rx PCS: 1930-1990 MHz 4.0 dB (max)
- Tx EGSM suppression: 85 dB
- Tx DCS suppression: 50 dB
- Harmonic Attenuation (Tx mode) 2f0, 3f0, ... 30 dB
- Far Out Selectivity (Tx mode) 40 dB
- Harmonic Generation (Tx mode) P1dB
- Insertion Loss Rx (Rx mode) 25 dB
- Harmonic Generation (Rx mode) P1dB

**GSM Modules 7 - Wideband DCS Rx Filter Frequency Response (Ladder-Type)**

- Specification 1
- Specification 2

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WLAN 2 - Front-End Topologies for Dual-Band WLAN

1 SPDT Switch Total Solution (Simplified Conceptual Idea)  
2 Options: 1 SPDT Switch.  
Low Cost Configuration, Potential to Low-Pass Deemphasis and a Lower Number of Filters.

WLAN 3 - Partitioning

Full Front-End Module (FEM)

WLAN 4 - Dualband FEM for 802.11 a/b/g

R005 - WLAN Combo FEM

Low-Cost WLAN Dualband Front-End Module for IEEE 802.11 a/b/g Applications  
Integrates 2 Diplexers, 2 Tx Filters, 2 Rx Filters, 1 Diversity Switch, All in a Small Package Size 5.4 x 4 x 1.4 mm³

GSM Modules 8 - Optimizations

GSM Modules 9 - Complex Matching (GSM 850)

Zout: 384 Ohm // 36 nH

... Based on EPCOS’ Ceramic and SAW Expertise

Ready for New Applications in the World of Passive Electronic Components!

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Thank You!

International Workshop on SiP/SoC Integration of MEMS and Passive Components with RF-ICs, Chiba, Japan

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