Passive Embedded Substrate for RF Integrated Package

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(KETI/Korea)

Passive Embedded Substrate for RF Integrated Package

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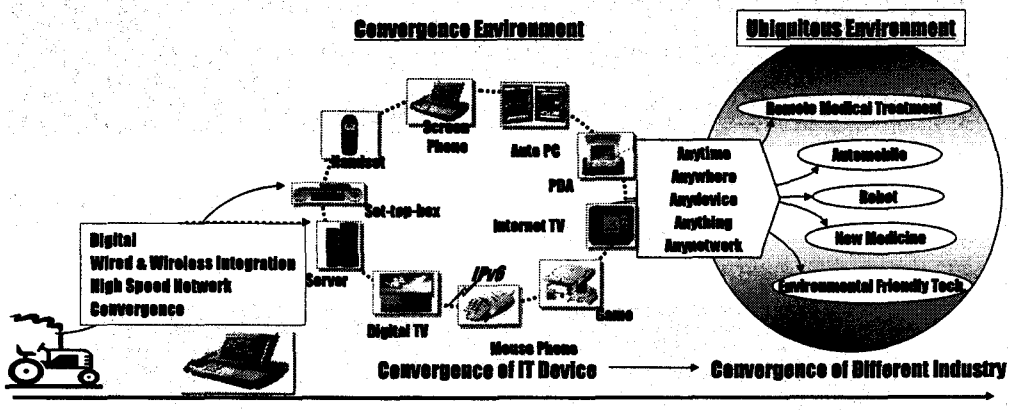
Outline

- IT Convergence
- System Integration
- CDMA FEM using Passive Embedded Substrates
  - Power Duplexer Module
  - Dual Band Front End Module
- Results

IT Convergence



Industrial Society	Information Society	Convergence Society	Ubiquitous Society
	Based on the Server / PC	Based On the Mobile Communication	

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System Integration

The Most important is not good products with Large Scale but good products with effect and in time !

Problems of the SOC

- [redacted]
  - •Increased chip size -> Reduced yield
  - •FAB investment expense: $ ~3 Billion
  - •Development period : Year base
  - •Development expense :$ ~1M base
- [redacted]
  - •Different Device / Process
  - •Digital / Analogue
  - •High capacity memory
  - •Limited passive component
- [redacted]
  - •Advanced company IP circulation

SOP using Passive embedded Substrate

Passive Embedded Substrate
- •Embedded lumped elements : L, C, R
- •Embedded Functional device

Reduced No. of Via, Line, Component on the substrate → Improved Reliability !

Reduced parasitic inductance → High speed response

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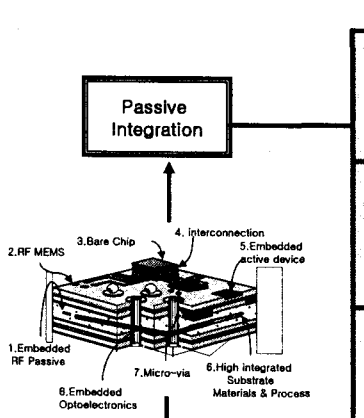
System on Package Process



Passive Embedded SOP-L
- Cost effective Solution
- Effective @ f < 5GHz

SOP-L (Laminated)

Passive Embedded SOP-C
- Performance effective solution
- Effective @ 2< f < 50GHz

SOP-C (Ceramic)

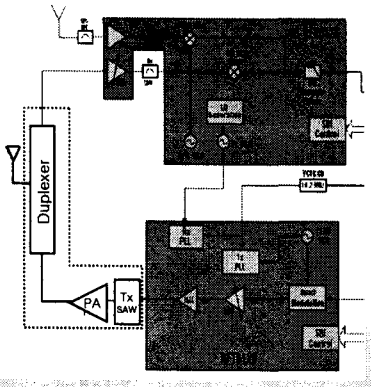
Passive Embedded SOP-D
- Size effective solution
- Effective @ f > 20GHz

SOP-D (Deposited)

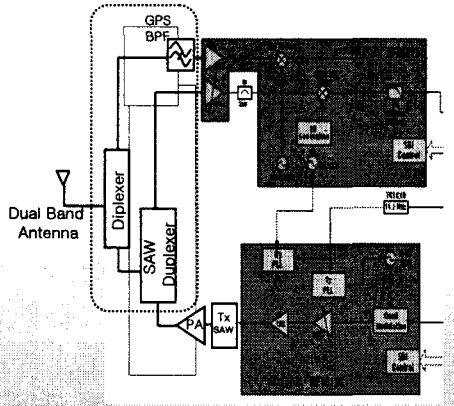
MCP (Multi Chip Package)
- Active Integration Solution

Chip Stacking
(Deep etch, Wafer thinning)

CDMA FEM using Passive embedded substrate

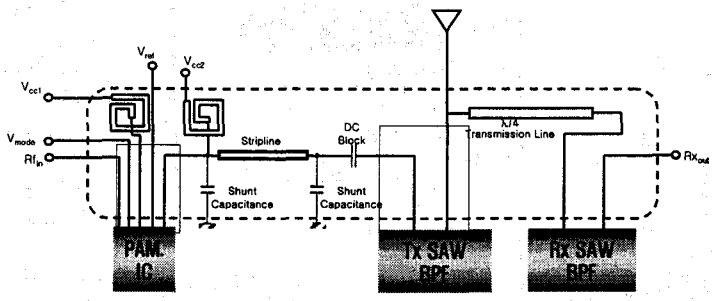


Power Duplexer Module



CDMA Dual Band Module

Power Duplexer Module



Power Duplexer Module Block Diagram

Module 3D Structure

- Embedded Parts
  - -3 Capacitors
  - -2 RF Choke
  - -2 transmission Line
- SMD Parts
  - - 2 Bare chip

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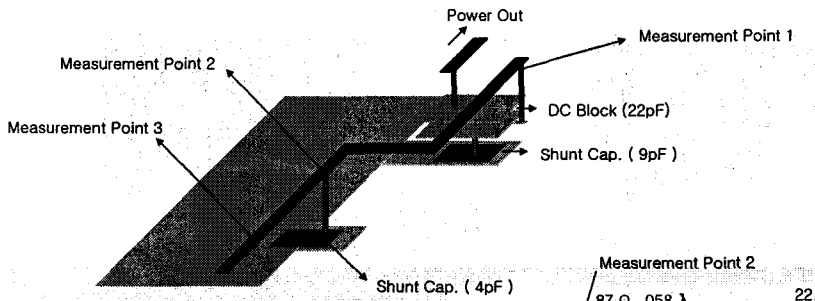
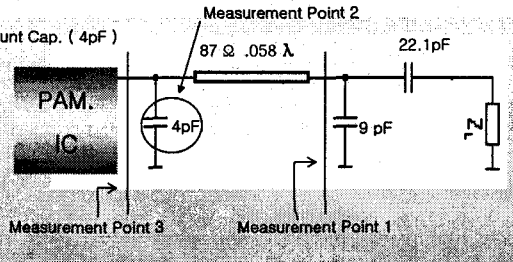
Measurement Points of the Embedded Parts



- PAM. Out matching CKT Structure -



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Integration of Duplexer and PA Module

SAW Duplexer(3.8mmX3.8mm)

PA Module(4mmX4mm)

CDMA Front End Module
(6mmX6mm)

No SMT Chip Components,
but only bare chips.
(1 SAW Duplexer Chip,1 PA Chip)

- **High K Material for the Embedding Capacitor**
  - more than double layers or areas are need with k=7.4 material
  - Increasing layers or pattern area, decreasing Q value of capacitor
- **Low K Material for the Strip line of the Duplexer**
  - 50Ω line width : 80㎛ with k=7.4 material
    11㎛ with K=17.4 material

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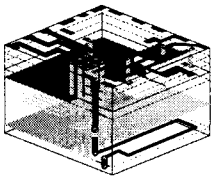
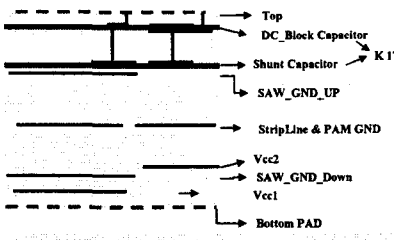
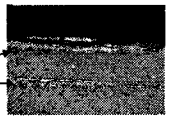
Fabrication : Co-firing of the Heterogeneous Dielectrics (K17.5/K7.4)

• 3-D structure of Power Duplexer Module : Small Size, High Performance

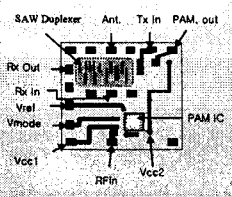




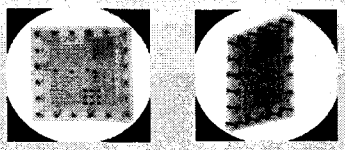
• Embedded Cap. : Paste



Voids after dielectric printing



• X-ray Transparency View



• Embedded Cap. : Green Sheet

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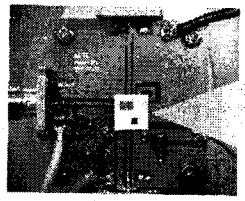
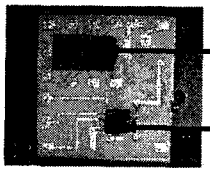
Electrical Characteristics of Power Duplexer Module





Parameter	Unit	Specification	Note
Output Power Level	dBm	25	Vcc: 3.4V
Gain @25dBm	dB	25.4	
Current / PAE @25dBm	mA	434	Vcc: 3.4V
ACPR1 @885kHz offset	dBc	-52	@25dBm, Vcc: 3.4V
ACPR2 @1.98MHz offset	dBc	-63	@25dBm, Vcc: 3.4V
Idle Current (Quiescent Current)	mA	116	
2nd Harmonics	dBc	-63	
3rd Harmonics	dBc	-58	
Tx Isolation	dB	< -47	

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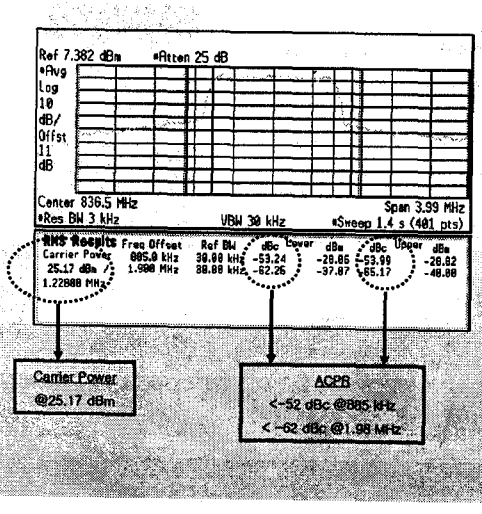
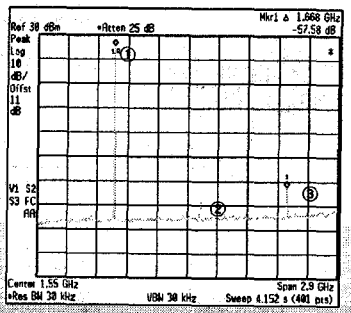
Measurement Plot of Power Duplexer Module

• ACPR Measurement Plot



• Harmonics Measurement Plot



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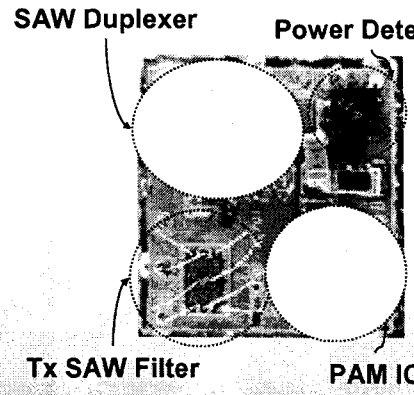
Fully Integrated CDMA Front End Module



- Size : 5X5.5 mm
- SAW Duplexer, Power Detector Tx SAW Filter, PA Integrated
- Out power : 25dBm
- Non-shrinkage Co-Firing Method

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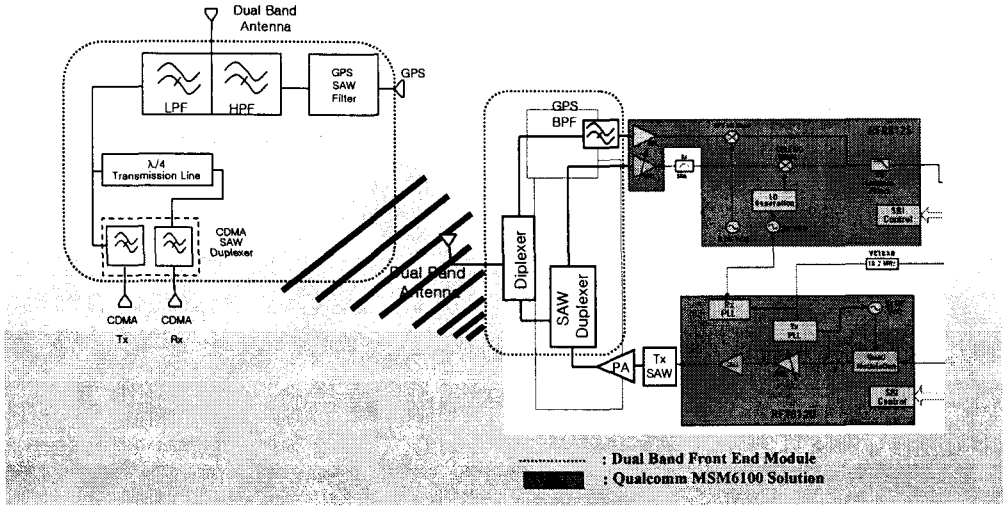
Dual Band module



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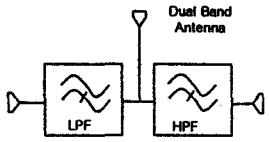
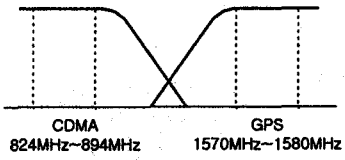
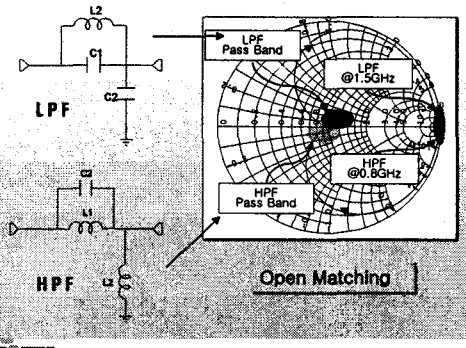
Dual Band module - Diplexer



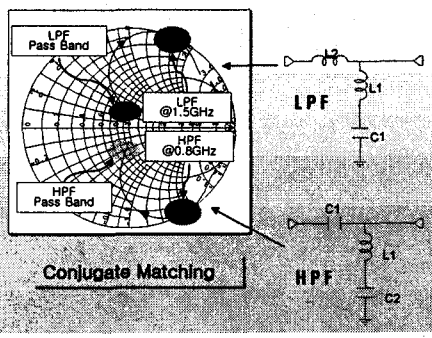
Diplexer



Diplexer Frequency Characteristics



Open Matching



Conjugate Matching

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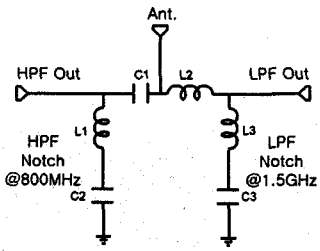
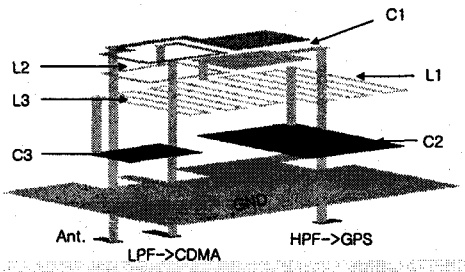
Dual Band module - Diplexer





Fabrication

- Pb-Free LTCC (εr=7.5, Tanδ=0.005, Layer Thickness=35 ㎛)
- Ag electrode
- Co-Firing Temp. = 860℃
- Insertion Loss = 0.5dB Max (@CDMA Band), 0.6 dB Max. (@GPS Band)

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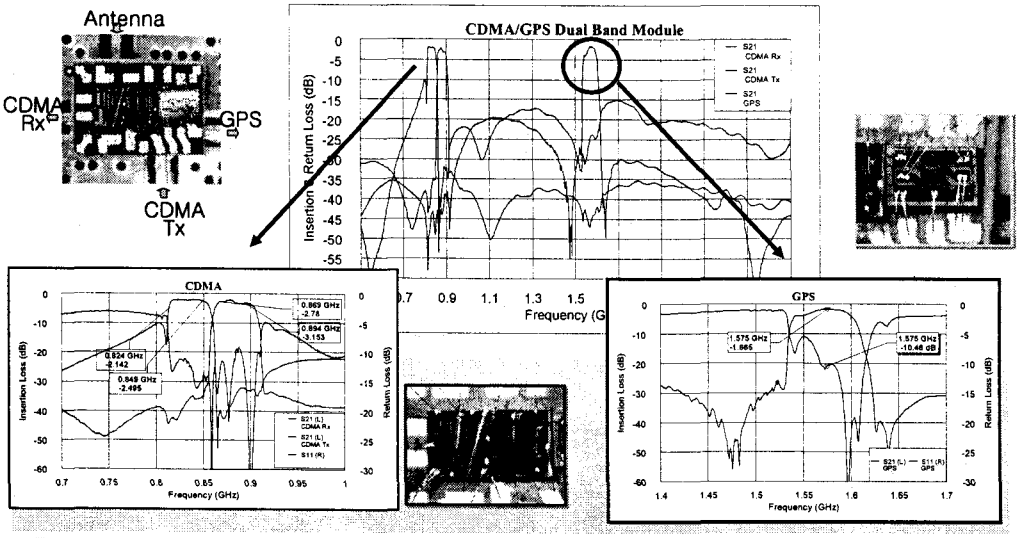
Dual Band module
(With CDMA Duplexer & GPS SAW Filter)



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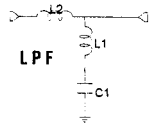
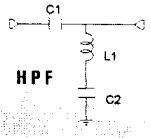
Design & Simulation of the Embedded Passives

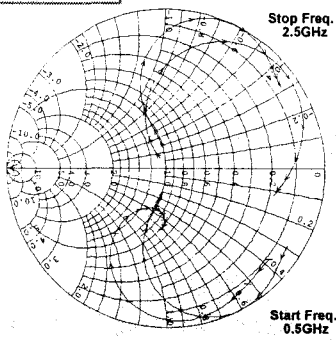
Design with ideal L,C elements



Schematic of LPF
(With ideal L,C)

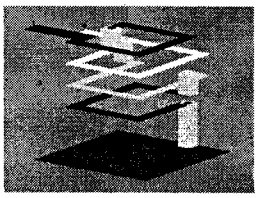


Schematic of HPF
(With ideal L,C)

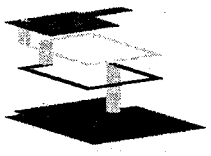


- Schematic of LPF
- Structure of LPF
- Schematic of HPF
- Structure of HPF

Difference between schematics & structures



Structure of LPF



Structure of HPF

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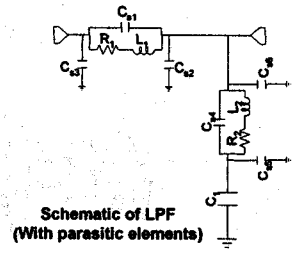
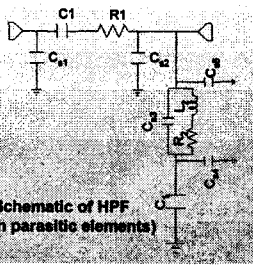
Design & Simulation of the Embedded Passives

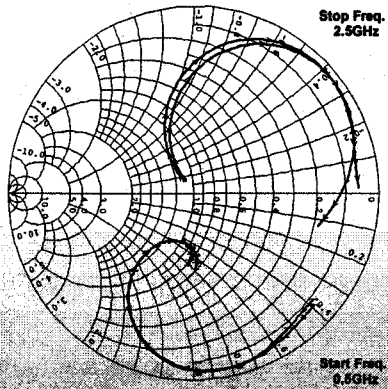
Design with elements including parasitic effects

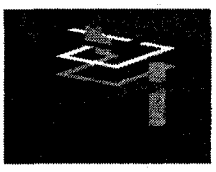


Schematic of LPF
(With parasitic elements)

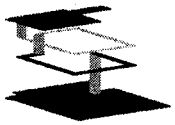


Schematic of HPF
(With parasitic elements)





Structure of LPF



Structure of HPF

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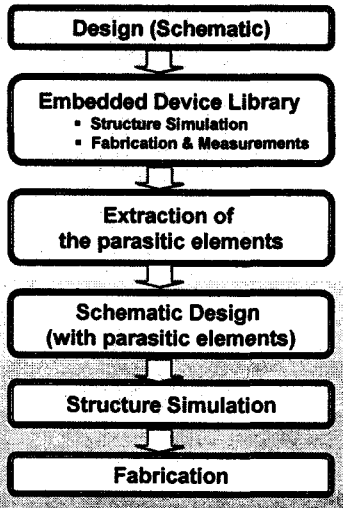
Design & Fabrication Flow of the Passive Embedded Substrate



Structure Simulation : Extract the parasitic elements.
Fabrication & Measurement : Extract the difference between Structure simulation and measurement.

Re-Design with parasitic elements :
Very important in design
- loss from the resistivity of the elements : ~ 0.35dB
- loss from the miss-matching due to the parasitic elements : ~ 2.5dB
- Understanding the parasitic elements make it possible to optimize the characteristics of the embedded substrate

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Conclusions

- Many possibilities to realize better performance.
  - Using conjugate matching, less efforts needed to optimize the characteristic of the individual components.
  - In the case of Power Duplexer module, advantages in harmonic characteristics of the amplified signal and ACPR characteristics.
  - In the case of CDMA/GPS dual Band Module, total insertion loss is less than the summation of the losses of the individual filters.
- Duplexers & Filters with SAW& BAW is essential(commercial mobile communication.)
- Filters with LTCC is the effective solution (Freq. Range > 2GHz)
- High integration is possible using co-firing heterogeneous dielectrics.
- More efforts needed to understanding parasitic effects.