세라믹 RF 부품의 모듈화 동향

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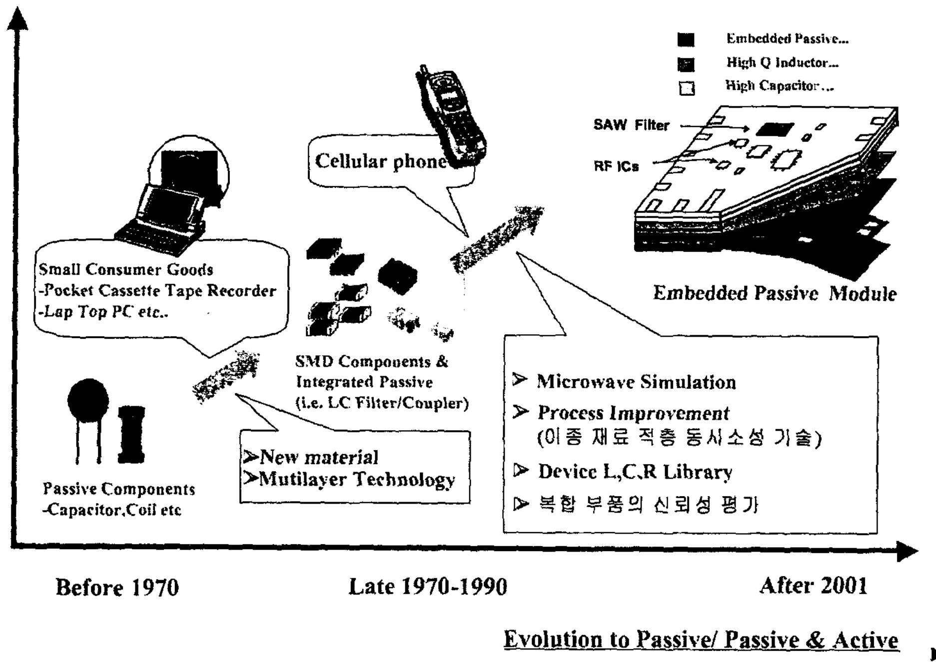
1. Introduction to ceramic RF modules

2. Embedded passives

3. Fabrication of multilayer ceramic modules

4. Applications

Component integration trend



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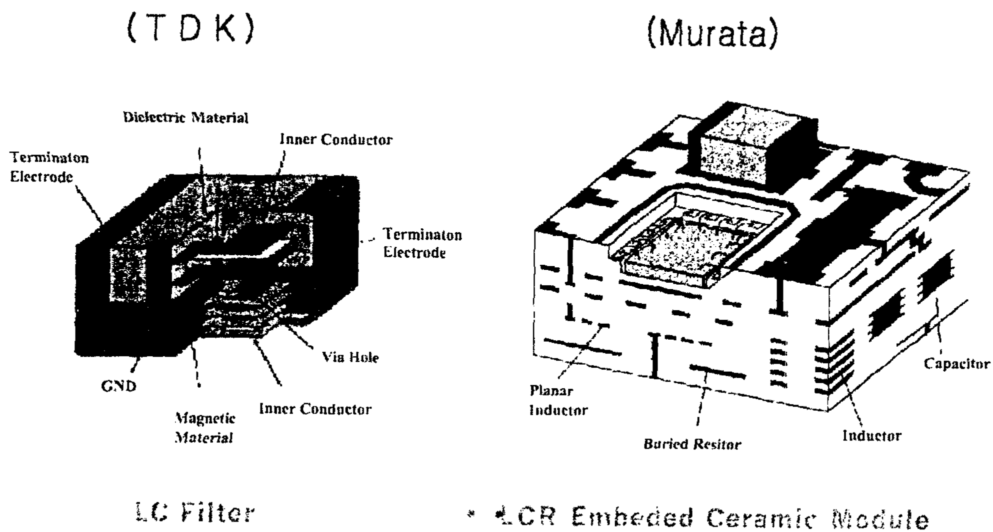
Embedded type ceramic modules



LC Filter

* LCR Embeded Ceramic Module

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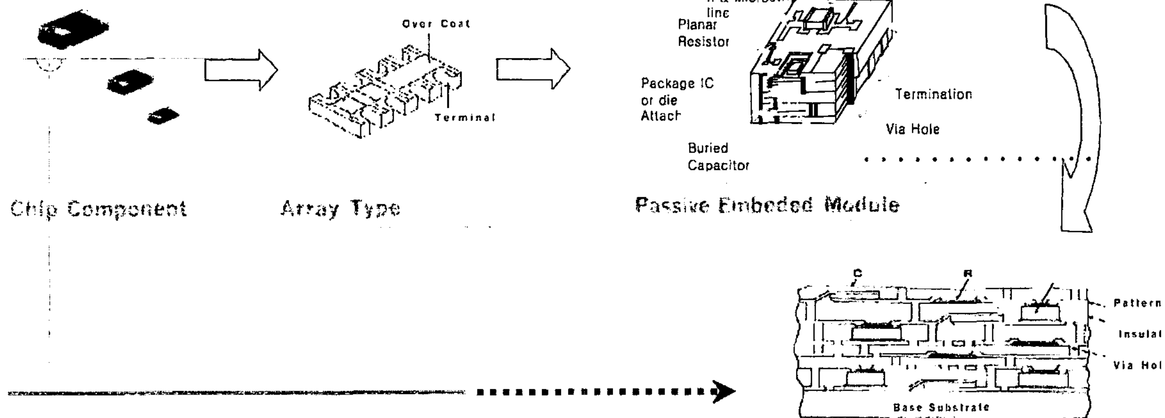
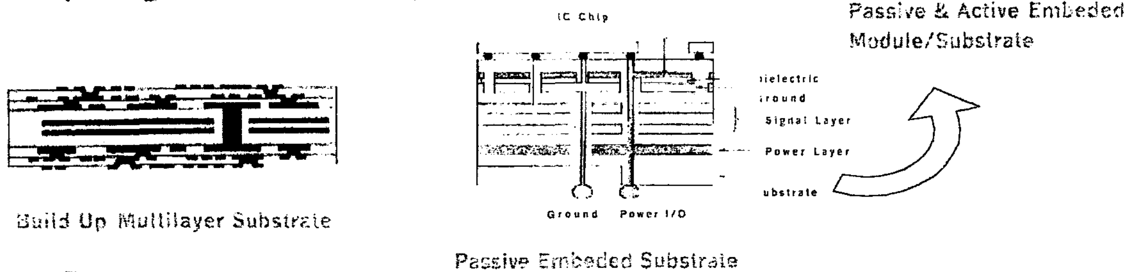
(Integrated Passive Devices)



(Integral Substrates)



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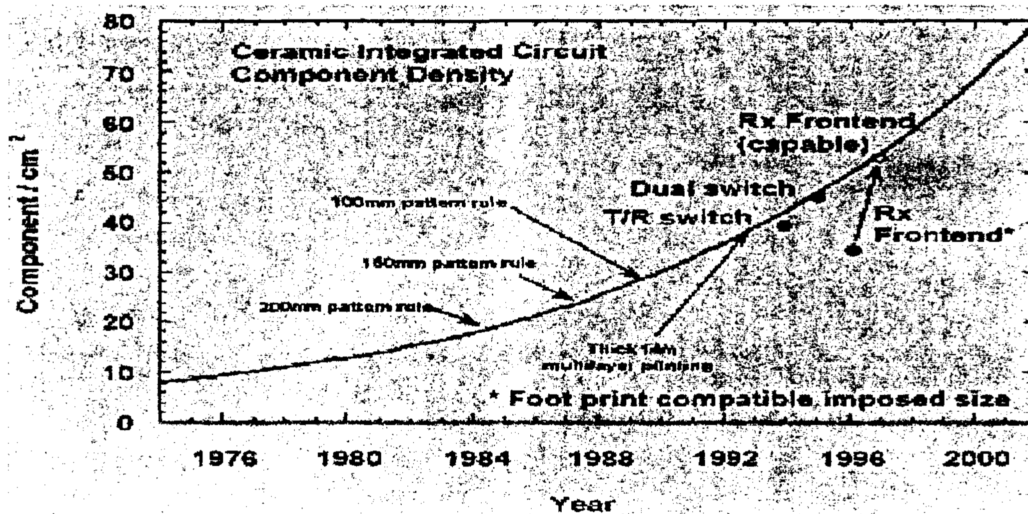
Ceramic integrated circuit component density trend



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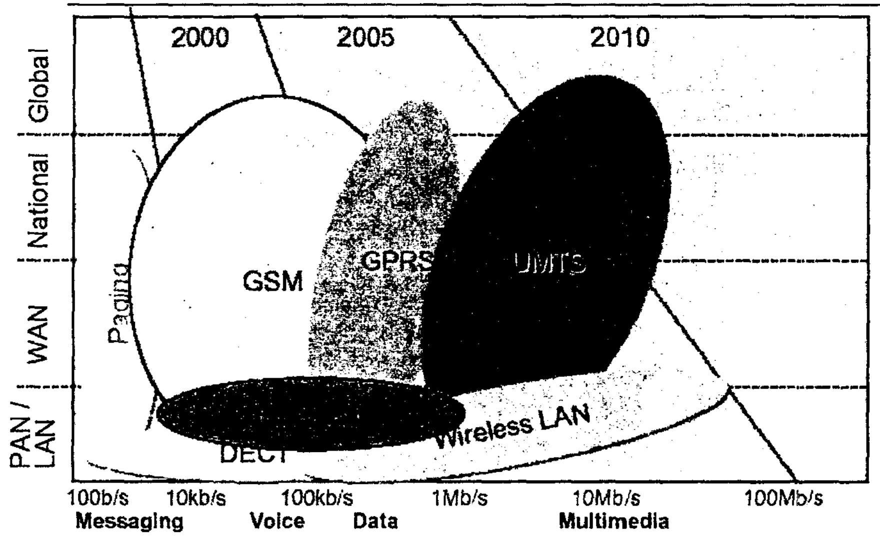
Development trend of telecommunications



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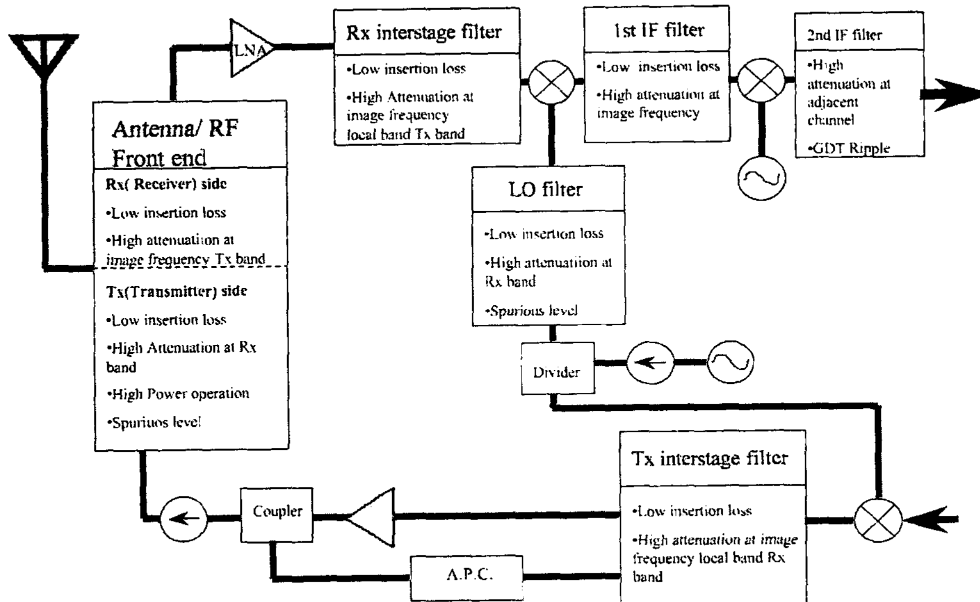
RF/IF filter blocks and their typical design targets



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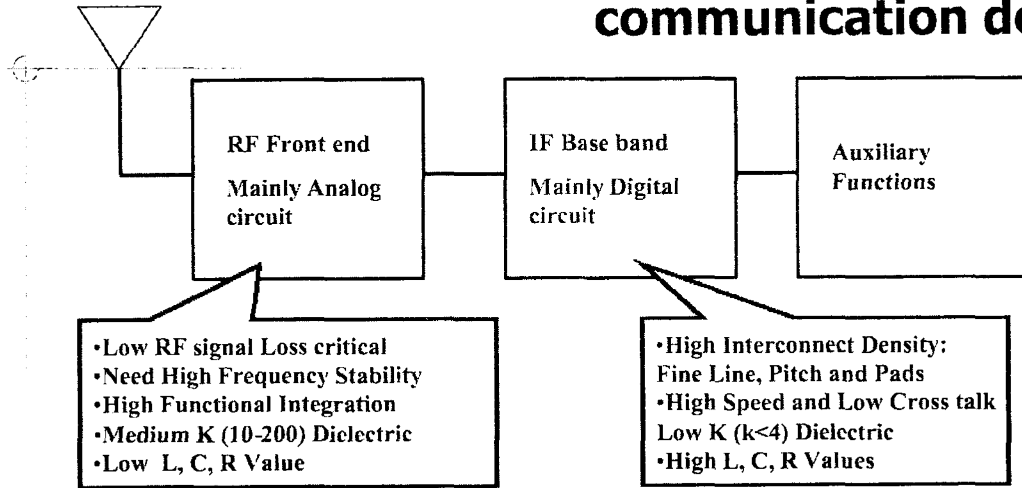
Conceptual diagram of a wireless communication device



Special Ceramic Components
- Filter
- Isolator
- VCO
- Balun Transformer
- PAM

Ceramic Chip Components
- Capacitor,
- Resistor,
- Inductor,
- Substrate
- .. Etc

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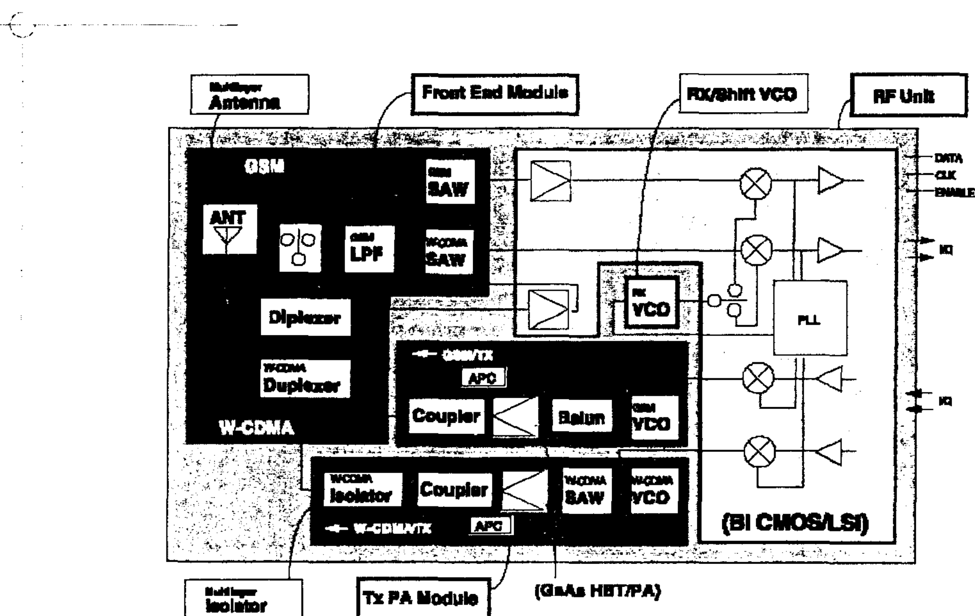
Integration trend for WCDMA/GSM dual mode



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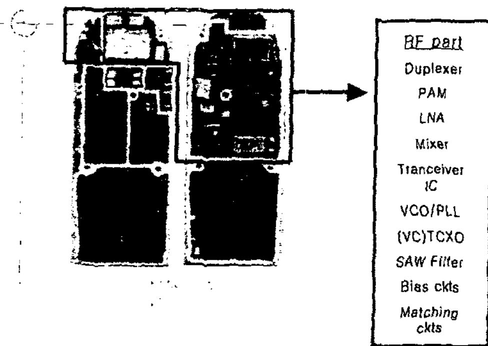
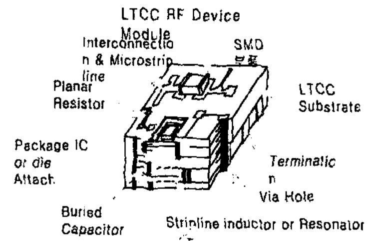
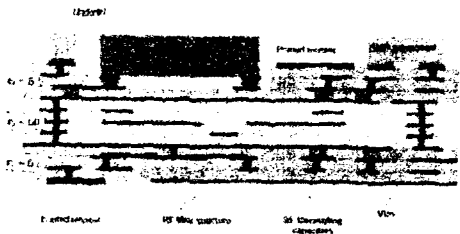
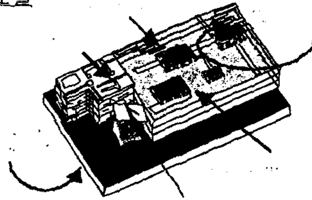
Dual band RF ceramic module







GSM/DCS 듀얼밴드 적층 세라믹 RF 모듈



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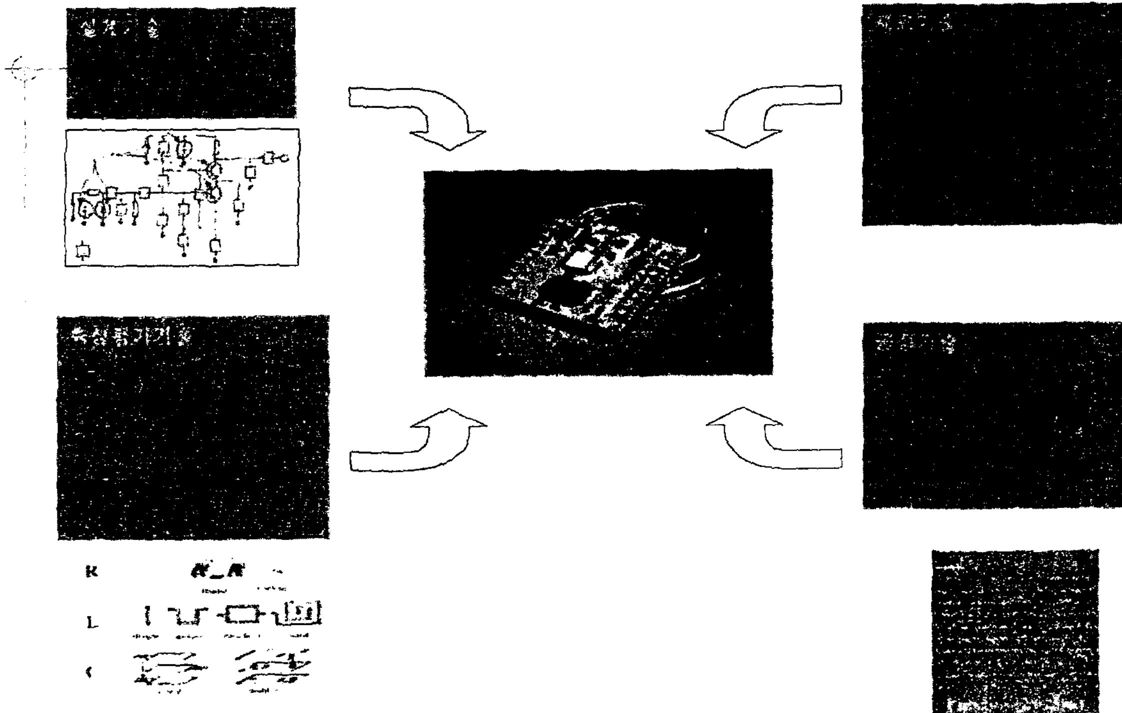
Related Technologies



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Process Flow

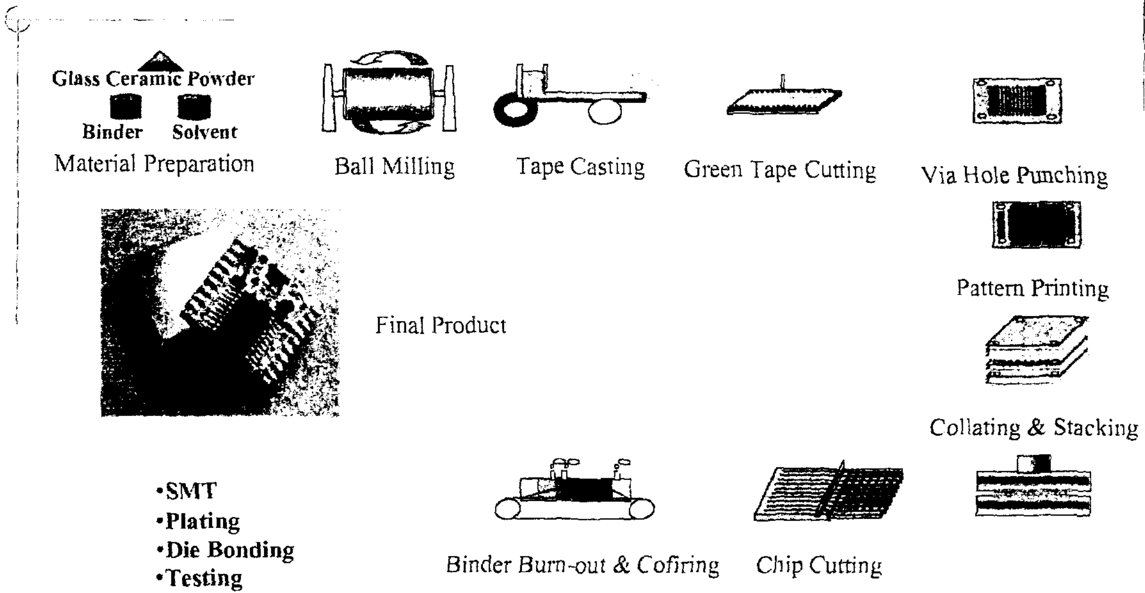

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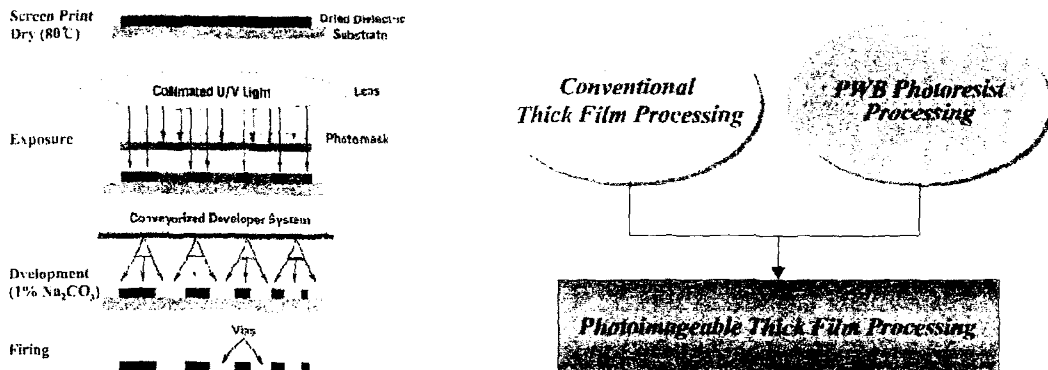
Photo-patterned fine line formation process



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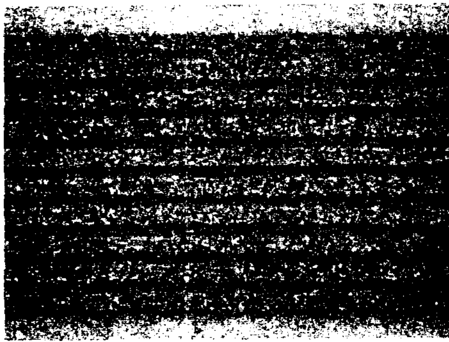
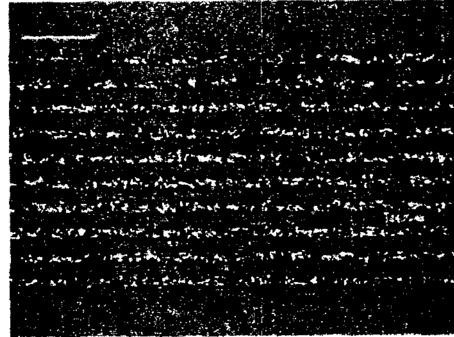
Photographs of fine line patterns

25㎛ line/space pattern (after cofiring)





(a) after developing　　　(b) after cofiring

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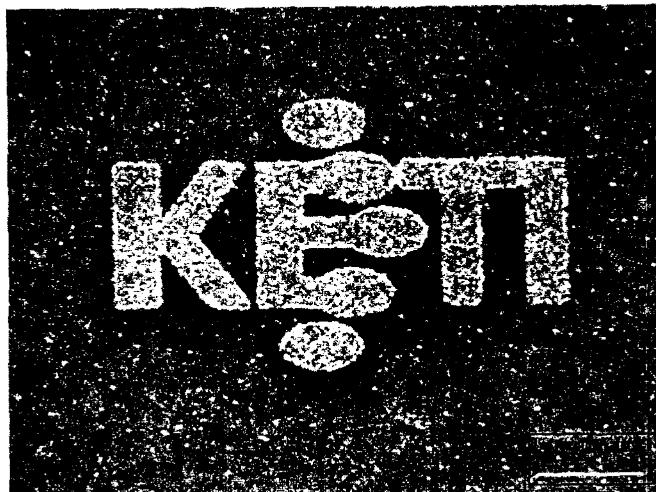
Photographs of fine line patterns



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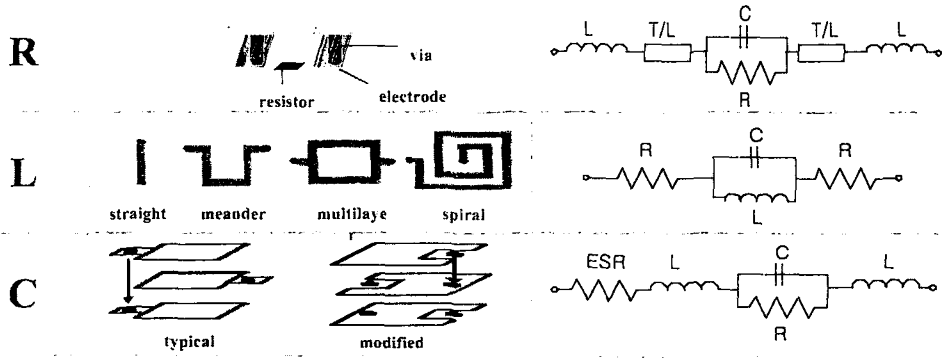
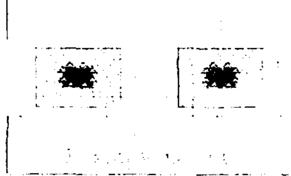
R, L, C library for ceramic module

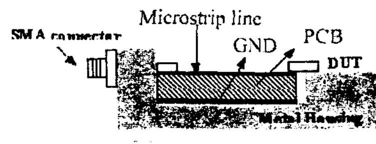


Simulation

S/W : Sonnet 5.1



Measurement (100㎒ ~ 6㎓)



Instrument : HP 8753D Network analyzer

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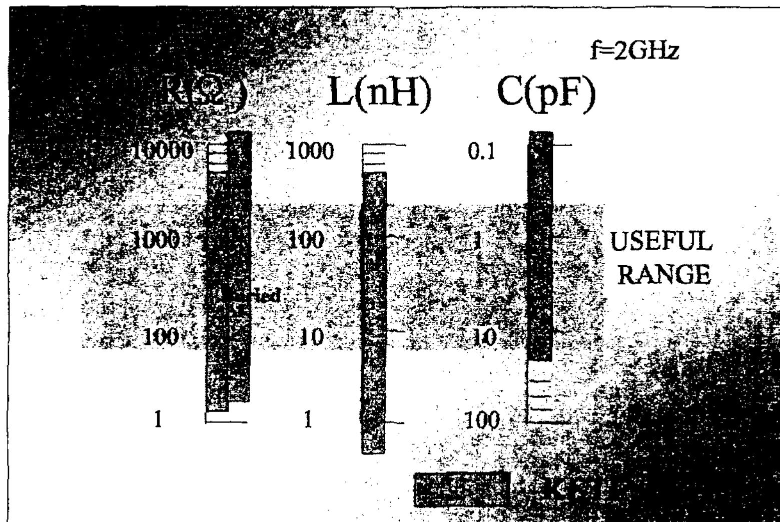
Component values for RF applications



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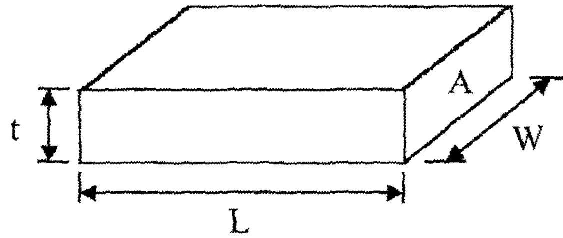
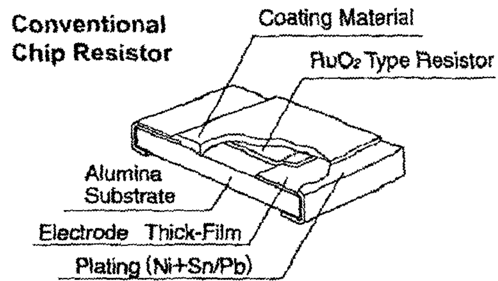
Resistor



$$R=\frac{\rho\cdot L}{A}=\frac{\rho}{t}\cdot\frac{L}{W}=\rho_s\frac{L}{W}$$

$$\rho_s = \textit{Sheet Resistivity}\ (\Omega/sq)$$

$$\frac{L}{W}=\frac{Length}{Width}=\textit{Number of Squares (Aspect Ratio)}$$



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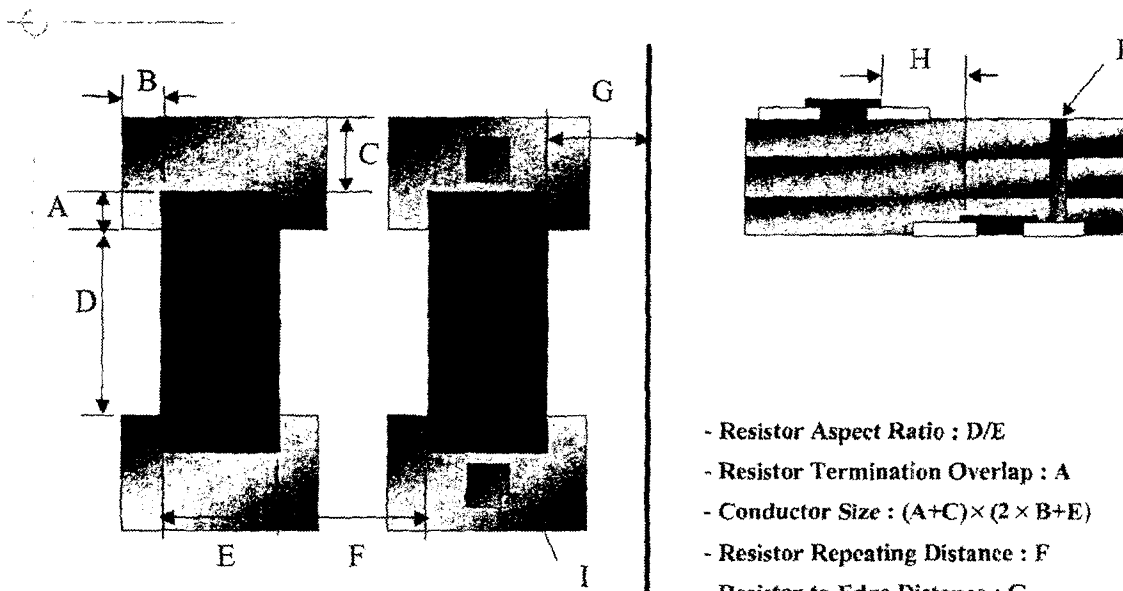
Resistor : design factors



- Resistor Aspect Ratio : D/E
- Resistor Termination Overlap : A
- Conductor Size : (A+C)×(2×B+E)
- Resistor Repeating Distance : F
- Resistor to Edge Distance : G
- Spacing between different tape layer : H
- Via effect : I

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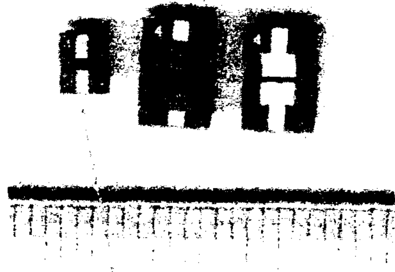
Resistor : top and buried

Buried Resistor without Via



Buried Resistor 단면

Top Resistor

Buried Resistor with Via

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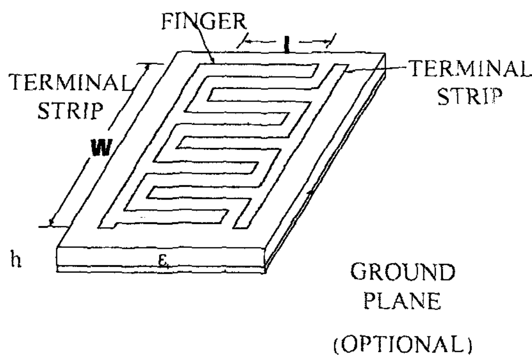
Capacitor design

Type 1

$$C = \frac{A \cdot Er \cdot (N-1)}{4.45 \cdot D} pF$$

N=total number of plates
Er= Relative Dielectric constant
A=Area of plate-Sq. In.
D=Distance between plates-In.

Type 2



$$C = \frac{Er+1}{W} l \; [(n-3)A_1 + A_2)]$$

N=number of fingers
A_1=0.089 pF/cm for h>w
A_2=0.1 pF/cm for h>w
l= finger length, cm
w=finger width
h=Dielectric thickness, cm

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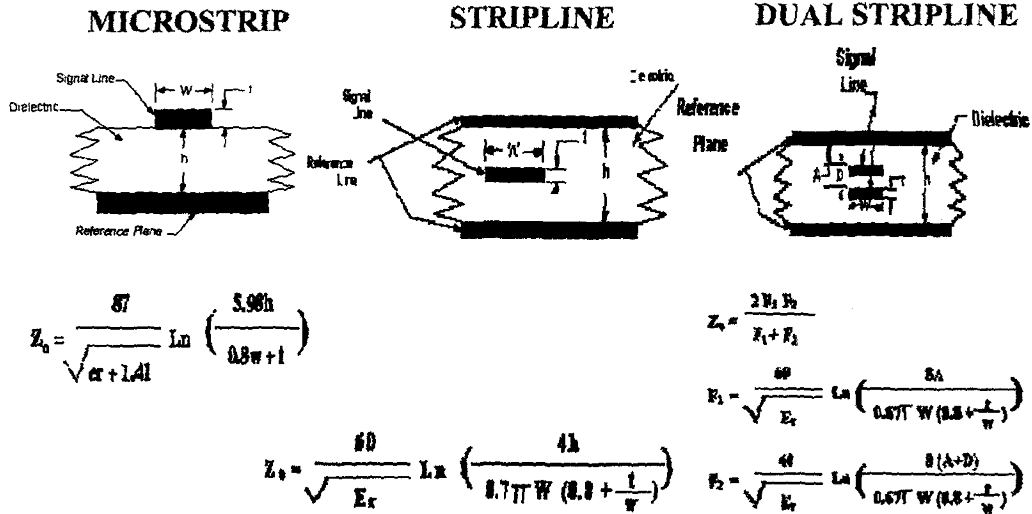
Impedance choice



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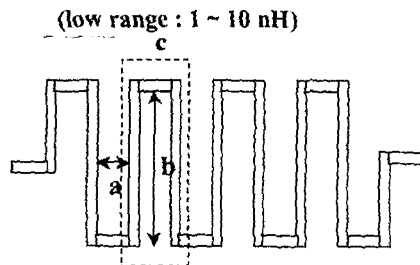
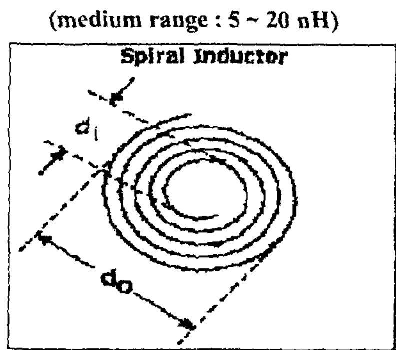
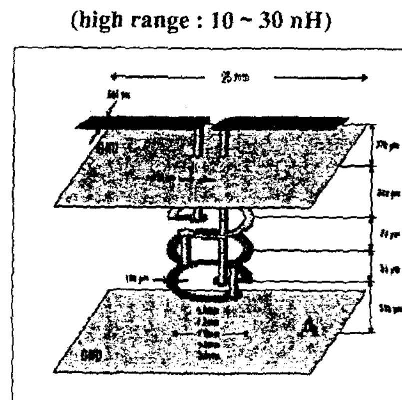
Inductor design







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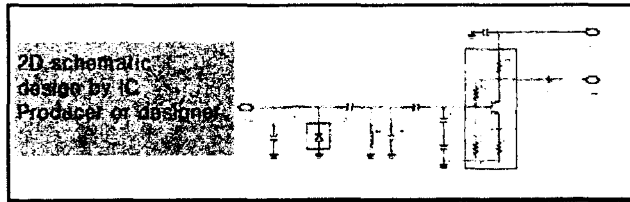
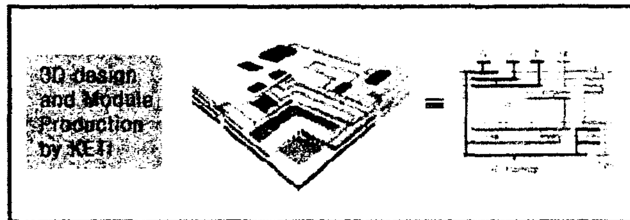
Process for multilayer ceramic RF module design



Simulation
: ADS, Serenade



3D Layout
: HFSS, Sonnet

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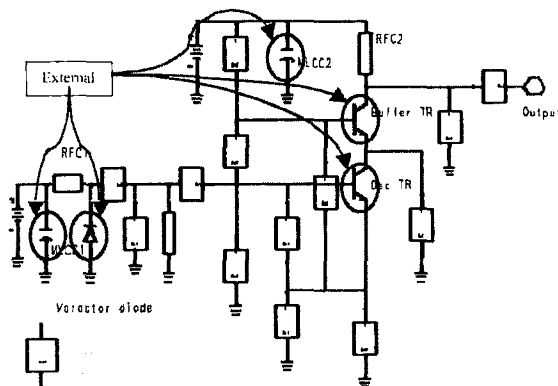
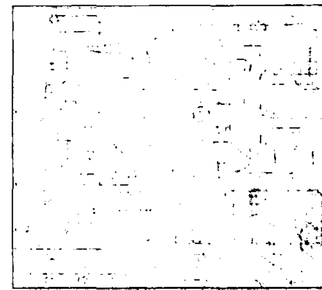
VCO circuit design



3-D Circuit Design Layout



- Total components = 21 , Layer : 12
- External : TR(2), diode(1), bypass cap.(2) : 24%, but some components may be added for tuning
- Buried : resistor(4), cap.(9), stripline(RFC 2, Resonator1) : 76% - 부품내장률

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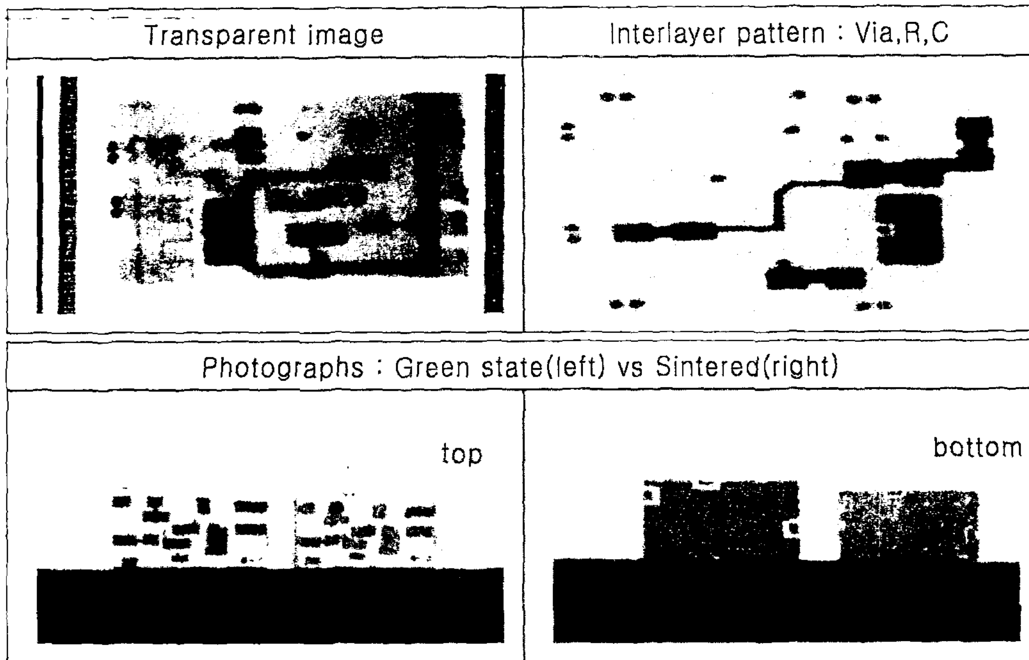
Fabricated sample short-cuts



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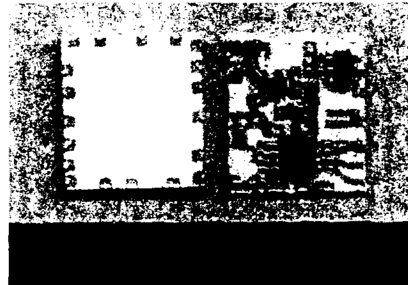
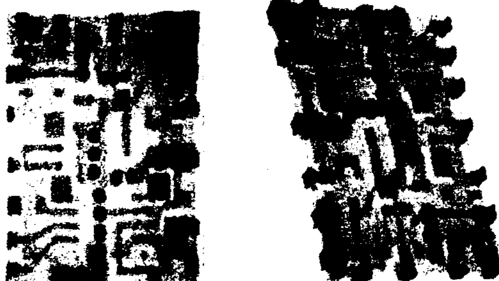
LNA/Mixer module for IMT-2K

- **Total components = 33 , Layer : 6**
- **External : FET(1), IC-Up Mixer: RF 2638;**
  Down CMY210(2), Cap.(8), R(4)
- **Buried : Cap.(10), Inductor(8) : 54% -** 부품내장률



LNA/Mixer 모듈 시작품



LNA/Mixer 모듈의 X-ray 3차원 투시 사진

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Bluetooth module comparison (1)

	National Semiconductor **Embedded** Antenna Front-end filter Rx/Tx Balun PA VCO & Loopfilter Image-rejection filter
	ERICSSON **Embedded** Antenna filter Rx/Tx Balun Inverted thin-film passive substrate Solder-ball connections to PCB Wirebonded discretes with glob top Underfilled flip chip IC
	agere systems **Embedded** Antenna filter Rx/Tx Balun LoopFilter VCO resonator

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Bluetooth module comparison (2)

UNIVERSITY OF ARKANSAS **Embedded** Front-end filter Rx/Tx Balun Loopfilter Image-rejection filter	LNA Balun VCO LMX3162 PA Balun Single-chip PA
zecal **"Z-strate" Substarate 이용** **; Direct Copper Plating on 90% Al** **; Bare-chip or flip-chip 실장에 유리**	LNA two-stage FET 사용 Balun VCO BJT with Buffer ? PA Balun Single-stage VMOS Tr 사용
MOTOROLA *** Zero-Tf Dielectric(T 2000) 이용** *** Satellite Rx Front-end module 제작** **Embedded** 18 Capacitors & 9 TL/Coil **External PA, VCO, Transciever**	Embedded solution Balun Balun

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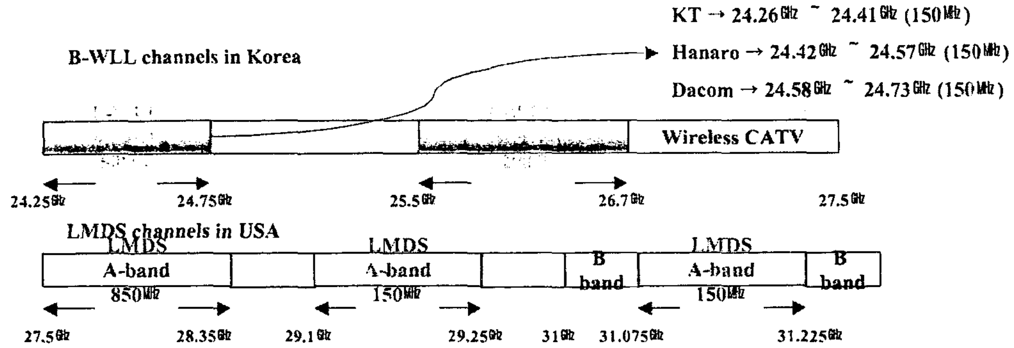
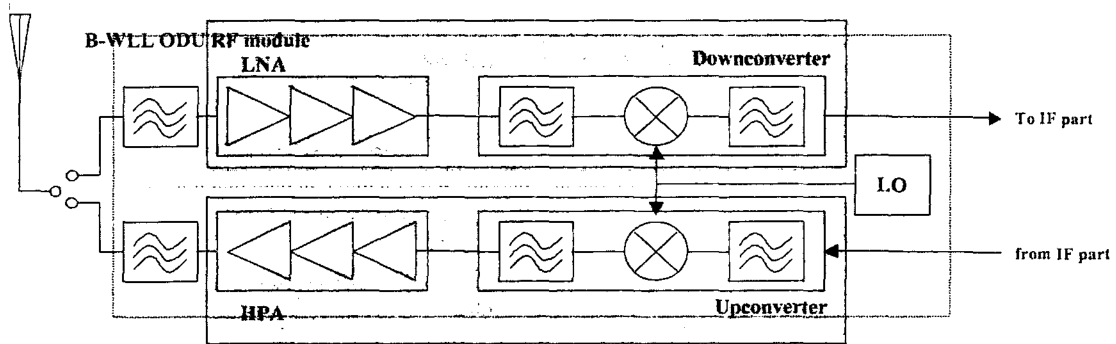
Our new challenge : B-WLL





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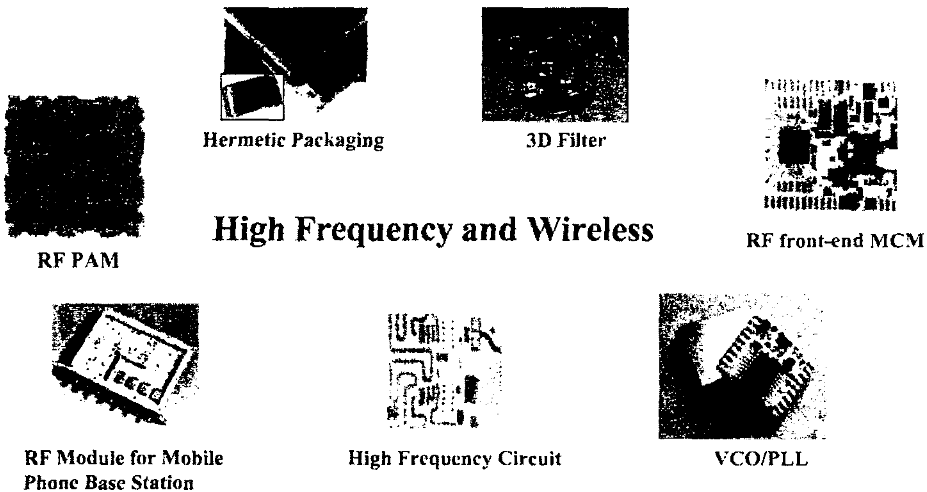
Multilayer ceramic application (1)



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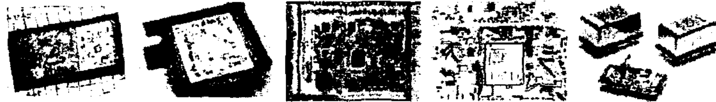
Multilayer ceramic application (2)

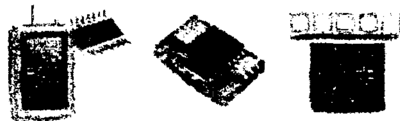
◌ Automotive : Throttle-valve Module (ETM) circuit, Car ABS, Automotive Engine Control
Advanced Continuously Variable Transmission (CVT) Controller, New-Generation Airbag Sensors



Military : Remote Terminals (multiplex circuits), Helicopter Module

Medical : Hearing Aid Circuit , Dental Bite Sensors

Industrial and Power : Portable LAN Tester, Multilayer Hybrid Device, DC/DC Power Module



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Conclusions

- Embedded Passives
- Embedded Passives & Actives
- Embedded MEMS Package
- Embedded Optical Devices
- Millimeter Wave Package etc.

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