Embedded passive components in PCB’s

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Outline

- Information about ITR
  - Accredited LAB (ISO 17025)
- Embedded components
  - Thin film resistors
  - Polymer thick film resistors
  - Capacitors
  - Inductors
  - demonstrator
- Summary
- Q&A
Tele- and Radio Research Institute

- Based in Warsaw/Poland
- State owned company
- 200 employee
- Divided in 5 discipline centers
  - CD, CM and CJ (ISO 17025)
    - PCB; assembly line
    - Cross-section, X-ray, climatic chambers,..
Printed Circuit Board (PCB)

Advantages:

- Shorter signal paths and reduced series inductance,
- Reduced cross talk, noise and EMI,
- Leave the surface on the outer layers for the active components (increased active component density),
- Improved reliability due to the elimination of solder joints,
- Elimination of discrete components,
- Board densification and/or size reduction,

Disadvantages:

- …
Materials and method for manufacturing thin- and thick-film passive components

Thin film resistors
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For the formation of resistors Ohmega-Ply ® RCM material (Resistor - Conductor Material) of the resistive layer thickness from 1 micron to 0.05 microns is used. Resistivity of this layer is between $10 \ \Omega/\square$ and $250 \ \Omega/\square$. 

![Diagram showing the materials used in thin film passive components]
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Panels preparation → Apply photoresis → Laminate photoresist and develop pattern → Strip photoresist → Selective etch Ni-P → 1\textsuperscript{st} etch copper → Apply photoresist → Laminate photoresist and develop pattern → 2\textsuperscript{nd} etch copper → Oxide treatment → Strip photoresist → Lamination

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1. Photoresis
2. Copper
3. Resistive layer
4. Dielectric layer

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The resistance value of a designed resistor can be determined with the following formula:

\[ R = \rho \cdot \frac{L}{W \cdot h} = \frac{\rho}{h} \cdot \frac{L}{W} = R_s \cdot \frac{L}{W} \]

where:
- \( R \) – resistance of the resistor [\( \Omega \)]
- \( \rho \) – resistivity of the resistive material
- \( h \) – thickness of the resistive layer
- \( R_s \) – resistive layer resistivity [\( \Omega / \square \)]
- \( L \) – length of the resistor
- \( W \) – width of the resistor

Which is equivalent to:

\[ R = R_s \cdot N \]

where: \( N \) – number of squares
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Polymer thick film resistors
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1. contacts etching

2. screen printing

3. drying

4. curing

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Capacitors
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Other electrical interconnection in PCB
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Capacitor in PCB manufactured with FaradFlex MC12TM – material with a 12 µm partially filled dielectric, $C_p(1\text{MHz}) = 700\text{pF/cm}^2$
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Inductors
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The simplest inductive coil integrated with the printed circuit board are made by forming a meander or spiral shape by etching the copper layer. It is also possible the designing of a solenoid coil made up of holes between the layers of the printed circuit board connected by the tracks.
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The designed inductor, view of layer 2 and layer 3; a, f, g, h, i - the different types of spiral inductors; b and c - solenoid inductor; d and e - meander inductors; h and i - inductors with a aperture for core.

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Measurements and tests:
- influence of the individual technological operations on the basic parameters,
- structure on the cross-sections,
- thermal stability during operation by using thermographic imaging camera,
- environmental exposure like:
  - (temperature cycling: -40 °C - +85 °C, thermal-humidity exposure: 85°C, 85% RH),
  - temperature shocks (-40 °C, +125 °C),
  - thermal aging,
  - thermal characteristic,
  - testing by using impedance spectroscopy,
  - long-therm stability,
  - storage time,
  - And ...
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In order to show the functional properties of all investigated materials the devices consisting of embedded passives were designed and fabricated among others:

1. Low and high pass filters.
2. The TCVCXO-16P Quartz Oscillator.
3. The 225 kHz radio for receiving the First Program of the Polish Radio.
4. The RFID passive keyboard,
5. The RFID tags,
6. The strain gauge,
7. The logarithmic resistance-to-frequency converter.
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- The RC filters
- The mobile wireless RFID keyboard
- The strain gauge.

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Layer 1 - TOP
Layer 2 – thin film resistors
Layer 3 – capacitors electrode 1
Layer 4 – capacitors electrode 2
Layer 5 – thick film resistors
Layer 6 - BOTTOM

The topography of TCVCXO-16P Quartz Oscillator pattern, the all layers of PCB.
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The 225 kHz radio for receiving the First Program of the Polish Radio

The logarithmic resistance-to-frequency converter

The strain gauge

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