Microwave & RF 2014 – Paris

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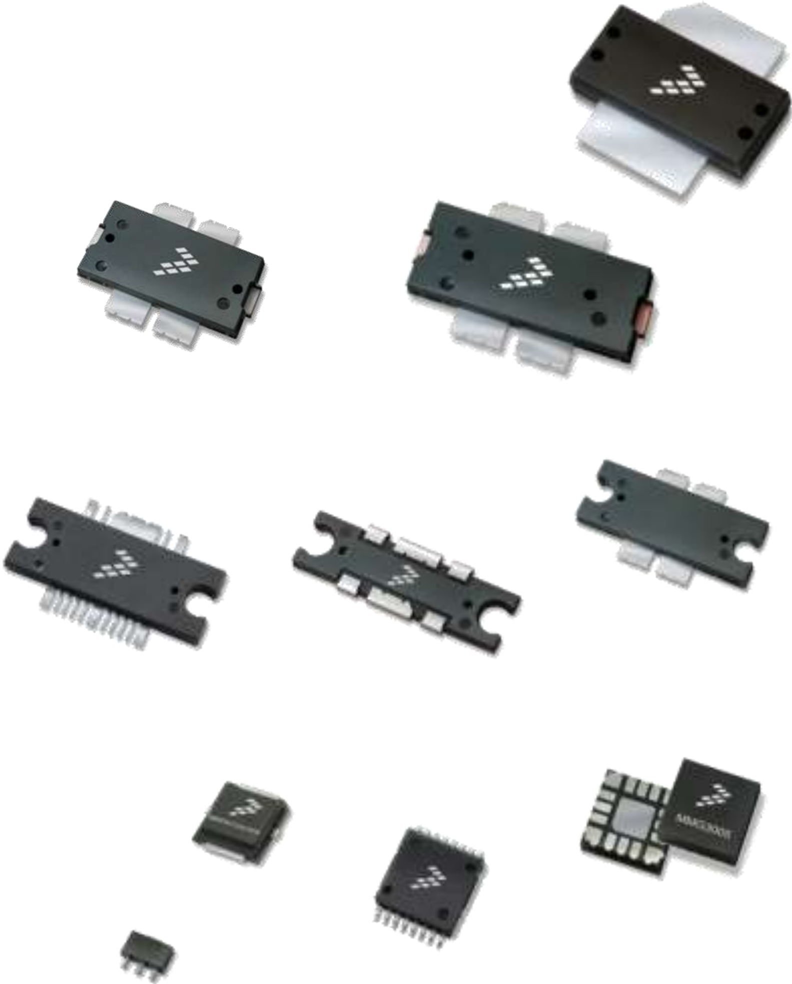
Radio Frequency Power Amplifiers in Plastic



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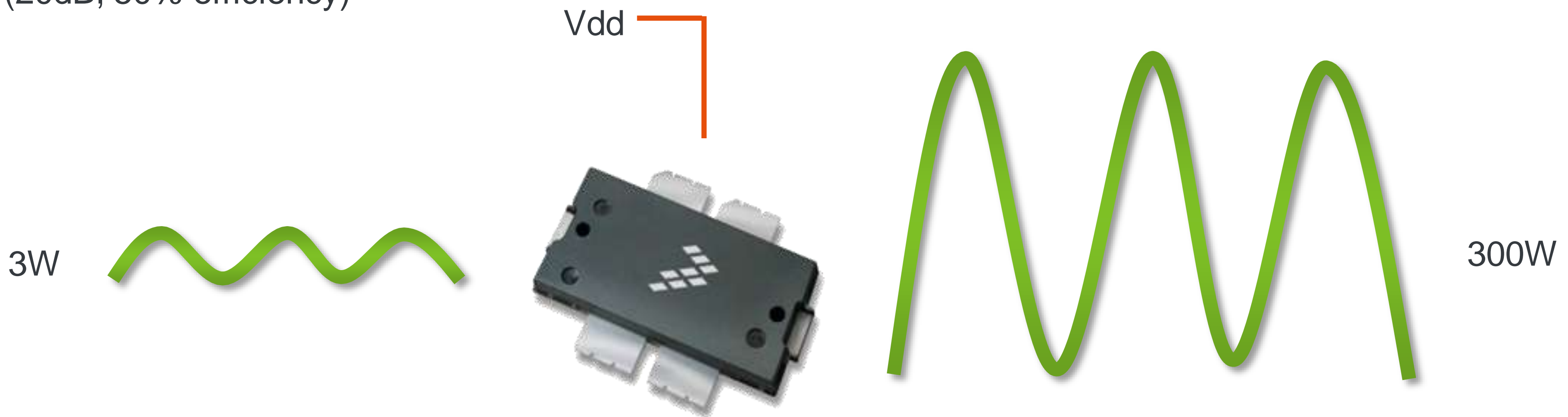
Challenges for RFPA packages

- **High frequency**
- **High output power**

Simplified Example:
(20dB, 50% efficiency)



Need to dissipate ~300W of heat

Plastic Packaging Evolution

Freescale Devices

Before 1990:

Primarily Bipolar device technology

Metal ceramic packages

<1990 — 1991 — 1996 — 2003 — 2007 — 2009 — 2014

1991: 28V LDMOS technology introduced in metal ceramic packages 200ºC Tj

1996: **65W** power (500-700 MHz) TO plastic packages

150ºC Tj

2003: **70W** power (1GHz) TO plastic

30W TO **RFIC** power (1GHz) plastic

200ºC Tj

2007: **120W** power (2GHz) TO Plastic

100W power (2 GHz) TO RFIC

225°C Tj

2009: **200W** power (1GHz) in OM780 plastic package at 225°C Tj

2014: **350W** power (1GHz) in OM780 plastic package at 225°C Tj

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Mold Compound Technology

The mold compound is made mostly of glass/quartz filler and polymer resins.

Transfer molding specifically developed for semiconductor applications.

Uses thermoset mold compound. Under temperature and pressure, this material polymerizes and crosslinks.

Once cured, thermoset compounds are very stable dimensionally over their operating temperature range.

Moisture Sensitivity

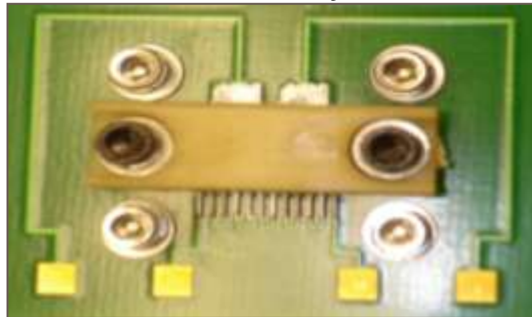
- All plastics absorb and retain some **moisture**.
- During solder reflow assembly operation, the moisture inside the package can induce stress, potentially leading to failures.
- Susceptibility of packaged device to moisture-induced stress is properly measured and classified under MSL rating, established by Standards Organizations: IPC, JEDEC under EIA. (JEDEC Standard J-STD-20B)
- MSL classifications of a part when properly followed (packaging for shipment, storing, and handling) avoids any thermo-mechanical damage during assembly, solder reflow and repair operation.
- Freescale Plastic Packages are MSL 3 rated at 260°C reflow capable

MSL levels:
MSL 6 – Mandatory Bake before use
MSL 5A – 24 hours
MSL 5 – 48 hours
MSL 4 – 72 hours
MSL 3 – 168 hours (1 week)
MSL 2A – 4 weeks
MSL 2 – 1 year
MSL 1 – Unlimited

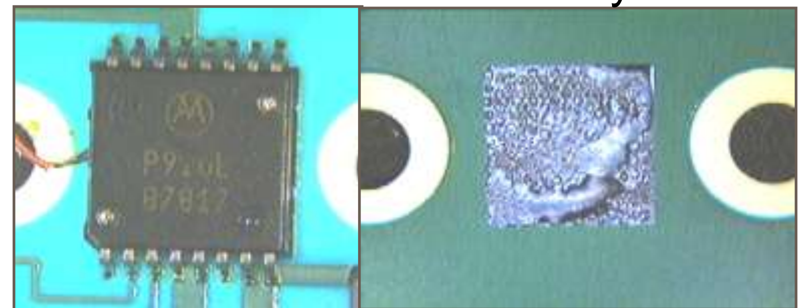
Four Different Ways of Mounting RFPA Devices

Bolt Down: Air-Cavity Ceramic only

Reflow in a Cavity



Clamped

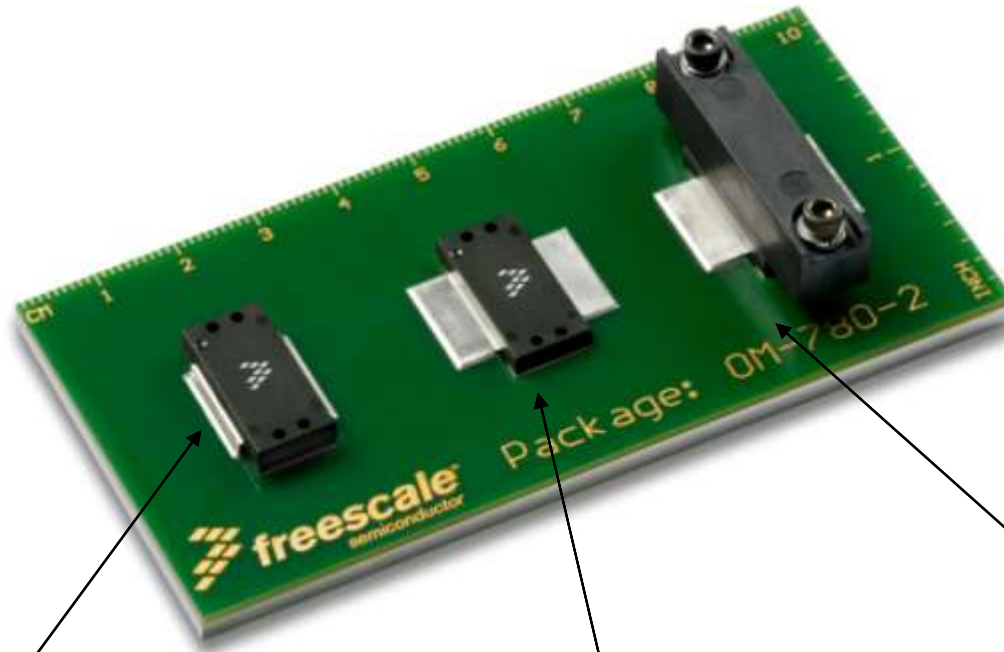


Surface Mount

- Manual Operation
- Handling of multiple of piece parts
- Source Impedance degradation
- Ease of Repair & Rework

- Integrated with rest of PA assembly
- Good electrical & thermal grounding
- Improved performance & reliability
- **Preferred Method in the Industry**

Three Possible way to Mount an Plastic Package



Gull Wing device Surface Mounted on top of PCB

Soldered into the Cavity of the PCB with Coin or Pallet

Clamped into the Heat Sink with opening in the PCB

RF Packaging Leadership

- Freescale has been the market leader in high power RFPA for over 25 years. Freescale has shipped to it customers:
  - ~ 500 million RFPA devices
  - ~ 200 million plastic RFPA devices
  - > 100 million plastic TO RFPA devices
  - ~ 4 million OMNI RFPAs shipped for 5 years

- Based on the FIT numbers & actual field return data, FSL's RFPA LDMOS devices in **both metal-ceramic and plastic packages have similar reliability.**

Thank You.

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