Technical Whitepaper | Estimation of Induced Current on Wire Bonding Under EMP via Antenna Effect

1. Introduction

Wire bonding in electronic packaging acts as an unintended antenna under Electromagnetic Pulse (EMP) exposure, inducing harmful voltages and currents. This paper provides formulas and methods to estimate such effects under various EMP strengths.

2. Antenna Effect and EMP

Wire bonding behaves like a dipole antenna under EMP, where induced current depends on:

- Wire length (L)
- Wire diameter (d)
- EMP frequency spectrum (up to GHz)
- Electric field strength (E in V/m)
- Load impedance (Z ~50Ω)

3. Induced Voltage and Current Formulas

Induced Voltage: $V_{induced} = E \times L$

Induced Current: $I_{induced} = V_{induced} / Z$

4. EMP Field Strength Reference

EMP sources vary in electric field strength and duration:

- Nuclear EMP (HEMP): ~50 kV/m, <100 nanoseconds (ns).
- Non-nuclear EMP: ~10 kV/m, lasting up to several microseconds (μs).
- High Power Microwave (HPM): 1kV/m to 100kV/m, durations from nanoseconds to microseconds.

5. Example Calculation

Assuming wire length = 3mm, EMP strength = 50kV/m, impedance = 50Ω:

V_induced = 50,000 V/m × 0.003 m = 150 V

I_induced = 150 V / 50Ω = 3 A
Such current levels can melt wires or damage ICs.

6. Flip Chip vs Wire Bonding

• Wire Bonding: 1-5mm length, susceptible to induced current.
• Flip Chip: Connection length ~tens of microns, minimal induction.
• Flip Chip offers intrinsic EMP resistance.

7. Conclusion

Estimating EMP-induced currents on wire bonding is vital for defense, nuclear, and aerospace electronics. Flip Chip packaging is the optimal solution for EMP resilience.