Return Paths and Power Supply Decoupling

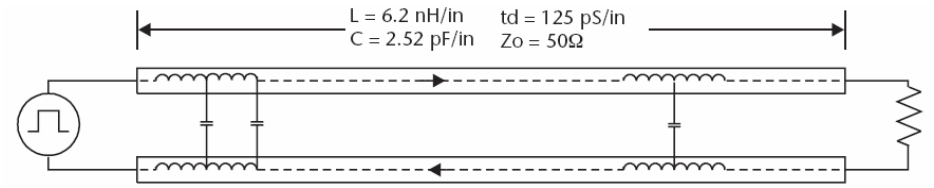
Dr. José Ernesto Rayas Sánchez

Outline

- Ideal return paths
- Microstrip return paths
- Stripline return paths
- Modeling metallic reference planes
- Power supply bypassing
- Ground bounce and SSN

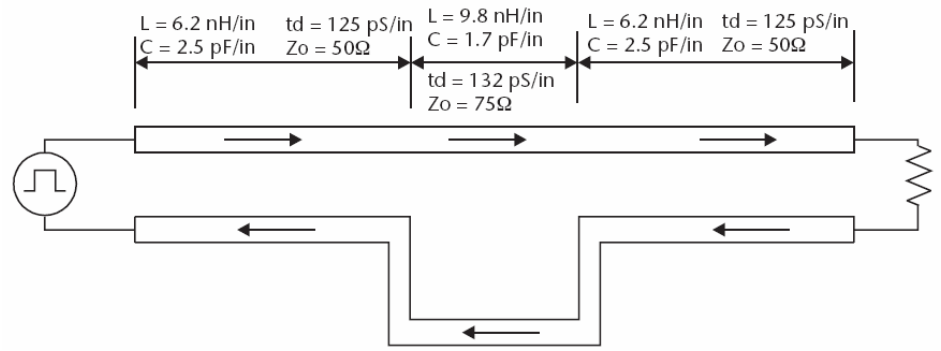
Dr. J. E. Rayas Sánchez
http://iteso.mx/~erayas erayas@iteso.mx

Ideal Return Path



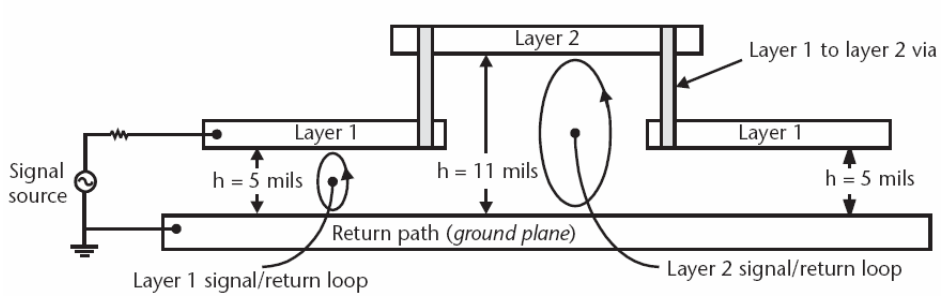
 (S. C. Thierauf, High-Speed Circuit Board Signal Integrity, Artech, 2004)

Return Path with a Discontinuity



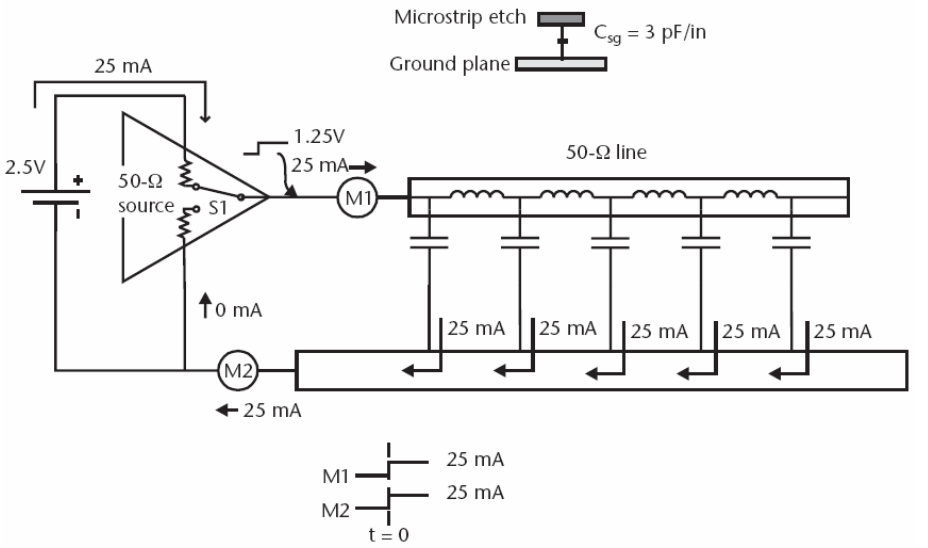
 (S. C. Thierauf, High-Speed Circuit Board Signal Integrity, Artech, 2004)

Discontinuity in the Signal Path



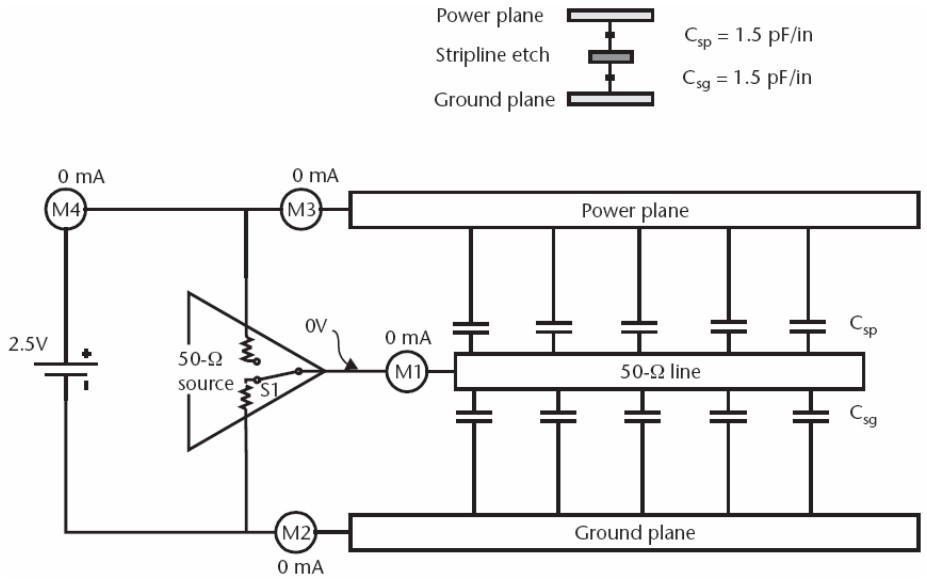
 (S. C. Thierauf, High-Speed Circuit Board Signal Integrity, Artech, 2004)

Microstrip Return Path



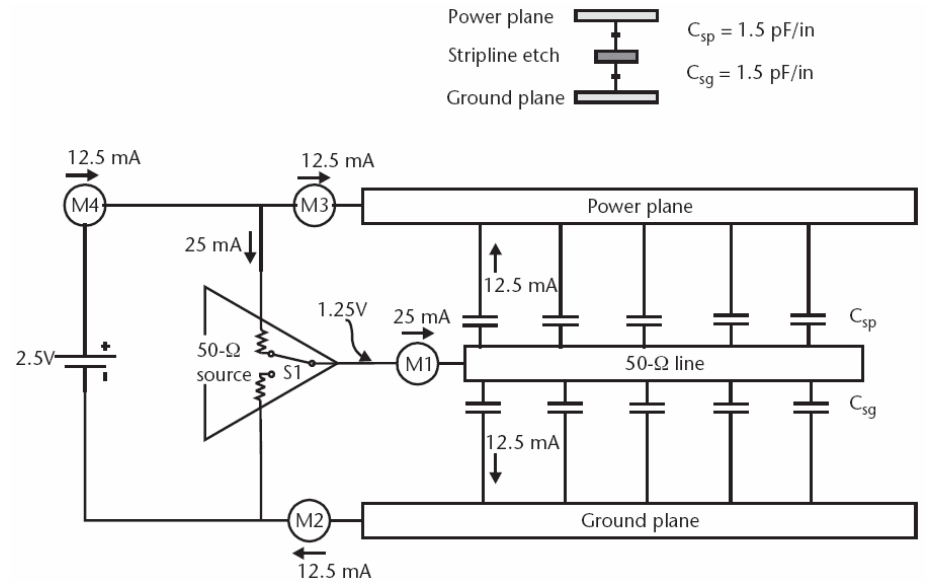
 (S. C. Thierauf, High-Speed Circuit Board Signal Integrity, Artech, 2004)

Stripline Return Path (Off – Steady State)



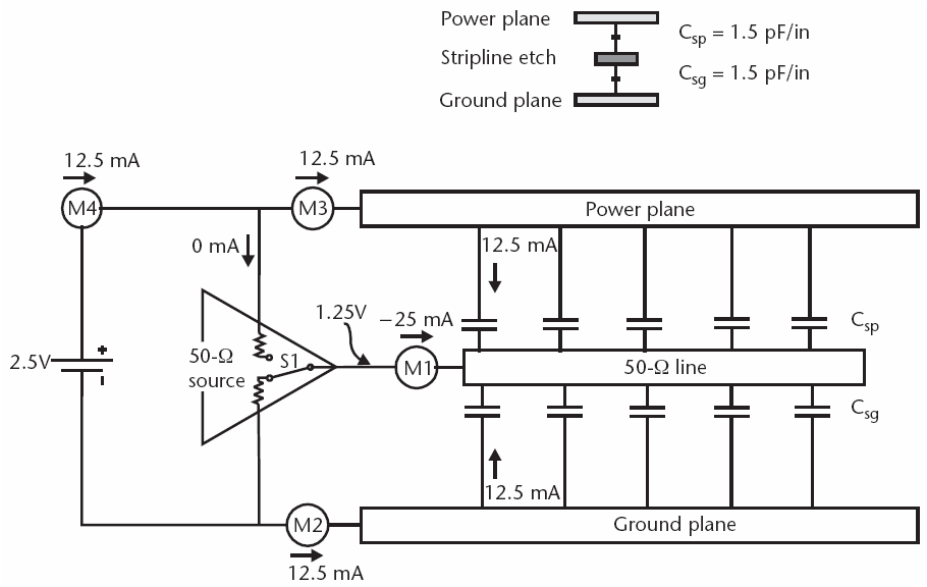
 (S. C. Thierauf, High-Speed Circuit Board Signal Integrity, Artech, 2004)

Stripline Return Path (Turn On)



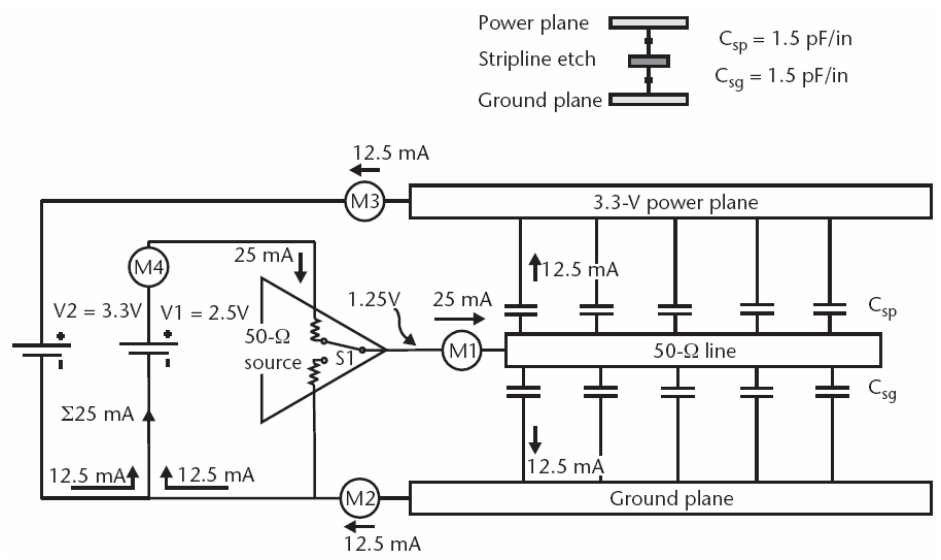
 (S. C. Thierauf, High-Speed Circuit Board Signal Integrity, Artech, 2004)

Stripline Return Path (Turn Off)



 (S. C. Thierauf, High-Speed Circuit Board Signal Integrity, Artech, 2004)

Stripline with Unrelated Power Plane (Turn On)

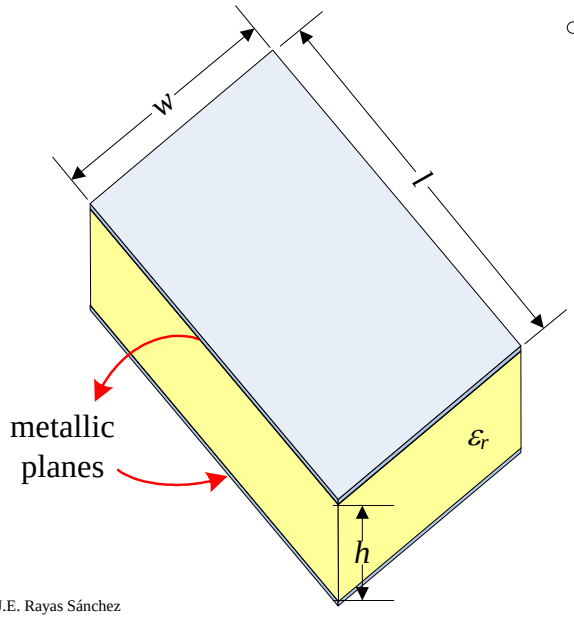


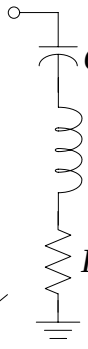
 (S. C. Thierauf, High-Speed Circuit Board Signal Integrity, Artech, 2004)

Return Paths

- The return paths in microstrips are very different to those in striplines
- For striplines, the current distribution in the two reference metallic planes can be very different
- Usually, the return path is considered as an ideal short circuit. However, any parasitic inductance in the return paths can significantly affect the signal integrity in both the return paths (metallic planes) and the signal trace

Modeling the Metallic Reference Planes





$$R_{plane} \approx \rho \frac{l}{tw}$$

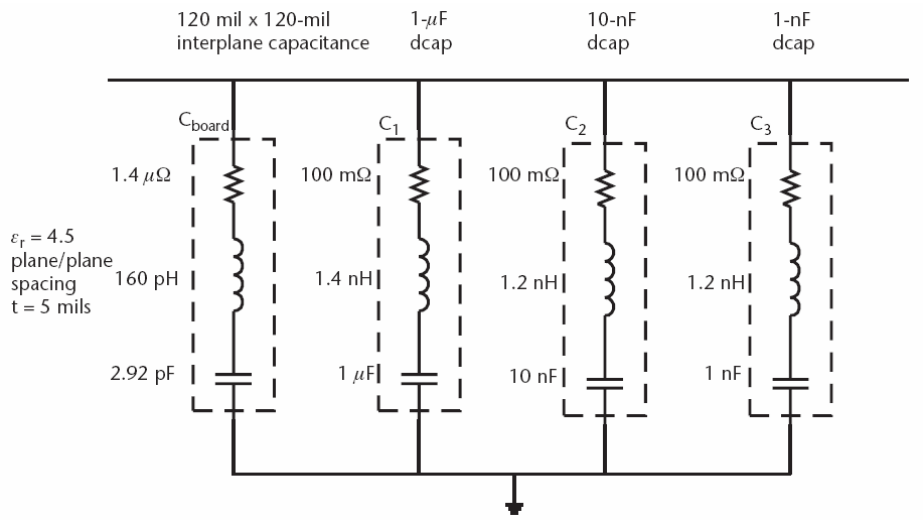
$$C_{plane} \approx \varepsilon_r \varepsilon_o \frac{lw}{h}$$

$$L_{plane} \approx \mu_r \mu_o \frac{hl}{w}$$

Using Decoupling Capacitors

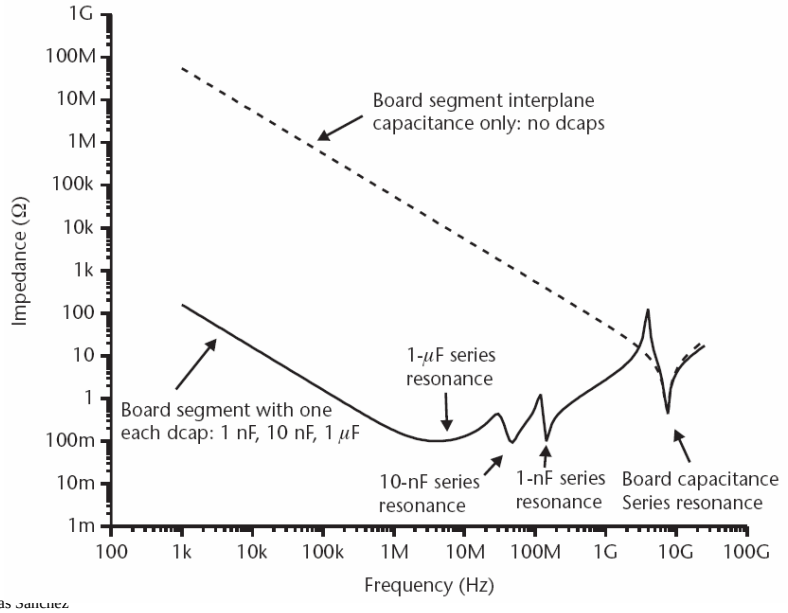
- Ideally, the metallic reference planes should be pure short circuits at the signal frequency range
- The metallic reference planes essentially behave as capacitors
- Decoupling capacitors are used to lower the metallic planes impedance at the frequency of interest

Using Decoupling Capacitors – Example

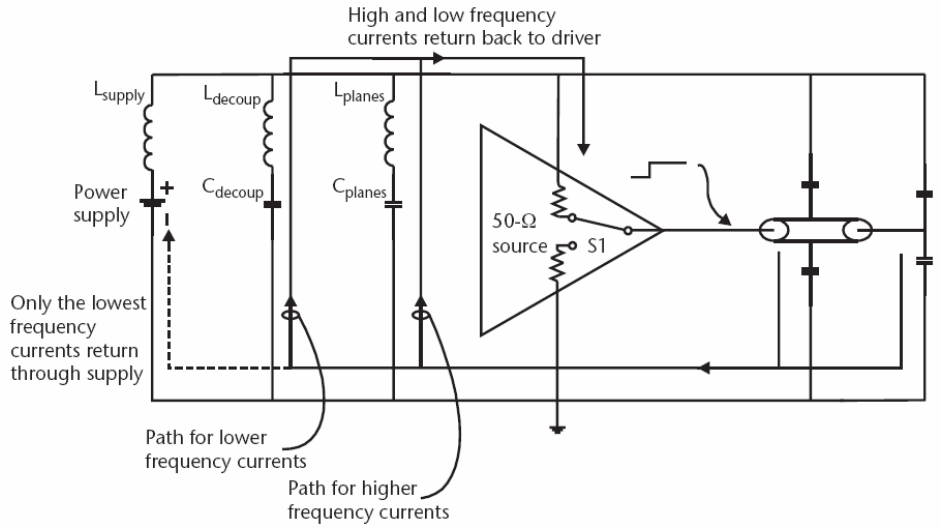


(S. C. Thierauf, High-Speed Circuit Board Signal Integrity, Artech, 2004)

Using Decoupling Capacitors – Example (cont)



Power Supply Inductance



(S. C. Thierauf, High-Speed Circuit Board Signal Integrity, Artech, 2004)

Ground Bounce

- Ground bounce refers to a change in the reference voltage caused by switching currents in the return paths
- It is also called “Simultaneous Switching Noise (SSN)” or “Delta-I Noise”
- It is mainly produced by the parasitic inductance in the return path
- The problem gets worse in digital systems when many drivers are switching simultaneously