



Laboratory Exercise #20

Building and Testing a High-Frequency Low-Pass Filter

Objective: To build a simple low-pass filter that has less than 3 dB of attenuation at frequencies below 50 MHz and more than 20 dB of attenuation at frequencies in the 500 – 3,000 MHz range.

Equipment:

- Vector Network Analyzer
- Two SMA cables
- Two N-type to SMA adapters
- Copper tape, utility knives, solder and solder station
- One filter kit, including:
 - Two SMA board-edge connectors
 - One 7.5-cm x 7.5-cm copper-clad board
 - One or more surface-mount capacitors (available values: 39, 47, 56, 68, 120, 150, 180 pF)

Background: I/O lines often comprise one part of the unintentional antenna in radiated EMI problems. The I/O lines are often filtered before being routed off the PCB to reduce noise that would otherwise be conducted off the board. Often this filter consists of a single capacitor.

However, physically implementing the filter provides some significant obstacles. Fabrication typically limits the distance between a capacitor and the signal conductor or reference conductor. The physical distance results in a parasitic inductance. The equivalent circuit for a filtering capacitor is basically an inductor in series with the capacitor. Beyond the series resonance of the equivalent circuit, the filter response begins increasing with frequency.

Procedure: Build a single-layer low-pass filter circuit. The circuit should provide more than 20 dB of attenuation at frequencies above 500 MHz (up to 3 GHz), but less than 3 dB of attenuation at frequencies below 40 MHz when connected to a 50-ohm source and a 50-ohm load.

- (a) Using a utility knife, cut away unwanted copper from one side of the 7.5-cm x 7.5-cm copper-clad board.
- (b) Solder the SMA probes to the board. **Each probe should extend no more than 2.5 cm in from the edge.**
- (c) Solder your components to the board. **Components cannot be closer than 1 cm to a probe. Probes cannot be closer than 5 cm to each other.**
- (d) Measure the insertion loss using the network analyzer from 0 to 3 GHz.
- (e) Repeat steps (a)-(d) if necessary to meet requirements. (You can use the other side of the board.)

Reporting: Your report should include a plot of your results plus any calculations, sketches, photos, or other material describing your design and your design methodology. Designs that meet the specifications at the lowest cost are best, although credit will be given for particularly unique or clever designs. Your write-up should not exceed 2 pages.

Please wear the wrist strap while using the network analyzer!