

An Investigation of Crosstalk
on the
Rapid Transfer BPM
Analog Transition Module
PC Board

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Acknowledgements

Thanks to :

Carl Seifrid

John Van Bogaert

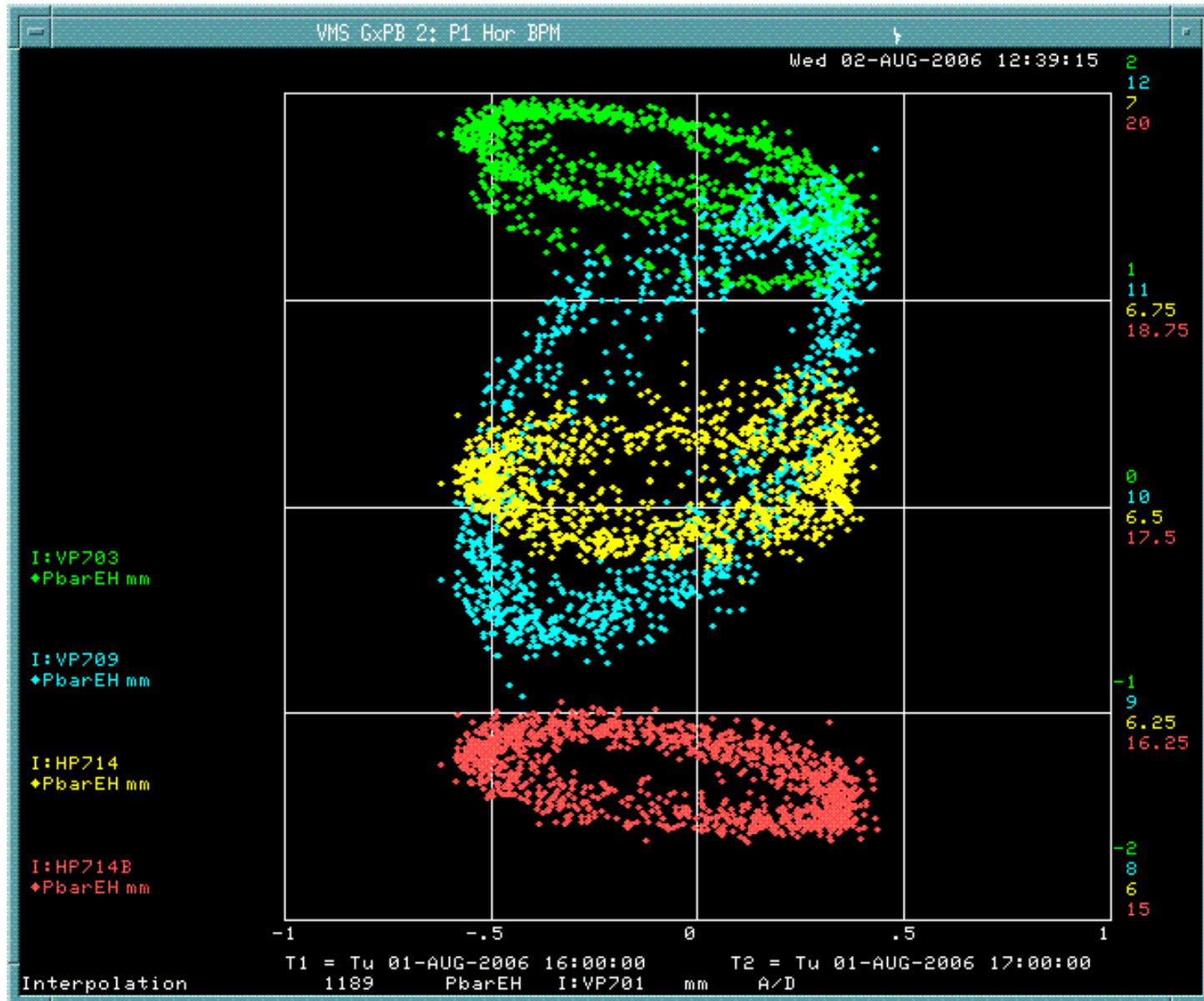
Bob Dysert

Peter Prieto

Bob Webber

Nathan Eddy

The Problem



Some Clues

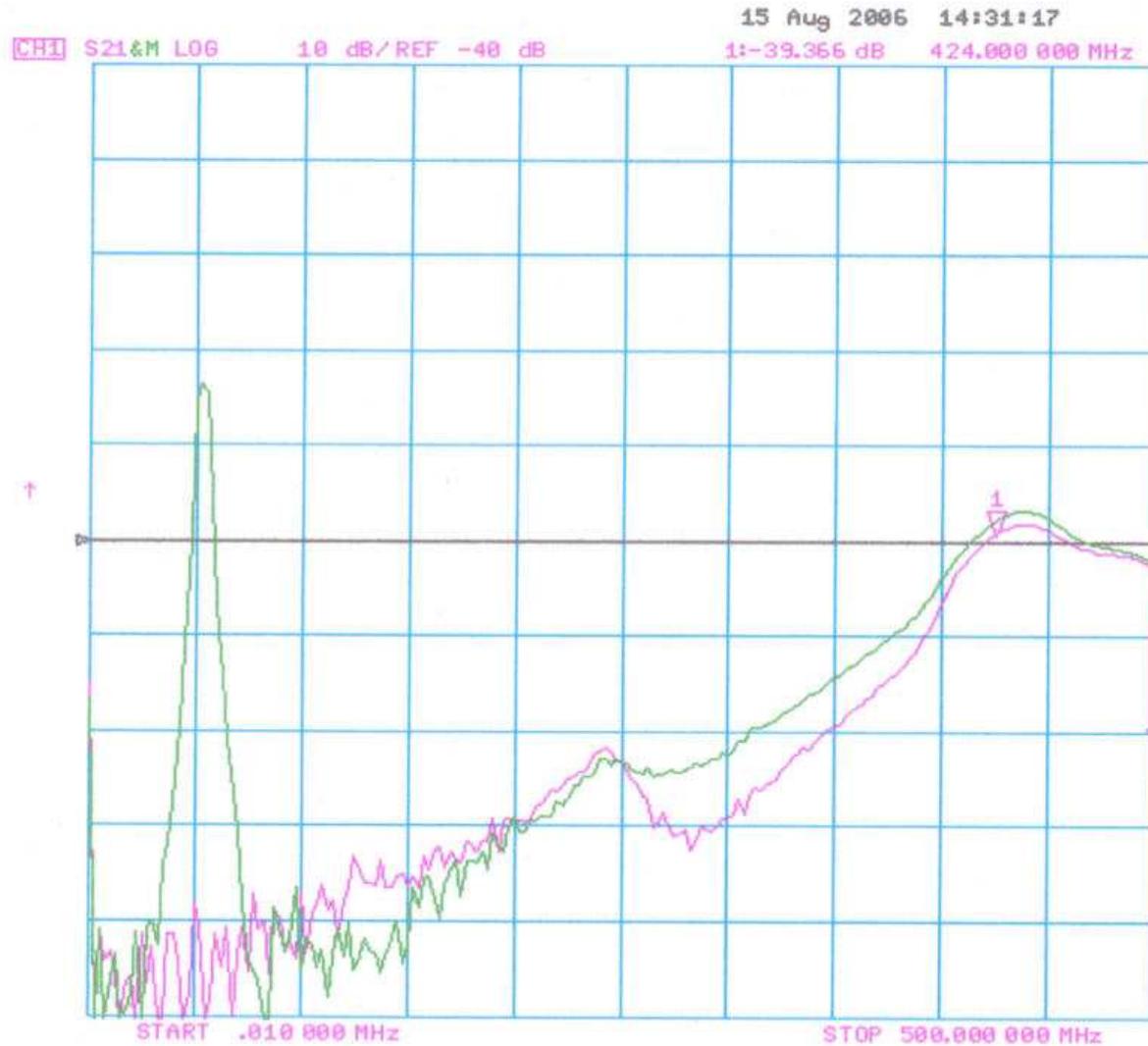
Beam signals after the Analog Transition card (53 MHz bandpass filtering) had

1. Strong 53 MHz
2. -40 dB 106 MHz
3. Weak 159
4. Some 212
5. Even more 265 and so on...
6. Strong 424 MHz!

More Clues

- Splitting one beam signal four ways into BPM also produced ellipses.
- Splitting one Arbitrary Waveform Generator signal four ways into BPM did not produce ellipses.
- Adding low pass filters to beam signals eliminated ellipses.

Frequency Response Measurement



Transition Board S21 showing desired channel and isolation to adjacent channel.

Green = A1 In to A1 Out
Violet = A1 In to B1 Out

More Tests

- The EchoTek board is sensitive to 424 MHz

ADC Counts:

Noise (No input) = 5-6

53.1MHz = 1,800

318.6MHz = 50

371MHz = 12

424.8MHz = 260

477.9MHz = 10

- The Transition PC card exhibited coupling from one input channel to all others.
- Coupling was not affected by DC power or relay settings.

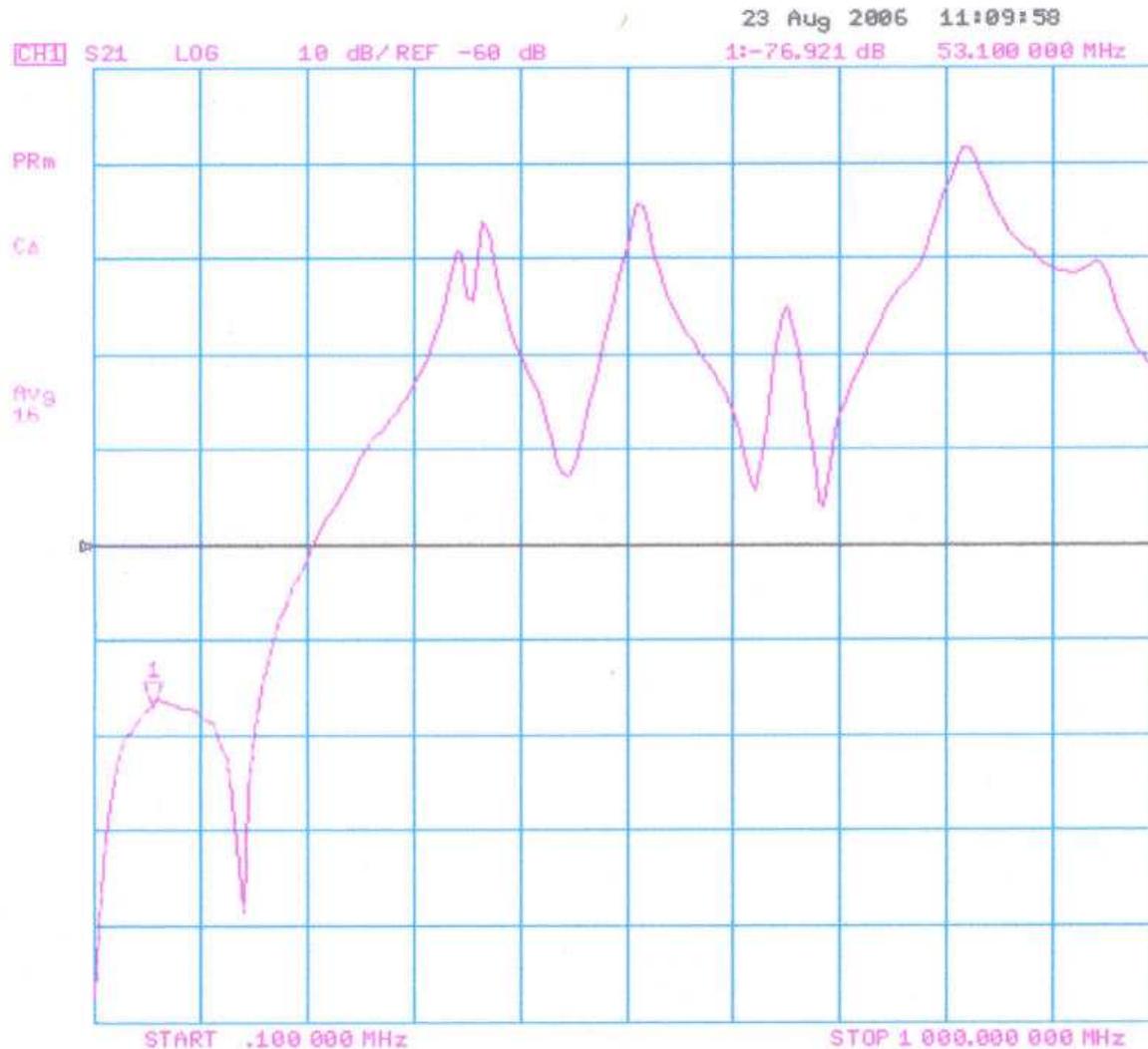
Where? How?

Needless to say, this was quite mysterious.

Since a bare prototype board was available it was decided to start with the SMB connectors and add components until the crosstalk was observed.

It didn't take long.

Only SMB Connectors on the board



ED-417048
PROTOTYPE
SMB CONNECTORS
ONLY.
TO CH A1 IN
CH B1 IN

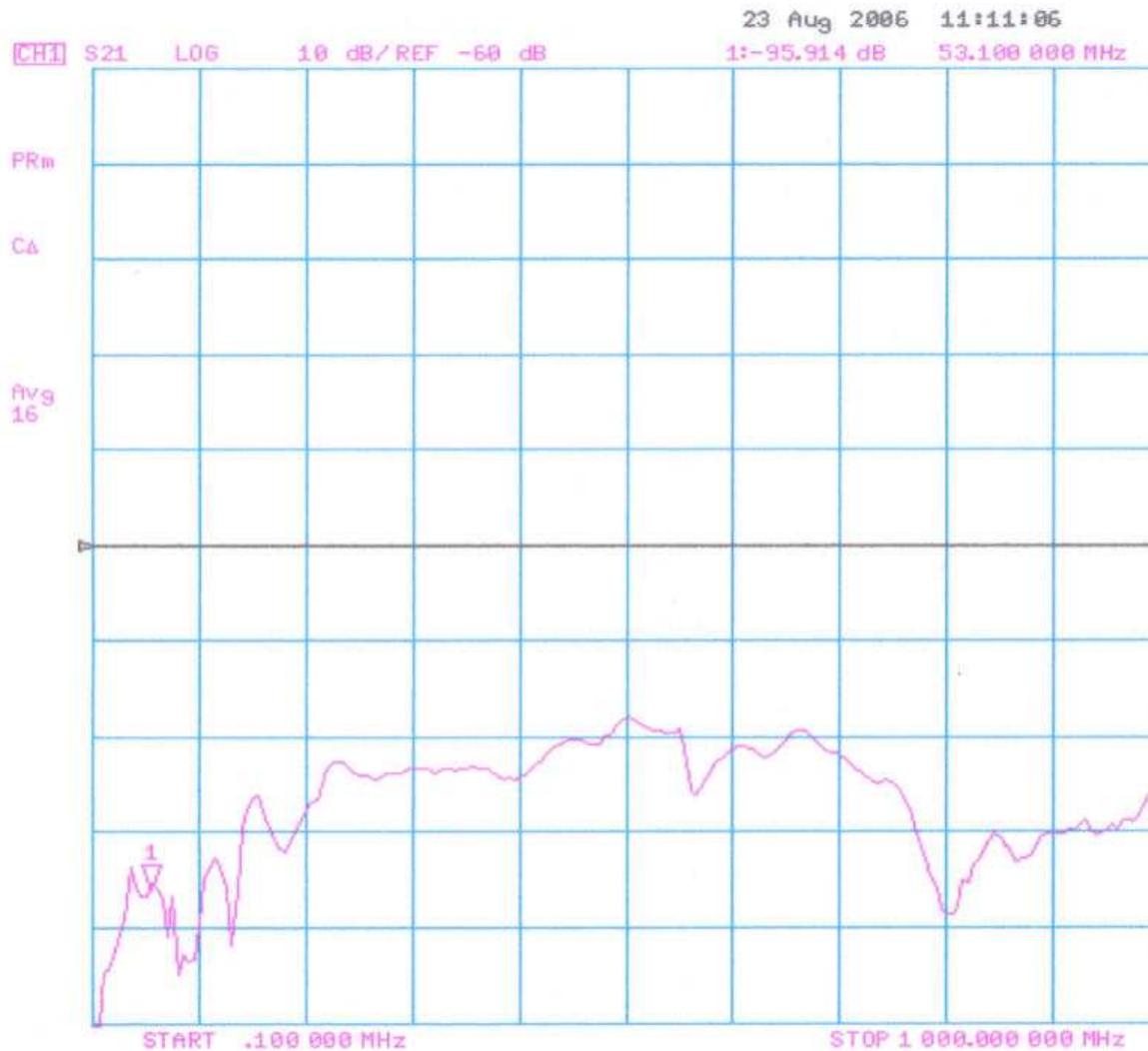
TOP
-5 V
⋮
GND
BOTTOM

D. PETERSON

Did I miss something?

Just to make sure RF fundamentals haven't changed, I put two SMB connectors on a simple test board with microstrip lines and the same spacing as on the Transition card.

Simple Test



DOUBLE SIDED
TEST BOARD
SMB CONNECTORS
TO 0.05" X 0.5"
MICROSTRIP
SAME SPACING AS
ED-417048

D. PETERSON

Why the Difference?

The simple test board only has signal and ground planes.

The Transition Card has 6 layers:

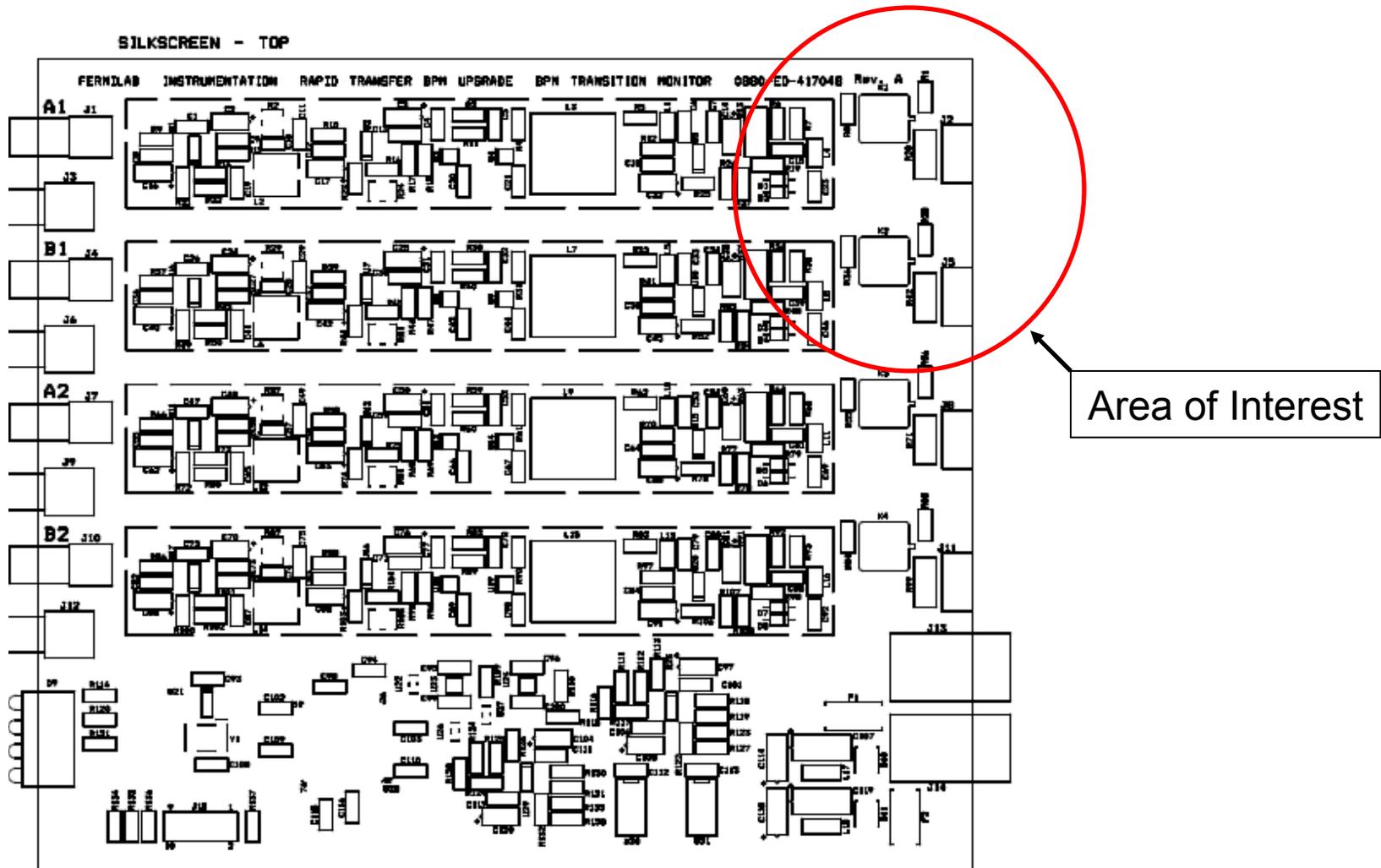
- 1) Top (signals and some grounding)
- 2) -5 volts (full size of board)
- 3) +5 volts (full size of board)
- 4) Signals
- 5) Ground
- 6) Bottom (some signals, mostly ground)

The ground pads of Top and Bottom all connect to the Ground layer.

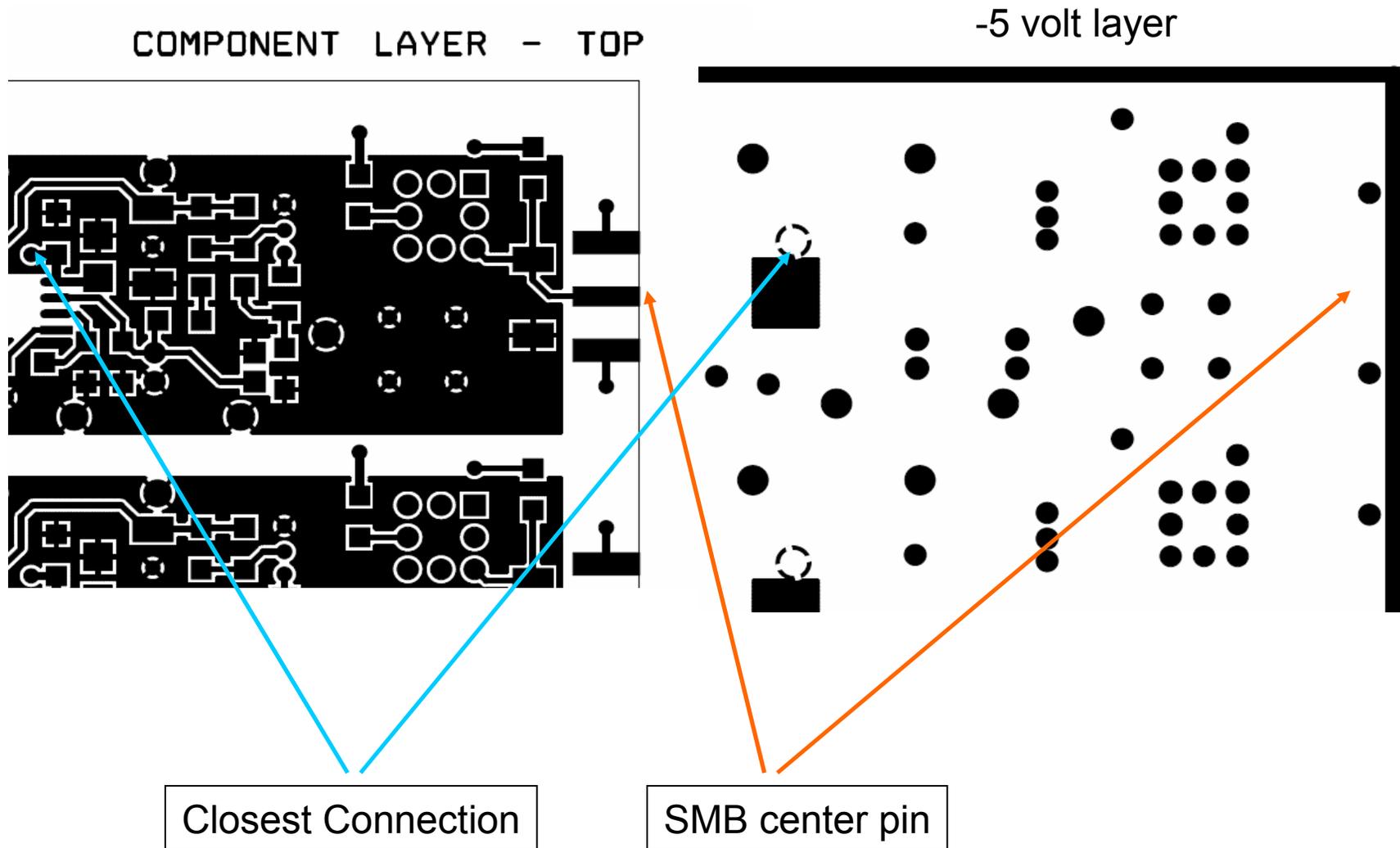
Unfortunately, the -5 volt layer is not bypassed to ground very near the input connectors.

This creates a nice broadside coupled line structure since the -5 volt layer is free to "wave in the breeze".

Board Layout



Board Layers



Recommendations

- Although it is common practice to use power planes as isolation layers, careful attention must be paid to the signal frequencies and return paths.
- A generous number of appropriately placed bypass capacitors might help.
- Better yet, if the design needs a ground plane, use a real ground plane.

Useful Reading

- Thomas P. Van Doren, *Grounding & Shielding of Electronic Systems*, short course notes (although you have to take the course to get the notes or talk to me)
<http://www.emclab.umr.edu/studfac/vandoren.html>
- Paul Horowitz and Winfield Hill, *The Art of Electronics*, 2nd Edition, Cambridge University Press, Chapters 7 & 12.
- Tips for Electronic Printed Circuit Board Design
<http://www.radioing.com/eengineer/pcb-tips.html>