Chemring
Technology Solutions

PCB Breakouts
for Small Form-Factor RF Circuits

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ARMMS RF and Microwave Society
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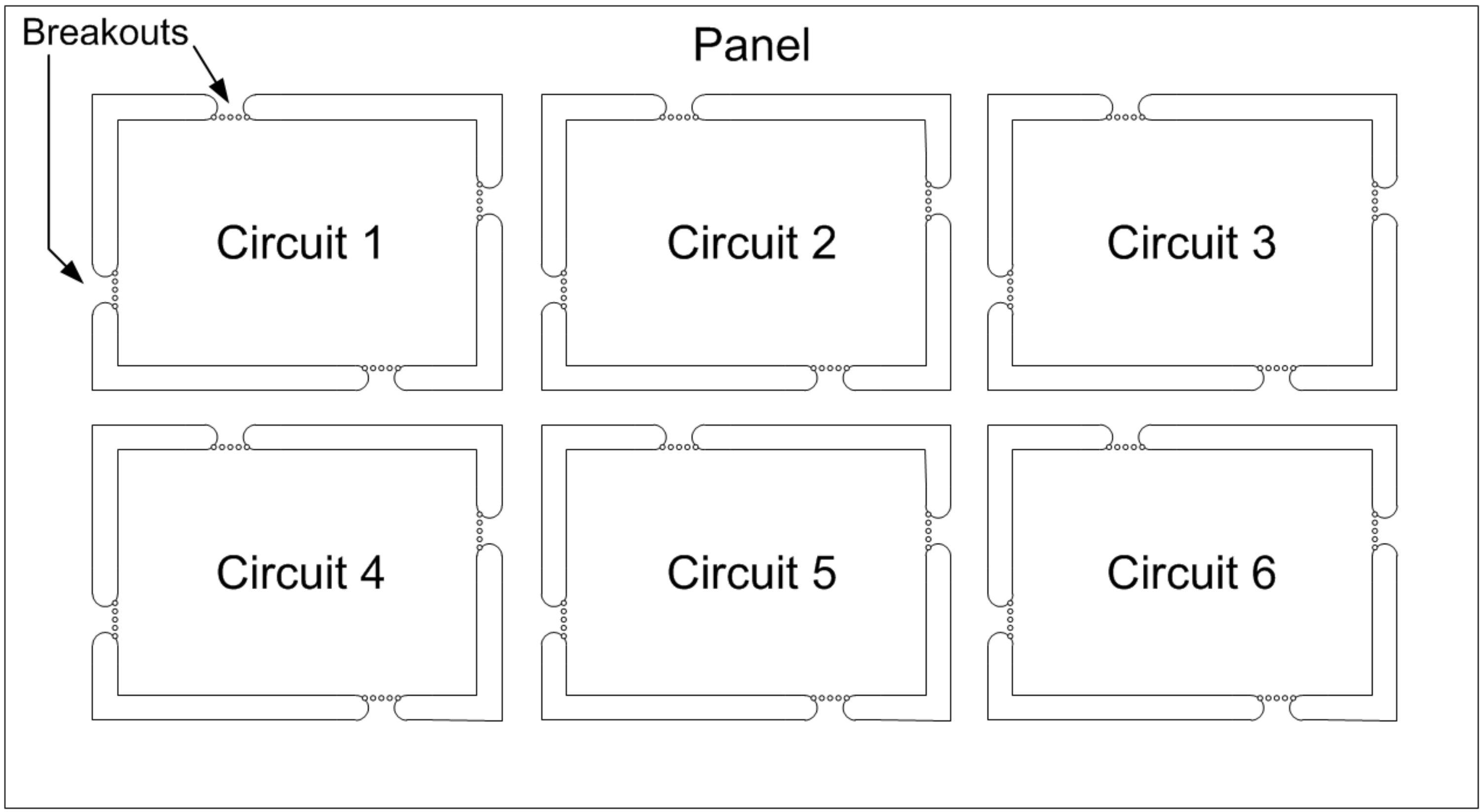
Sensors & Electronics | Countermeasures | Pyrotechnics & Munitions | Energetic Sub-Systems

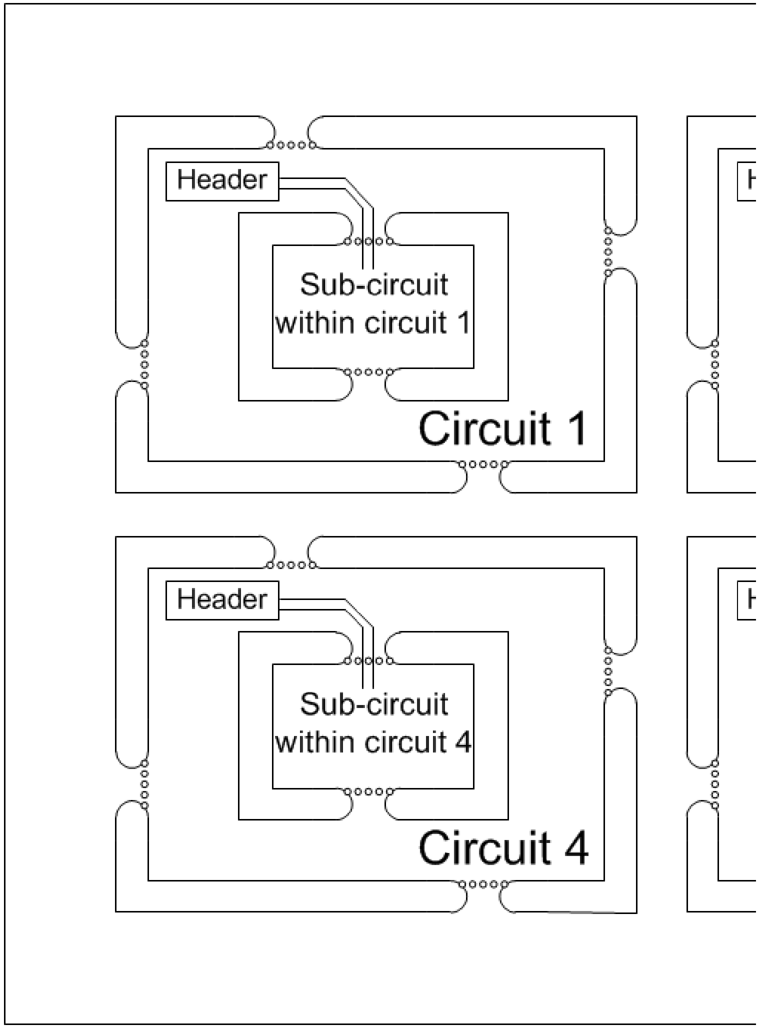
Typical PCB Breakout Usage

- Bare PCB has multiple circuits, stepped and repeated within a panel
- Whole panel assembled with SMT process and circuits broken out prior to use

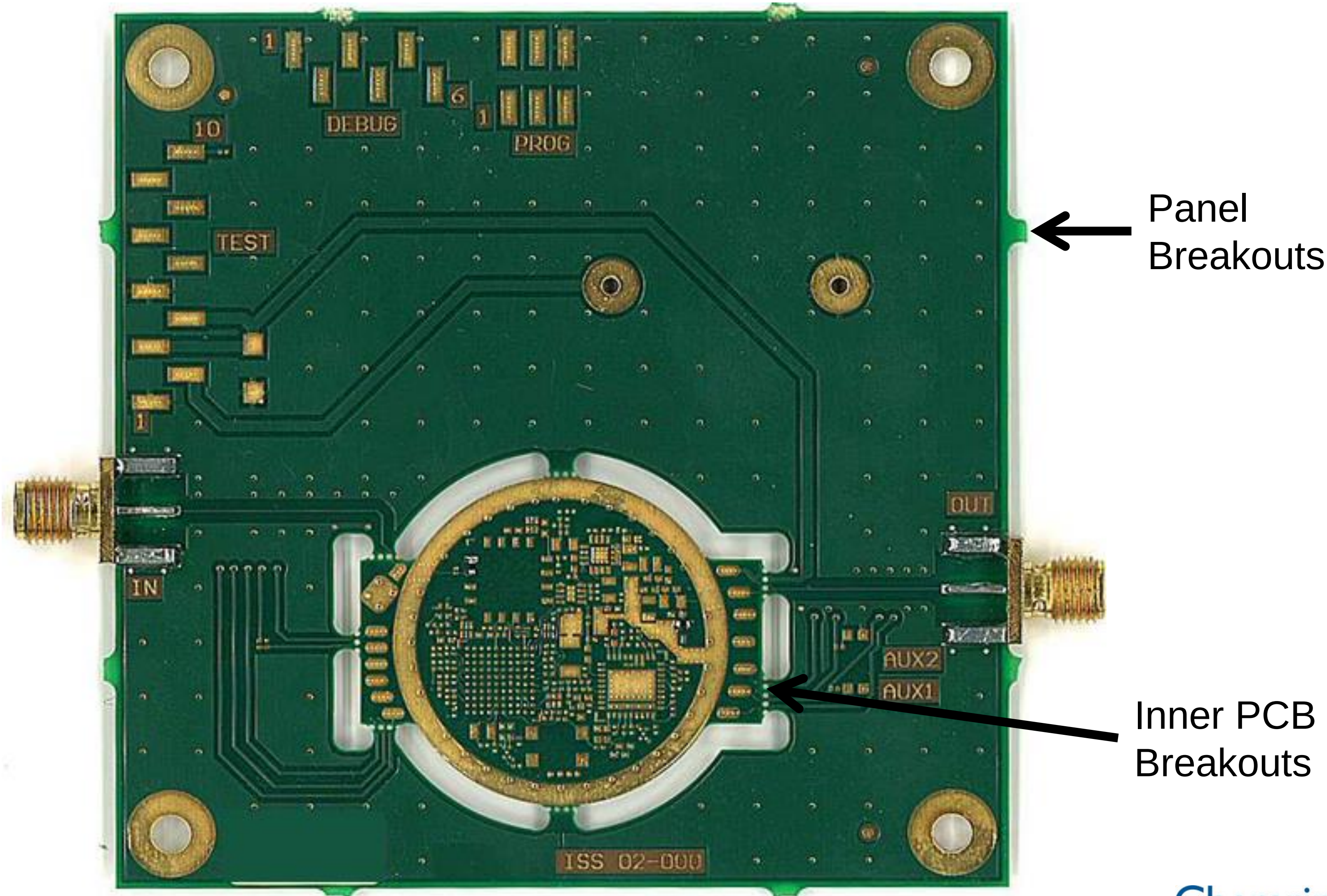


Tracking over the Breakout

- If the breakouts are drilled and not scored, it is possible to route tracks over them
- Still step and repeat, with some additional router cuts and drilling
- Standard PCB production process
- Assemble as normal
- Break each circuit out of the panel after assembly
- Sub-circuits can be left in situ and broken out when required for deployment
- Thin tracks over the breakout are designed to break automatically



PCB Breakout Example



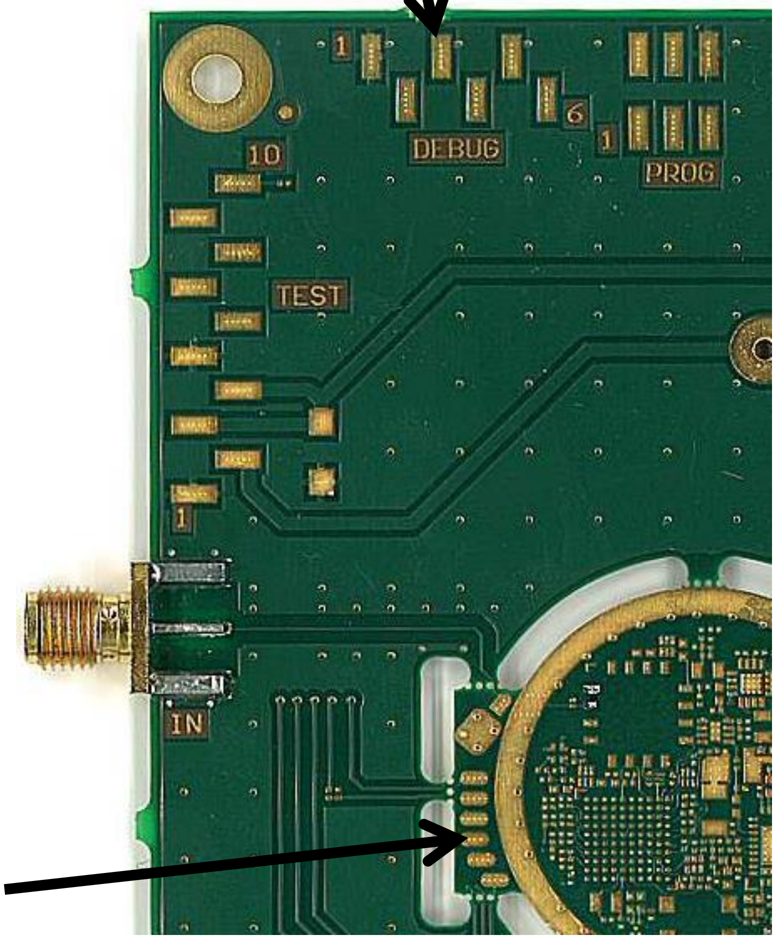
Advantages and Applications of the Technique

- Reduce circuit size without compromising
  - Programmability
  - Testability
  - Functionality
- Reduce design risk
  - Often there is a proof of concept PCB version, then a size reduced version
  - Use 1 PCB iteration to do both at the same time
  - Large reduction in design cycle time for small increase in PCB layout effort
- Applications
  - Early use at Chemring Technology Solutions (Roke) in development work for Siemens Mobile Phones, circa 2001
  - Currently applied to a variety of projects, mostly small and low power RF circuits with specific constraints on size of the final PCB

Programming and Debug

- Concept with motherboard and smaller breakout PCB containing programmable device e.g. microcontroller or FPGA
- Implement 0.1” headers on motherboard
- Use to program devices and for access to serial debug port
- Can implement level shift or USB interface on motherboard if necessary
- Breakout PCB can have pads to allow reprogramming after breaking out, using connecting wires or a bed of nails jig

Header locations



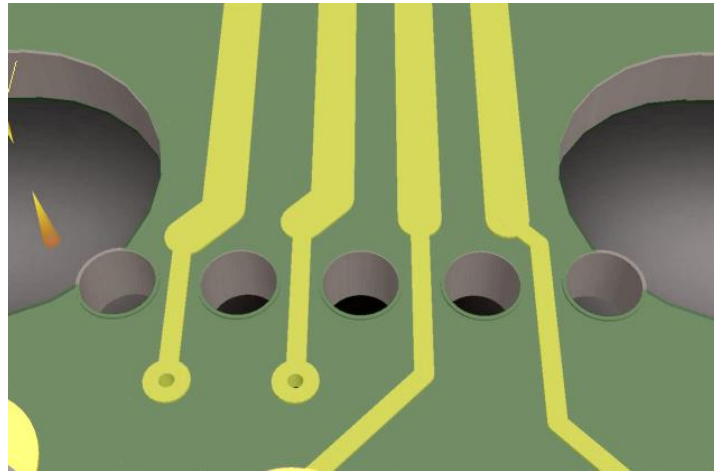
Programming pads

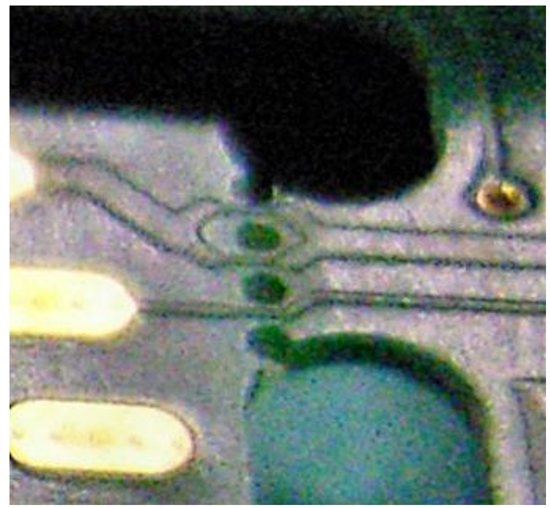
Functionality, Test and Verification

- Increasing use of chip scale packages and BGAs to reduce size
- However larger packages sometimes chosen to improve testability
- Conflicting requirements result in compromise and less functionality for a given PCB area
- Use breakout PCB to implement final size solution, with smallest device packages available. Hidden nodes e.g. under BGA can be tracked to the breakout.
- Bring out any other nodes required for test and some GPIO signals
- Add switches and LEDs to the motherboard to speed up testing – no separate jig!
- Battery holder can be included on motherboard, or a DC connector and regulators
- Space to fit SMA RF connectors without impact on size of breakout PCB
- Can do RF tests without specialised probes e.g. RX sensitivity, TX output power
- Use additional RF test nodes to optimise sub-circuits e.g. RF stripline filters

Design Rules

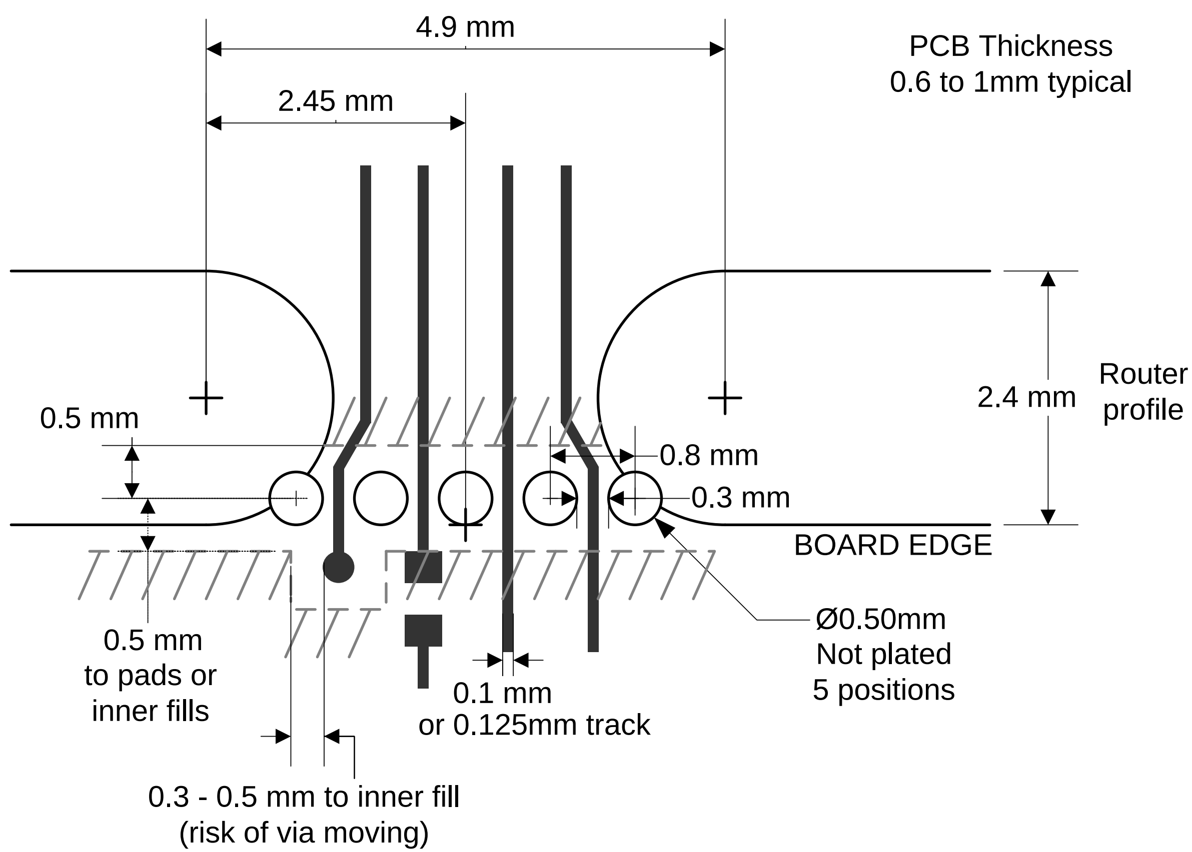
- Best practice is to keep to surface layers to allow inspection after breaking out
- Possible to use internal layer if there is sufficient separation
- Best practice design rules have been developed over a number of projects
- Suitable for signals, power and RF up to 2GHz with care
- Sometimes there are issues with DRC in the CAD tool but these can be overcome
- PCBs made at ACB, Express and Graphic
- Hundreds of PCBs have been produced, and many have been deployed





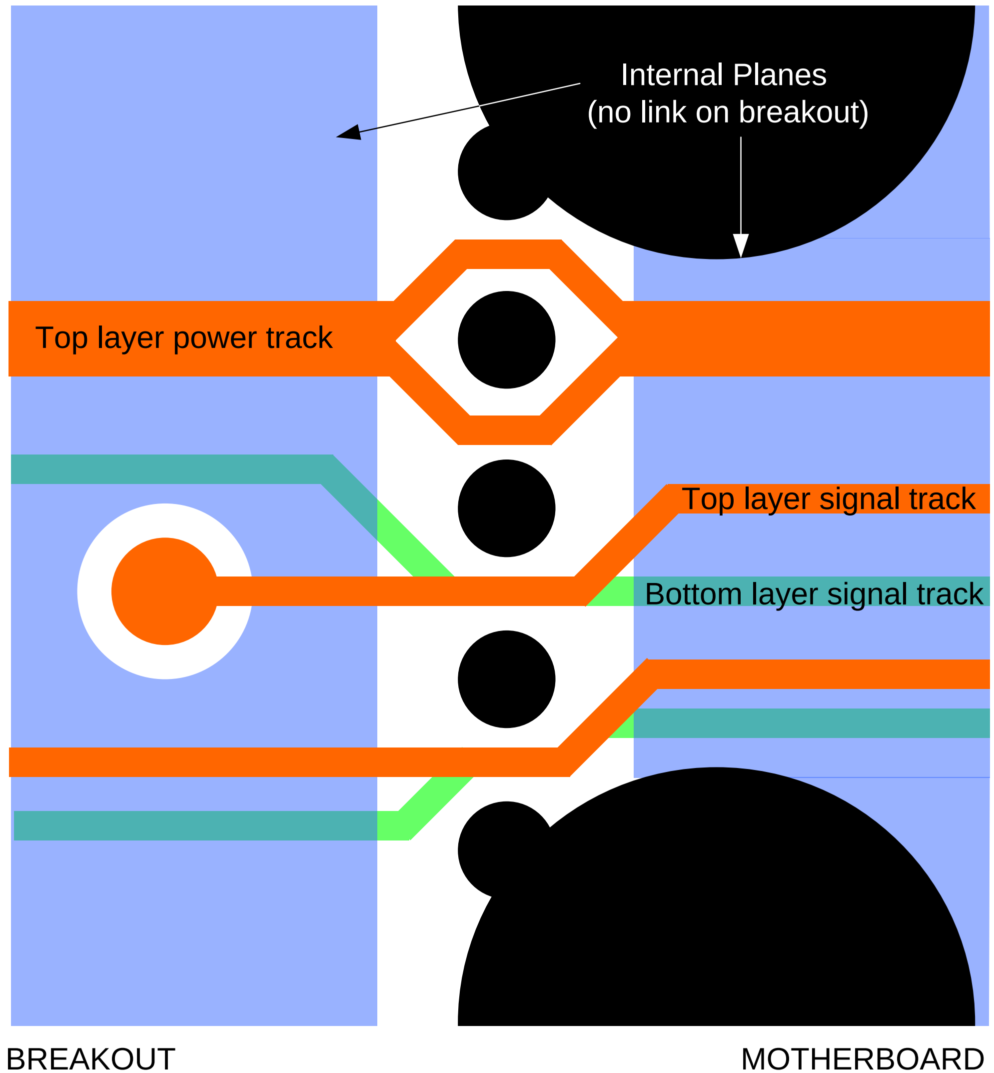
Design Rules

MOTHERBOARD SIDE

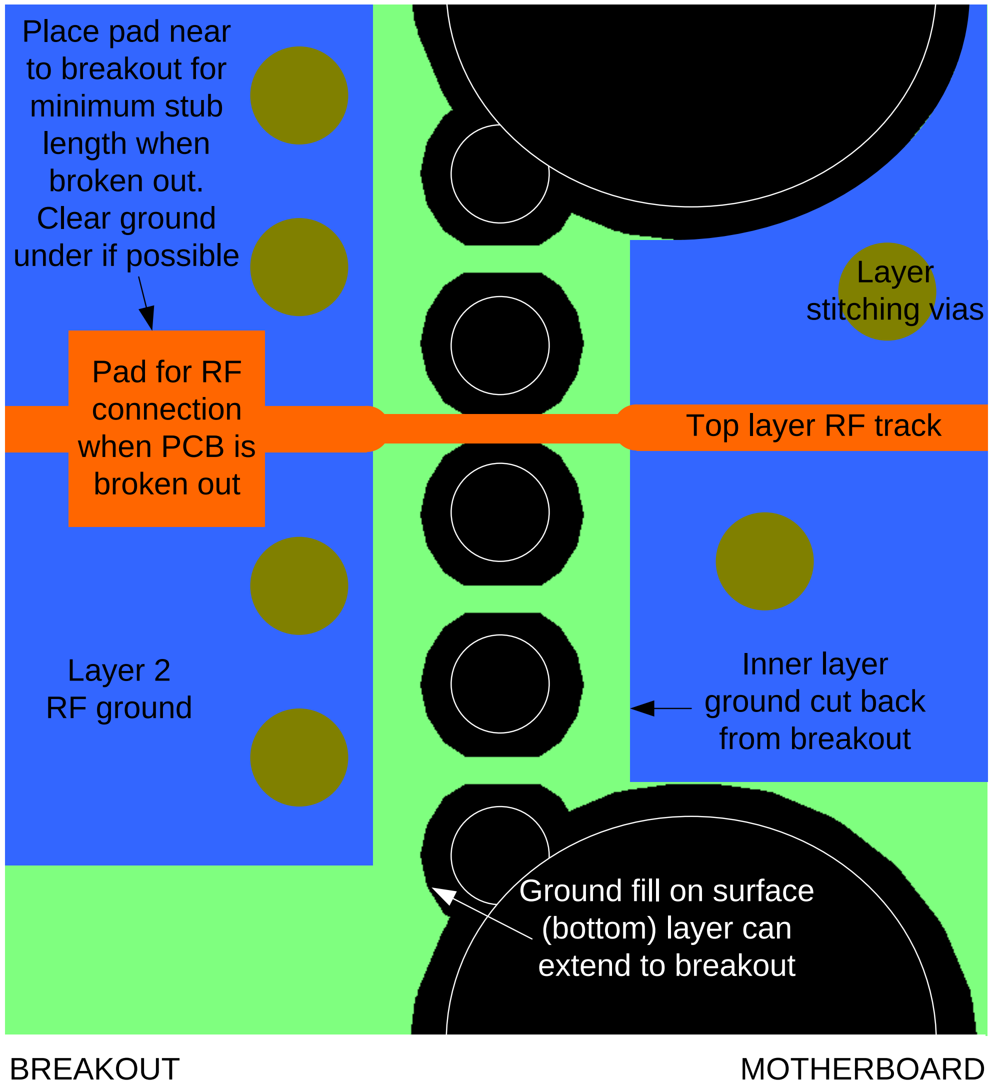


BREAKOUT PCB SIDE

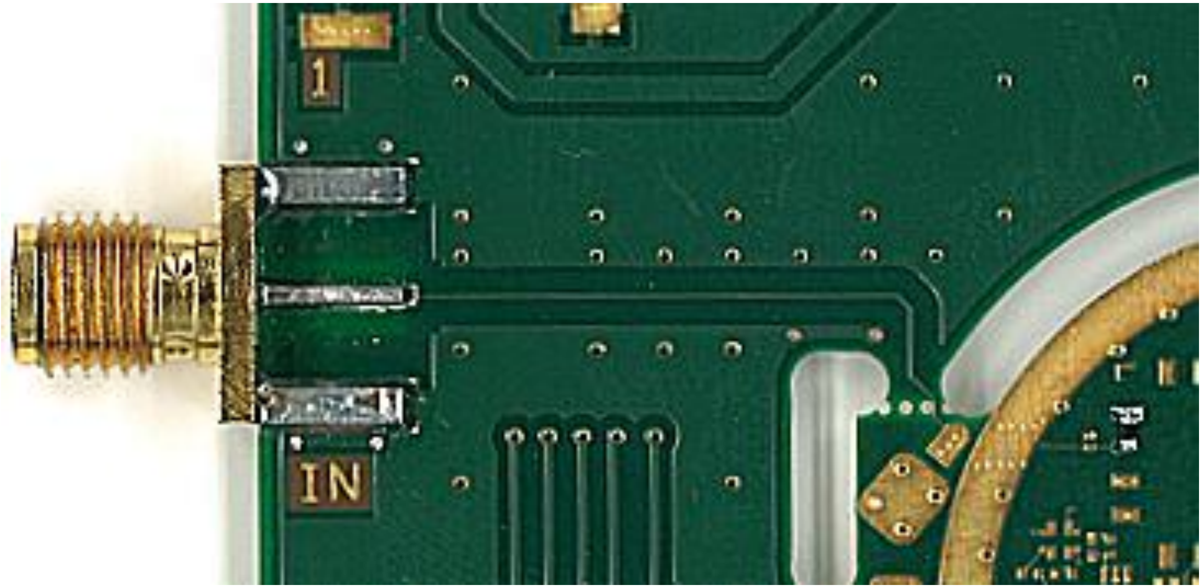
Signal and Power Tracking Example



RF Tracking Example

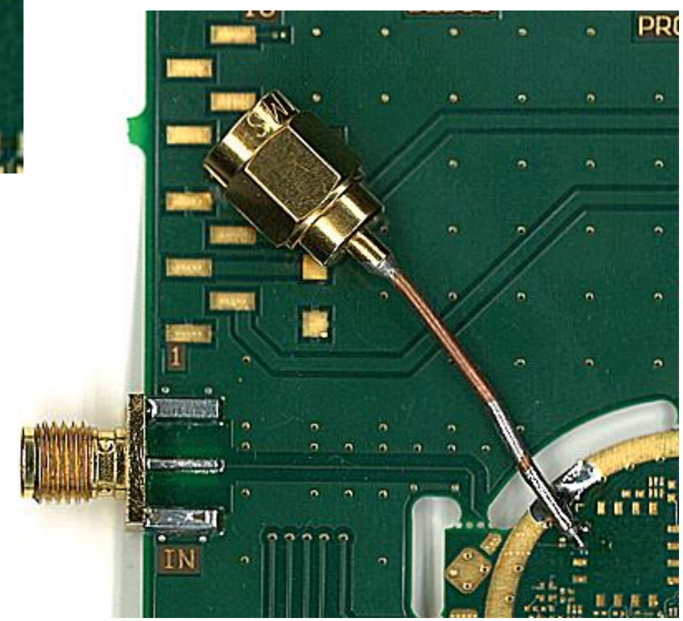


Input Track Measurement

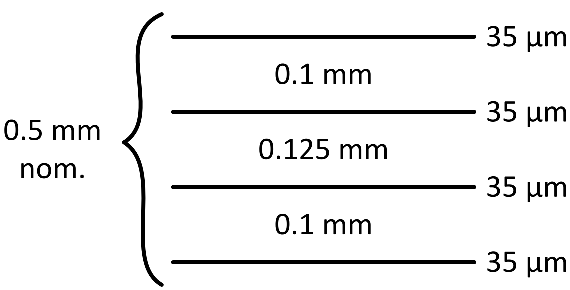


Return Loss

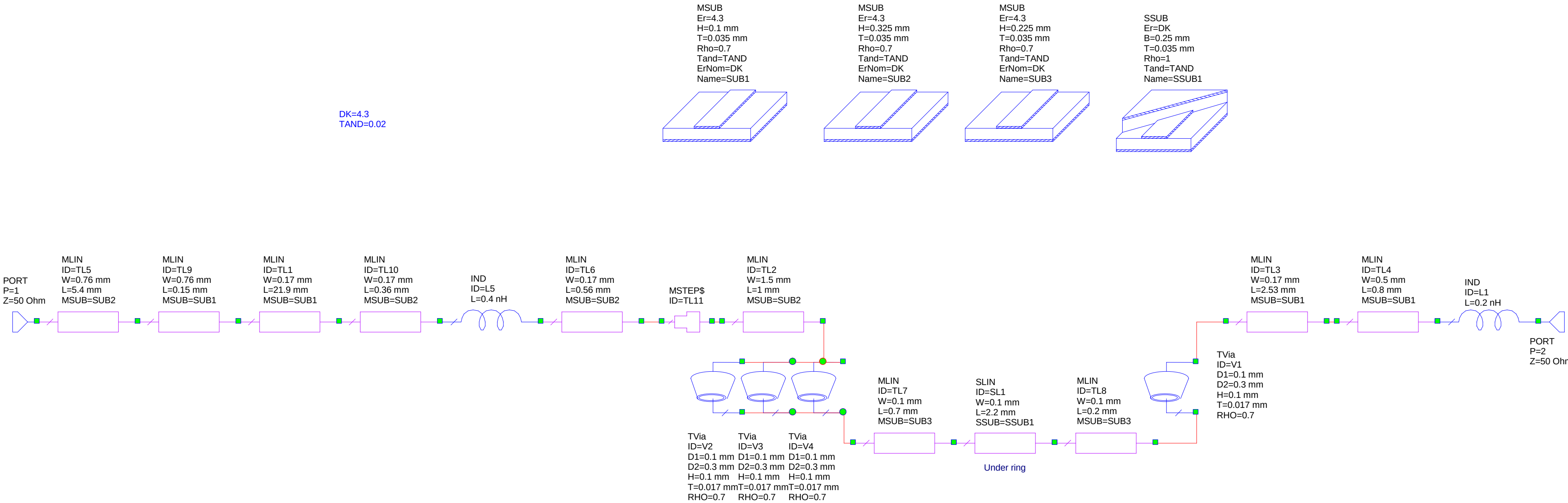
Insertion Loss



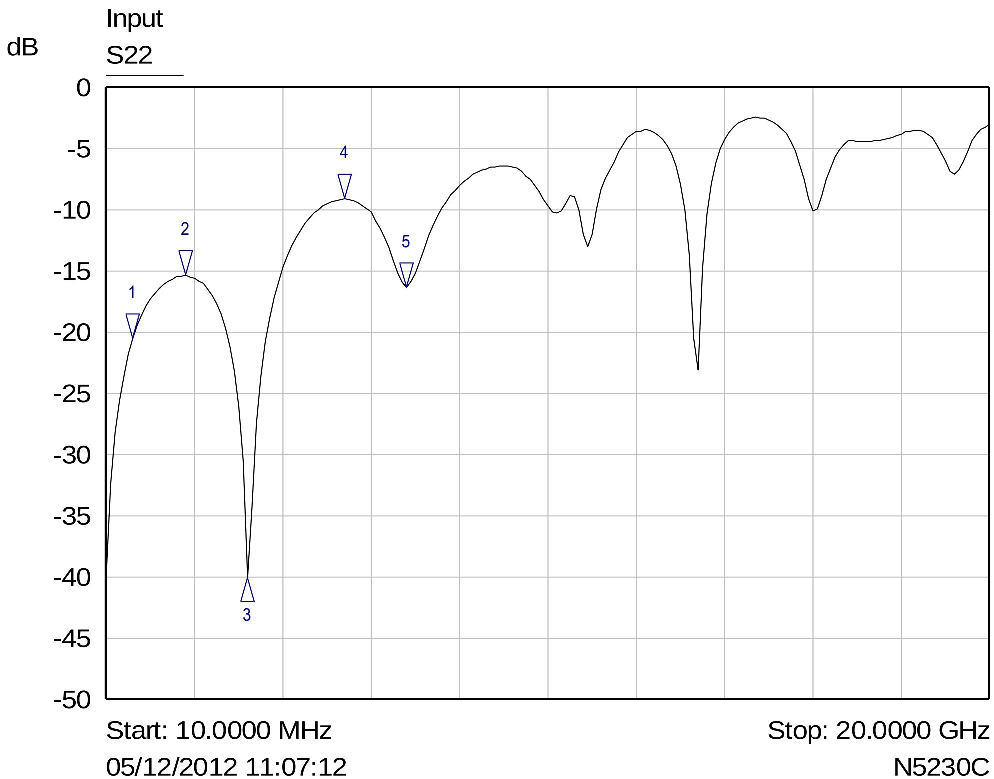
FR-4 PCB Build

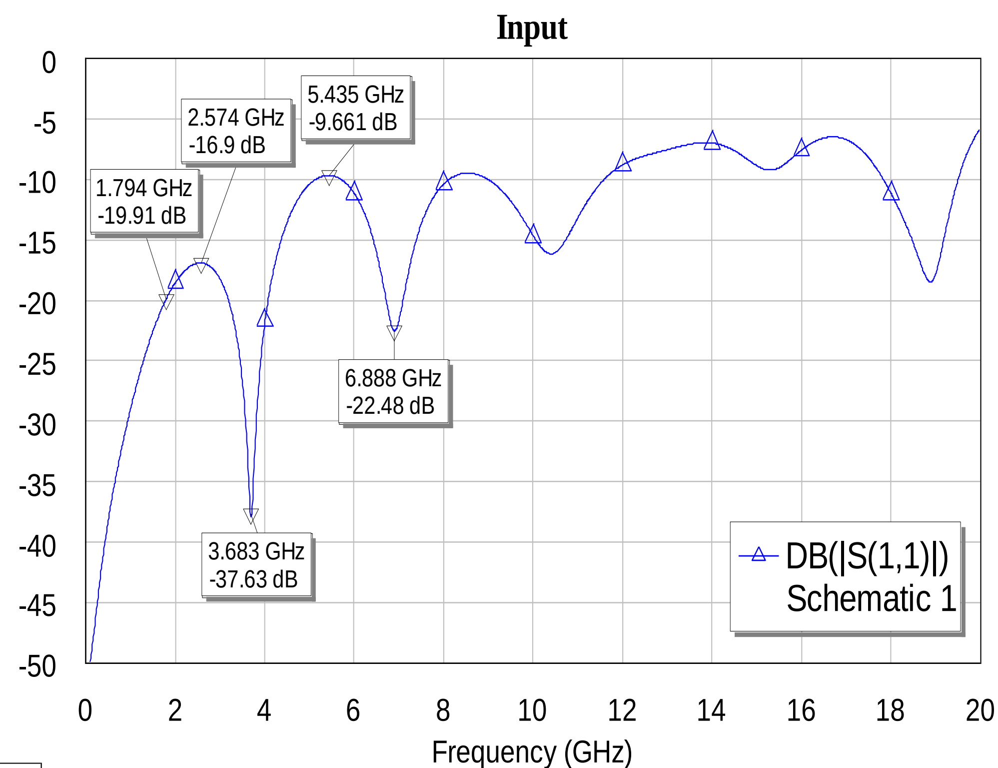


Input Track – Microwave Office Simulation Schematic



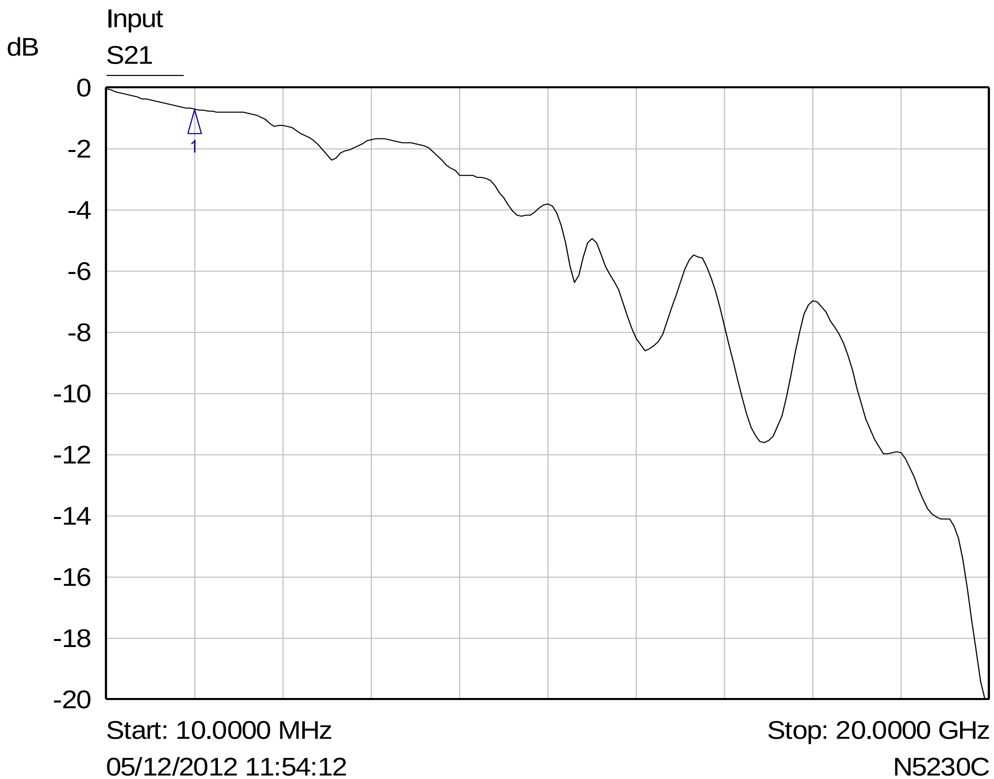
Input Track Measured and Simulated Return Loss



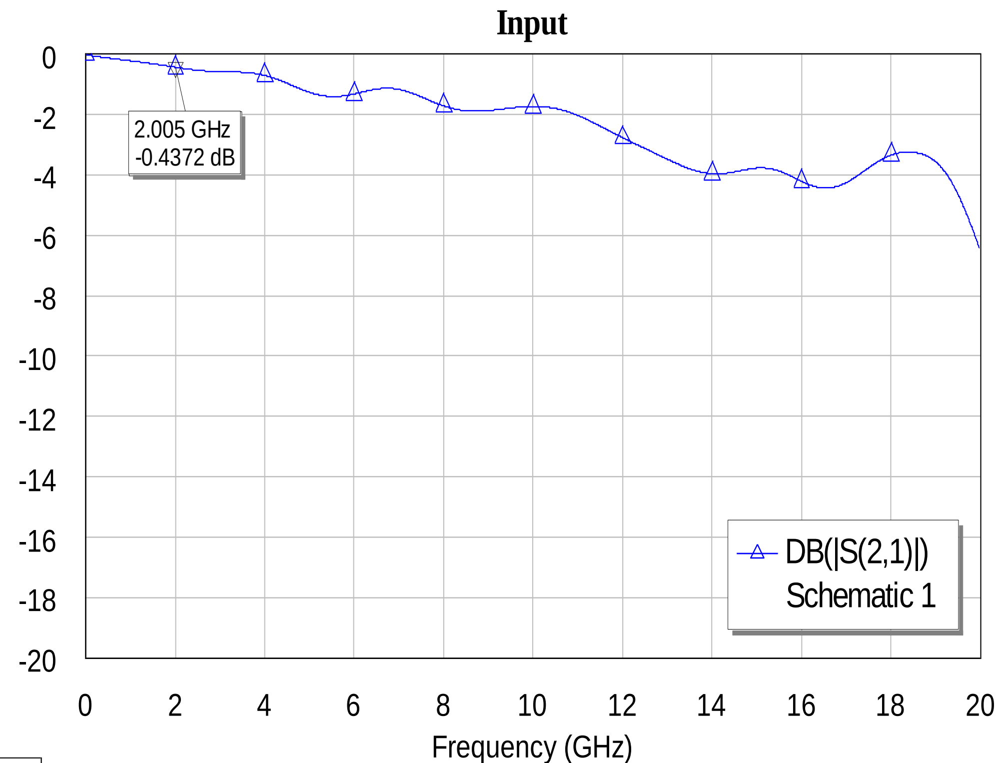


Mkr	Trace	X-Axis	Value	Notes
1 ▽	S22	609.7000 MHz	-20.50 dB	
2 ▽	S22	1.8091 GHz	-15.36 dB	
3 ▽	S22	3.2084 GHz	-39.98 dB	
4 ▽	S22	5.4073 GHz	-9.12 dB	
5 ▽	S22	6.8066 GHz	-16.33 dB	

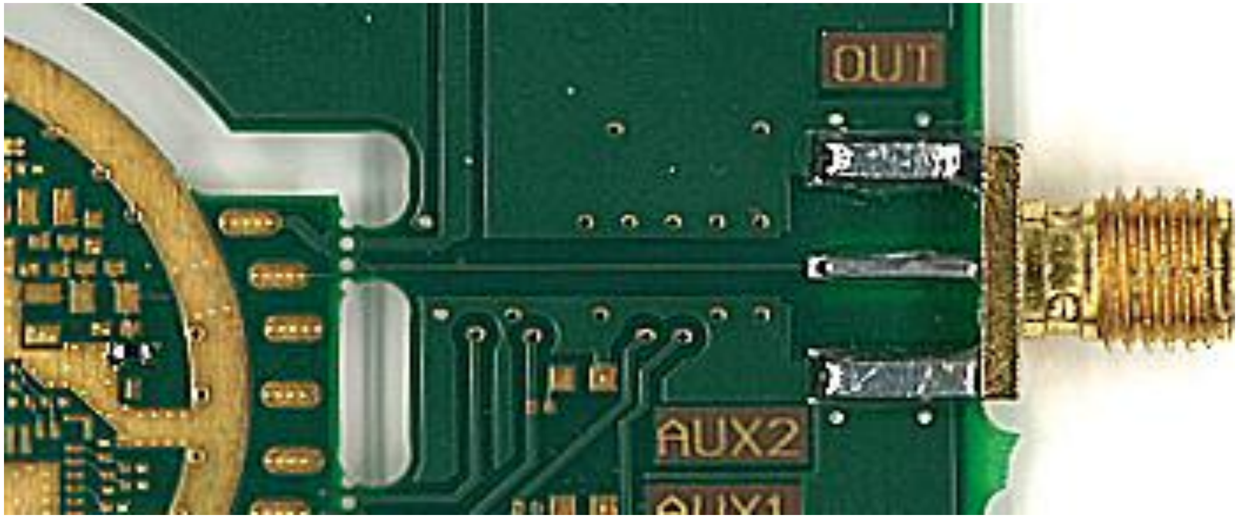
Input Track Measured and Simulated Insertion Loss



Mkr	Trace	X-Axis	Value	Notes
1 ▽	S21	2.0090 GHz	-0.70 dB	

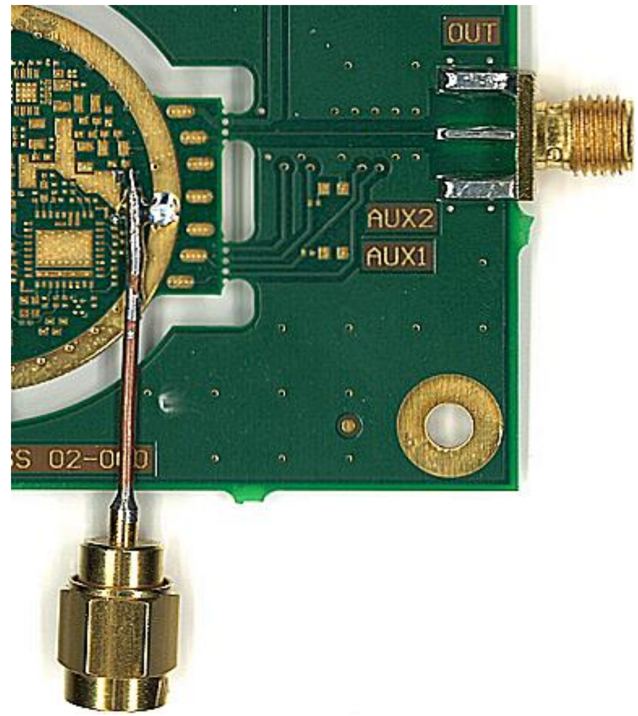


Output Track Measurement

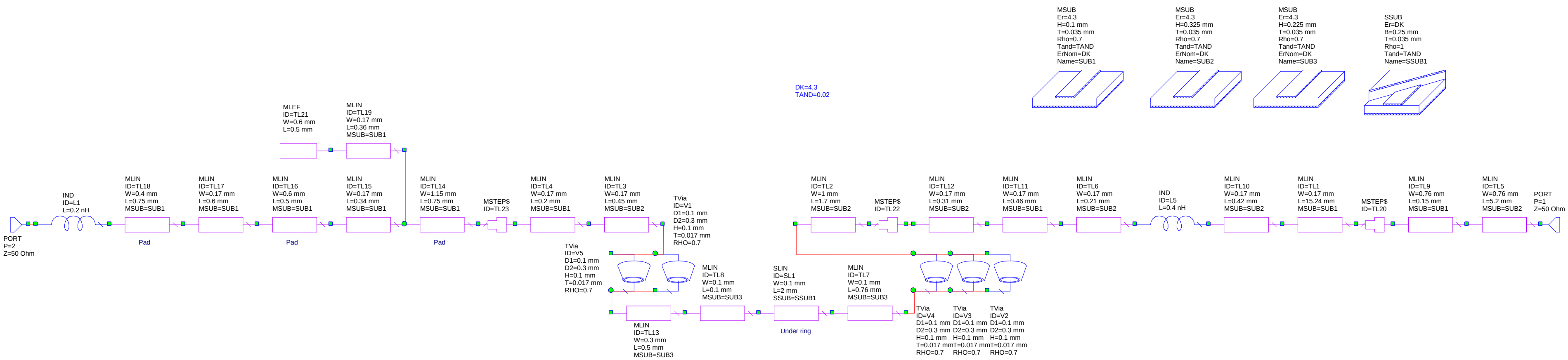


Return Loss

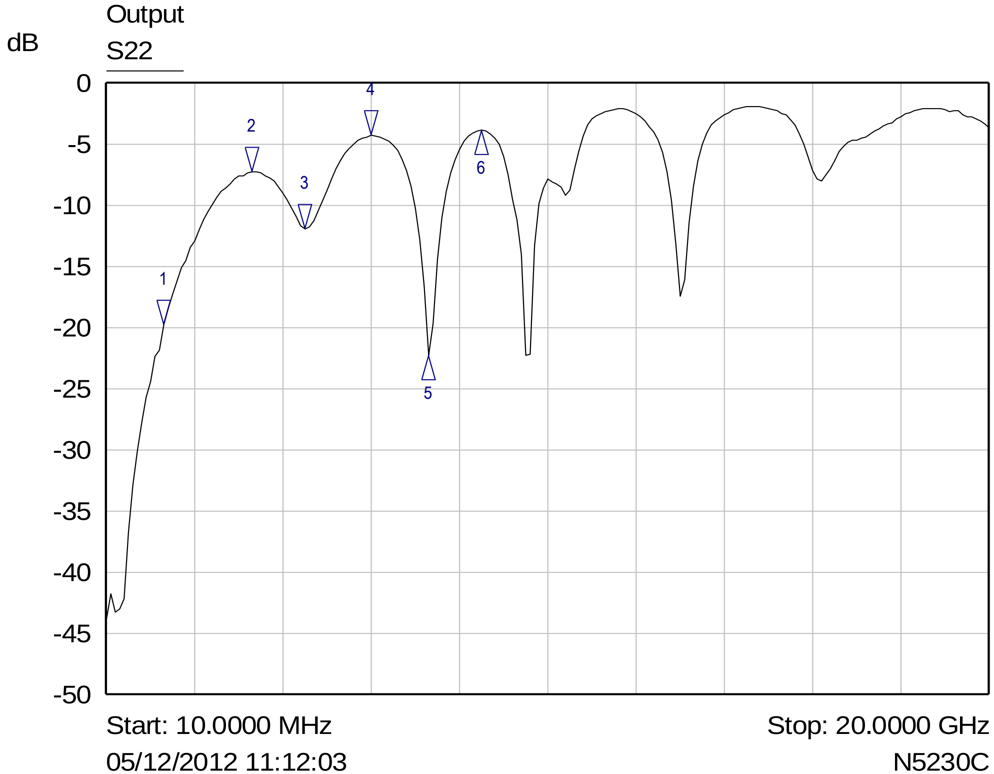
Insertion Loss



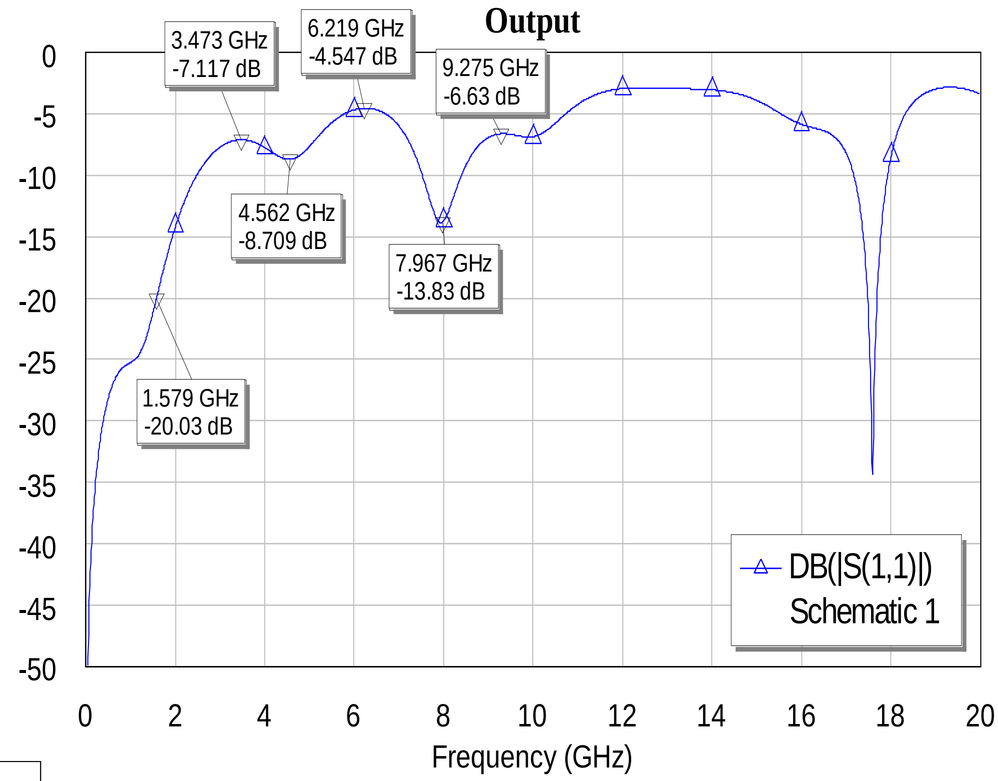
Output Track – Microwave Office Simulation Schematic



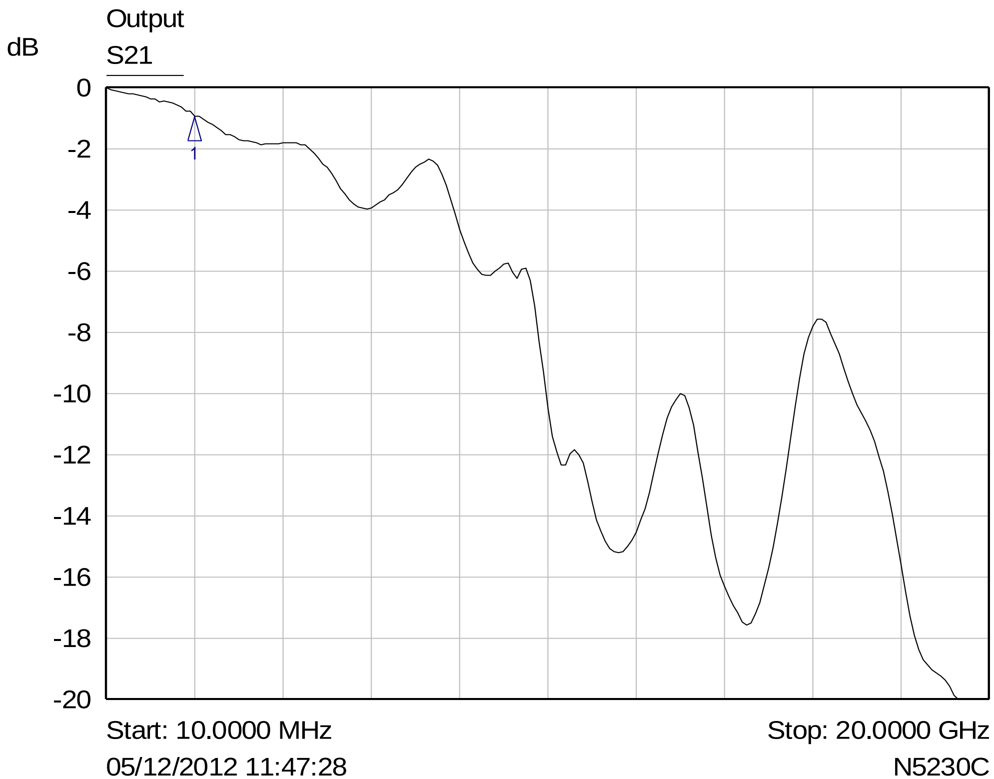
Output Track Measured and Simulated Return Loss

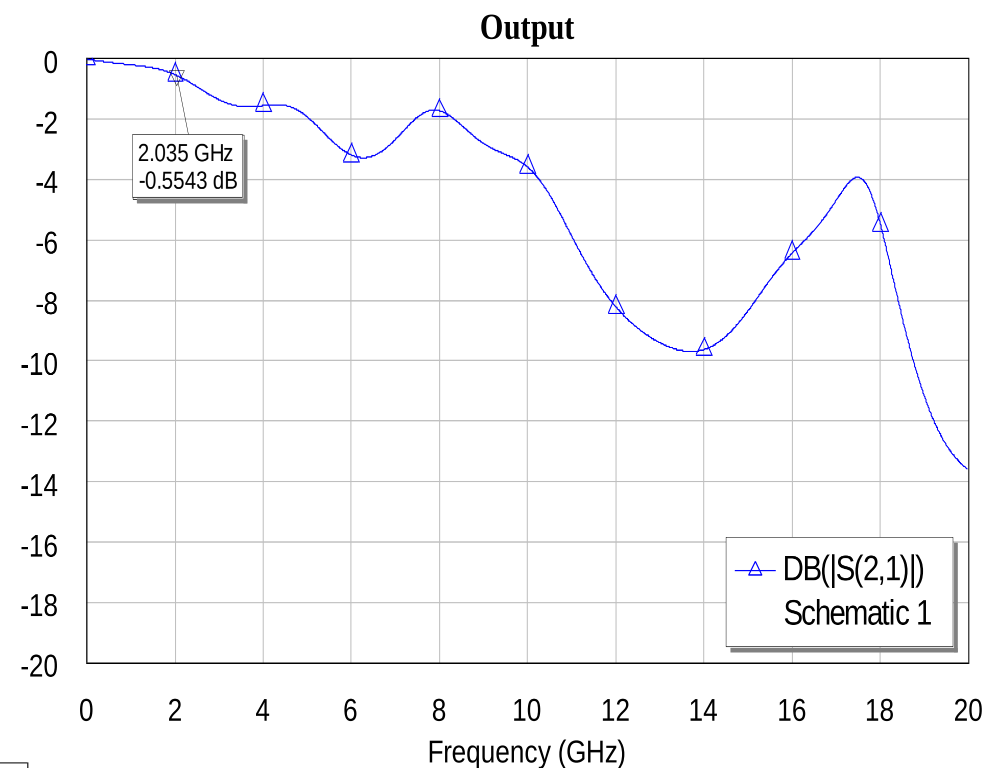


Mkr	Trace	X-Axis	Value	Notes
1 ▽	S22	1.3094 GHz	-19.78 dB	
2 ▽	S22	3.3084 GHz	-7.26 dB	
3 ▽	S22	4.5078 GHz	-11.89 dB	
4 ▽	S22	6.0070 GHz	-4.26 dB	
5 ▽	S22	7.3064 GHz	-22.27 dB	
6 ▽	S22	8.5058 GHz	-3.87 dB	



Output Track Measured and Simulated Insertion Loss





Mkr	Trace	X-Axis	Value	Notes
1 ▽	S21	2.0090 GHz	-0.92 dB	

PCB Breakout Conclusions

- Size reduction without the risk
- Reduce number of PCB design iterations
- Same PCB is both testable, programmable and deployable
- Wide applicability for digital and RF circuits
- Easily implemented up to 2GHz
- Use at higher frequencies is possible but simulation is recommended
- Keep to the tried and tested design rules and dimensions suggested

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