Application of a Series Coupler Based on Infinite Wavelength Phenomenon

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Criteria for Power Dividing and Power Combining

Power dividing

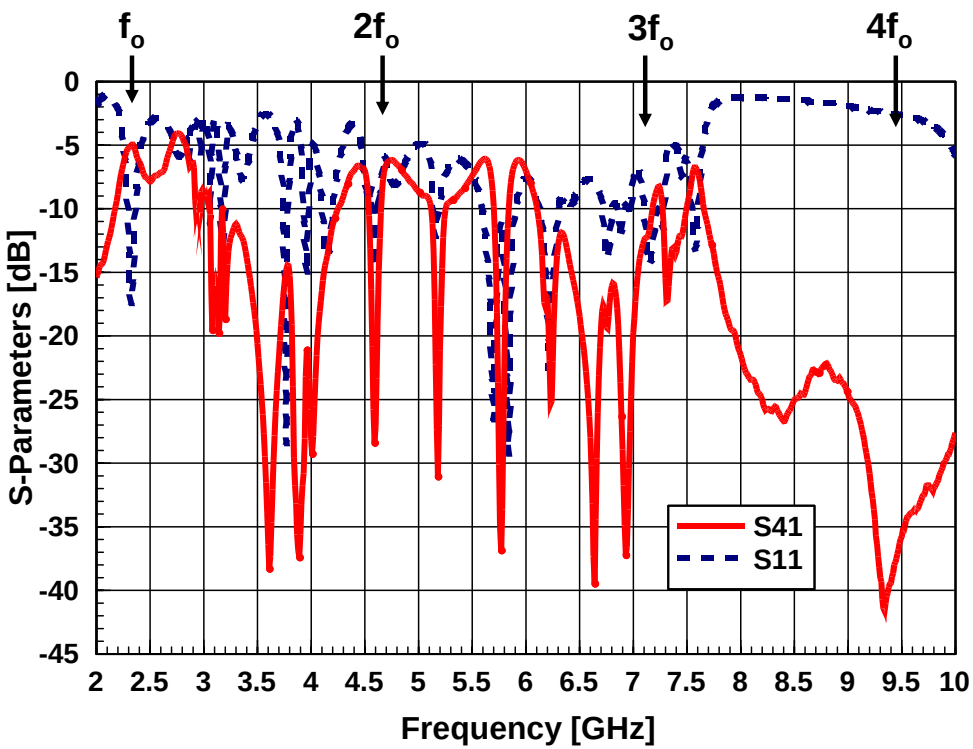
- Equal amplitude/equal phase
- Compact size
- Low loss

Power combining

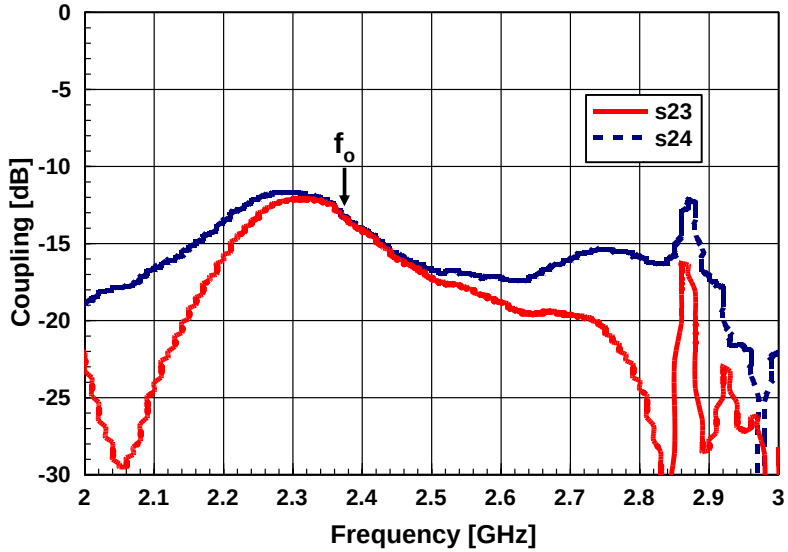
- Need optimized coupling between ports for synchronization (injection lock)
- Compact size
- Scaleable (n-port)
- Low loss

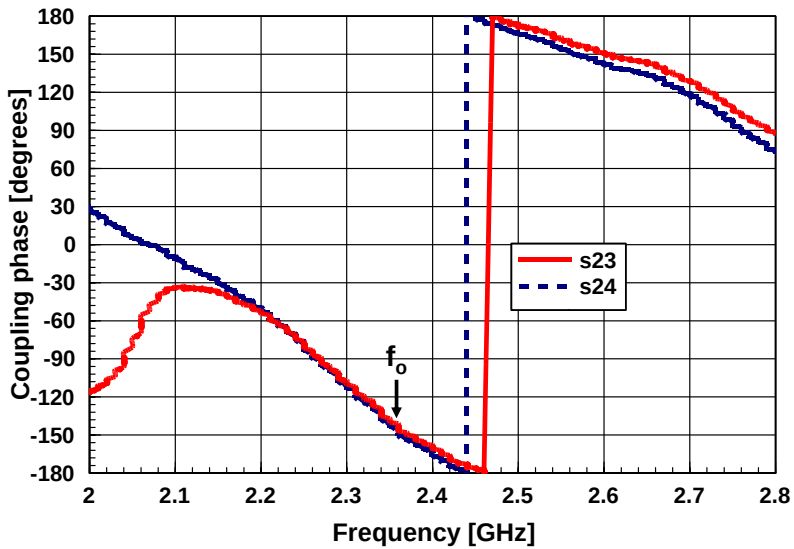
Infinite wavelength coupler for power dividing/combining

Input (port1) to output (port 4) coupling



Port-to-port coupling





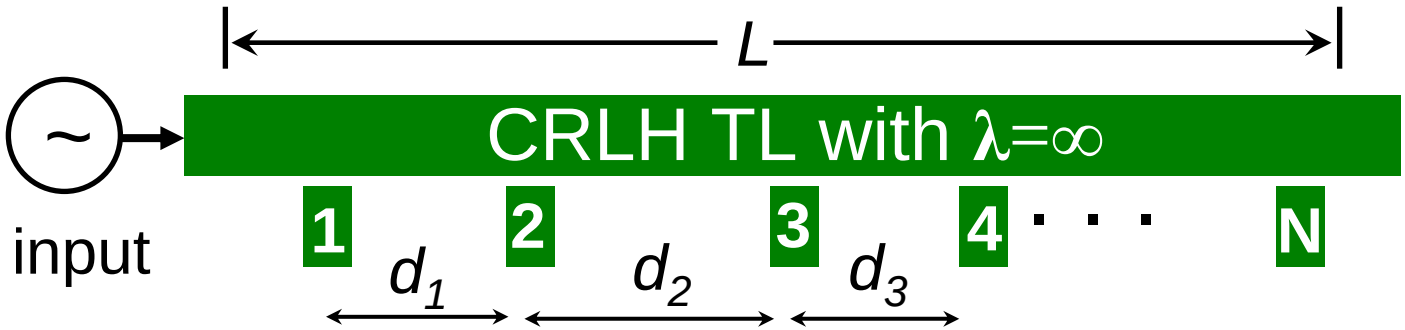
Benefits as a divider

Built in harmonic suppression (filtering)

Benefits as a combiner

Same power and phase coupling between ports

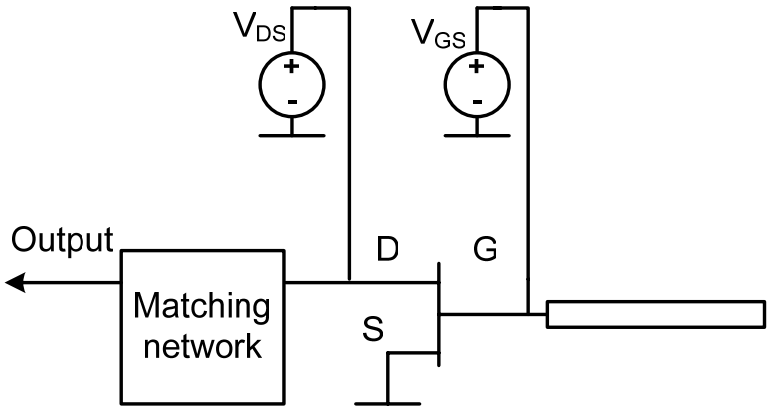
Infinite wavelength CRLH-TL for Power Dividing



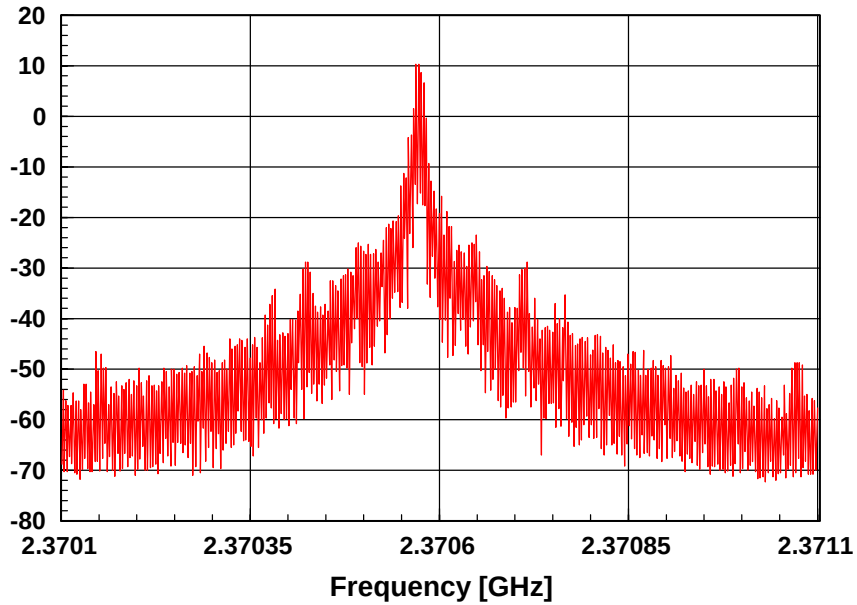
- Equal amplitude/phase output independent of spacing (d) or length (L)
- Compact size
- Filtering of harmonics
- Scalable

Single Oscillator Design and Measurements

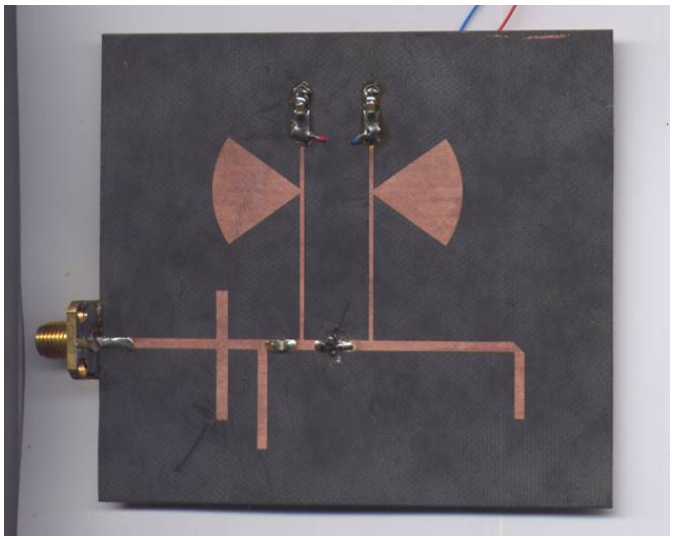
Common source oscillator schematic



Measured spectrum

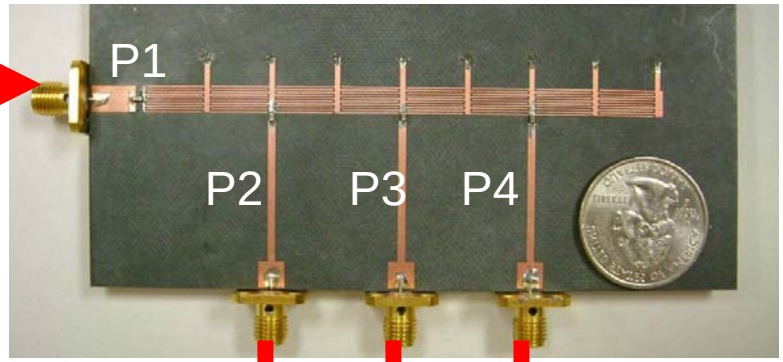


Fabricated circuit



- Pout: 10.33 dBm @ 2.3705 GHz
- phase noise: -41.83 dBc at 100 kHz offeset

Power Dividing Measurements-Uniform spaced ports



10.33 dBm

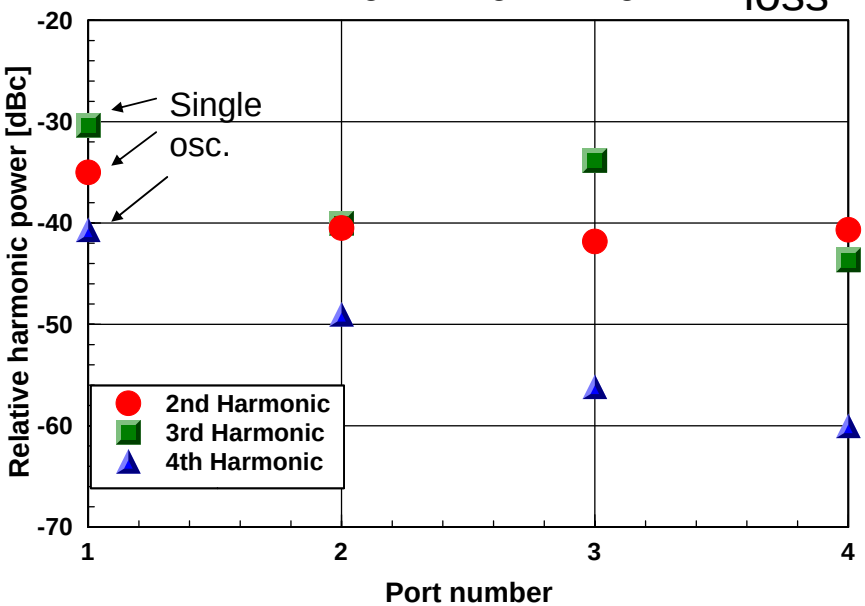
4.5 dBm

5 dBm

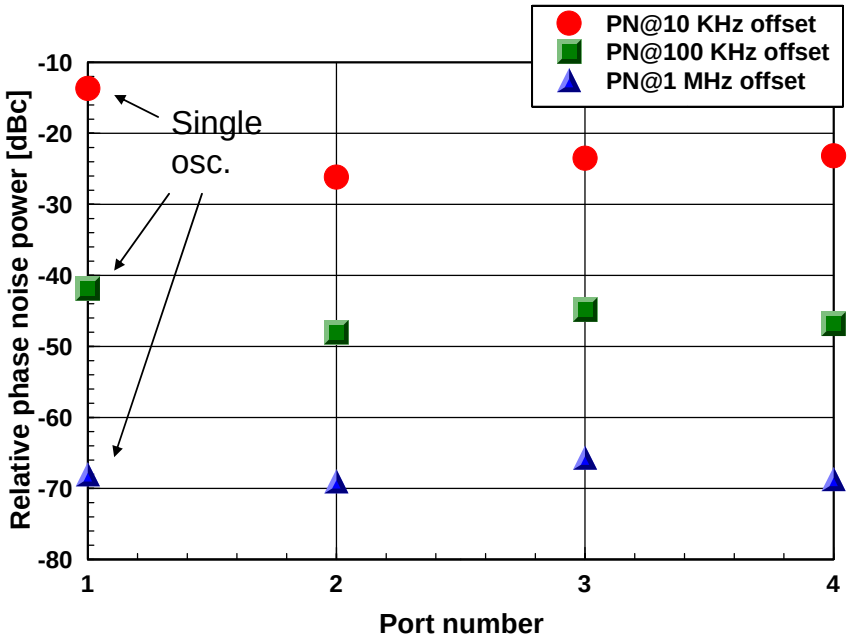
5.17 dBm

0.67 dBm loss

Harmonic measurement

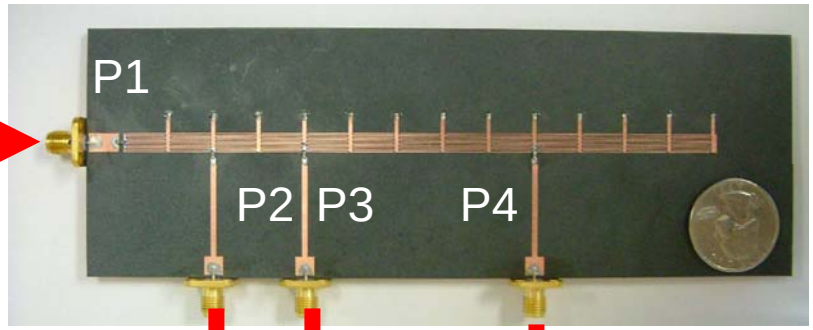


Phase noise measurement



- Equal amplitude distribution observed
- Harmonic suppression observed
- Reduction in phase noise

Power Dividing Measurements-non uniform spaced ports



10.33 dBm

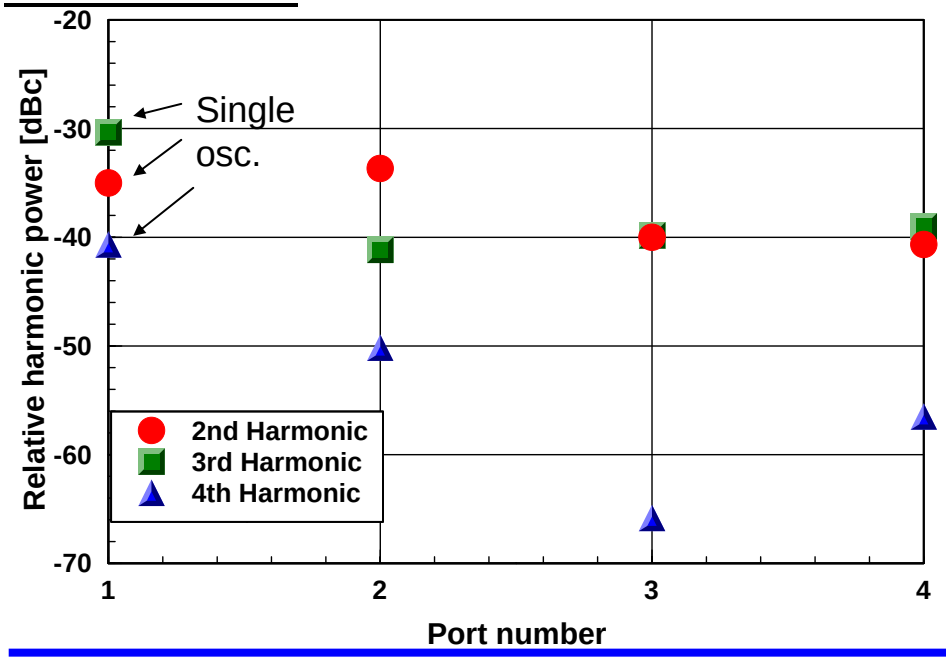
5 dBm

4.83 dBm

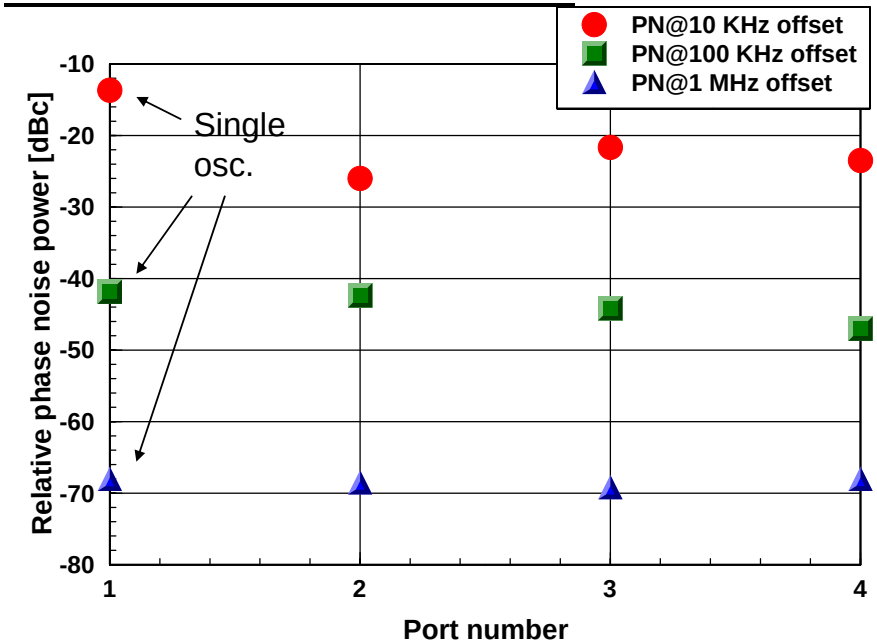
4.83 dBm

0.67 dBm loss

Harmonic measurement

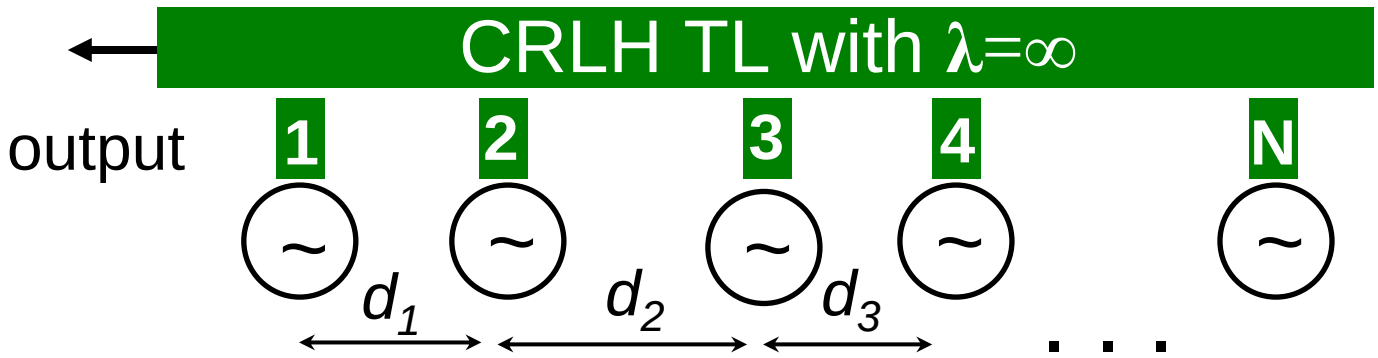


Phase noise measurement



- Equal amplitude distribution observed
- Harmonic suppression observed
- Reduction in phase noise

Infinite wavelength CRLH-TL for Power Combining

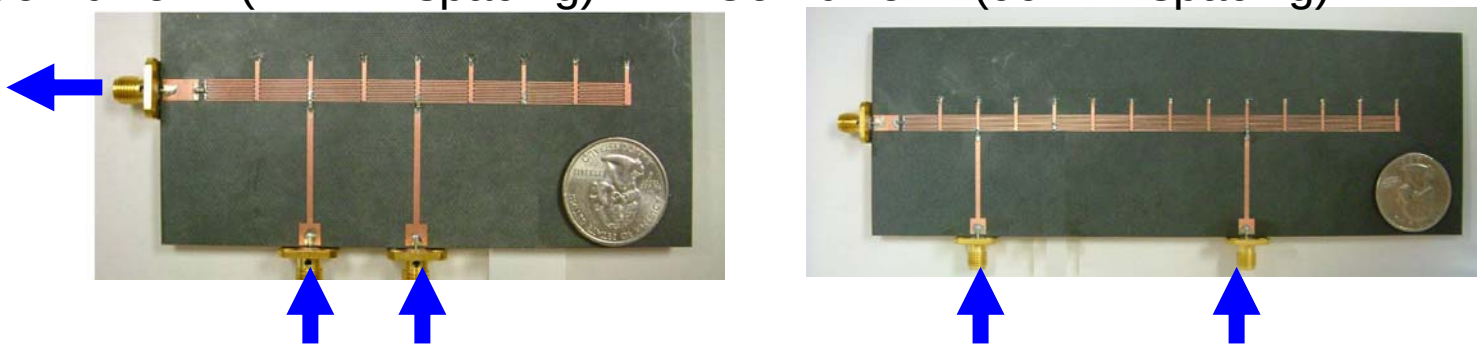


- Equal amplitude/phase between each oscillator and output port independent of d (in-phase combining)
- Filtering of harmonics
- Scaleable (n-ports)

Power Combining Measurements-non uniform spaced ports

Combiner 1 (22 mm spacing)

Combiner 2 (99 mm spacing)

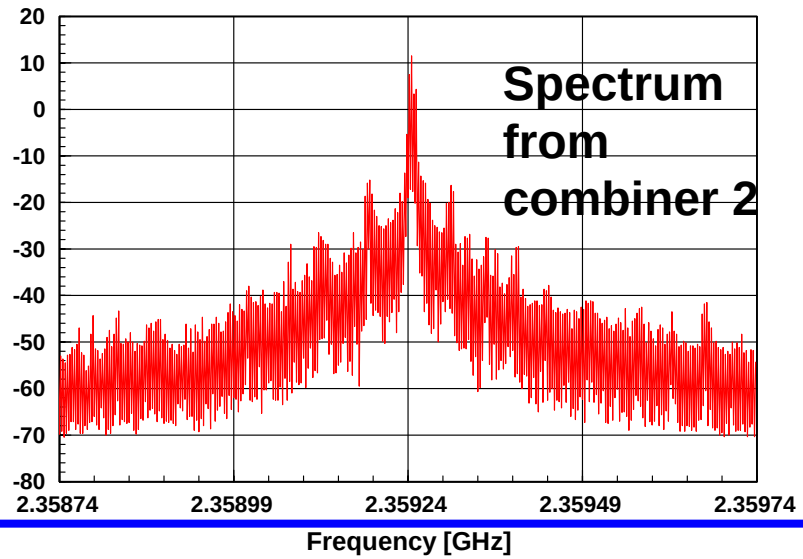


Results for both combiner 1 and 2

- Pout: 12 dBm (73% combining efficiency)
- Phase noise: -23 dBc @10KHz offset, -44 dBc @100KHz offset, -68 dBc @1 MHz offset,
- Improvement in phase noise at 10 KHz offset compared to single osc.

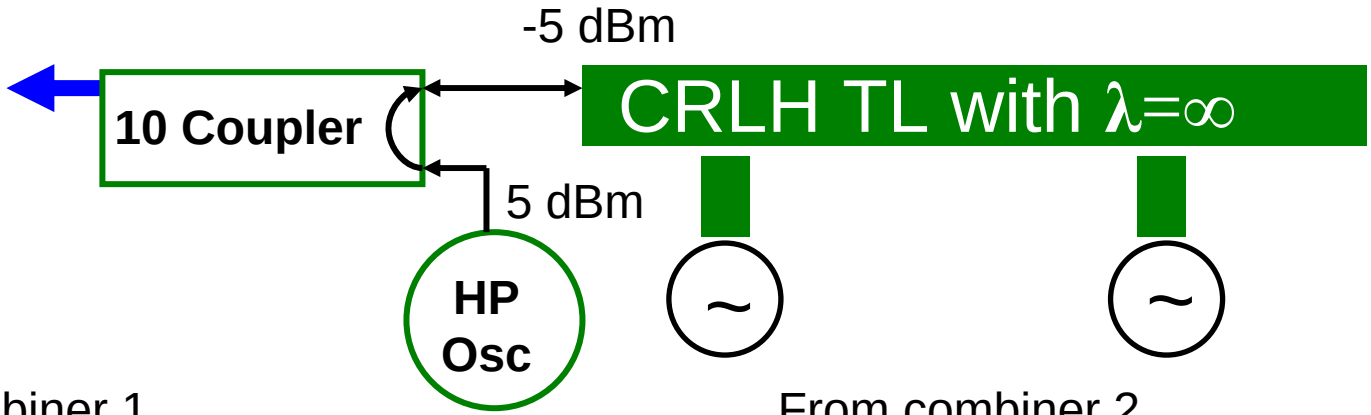
Single oscillator

- Pout: 10.33 dBm
- Phase noise: -13 dBc @10KHz offset, -42 dBc @100KHz offset, -68 dBc @1 MHz offset,

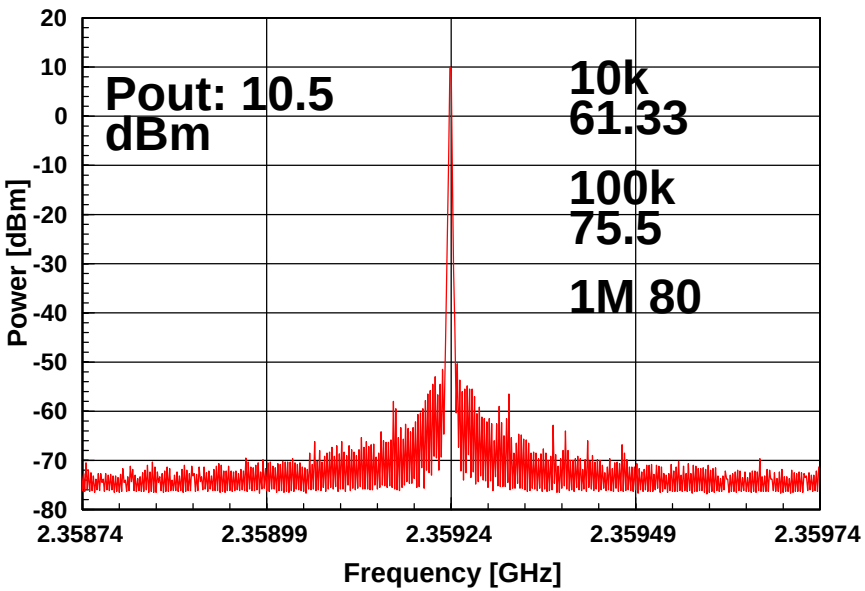


Power Combining Measurements with External injection locking

External injection locking measurement setup



From combiner 1



From combiner 2