A Progressive Mixing 20GHz ILFD with Wide Locking Range for Higher Division Ratios

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Outline

- **Motivation**
- **Conventional ILFD**
- **Proposed ILFD**
- **Measurement Results**
- **Performance Comparison**
- **Conclusion**

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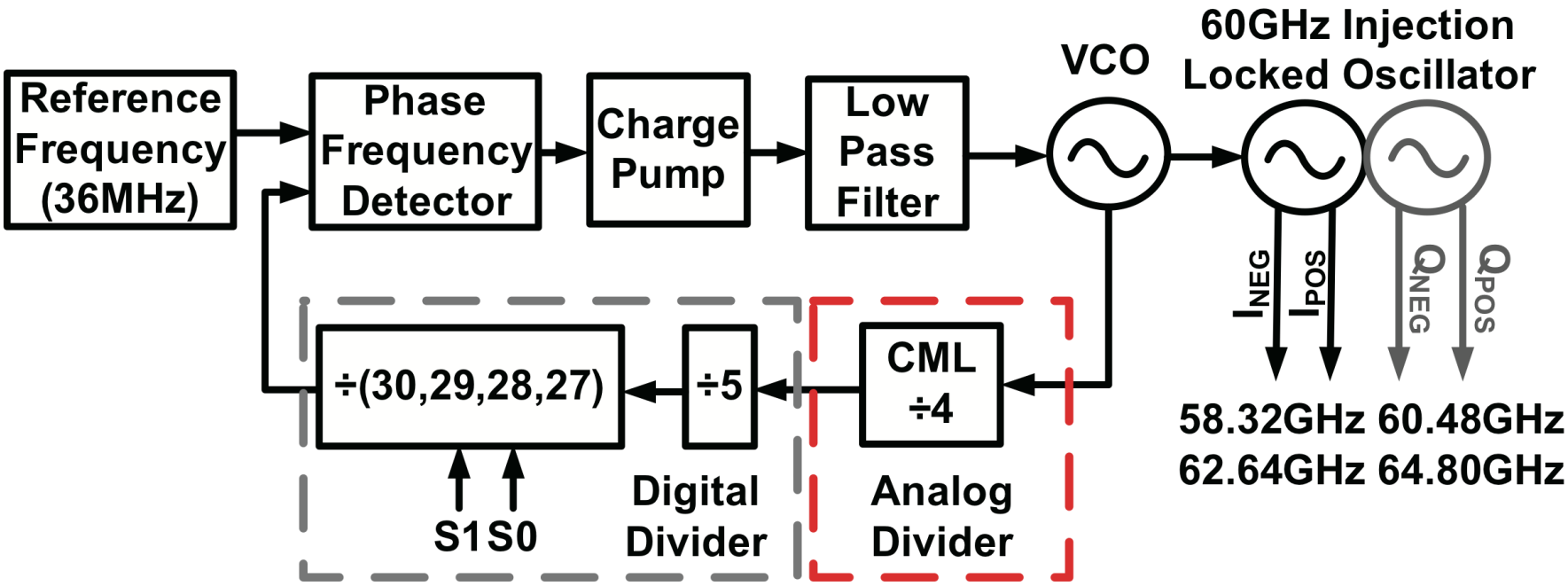
High Frequency PLLs



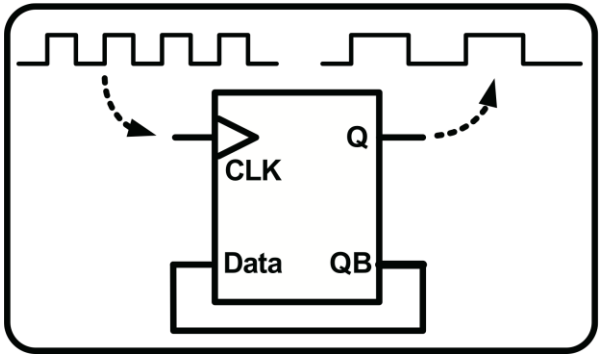
- High Frequency PLLs are becoming more popular
- Static prescalers consume considerable power
  - 40% of PLL total power consumption [1].

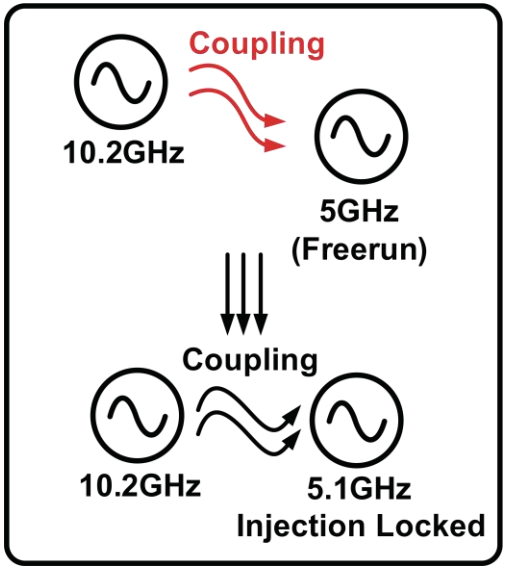
[1] A. Musa et. al, JSSC 2011

High Speed Frequency Dividers

High speed frequency dividers and VCO are the most power hungry parts of modern high frequency PLLs.

- **Static Frequency Dividers:**
  - **Wide locking range**
  - **Consume considerable power**
  - **Conventionally only divides by 2**
- **Injection Locked Frequency Dividers (ILFDs)**
  - **Limited locking range**
  - **Low power consumption**
  - **Can divide by higher than 2**





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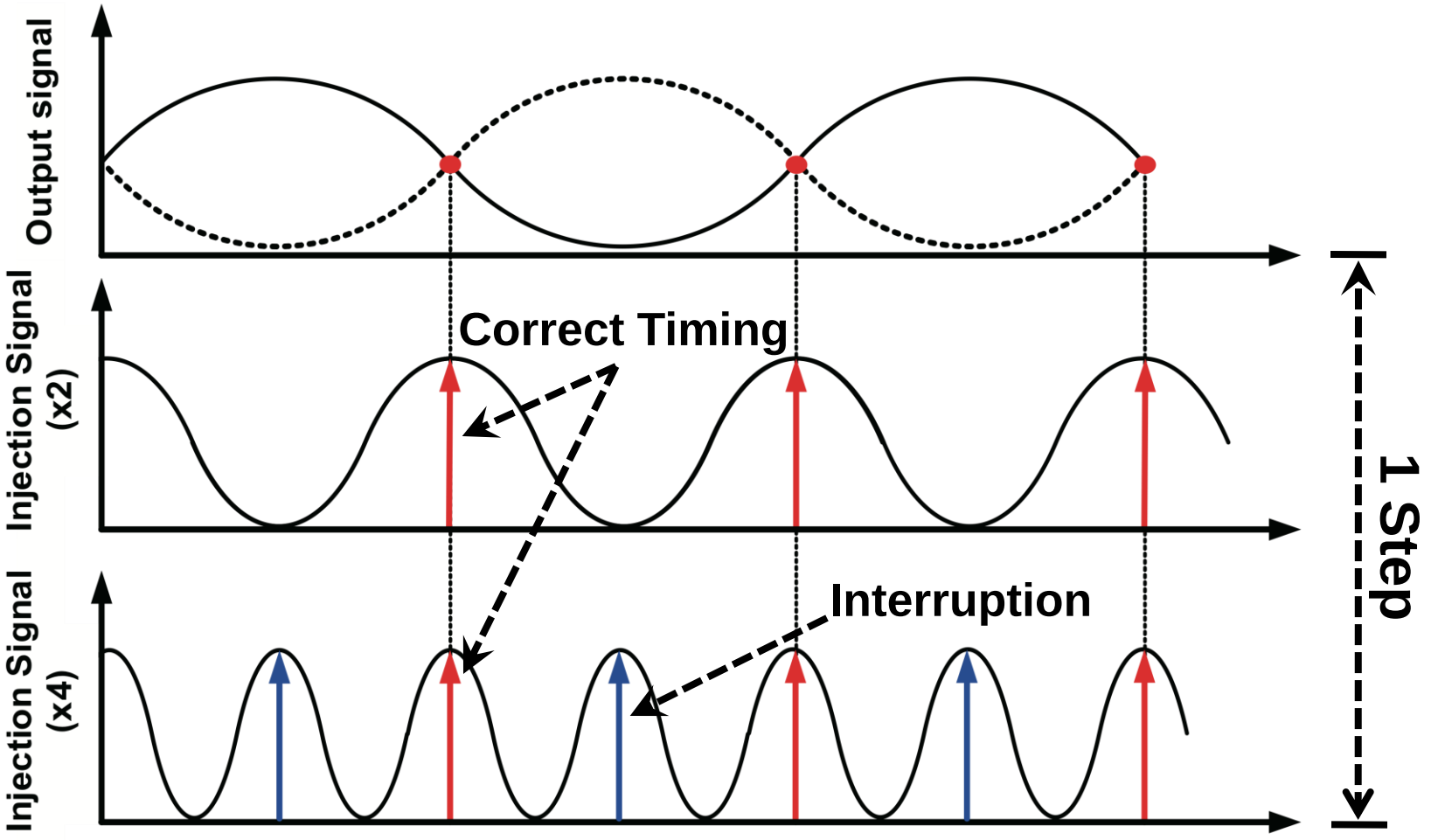
Conventional ILFD



Red arrows indicate desired injection

Blue arrows indicate harmful injection

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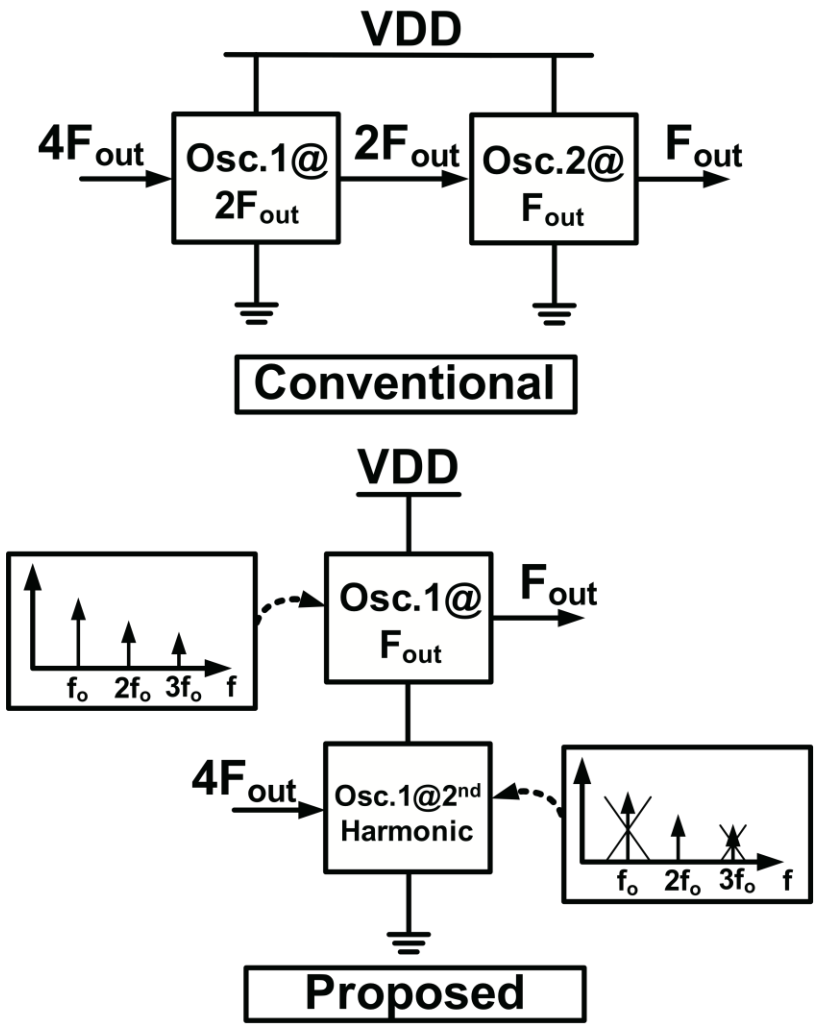
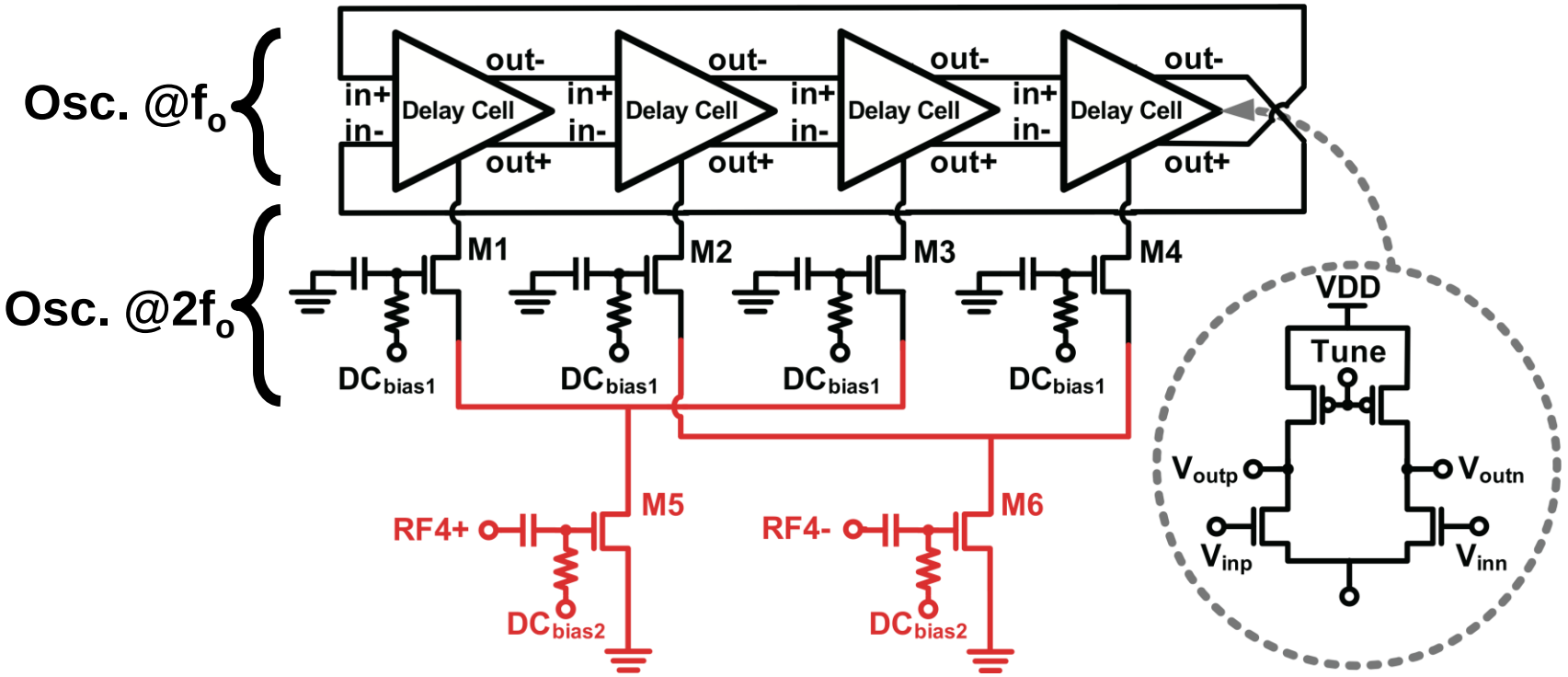
Proposed ILFD Configuration

- One oscillator
  - Direct division power consumption
- Reuse fundamental higher harmonics
  - Cascaded wider locking range
- Vertical configuration
- Extendable



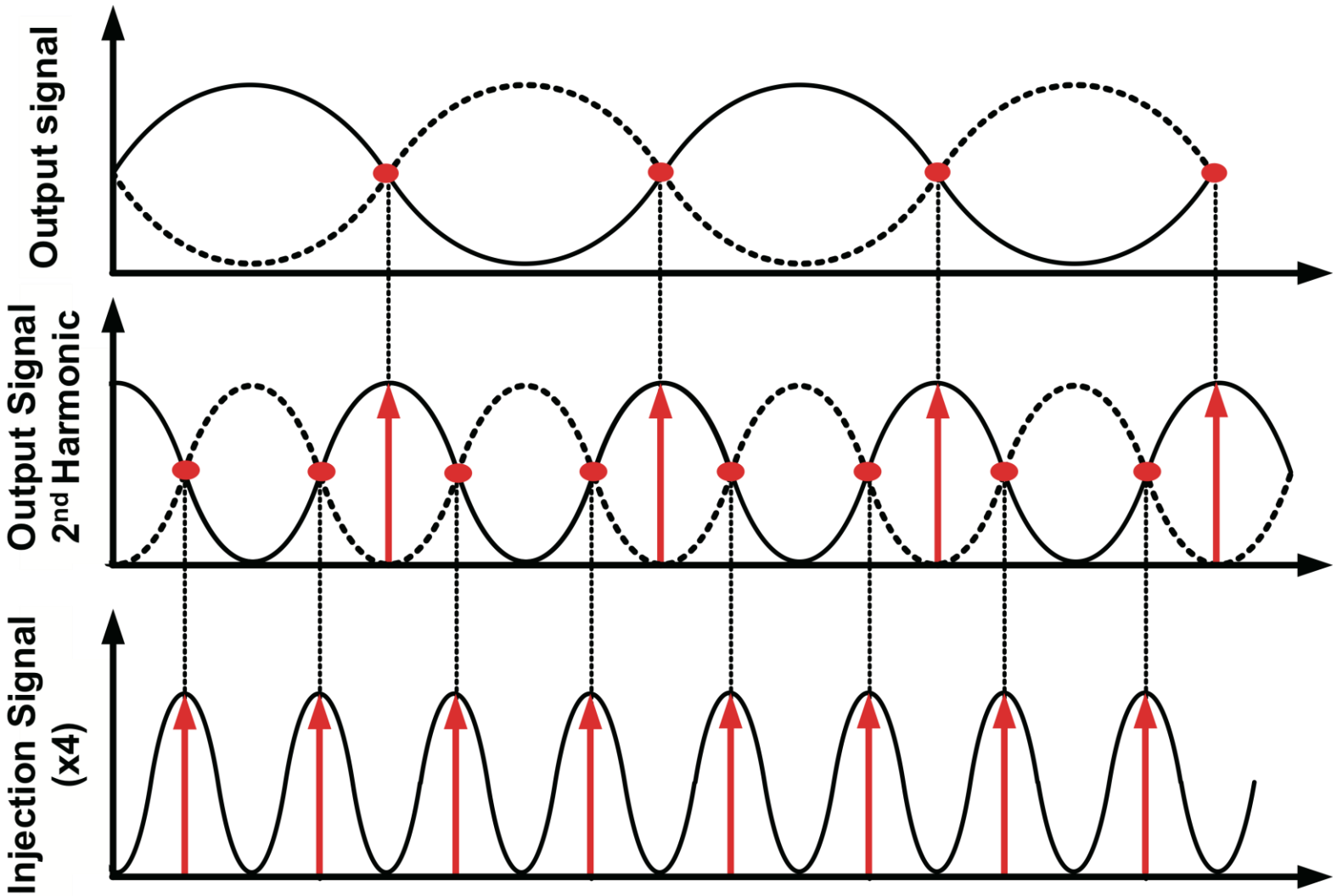
Proposed ÷4 ILFD Schematic

Advantages of both approaches are combined by reusing higher harmonics that naturally exist in any osc.



Schematic of the Proposed Progressive Mixing ILFD

Proposed ÷4 ILFD Timing Waveform



Red arrows indicate <u>desired</u> injection

Blue arrows indicate <u>harmful</u> injection **(NA)**

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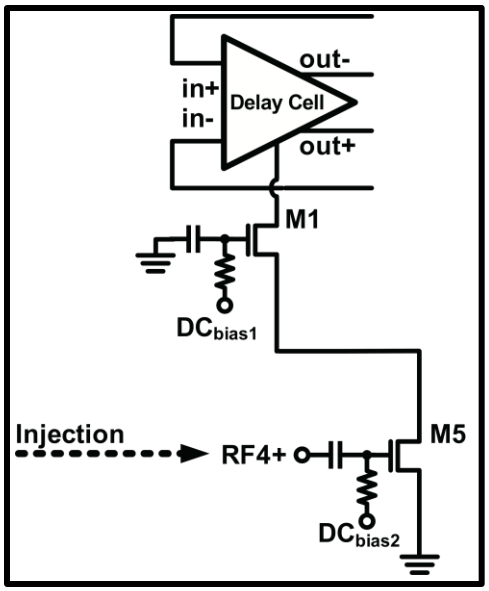
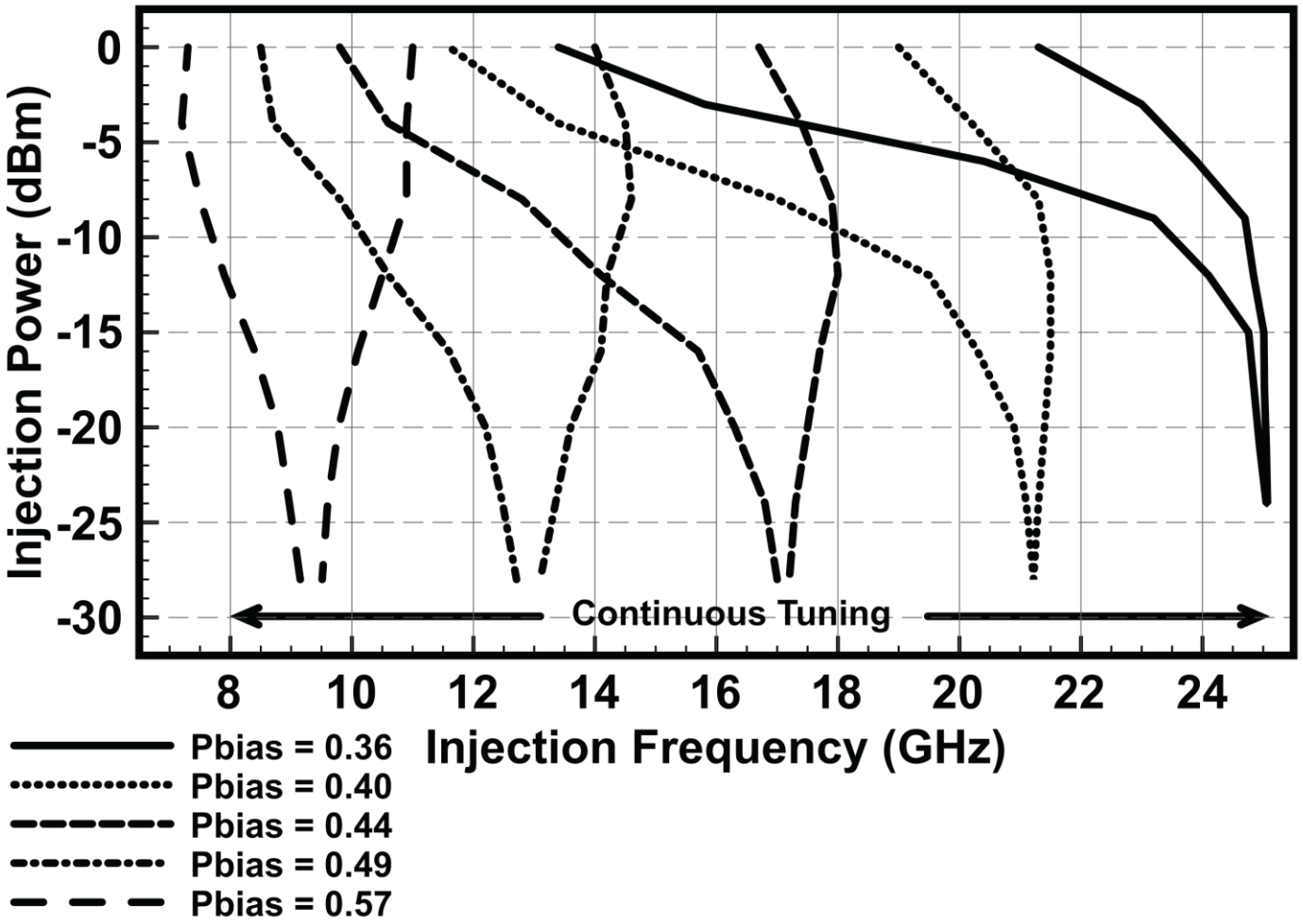
Sensitivity Curve ÷4 (Measured)

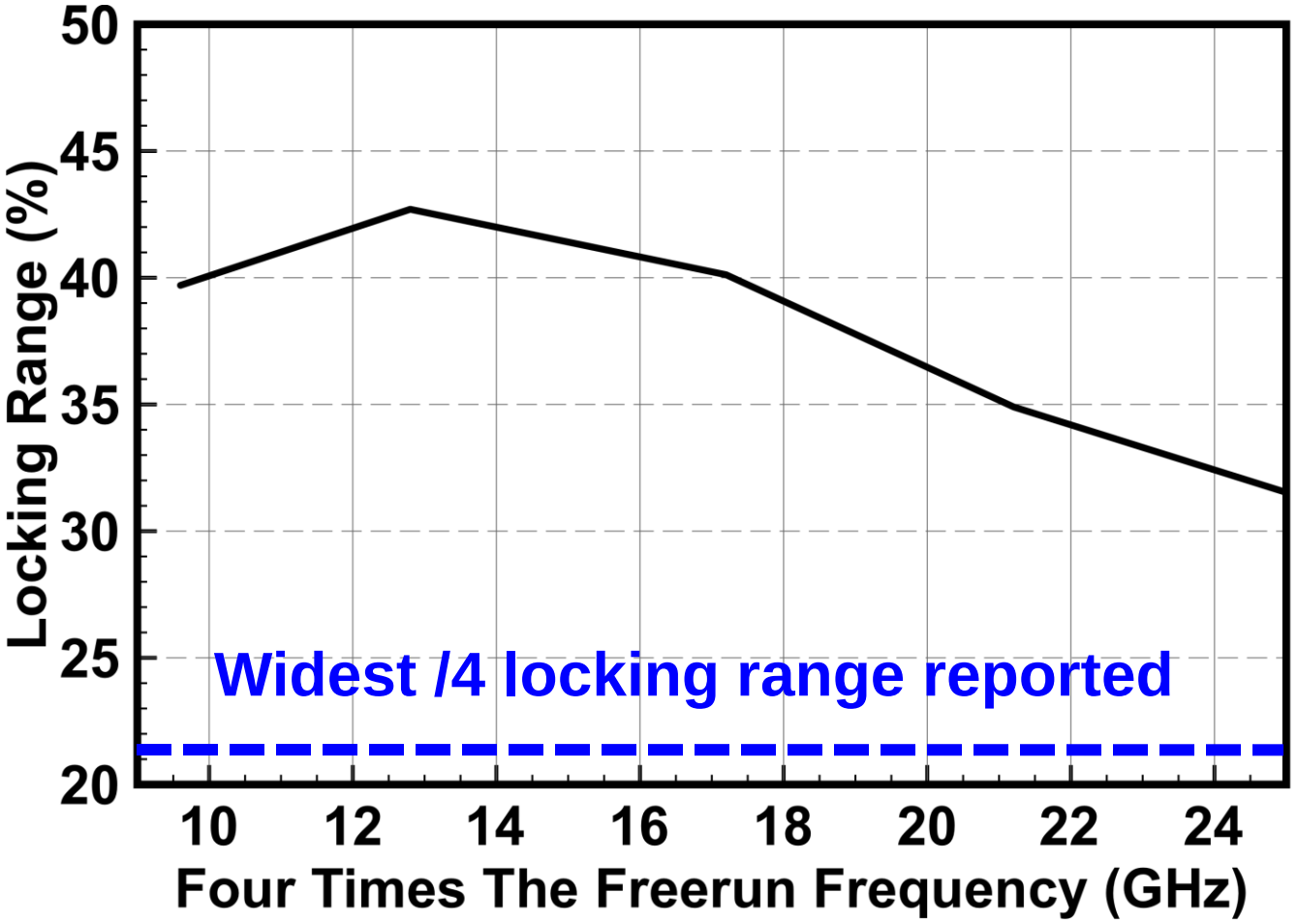




31.4% Locking range@20GHz

50% increase over conventional

Locking Range Vs Tuning (Measured)

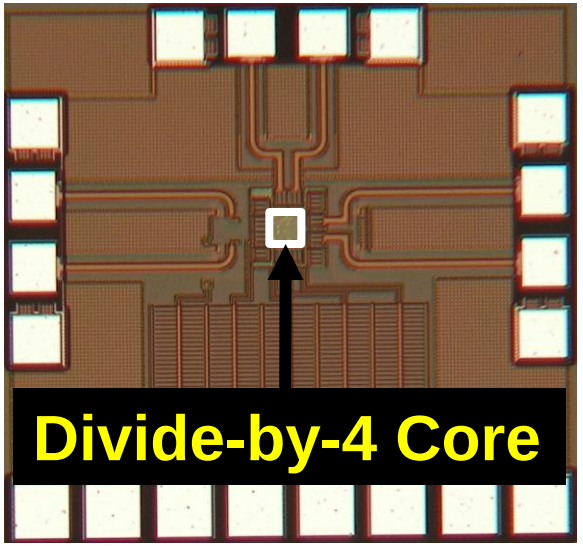


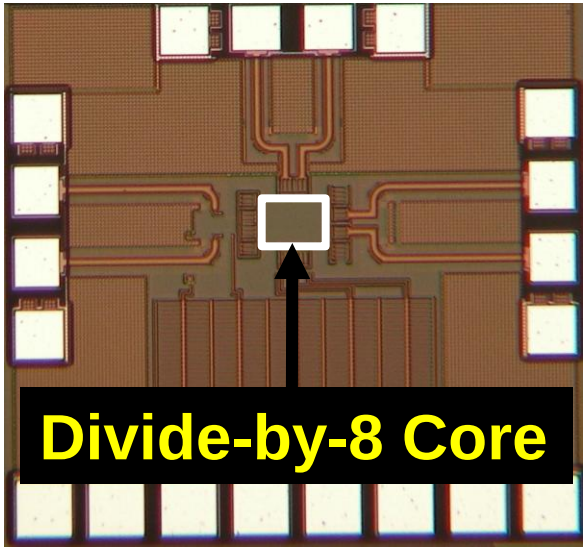
42.7% Maximum Locking Range

~100% increase over conventional

Chip Micropraph

- **Chip Area:**
  - **÷4**
    - **750µm x 810µm**
    - **Divider**
      - **52µm X 48µm**
  - **÷8**
    - **750µm x 810µm**
    - **Divider**
      - **66µm x 86µm**





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Comparison & Conclusion

		TEG 1	TEG 2	[3]	[2]	[5]	[6]
Division Ratio(s)		2, 4	4, 8	2, 4	2, 4	4	2, 4, 6, 8
Power (mW)		3.9	7.1	3.0	12.4	2.8	6.8
Lock Range (GHz)	/2	4.5-16.1 (92%)	-	51.0-74.0 (34%)	82.0-94.1 (15%)	-	2.3-4.3 (56%)
	/4	13.4-21.3 (31%)	9.8-13.8 (32%)	82.5-89.0 (7.3%)	79.7-81.6 (2.4%)	70.0-71.6 (2.3%)	6.0-7.6 (22%)
	/8	-	20.9-24.7 (15%)	-	-	-	14.4-14.7 (1.7%)

[3] C.C. Chen et. al, MTT 2009

[2] P. Mayr et. al, ISSCC 2007

[5] K. Yamamoto et. al, ISSCC 2006

[6] M. Acar et. al, RFIC 2004

An improvement by ~50% for divide-by-4 and ~780% for divide-by-8 at no increase in power is achieved

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- **A new injection locked frequency divider (ILFD) is proposed.**
- **The divider uses progressive mixing (multistep mixing) to allow injection at higher harmonics of the fundamental.**
- **The widest locking range has been achieved especially for higher division ratios.**
  - **÷2 (93%)**
  - **÷4 (43%)**
  - **÷8 (17%)**

Acknowledgement

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