A 1.6GHz 0.5mW CMOS LC Low Phase Noise VCO Using Bond Wire Inductors

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Outline

- Background and Motivation
- Goals
- Circuit
- Results

Tradeoffs in Oscillators

Types

	Relaxation	Resonant Tank
Advantages	simple small area large tuning range	built-in filter low power
Disadvantages	phase noise power for speed	component tolerance component precision small tuning range

Type of Inductor

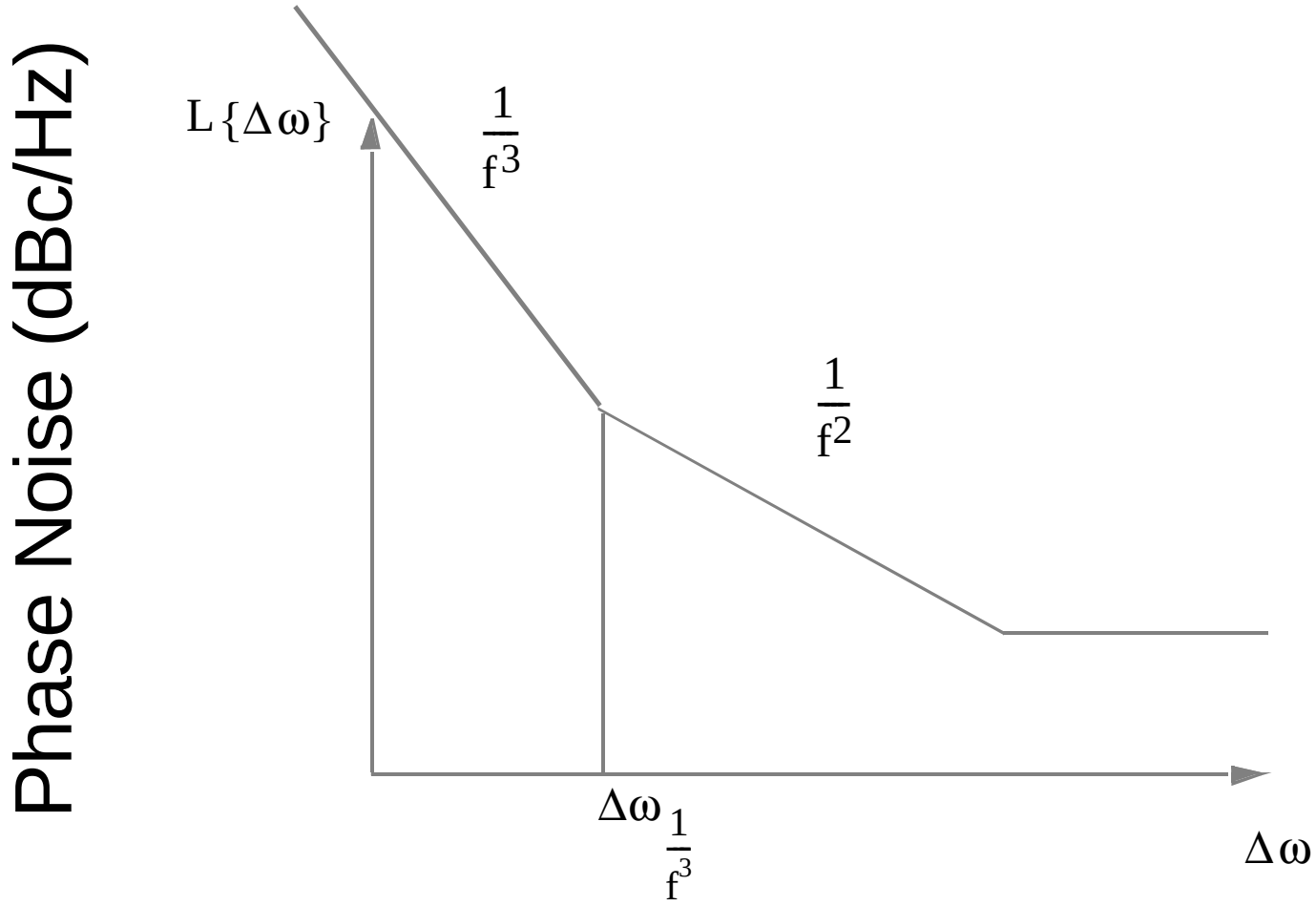
Bond wire vs. Spiral

- less precision in value
- lower parasitic capacitance
- less die area
- higher Q

Goals of Design

- 1.6GHz (GPS)
- Low Power
- Minimum Phase Noise
- Tunable
- Reasonable Area

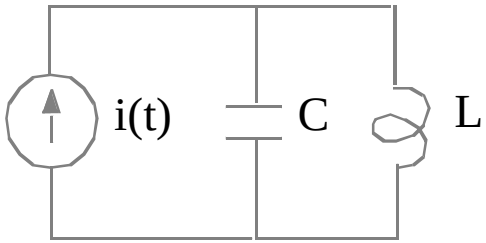
Typical Phase Noise Plot



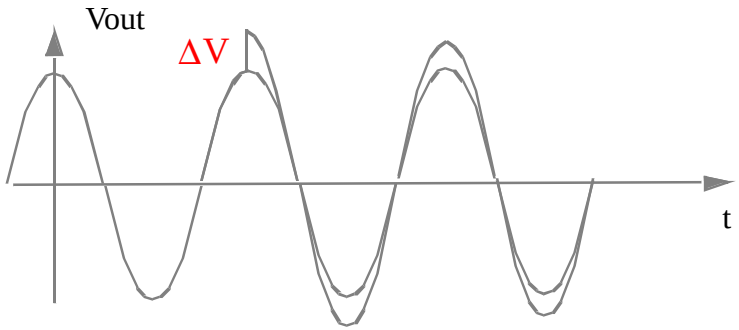
Hajimiri Phase Noise Model

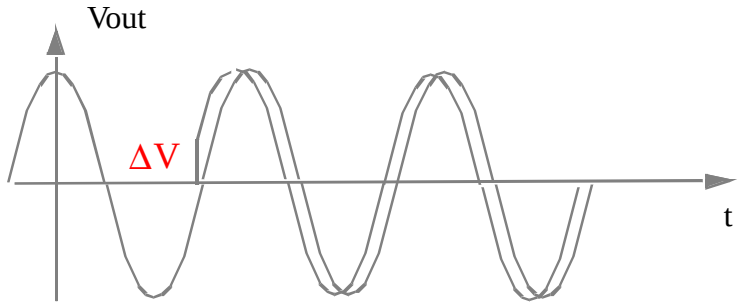
Impulse injection:

At peak



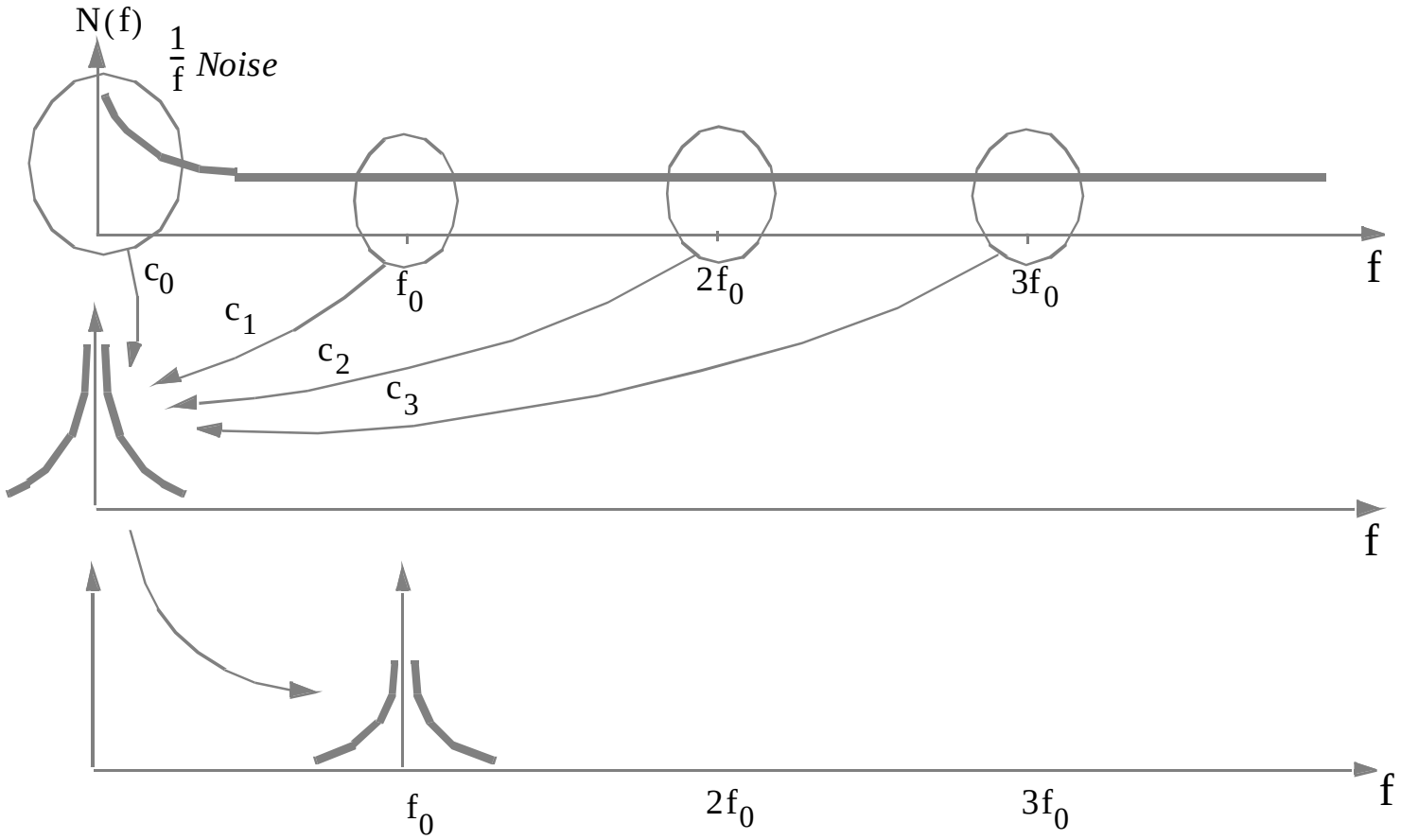
At zero crossing





Oscillators are Linear Time-Variant Systems

Hajimiri Phase Noise Model



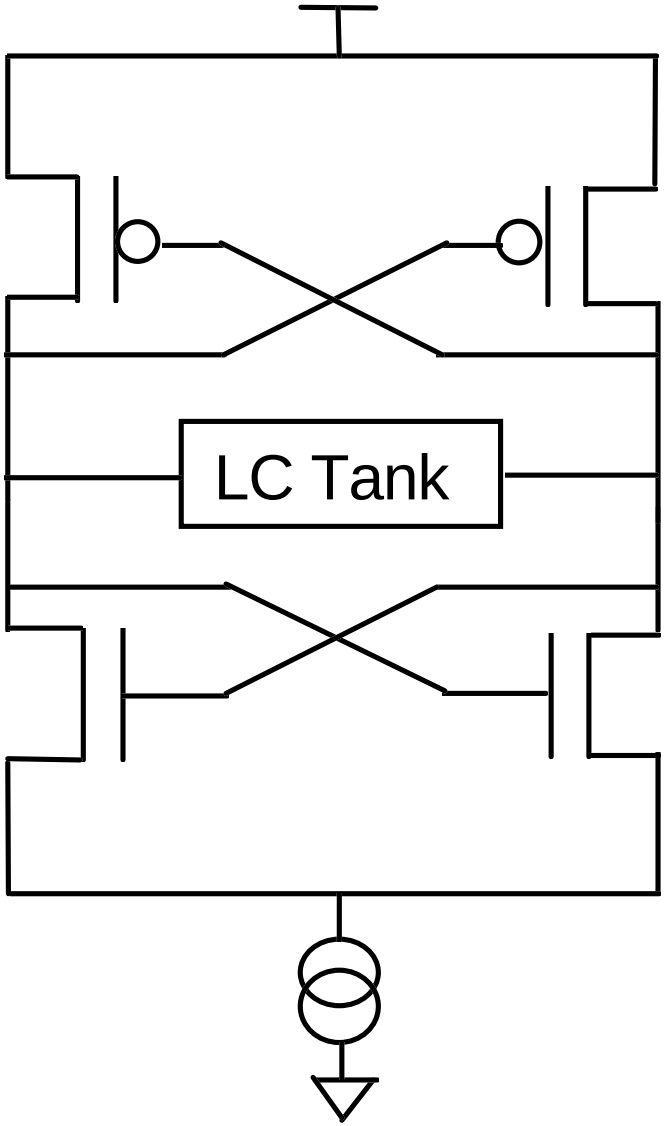
Conversion of noise to phase fluctuations and phase noise sidebands

How To Achieve Low Phase Noise

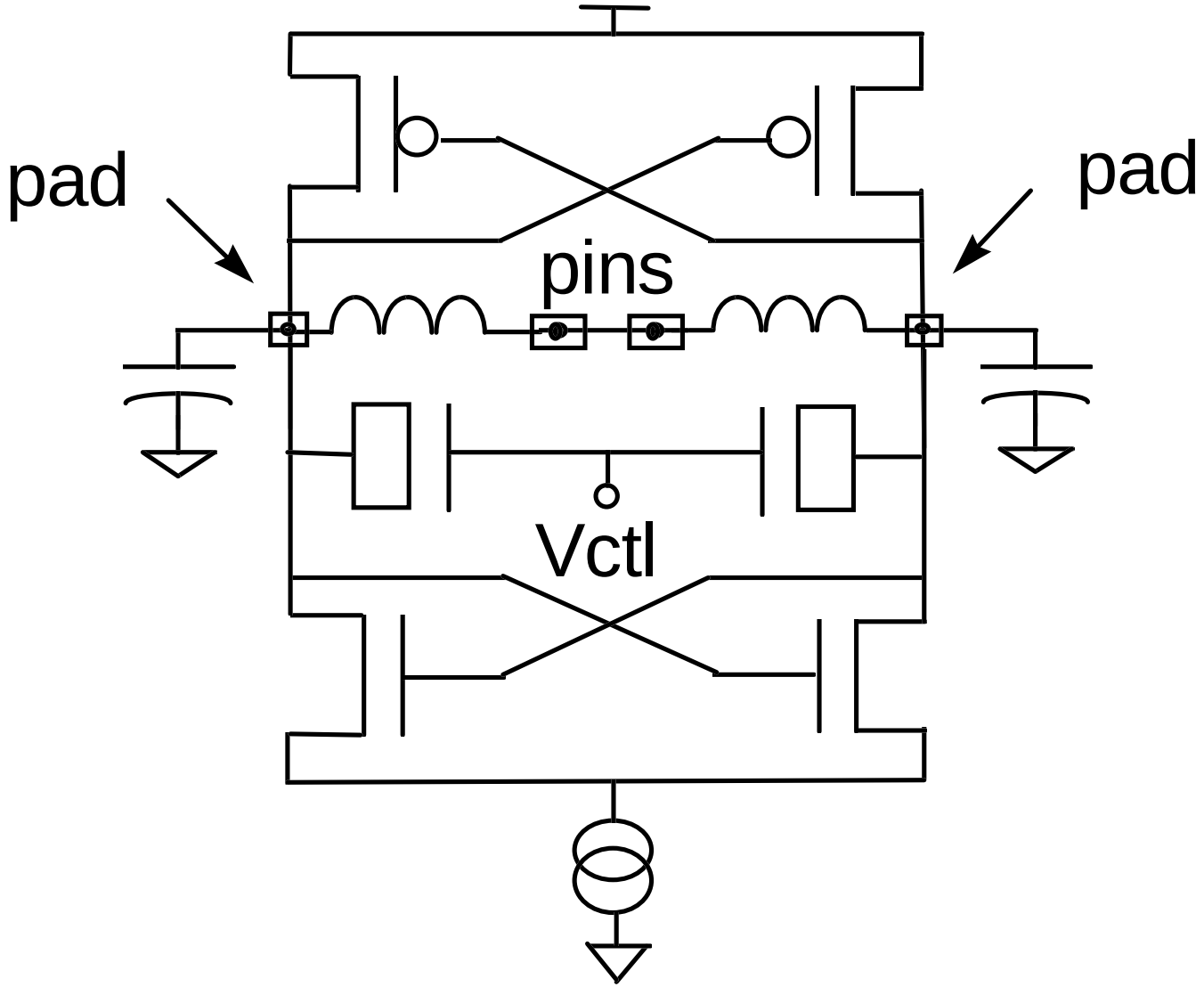
- More Power
- Higher Q Resonant Tank
- Single-ended Symmetry

Basic Design Configuration

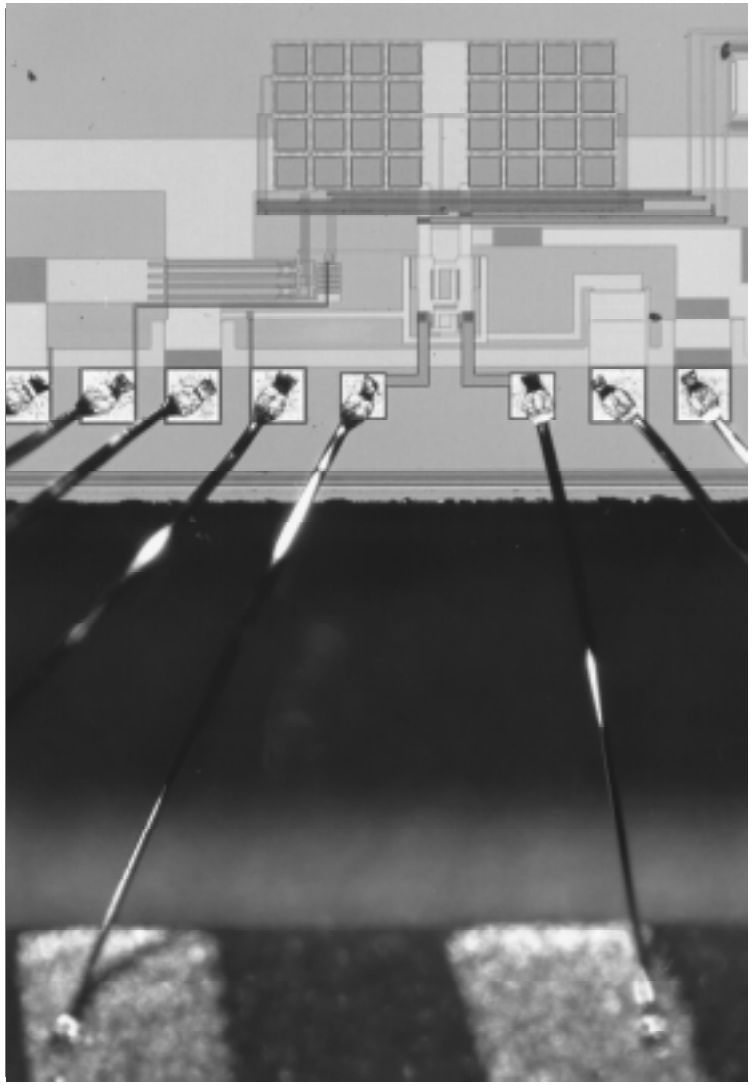
$$W_p = 2 \times W_n$$

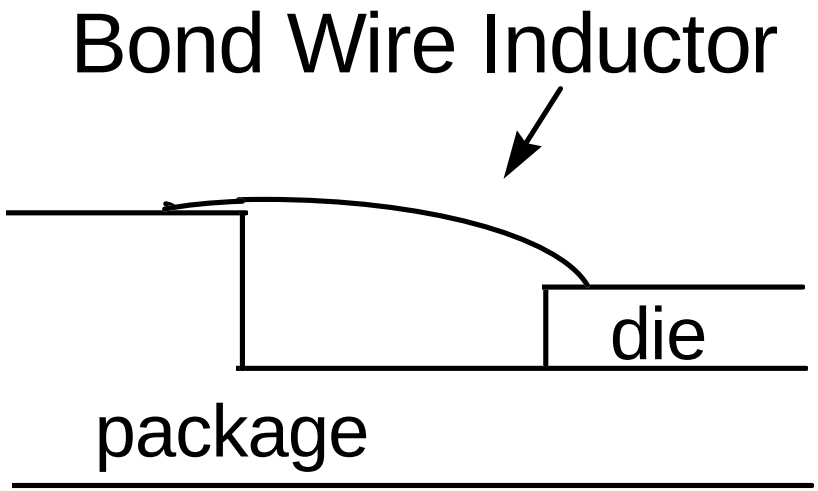


Circuit Diagram



Die Photo and Packaging





Results

Frequency	1.6GHz
Power	0.5mW at 2.0V supply
Phase Noise	-95dBc/Hz (100kHz offset)
Tuning Range	130MHz
Process Technology	0.5-μm MOSIS standard CMOS

Figure of Merit at 100kHz offset

Technology	Frequency	Power	Phase Noise @100kHz	FOM
[7] Bipolar	**1.6GHz**	**3mW**	**-95.1dBc/Hz**	**212dBF**
CMOS	**1.6GHz**	**0.5mW**	**-95dBc/Hz**	**220dBF**

Figure of Merit = 10 log (Freq/(Phase Noise x Power))

Figure of Merit at 10kHz offset

Technology	Frequency	Power	Phase Noise @10kHz	FOM
[5] Bipolar	**1.13GHz**	**2mW**	**-75dBc/Hz**	**192.5dBF**
CMOS	**1.6GHz**	**0.5mW**	**-64dBc/Hz**	**189dBF**

Figure of Merit = 10 log (Freq/(Phase Noise x Power))

Conclusions

- Bond wires offer a high quality monolithic inductance.
- The Hajimiri Phase Noise model provides methods to minimize close-in phase noise in oscillators.
- CMOS is a growing and attractive solution for RF oscillators.

Acknowledgements

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