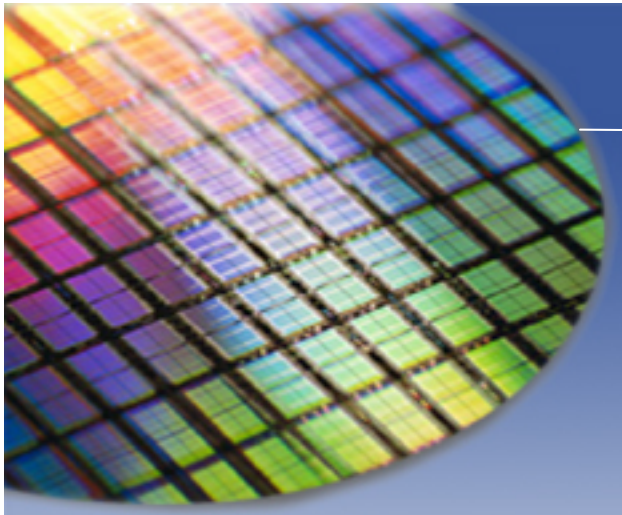
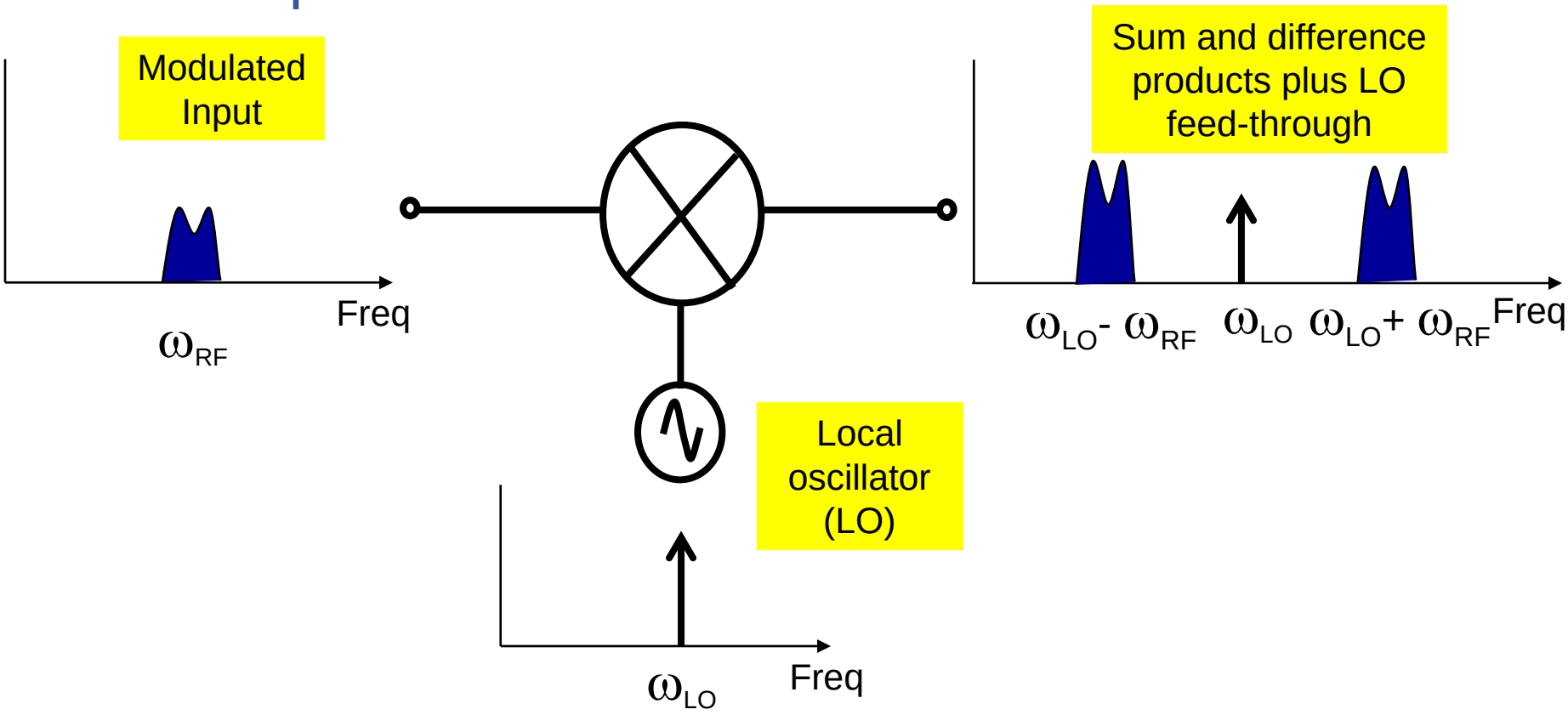


ADI 2006 RF Seminar

Chapter IV
RF Components
Active and Passive Mixers

ANALOG DEVICES

RF Components – Mixers

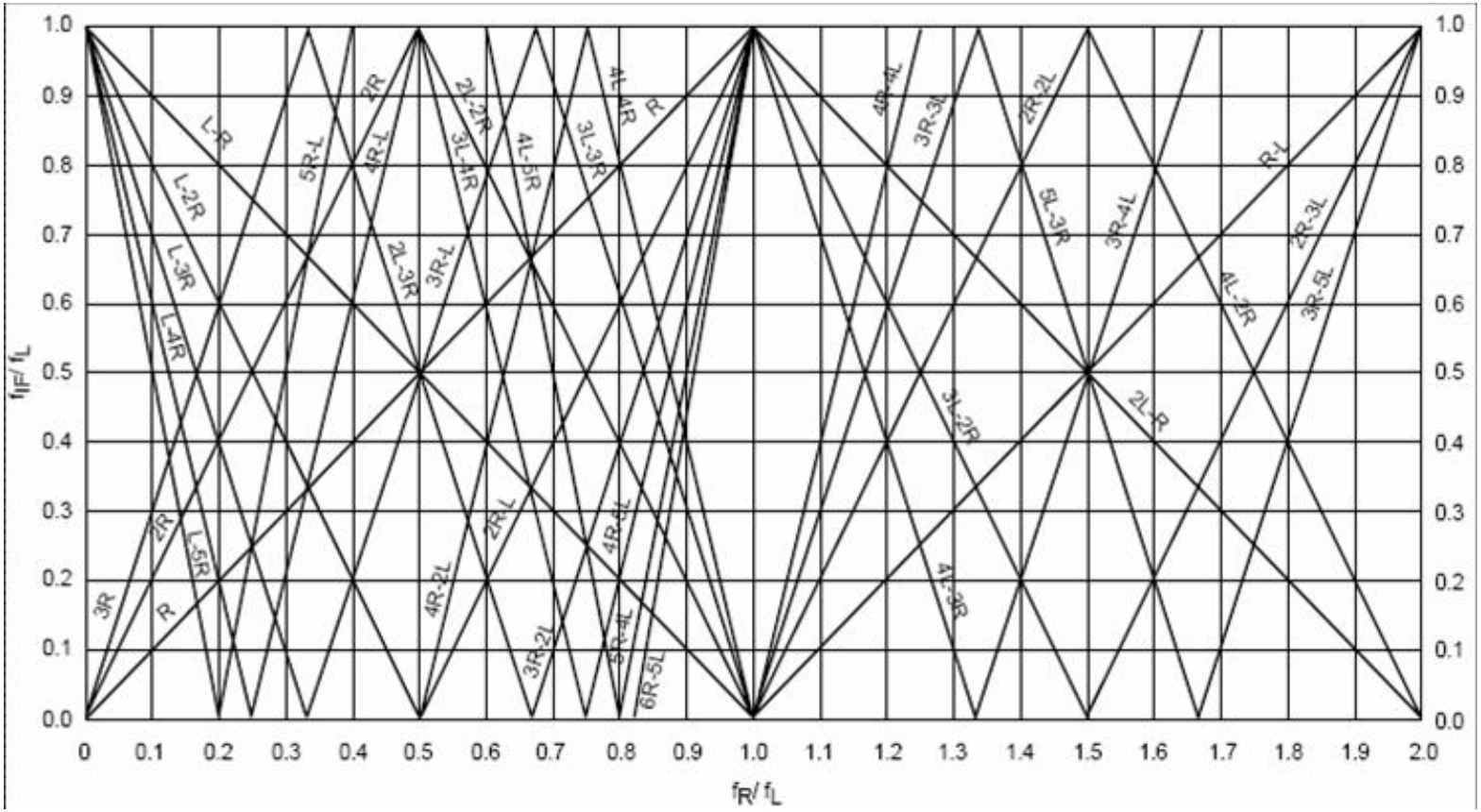


- **Mixers translate modulated carriers from one frequency to another by multiplying the input by a square wave (a sum of odd harmonics)**
- **In addition to generating sum and difference components, mixer will also generate unwanted spurs at multiples of the LO and Carrier frequencies**
- **Mixers also add noise, IMD products and LO leakage to the output spectrum**

Mixer Spurious Distortion Components

High Side LO Injection

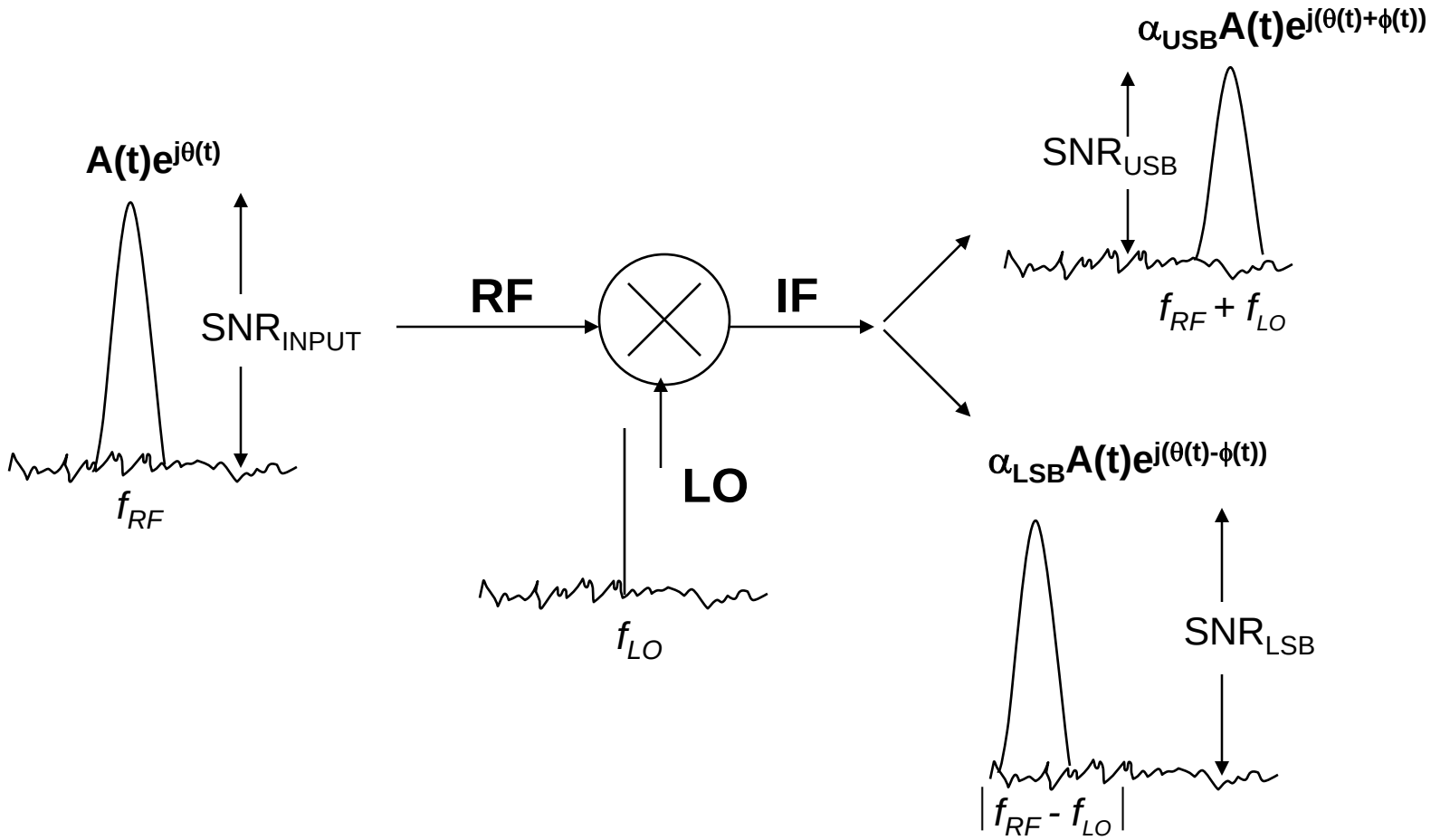
Low Side LO Injection



- **Mixer Spurious Trajectory Maps are often used to find optimum IF's for a given mixer architecture**
- **A Mixer Spur table helps to provide systems engineers with knowledge of the $mf_{RF} \pm nf_{LO}$ rejection capability of a given mixer**

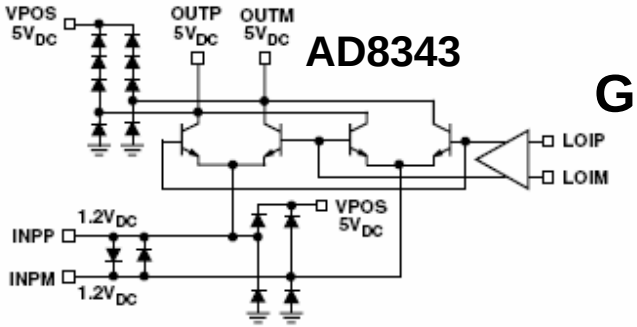
ANALOG DEVICES

Noise Figure of a Mixer

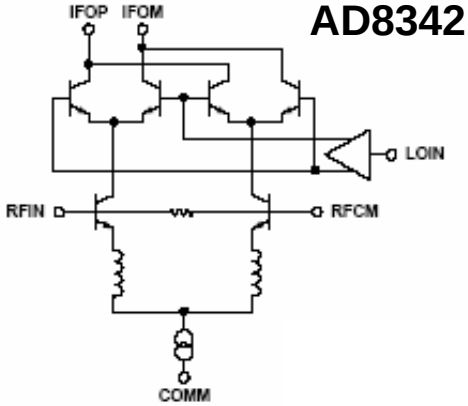


Input signal is split between upper and lower side-bands, not necessarily with equal gain or loss. Need to consider conversion gain or loss relationship versus frequency. Noise figure can be different for upper and lower sidebands. This may result in a slight difference between conversion loss and NF for a passive mixer

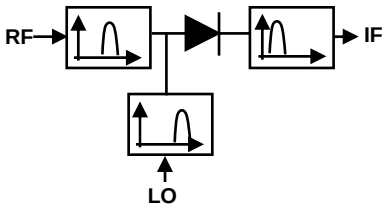
Many Different Mixer Architectures



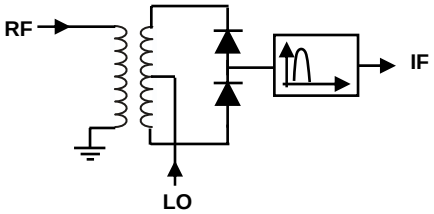
Gilbert Cells



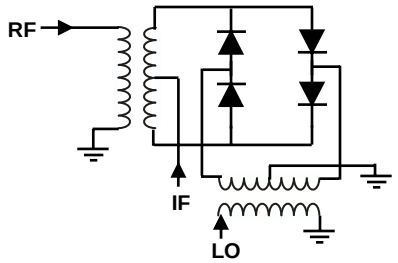
Single-Ended



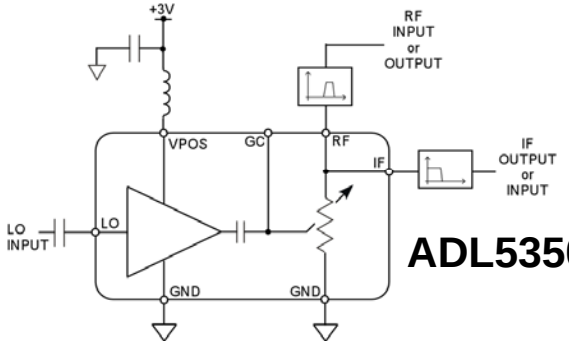
Singly-Balanced



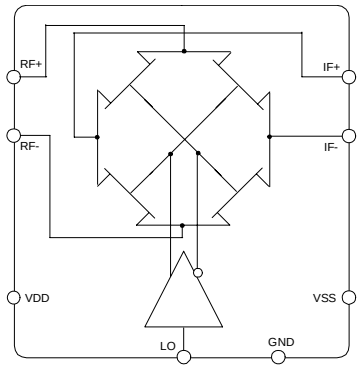
Doubly-Balanced



Single-Ended Resistive FET



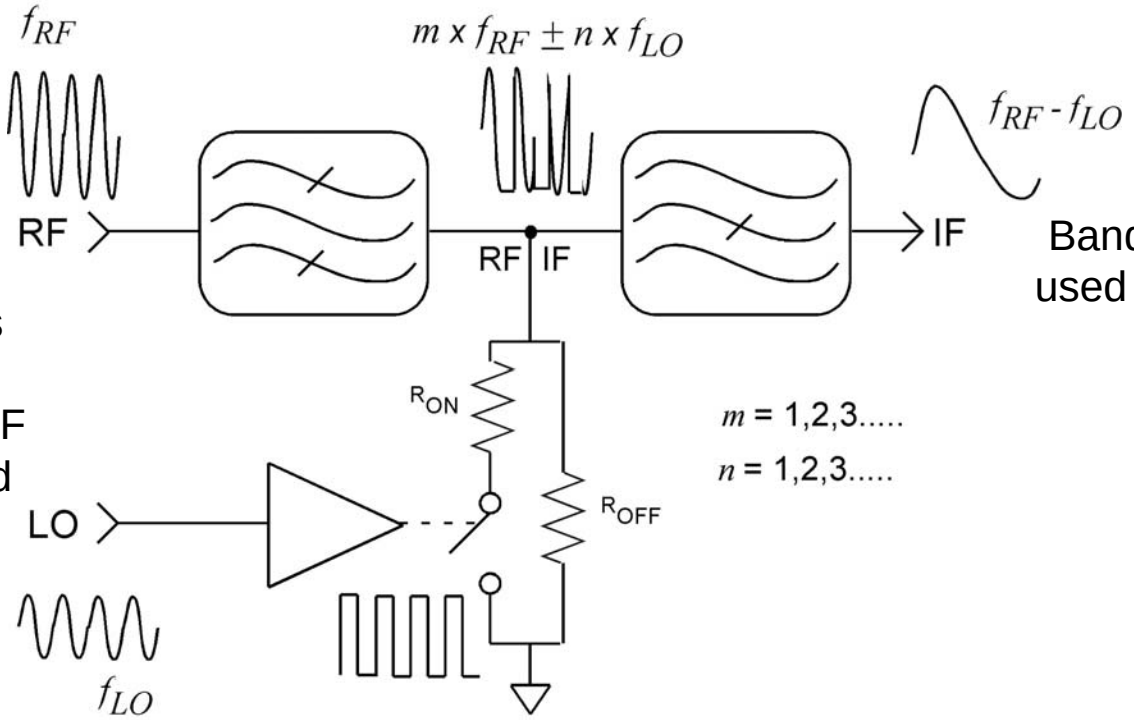
ADL5350



Doubly-Balanced Quad FET

ANALOG DEVICES

Single-Ended Passive Mixers



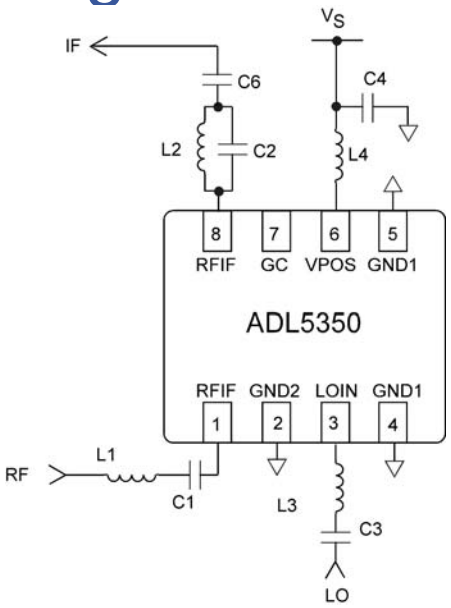
Band Pass Filter is used to pass RF signal and Isolate RF port from presented IF load impedance

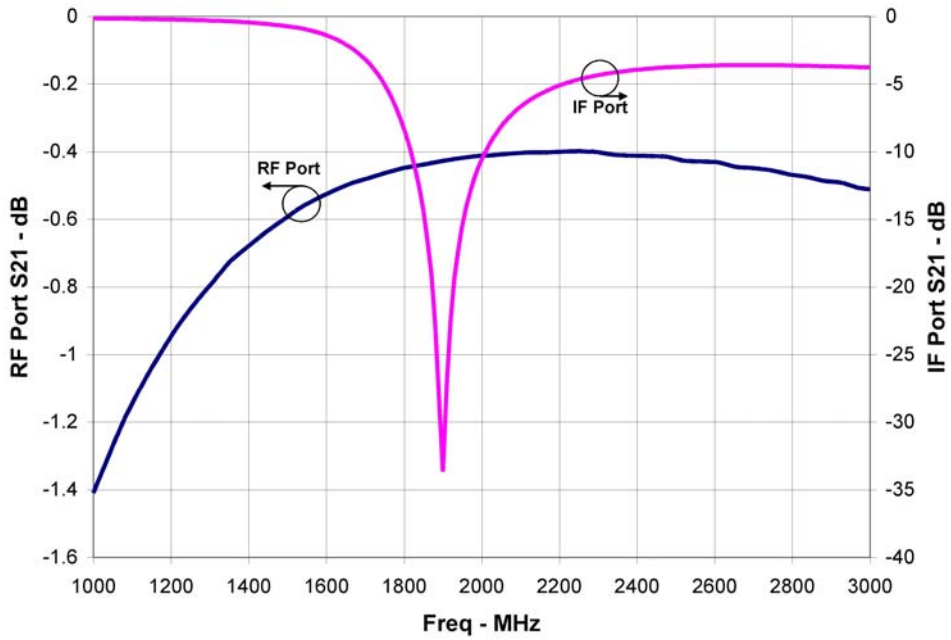
Band Reject Filter is used to reject RF and LO signal

- **Single-Ended Mixers share a common node for the RF and IF ports**
- **The RF Envelope is Modulated by the switching action of a diode of FET junction at the rate of the applied oscillator**
- **It is desirable to switch the RFIF node impedance between a short and open to provide maximum frequency conversion to the sum and difference frequencies**
- **Sharp switching also has a positive impact on inter-modulation performance**
- **Often an LO buffer is employed to ensure adequate On/Off switching of the RFIF node**

ANALOG DEVICES

Single-Ended Mixer Implementation





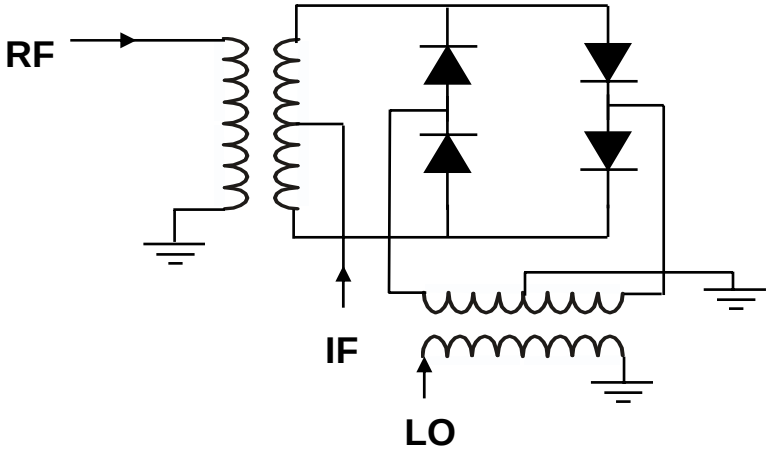
Desired LO frequency	Recommended LO bias inductor (L4)
750 MHz	24 nH
1000 MHz	18 nH
1750 MHz	3.8 nH
2000 MHz	2.7 nH

RF Frequency	L1	C1	L2	C2	L3	C3
850 MHz	6.8 nH	4.7 pF	4.7 nH	5.6 pF	8.2 nH	100 pF
1950 MHz	1.7 nH	1.5 pF	1.7 nH	1.2 pF	3.5 nH	100 pF

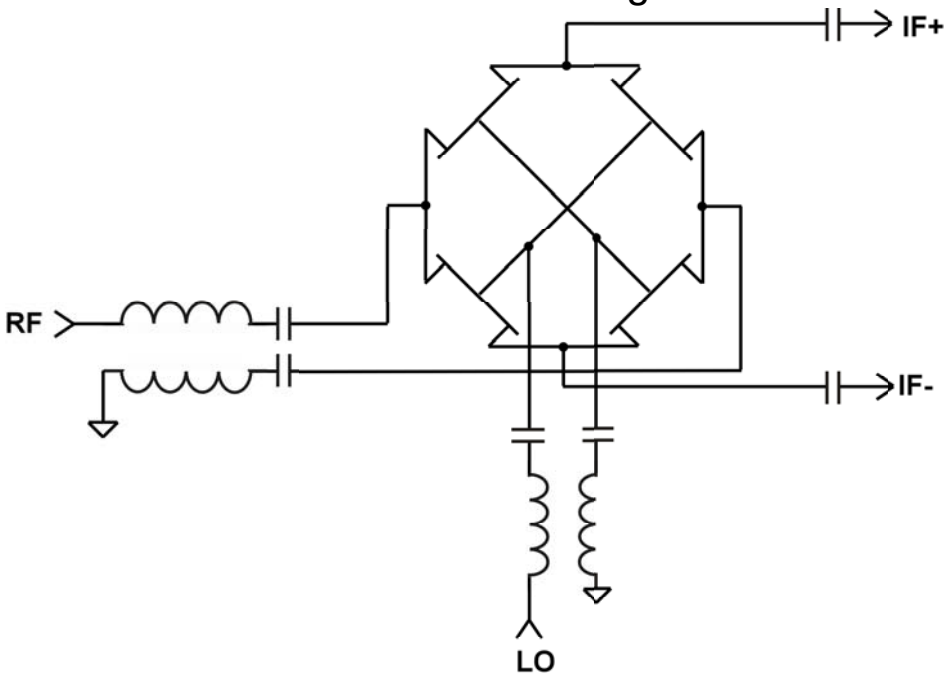
Step 1. Tune the LO buffer supply inductor for minimum supply current.
Step 2. Tune the LO port input network for optimum return loss.
Steps 3 and 4. Design the RF and IF filter networks.

Doubly Balanced Passive Mixers

Diode Based Ring Mixer



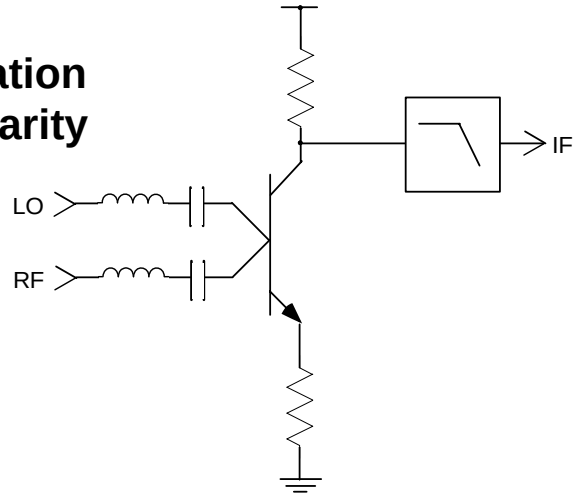
FET Based Ring Mixer

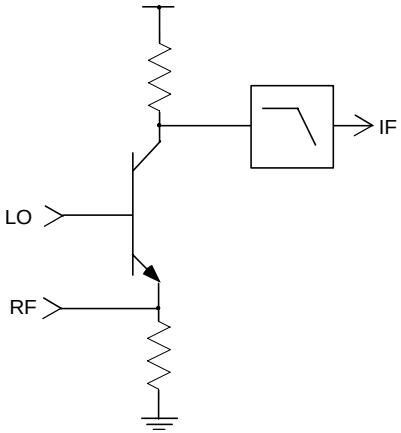


- **Passive Ring Mixers are the most popular type**
- **All Passive Mixers require Balun/Transformer structures on RF and LO ports in order to achieve good performance**
- **Balanced LO and RF drive results in improved even order spurious performance and improved LO to RF and LO to IF leakage**
- **Less popular balanced passive mixers include Star Mixers and Double-Doubly Balanced Mixers**

Simple Active Mixers Using BJTs

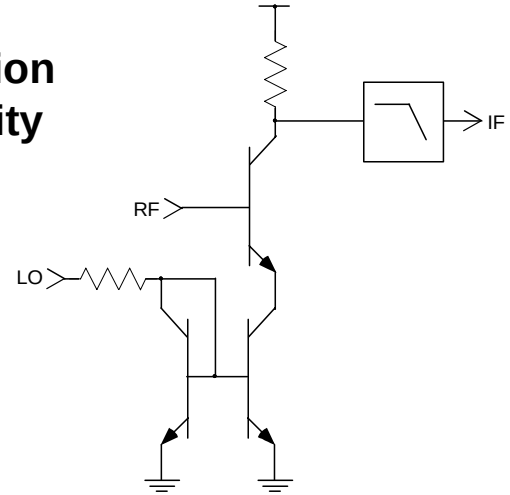
Poor Isolation
Poor Linearity

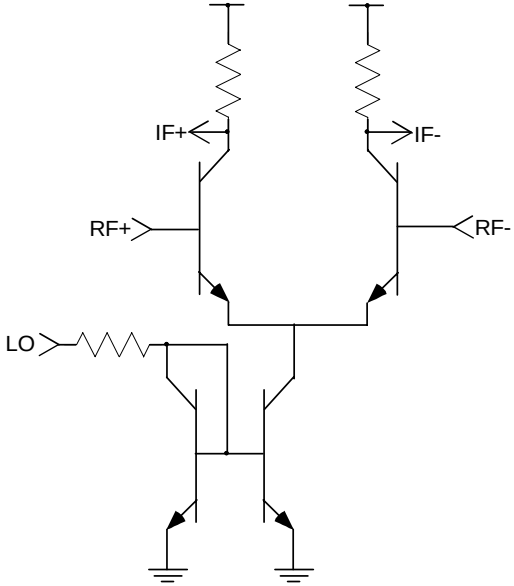




Poor Isolation
Better Linearity
Poor NF

Better Isolation
Poor Linearity
Better NF



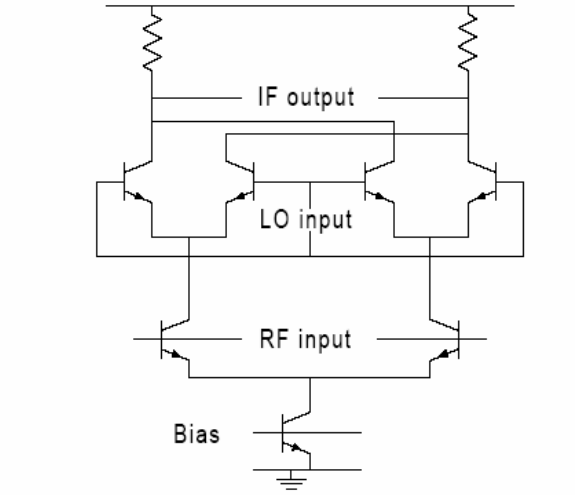


Better Isolation
Better Linearity
Better NF

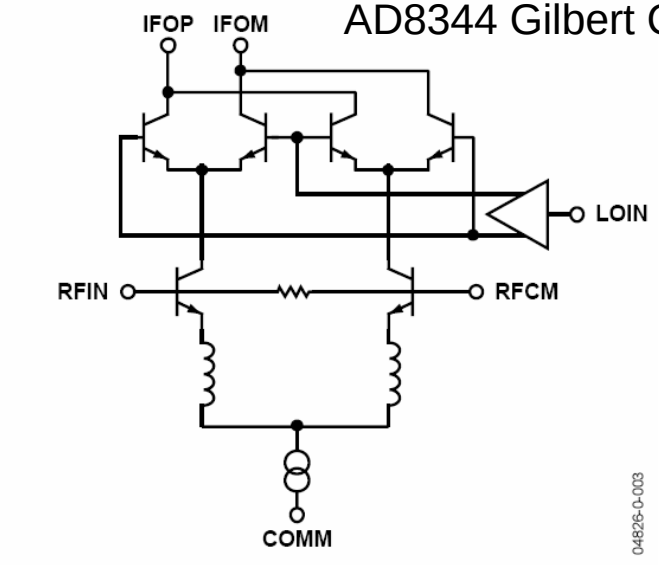
ANALOG DEVICES

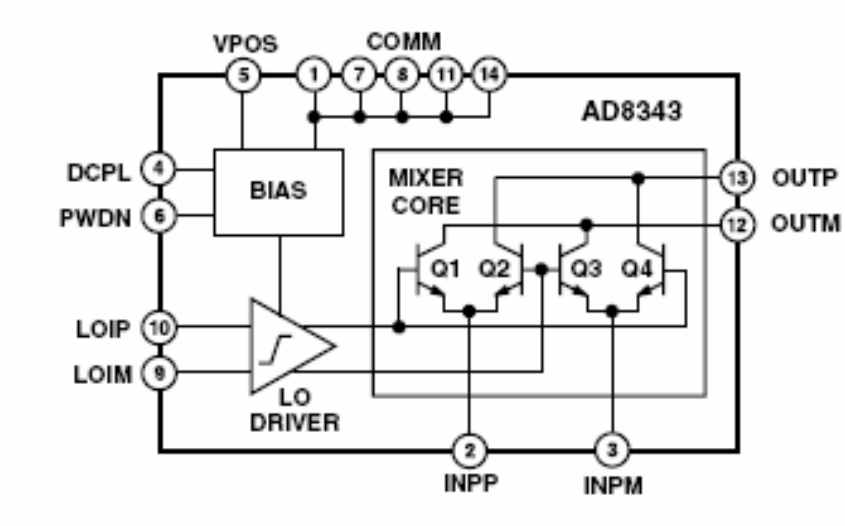
Gilbert Cell Mixers

Basic Textbook Gilbert Cell



AD8344 Gilbert Cell





Several varieties. The AD8343 is very generic, requires some off-chip biasing and matching, but can be used over a broad range of frequencies. The AD8344 is optimized for 900MHz cellular applications and provides matched RF and LO ports. The AD8342 provides matched ports and is more broadband than the AD8344.

ANALOG DEVICES

A Low Frequency to 500 MHz Active Mixer

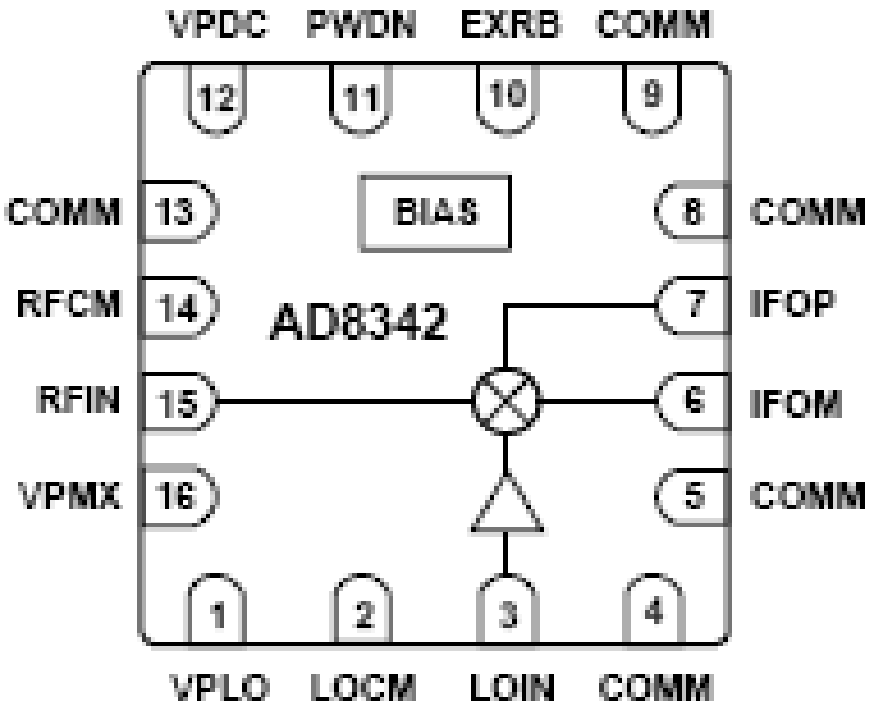


Figure 1.

- 3.7 dB Conversion Gain
- Integrated LO Drive
- Single Ended RL and LO Drive
- Differential IF Output
- +8 dBm IP1dB, 12 dB Noise Figure, +23 dBm IIP3

ANALOG DEVICES

Active vs Passive Mixers

	Pros	Cons
Balanced Active Mixers	• Provides Some Gain • Requires no balun/transformers • Good LO to RF Isolation • Requires low LO drive	• Tend to have higher NF than passive mixers • Tend to have lower input linearity than passive mixers • Requires DC Power
Single-Ended Passive Mixers	• Small and Low-Cost • Good Input Linearity • Low Noise • Low LO drive when includes integrated LO Buffer	• Poor LO to RF Isolation • Poor 2nd Order Distortion Performance • Requires Off-Chip Diplexer Networks to separate RF and IF ports
Balanced Passive Mixers	• Offers the best Input Linearity • Reasonably Low Noise • Good LO to RF Isolation	• Requires Strong LO Drive unless LO Buffer is included • Requires Off-Chip Baluns • May be size and cost prohibitive due to required magnetics

High Linearity Mixers

Part No.	RF Freq (MHz)	IF Freq (MHz)	LO Freq (MHz)	Conversion Gain (dB)	IP3 (dBm)	P1dB (dBm)	NF (dB)	Package Type
AD8342	dc to 500	dc to 400	LF to 850	4	24	9	11	16-lead CSP
AD8343	dc to 2500	dc to 2500	dc to 2500	7	16.5	2.8	14	14-lead TSSOP
AD8344	400 to 1200	70 to 400	470 to 1600	4	24	8	11	16-lead CSP
ADL5350	200 to 3000	LF to 3000	LF to 3000	-7	26	18	7	8-lead LFCSP