Oscillators and Synthesizers

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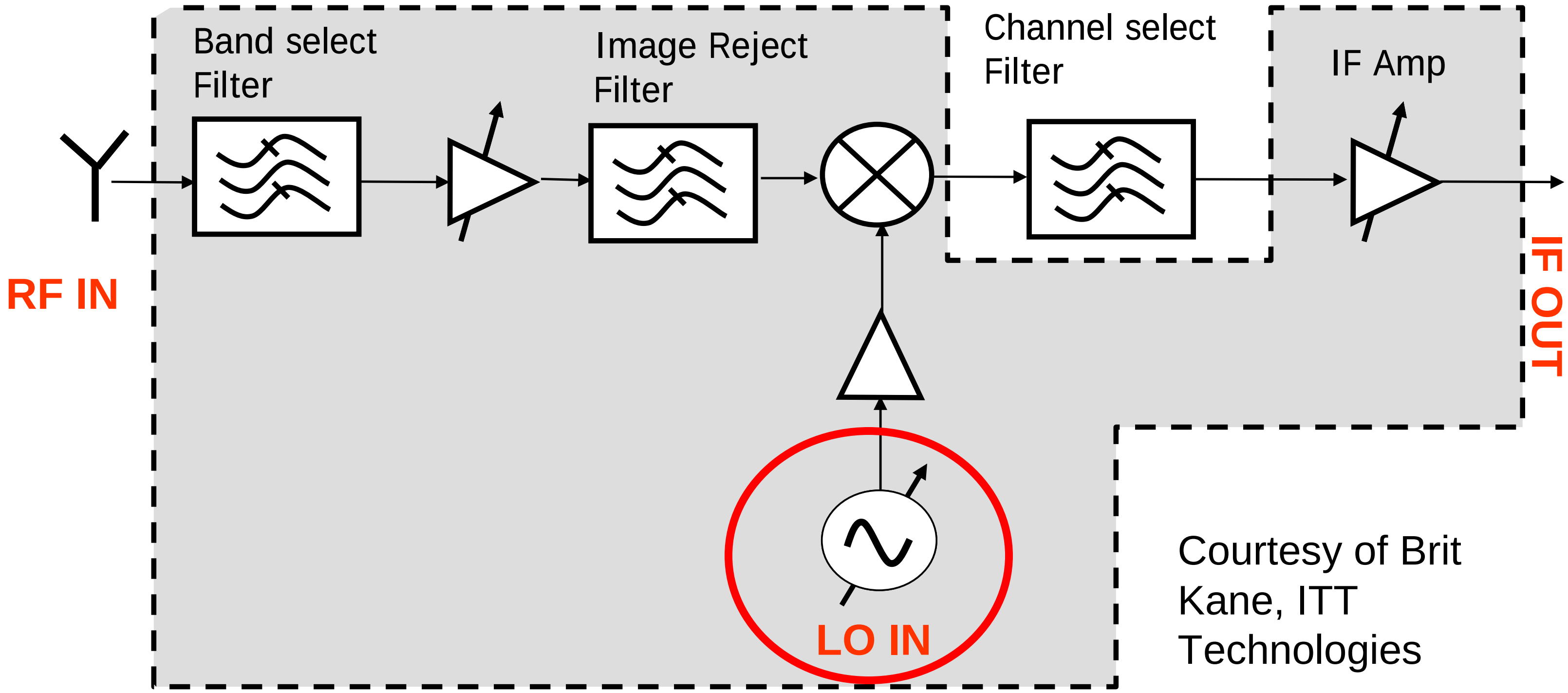
Oscillators and Synthesizers

- Functional description
- Implementation
- System implications

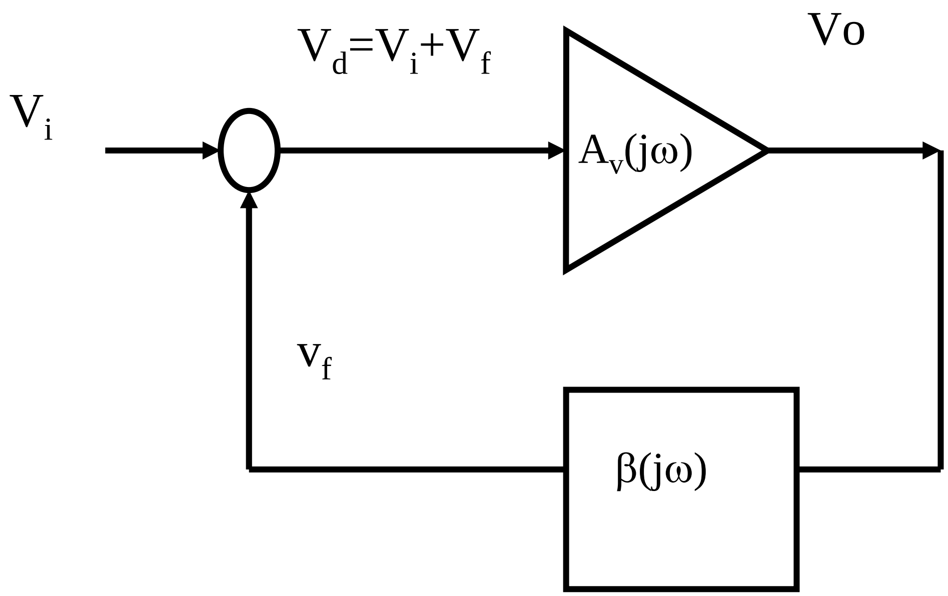
Functional Description



Courtesy of Brit Kane, ITT Technologies

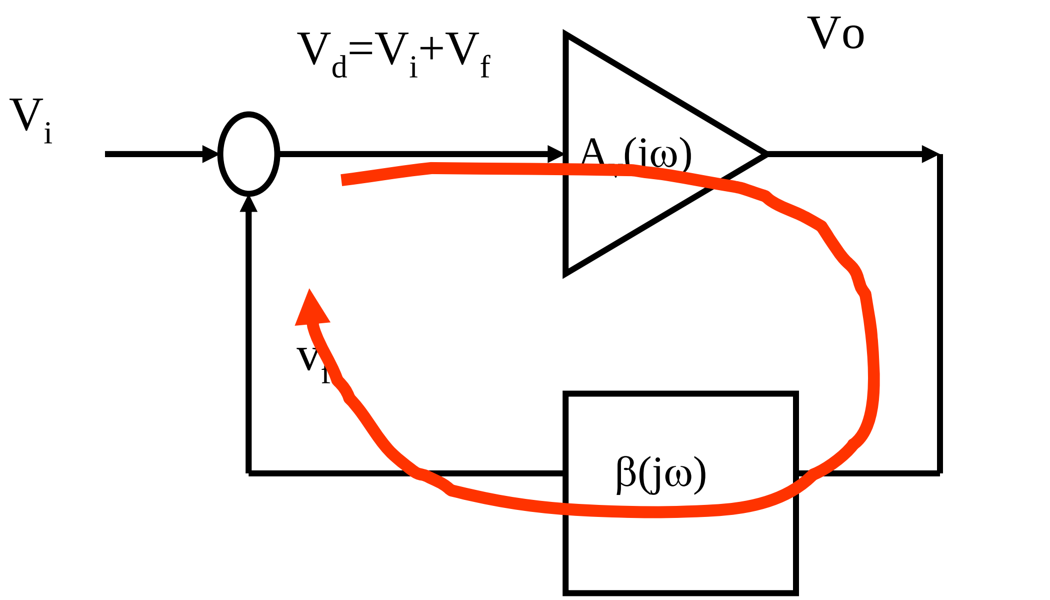
Functional Description

- A_v is the amplifier (or open loop) gain
- β is the feedback transfer function
  - Positive feedback occurs when V_f and V_i are in phase



Functional Description

- Oscillation condition: the total phase through the feedback loop should be n·360°



$$\frac{v_o}{v_i} = A_{vf}(j\omega) = \frac{A_v(j\omega)}{1-\beta(j\omega)A_v(j\omega)}$$

Functional Description

- We require an output signal to exist with zero input signal → the denominator must be zero

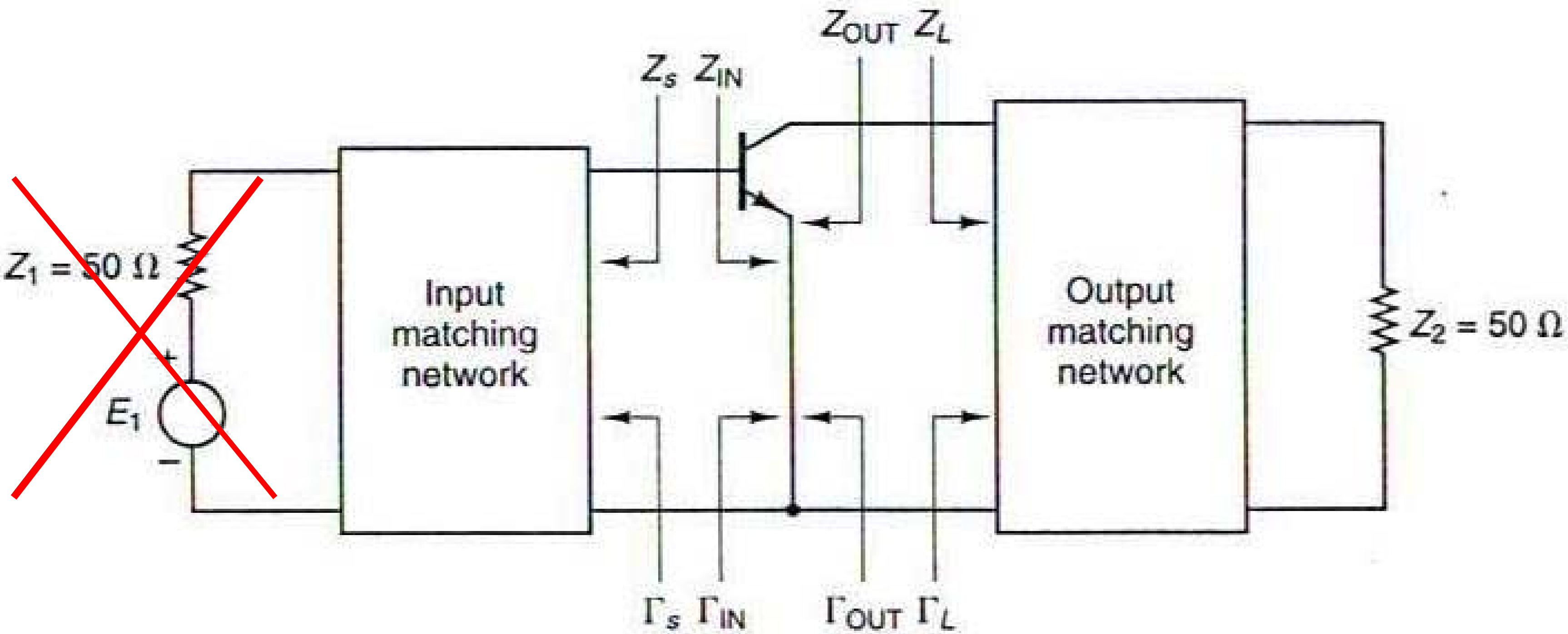
$$\frac{v_o}{v_i} = A_{vf}(j\omega) = \frac{A_v(j\omega)}{1 - \beta(j\omega)A_v(j\omega)}$$

Zero!

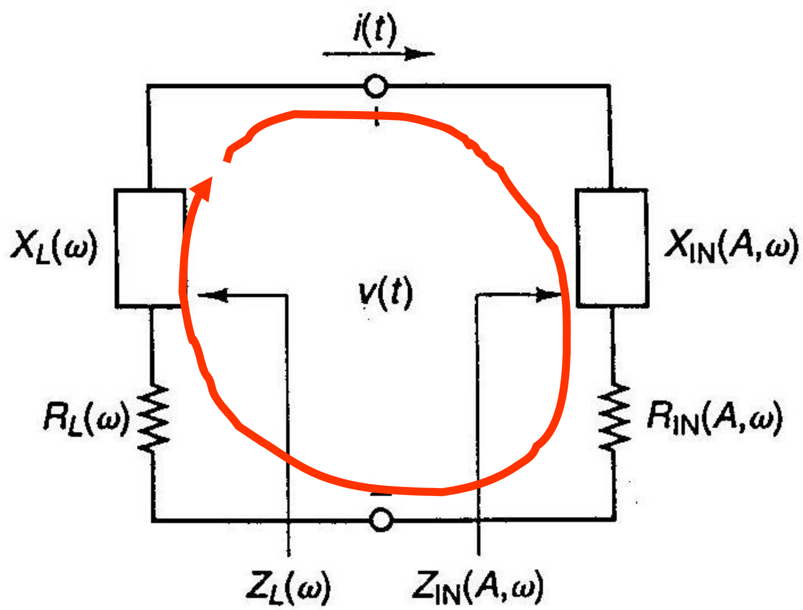
$$1 = \beta(j\omega)A_v(j\omega)$$

Barkhausen Criterion

Implementation



Implementation



For this configuration the Barkhausen criterion is equivalent to this relationship:

$$\Gamma_{IN}(j\omega_o)\,\Gamma_L(j\omega_o) = 1$$

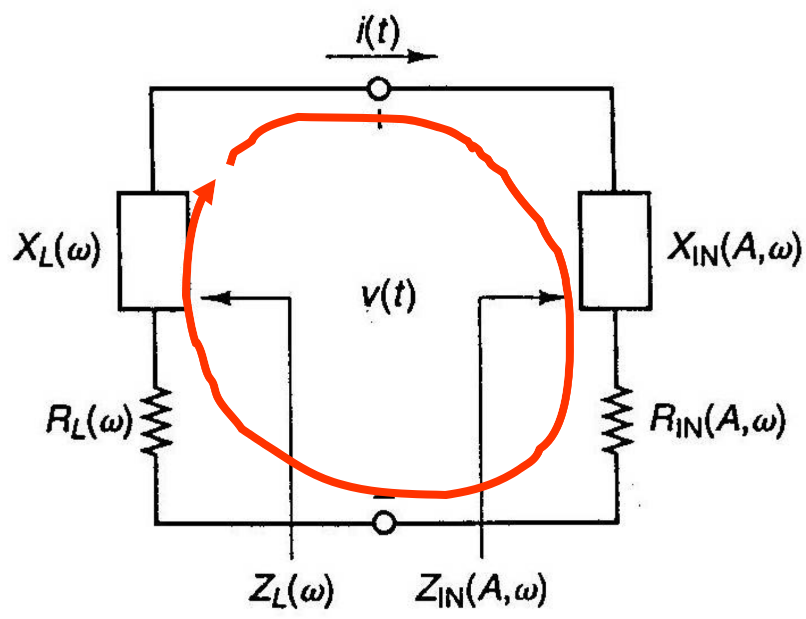
Implementation

$\Gamma_{IN}(\omega_o)\,\Gamma_L(\omega_o)$ = 1 is equivalent to the following:

$$R_{in}(\omega_o) + R_L(\omega_o) = 0$$

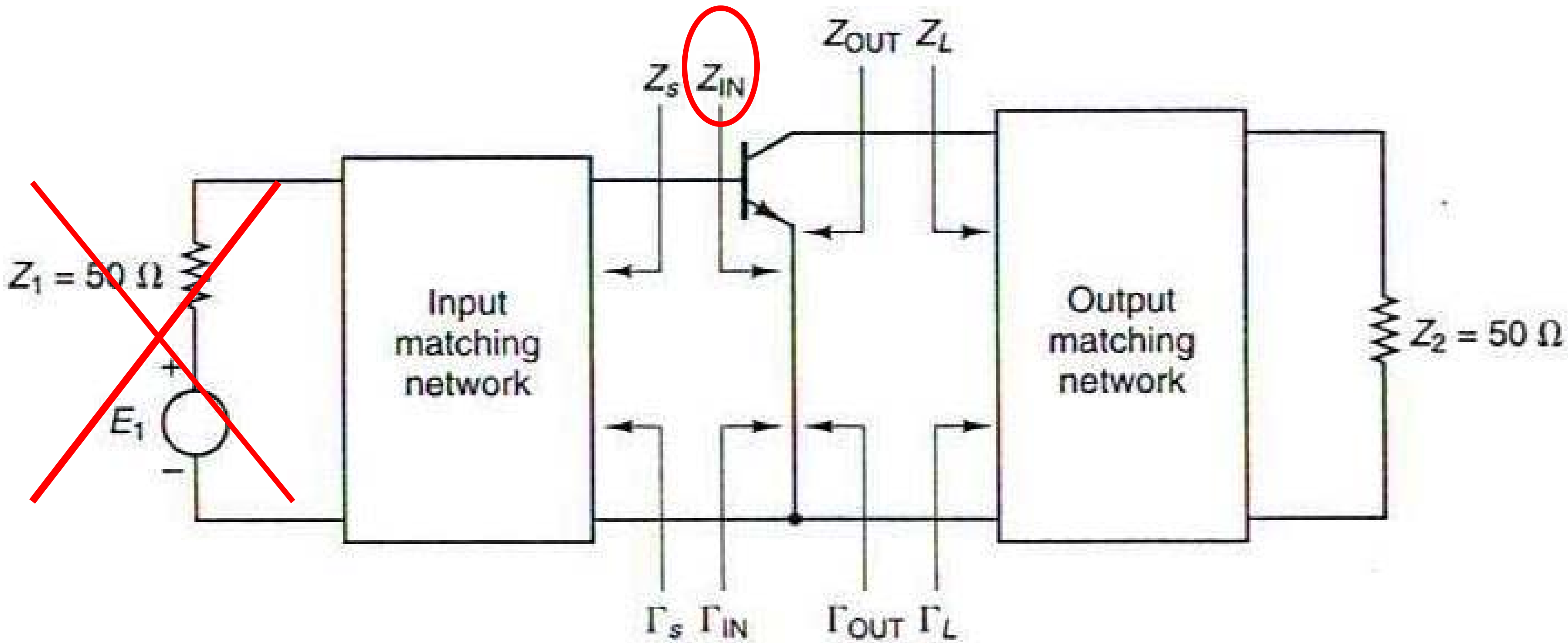
$$X_{in}(\omega_o) + X_L(\omega_o) = 0$$

These are the oscillation conditions

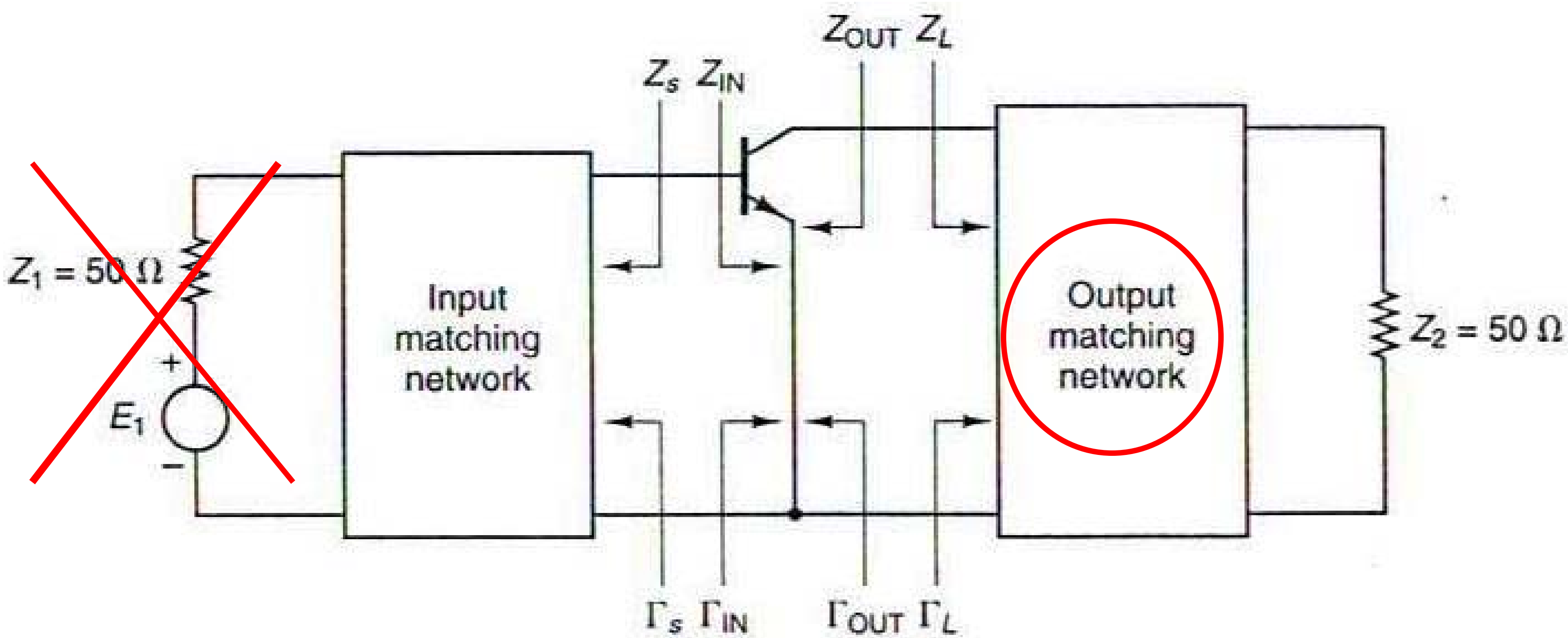


Implementation

Q: How do we make Re{Z_{in}} negative?



Implementation



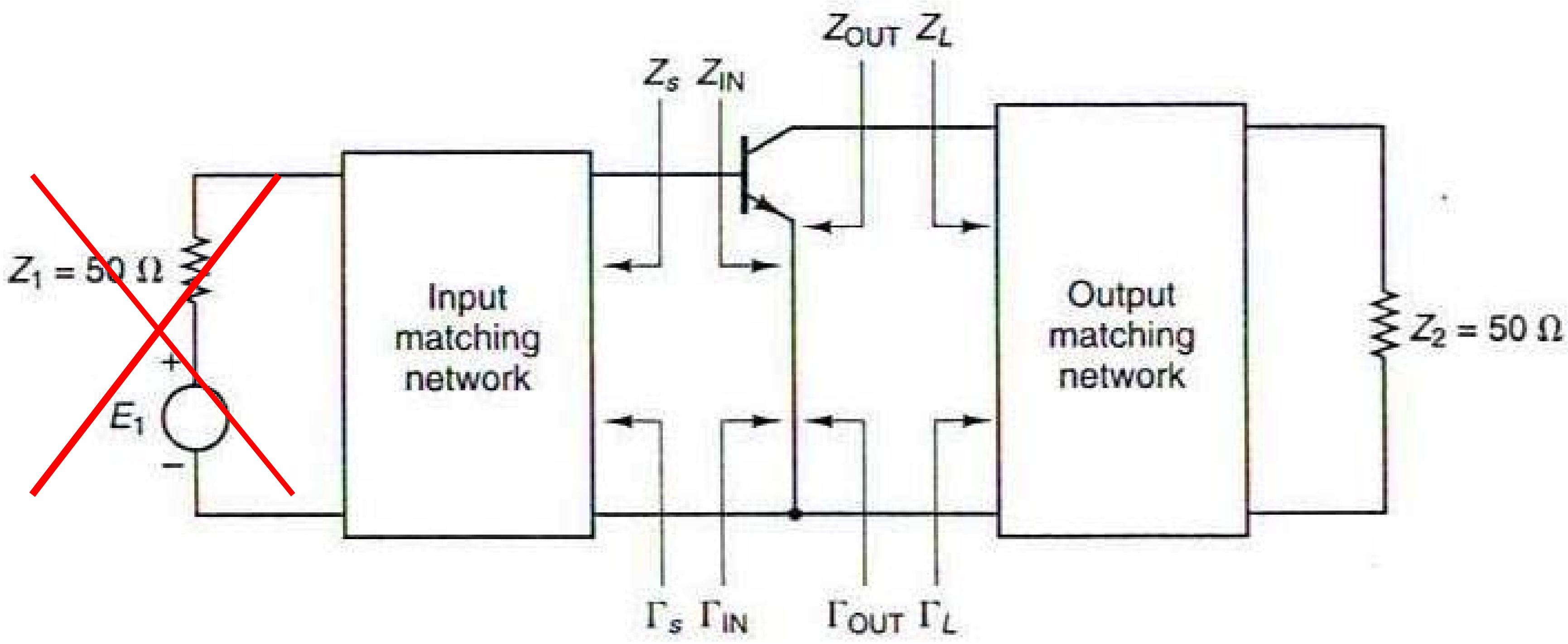
A: By properly designing the output network.

Implementation

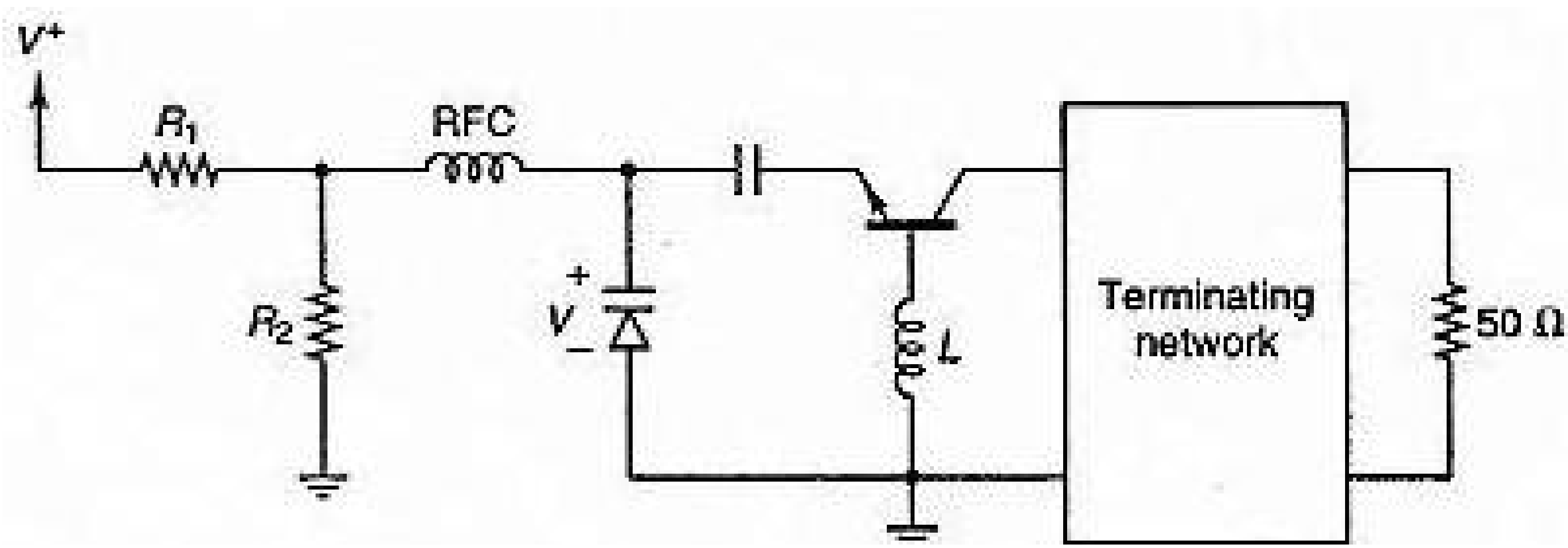
- Design Process:
  - Transistor is biased and configured so it is potentially unstable (equations can be used to determine these conditions)
  - Output (or input) matching network is designed to present a negative impedance at the opposite port
  - Input (or output) matching network is designed to achieve the Barkhausen condition at the desired frequency of oscillation

Voltage-Controlled Oscillators

In order to control the frequency of oscillation a voltage-tunable reactance (typically a varactor diode) is used in the matching network to control the frequency at which the Barkhausen criterion is satisfied → this is a VCO

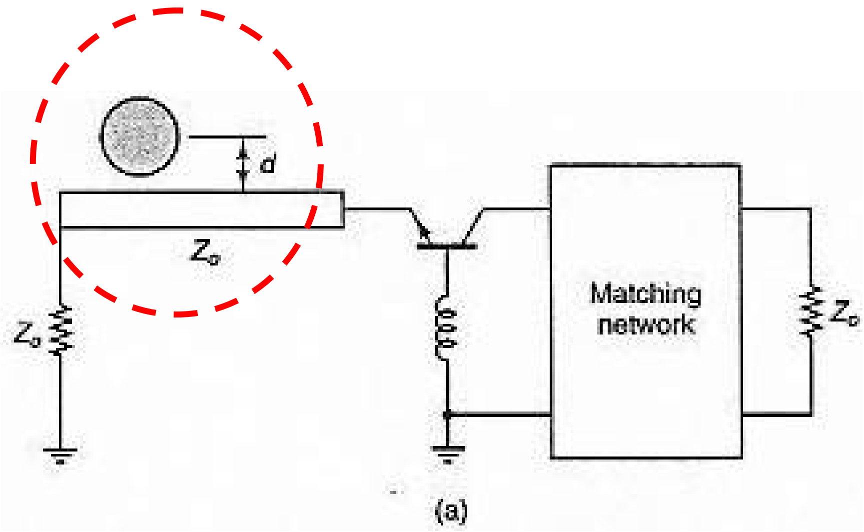


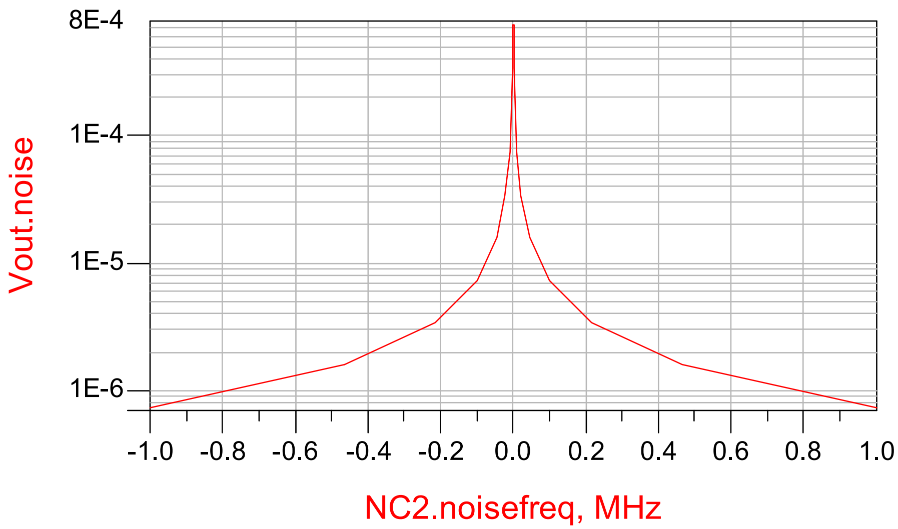
Voltage-Controlled Oscillators



Oscillators

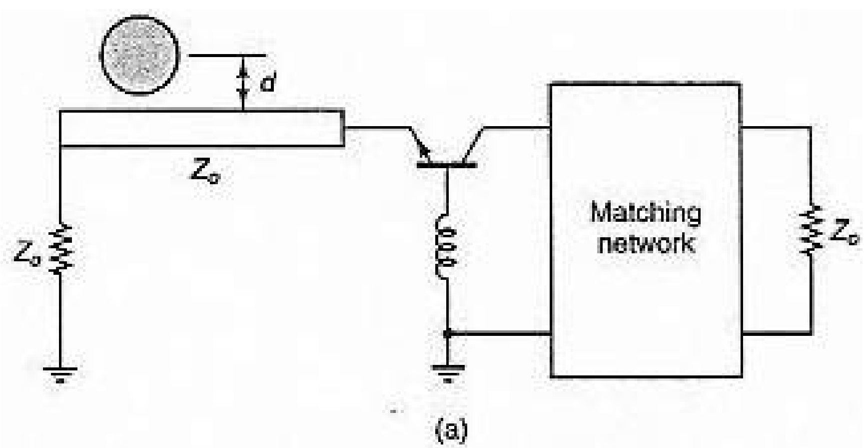
In order to generate a “clean” signal the feedback network is designed to be very narrow-band such that the oscillation condition is strongly perturbed if the frequency tries to change by only a small amount → a “clean” signal has a narrow spectrum and low phase noise

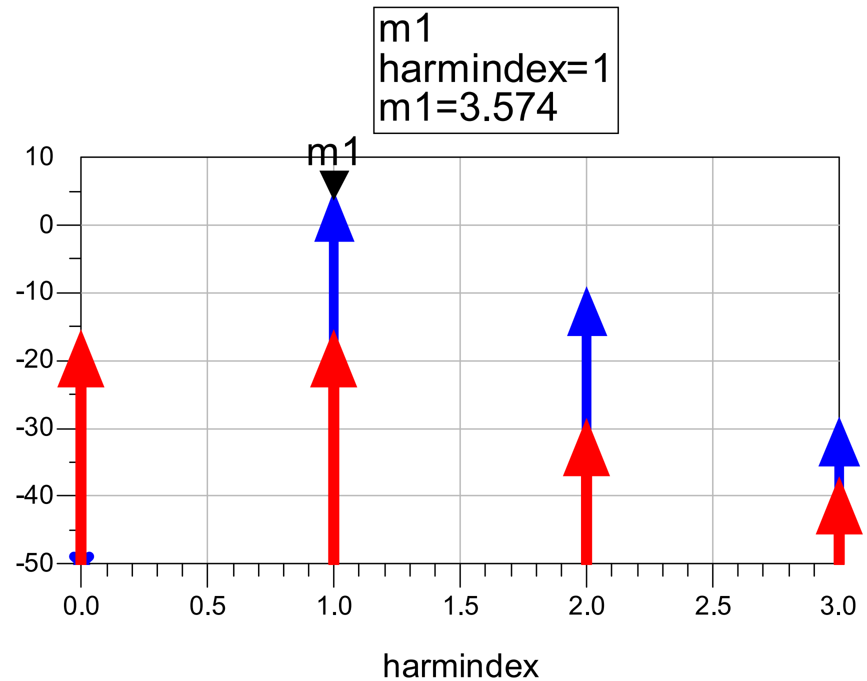




Oscillators

In general the Barkhausen criterion will be satisfied at harmonics of the fundamental frequency, too!





Oscillators

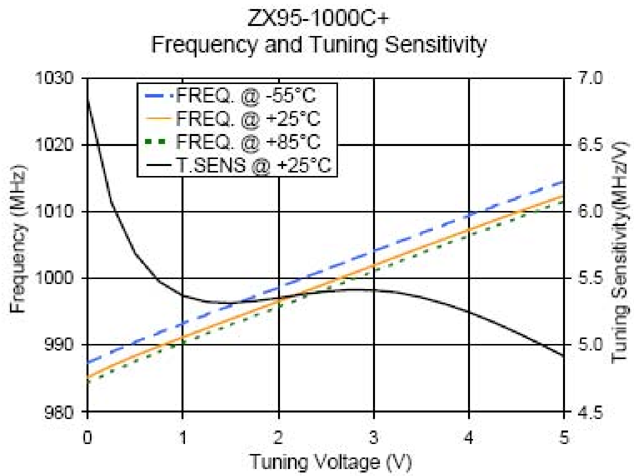
VOLTAGE CONTROLLED OSCILLATORS

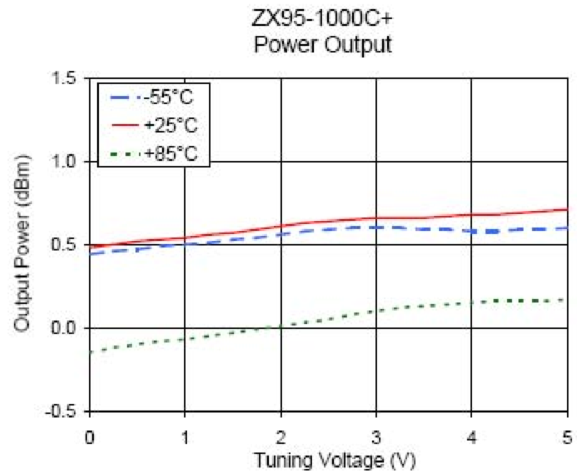
5V TUNING FOR PLL IC's 24 to 2600 MHz

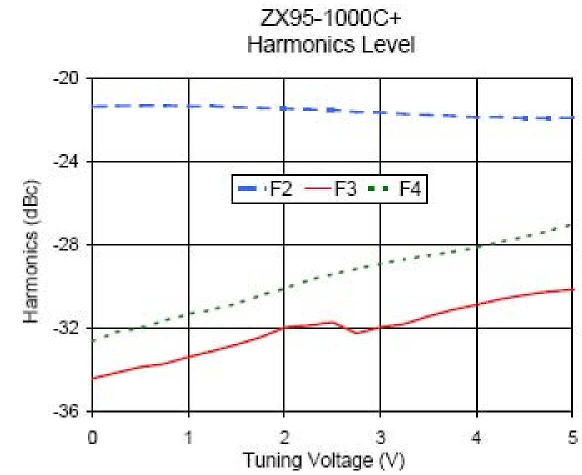
JTOS MOS ROS

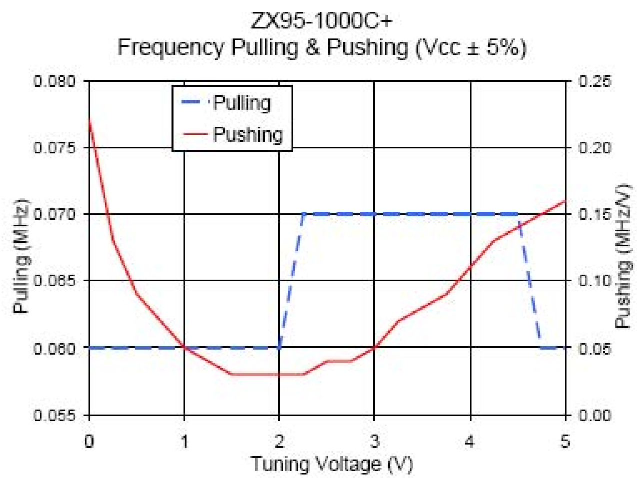
MODEL◆ NO.	FREQ. (MHz)		POWER OUTPUT (dBm)	PHASE NOISE (dBc/Hz) SSB@ offset frequencies: Typ.				PULLING (MHz) pk-pk @12 dBr	PUSHING (MHz/V)	TUNING SENSITIVITY (MHz/V)	HARMONICS (dBc)		3 dB MOD. BANDWIDTH (kHz)	V
	Min.	Max.	Typ.	1 kHz	10 kHz	100 kHz	1 MHz	Typ.	Typ.	Typ.	Typ.	Max.	Typ.	
JTOS-50P	24-29		+9.5	-88	-108	-127	-147	0.06	0.04	2-2.5	-14	-12	50	
JTOS-75P	35-43		+9	-89	-110	-130	-140	0.15	0.11	2.5-4	-25	-20	125	
JTOS-100P	48-59		+9	-83	-108	-128	-140	0.6	0.2	3.5-4	-30	-20	100	
JTOS-150P	72-91		+9.5	-82	-106	-127	-147	0.8	0.3	6-9	-30	-17	112	
JTOS-200P	95-120		+8.8	-84	-105	-124	-145	1.0	0.2	7-10	-30	-20	110	
JTOS-300P	148-174		+10	-82	-102	-122	-142	1.0	0.2	10-14	-27	-20	120	
JTOS-400P	194-220		+11	-82	-102	-122	-142	1.4	0.4	13-18	-25	-20	130	
JTOS-535P	278-325		+9.5	-75	-97	-117	-137	2.0	0.5	17-22	-30	-20	115	

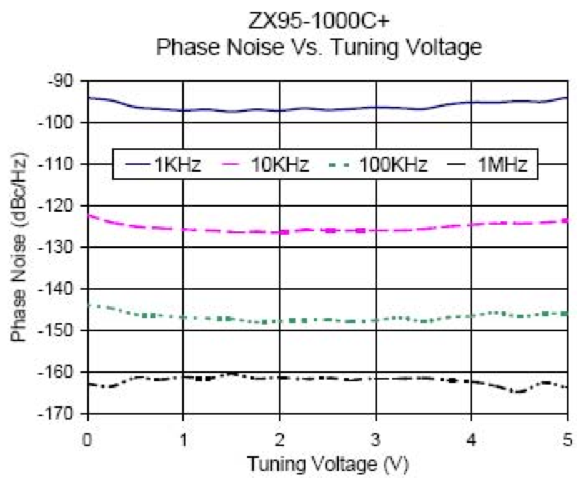
Oscillators

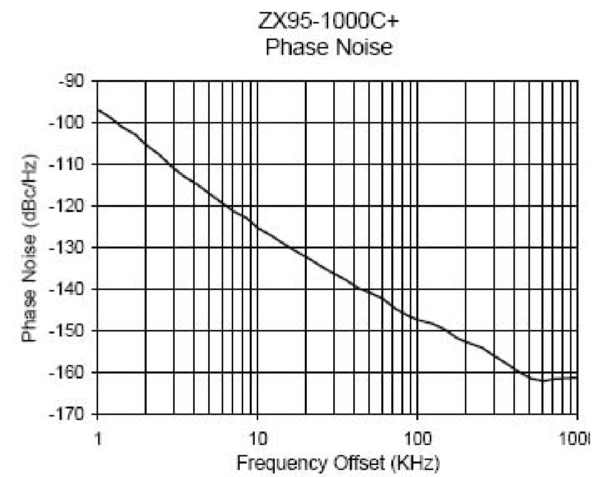












Synthesizer

- A synthesizer is essentially a VCO with a computer attached to it
- The required frequency is specified, and the processor then adjusts the VCO until it detects that the correct frequency is being generated

System Implications

- DC power consumption
- Frequency accuracy
- Harmonic generation → filtering
- (Phase) noise

Oscillators and Synthesizers– Conclusions

- Oscillators convert “noise” into RF signals and are thus the basic component of any “source”
- Basically an amplifier designed such that positive feedback is achieved at a specific frequency
- VCO’s use tunable reactance to change the frequency at which positive feedback occurs
- DC consumption, phase noise, harmonic output, frequency accuracy and tunability are related system level issues

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References

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- http://www.minicircuits.com/pages/pdfs/an95003.pdf