# Chapter 20 – Frequency Translation

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Using one frequency to generate another.

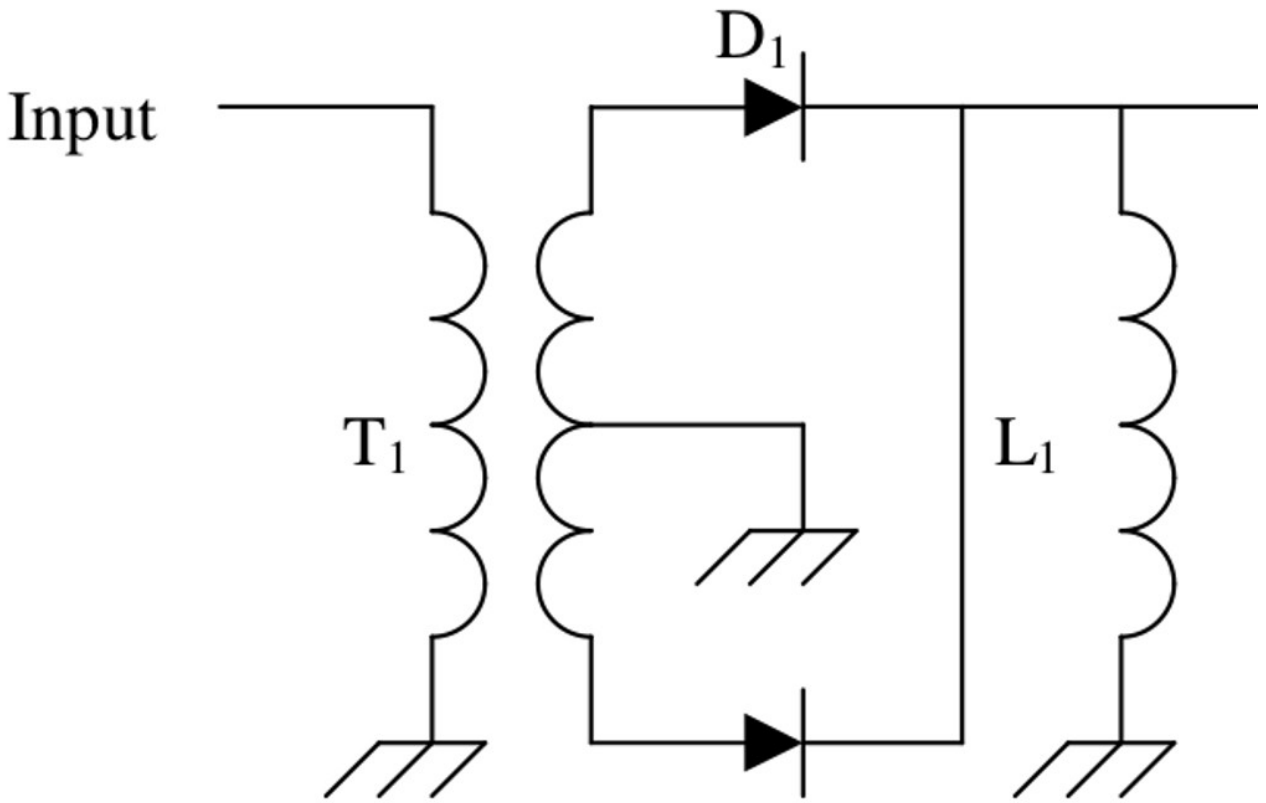
Multiply frequencies.

# Chapter 20
# Frequency Translation

Oscillators are used to generate the signals of various frequencies that are needed by in transmitters and receivers. However, it is often useful to be able to create a signal of a desired frequency from signals of other frequencies. For example, it can be very beneficial to generate a signal at the precise output frequency the user has chosen from a very stable reference signal at a fixed frequency. The circuits we use to do this are frequency multipliers, dividers, frequency synthesisers and mixers.

# Frequency Multipliers 1

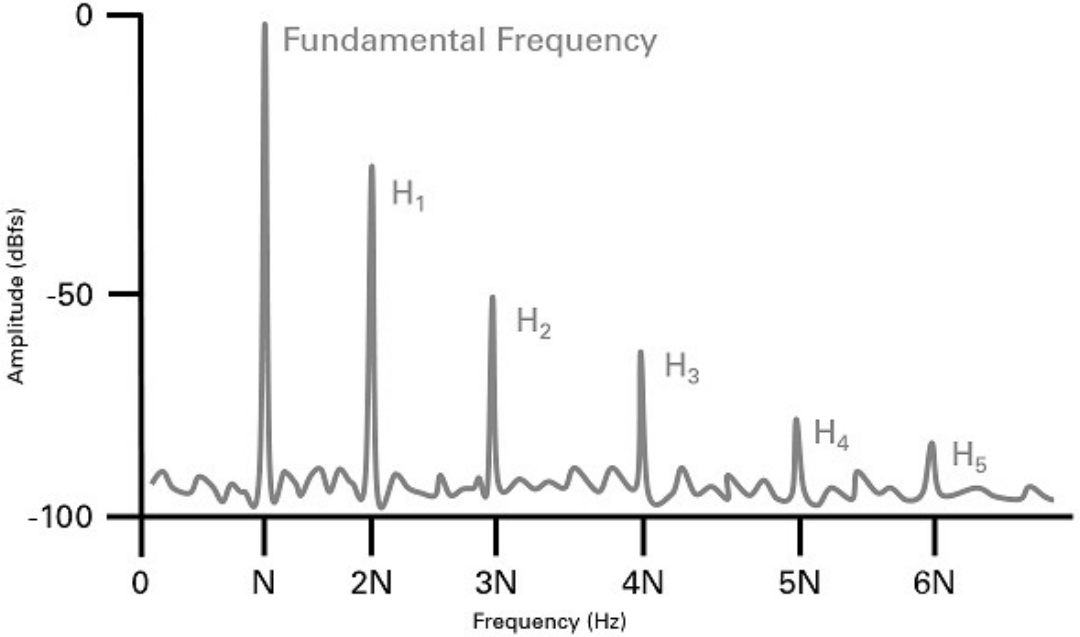
Input frequency
1 MHz
**pure**
sine wave




Output frequency
2 MHz
4 MHz
6 MHz
8 MHz
...

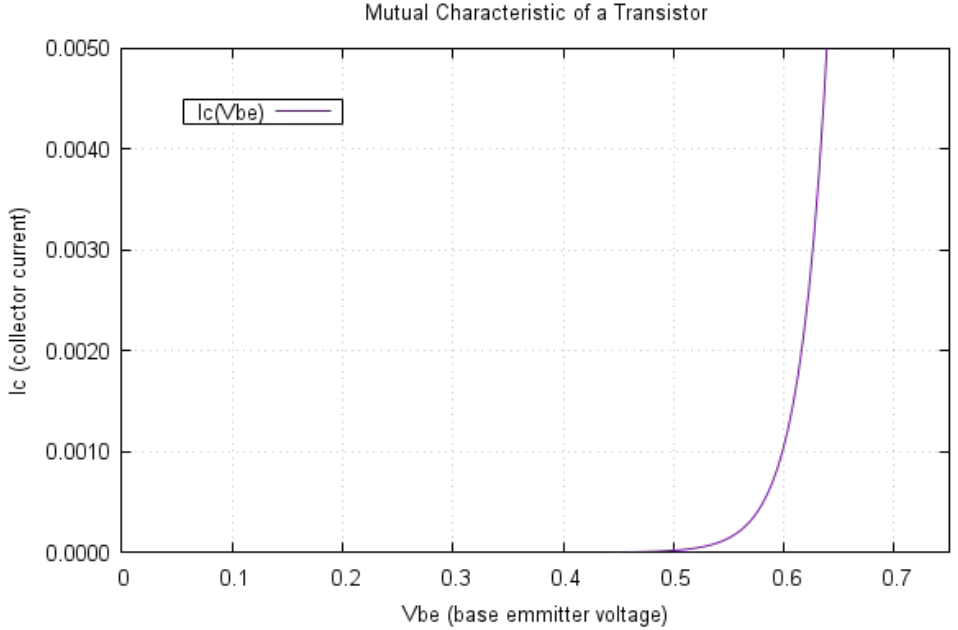
Interestingly this is the only circuit that generates a ‘pure’ second harmonic ouput series. So long as the diodes and transformer secondary are ‘balanced’.

# Frequency Multipliers 2



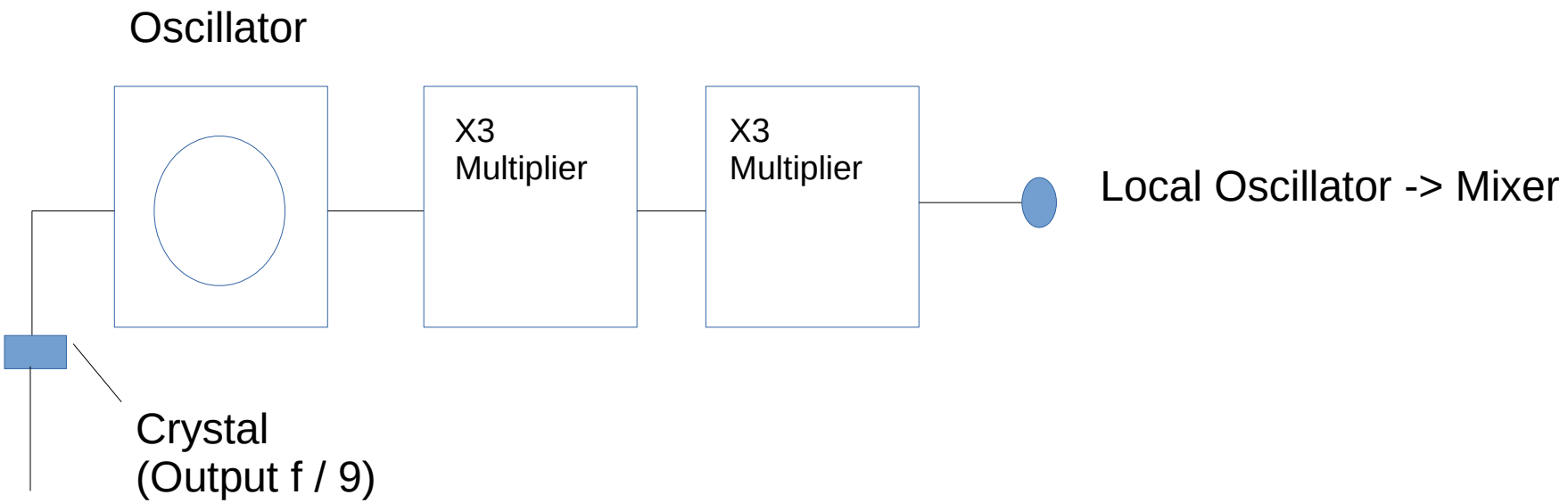

All amplifiers have distortion.

They are all "**non-linear**" to some degree.




When you '**starve**' a transistor of base current, you generate harmonics...

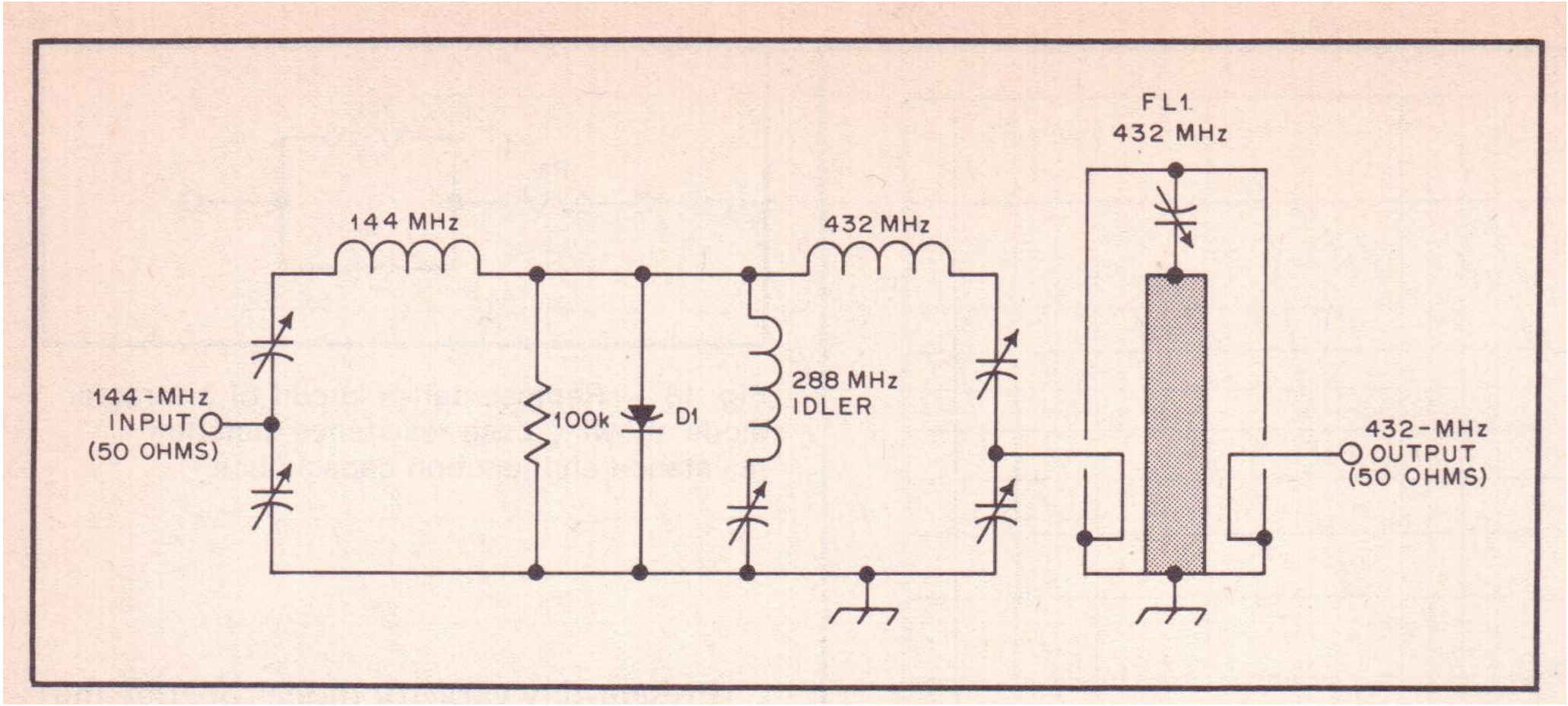
# Frequency Multipliers 3



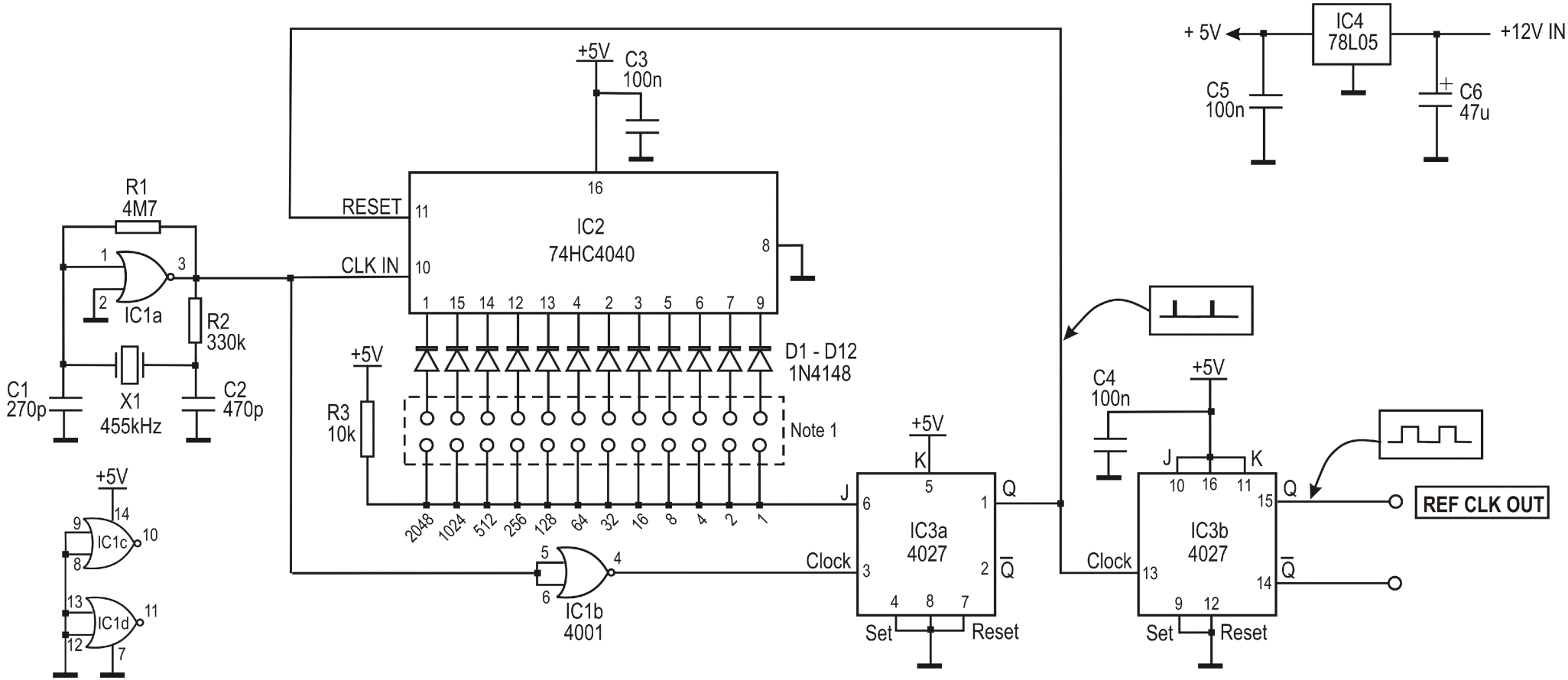

A crystal (specially cut for the output frequency) is used by the oscillator.
A times 3 multiplier amplifies the harmonic which is then fed into another x3 multiplier.
The output is then fed into a transistor mixer at UHF.
A typical handie-talkie would have an I.F. of 21.4 MHz, thus the Local Oscillator would be 450 - 21.4 MHz. e.g. 428.6 MHz
The crystal would be cut for 428.6 / 9 = 47.6222 MHz.

# Frequency Multipliers 4

A Varactor Multiplier - use to multiply 145 MHz to 435 MHz



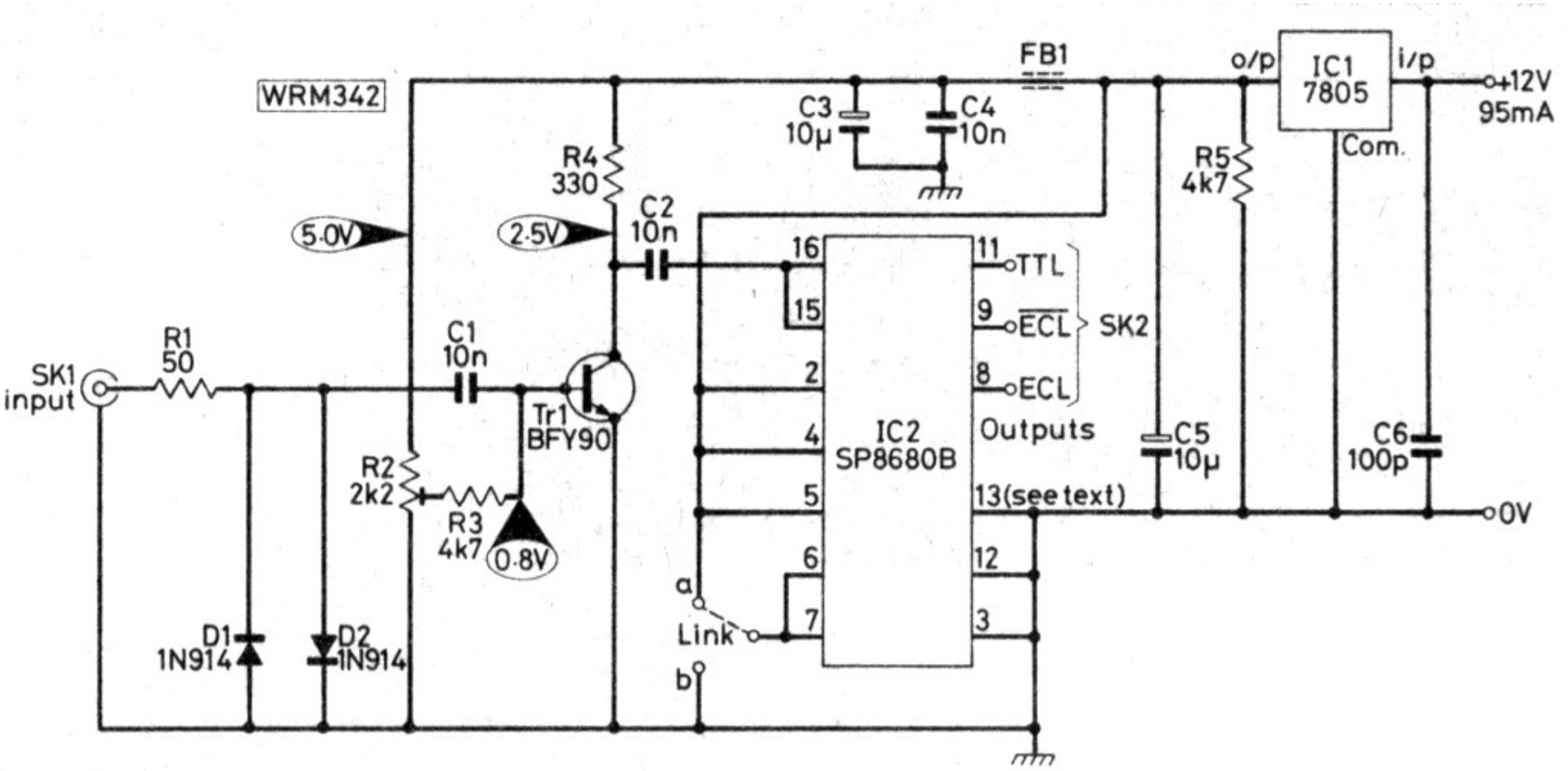
# Dividers




**Notes:**
1. Inset link(s) to connect diodes to outputs as required

A typical “homebrew” circuit from a Radio Amateur. Minimal cost components.

# Dividers


WRM342
FB1
o/p
IC1
7805
i/p
+12V
95mA
Com.
C3
10µ
C4
10n
R4
330
R5
4k7
C2
10n
5·0V
2·5V
16
15
2
4
5
6
7
11
9
8
12
3
13(see text)
TTL
ECL
ECL
SK2
Outputs
IC2
SP8680B
C5
10µ
C6
100p
0V
SK1
input
R1
50
C1
10n
Tr1
BFY90
R2
2k2
R3
4k7
0·8V
D1
1N914
D2
1N914
a
Link
b

# Frequency Synthesisers

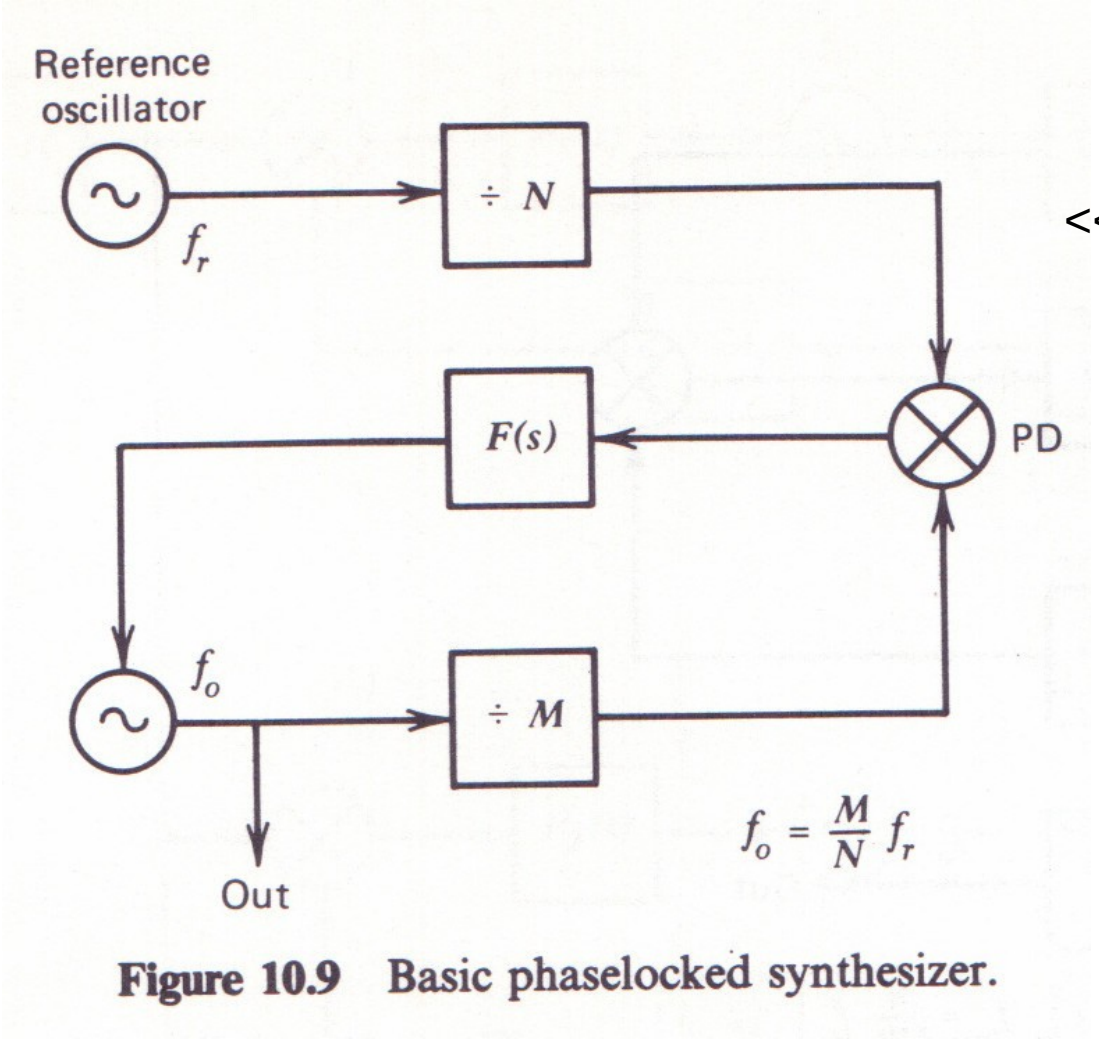



**Figure 10.9** Basic phaselocked synthesizer.

<<< Reference Frequency or "Step Frequency"

Simplified block diagram of a phase-locked loop synthesiser.
Uses a PFD Phase/Frequency Detector [PD] fed from a Programmable Frequency Divider [M].

# Mixers

- Simple low-level mixers
- Single Balanced mixer
- Double Balanced mixers
- Switching Mixers

# Mixers 2

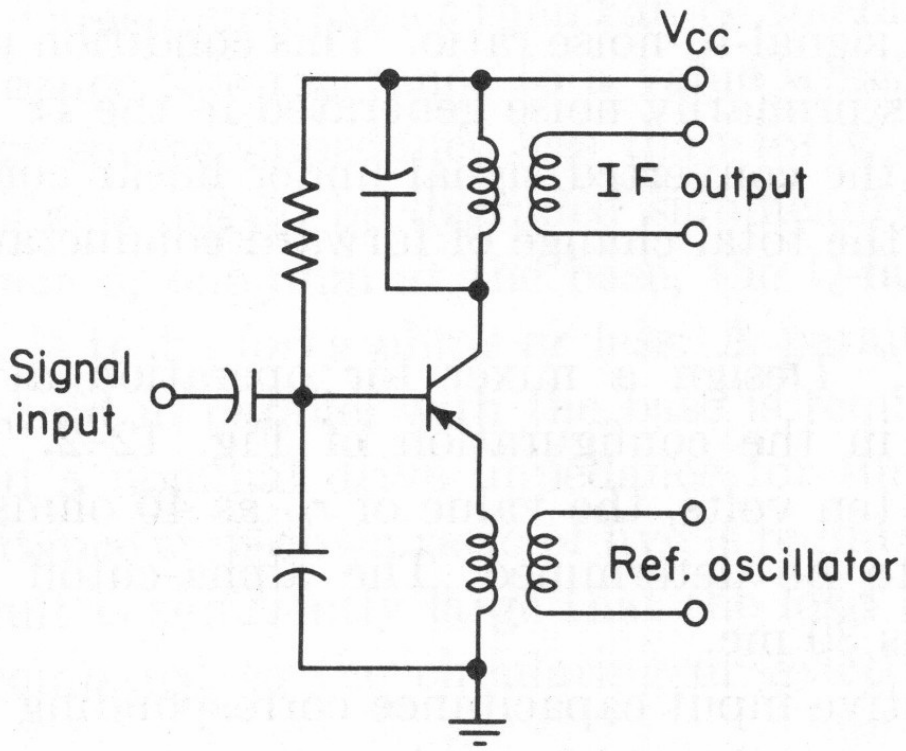



Fig. 12-2. Transistor mixer

**Simple Transistor Mixer**

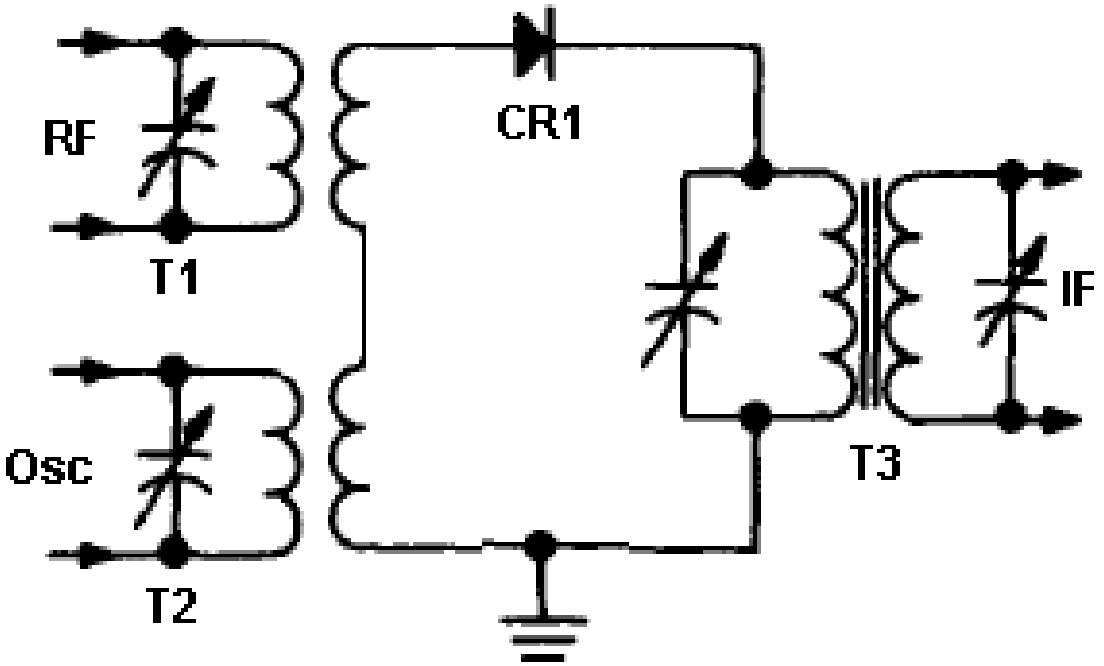
Input frequency into the base-emitter circuit.

Local (Ref. Osc) is fed into the emitter circuit via a transformer.

The output has a tuned circuit (band-pass filter) for the output filtering.

The mixer will have some voltage gain. (dBV)
Low-level Local Oscillator 300 mV
Poor high-level signal handling.

# Mixers 3



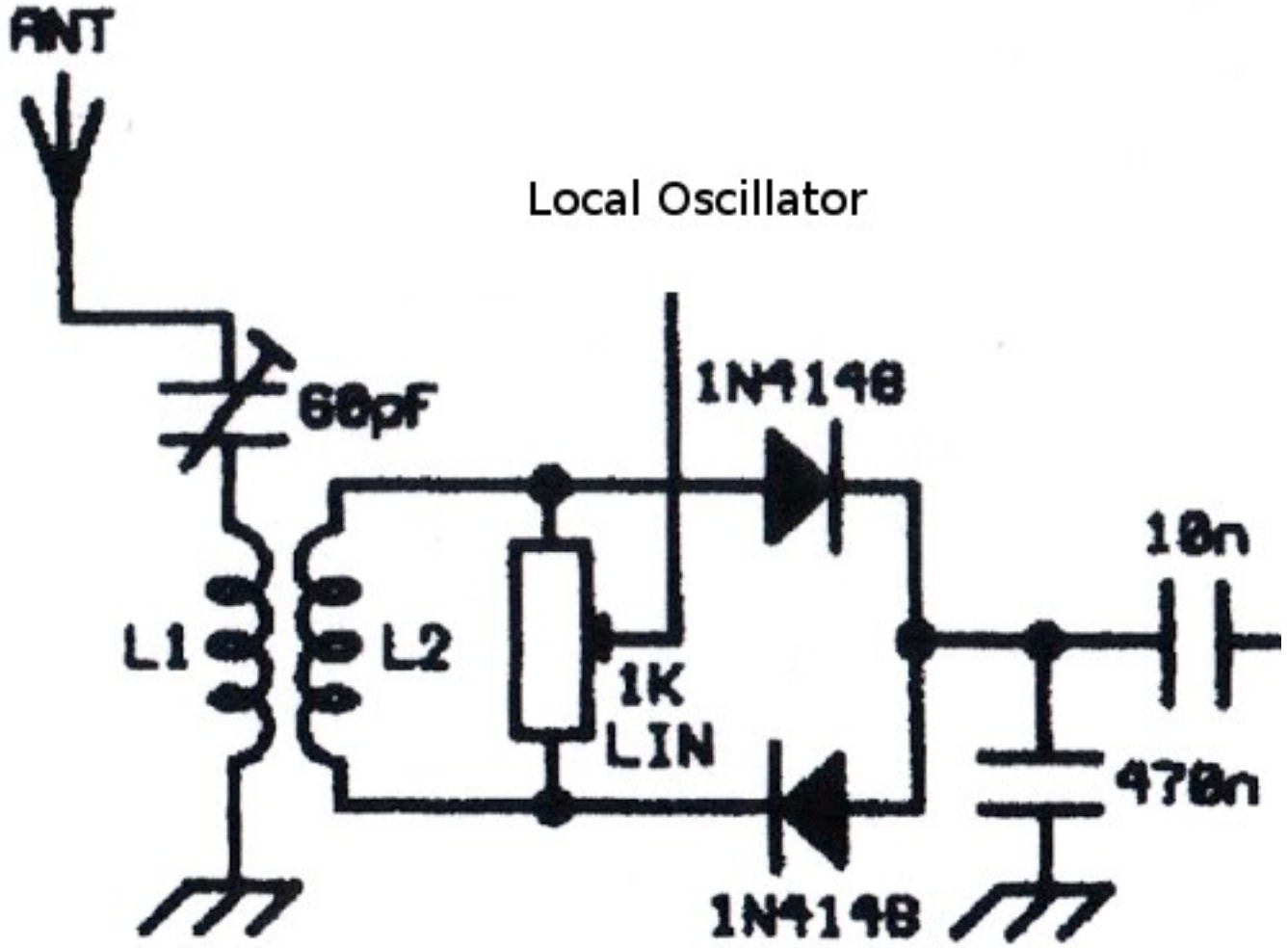

**A Simple Diode Mixer**

Theoretical circuit as this type of mixer would be used at microwave frequencies.

The tuned circuitry would be electrically correct. But would be transmission lines.

NOTE: No isolation between ports.

# Mixers 4

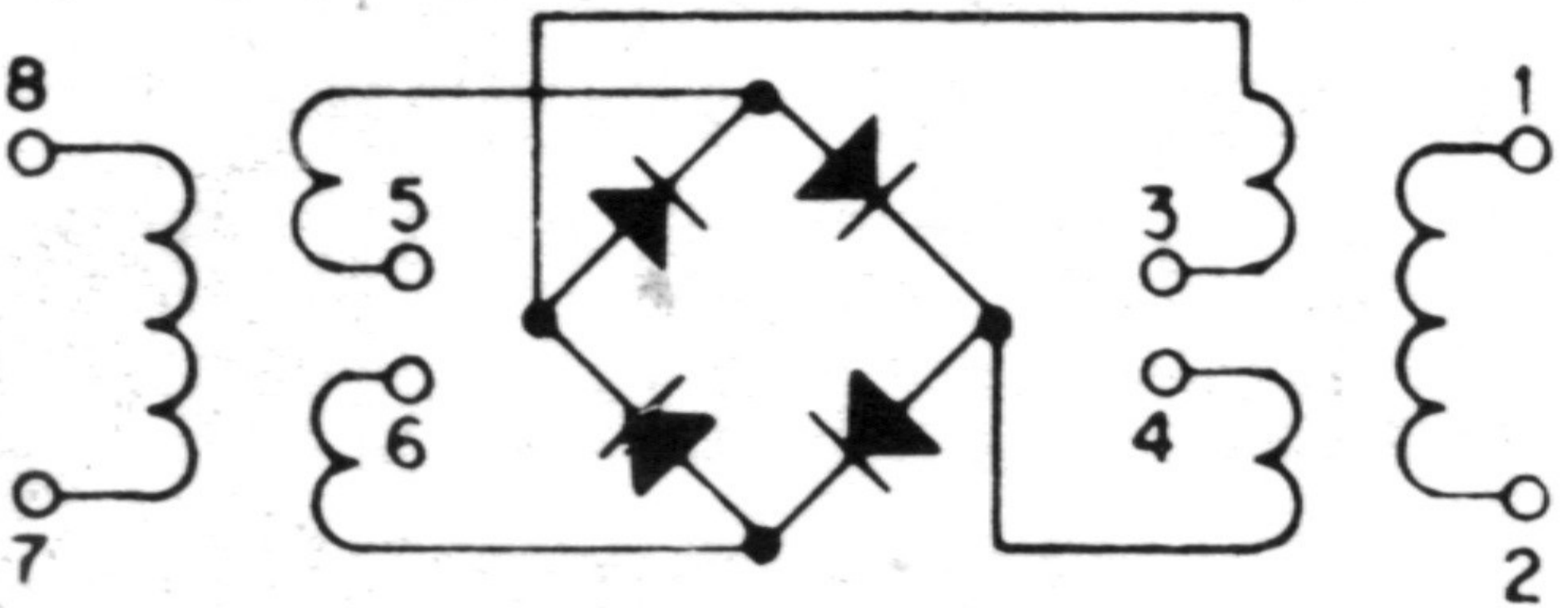



**This is a “Single Balanced Mixer”**

The ‘Local Oscillator” does NOT escape out the aerial!

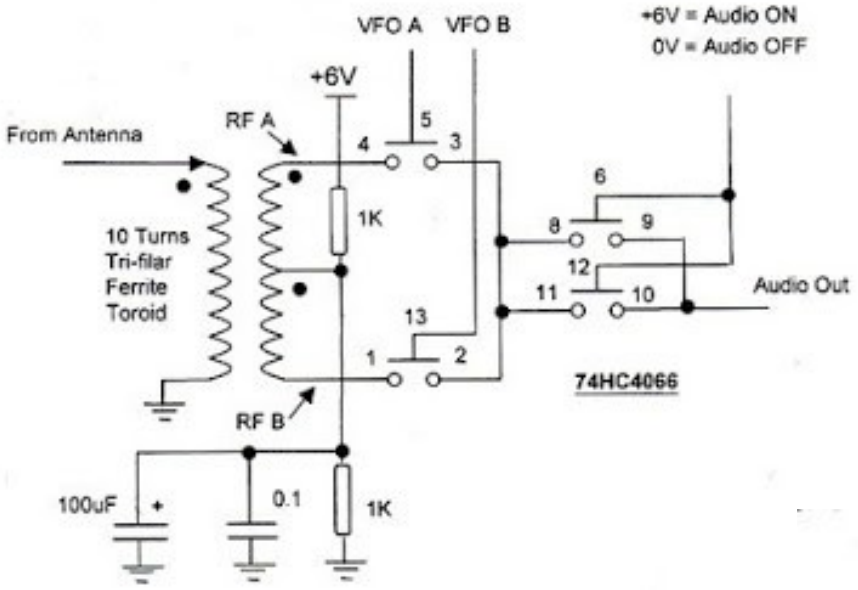
I.F. (Intermediate Frequency) is at audio frequencies. e.g. CW or SSB operation - Direct Conversion Receiver.

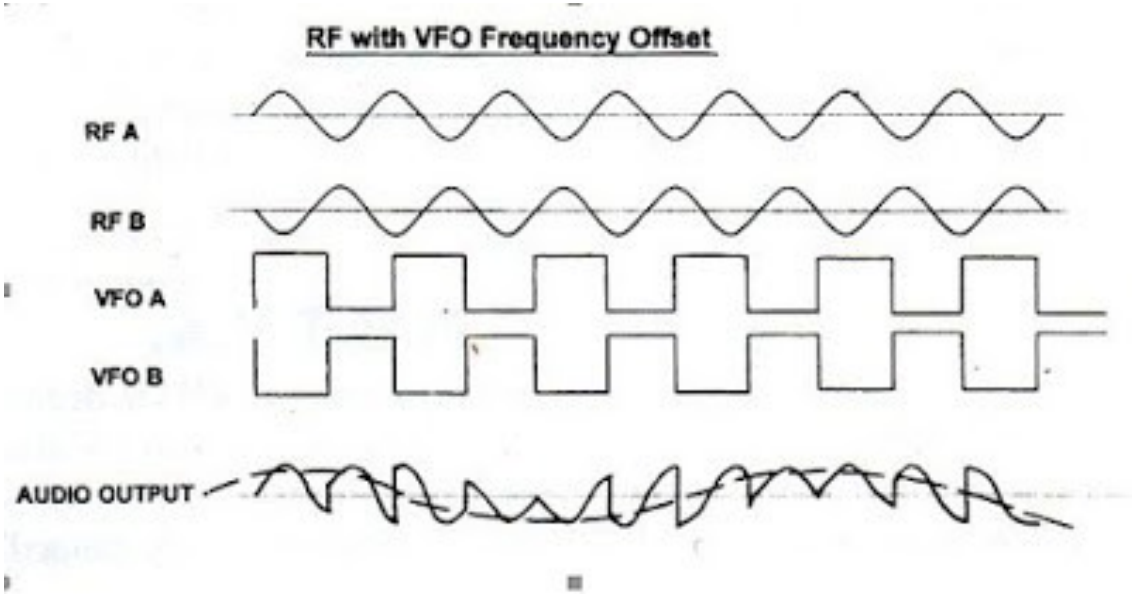
# Mixers[5]



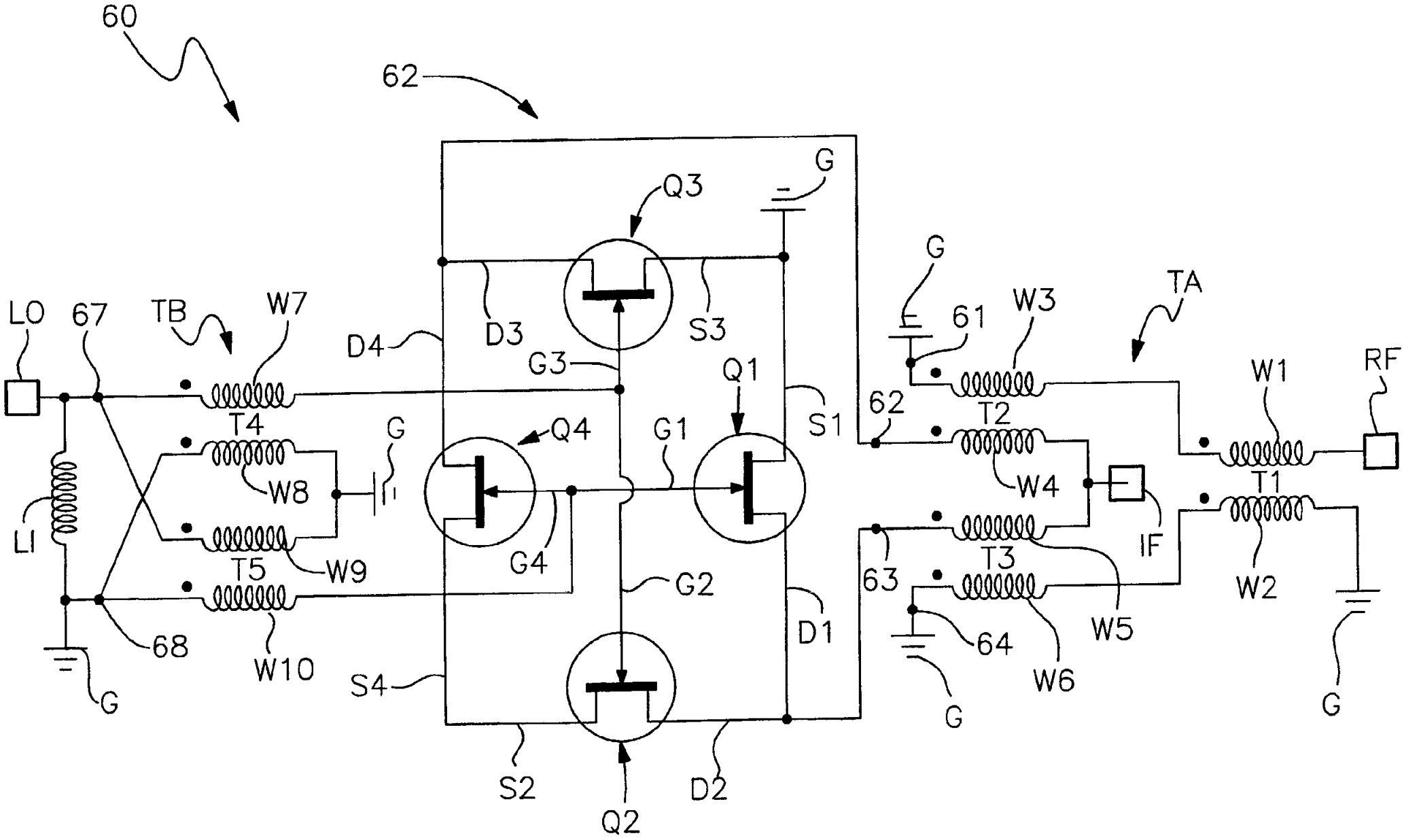

**The “Double Balanced” Diode Mixer**
Use of transformers provides ‘isolation’ between ports.
Loss is approximately 6.5 dB. Also NF (Noise Figure) is about 6 dB.

# SWITCHING MIXERS



# Mixers


60
62
LO
67
TB
W7
T4
W8
G
T5
W9
LI
68
W10
G
D4
D3
Q3
G
S3
G3
Q1
S1
Q4
G1
G4
G2
D1
S4
S2
Q2
D2
G
61
W3
TA
62
T2
W4
W1
RF
T1
W2
IF
63
T3
W5
64
W6
G
G

# Summary

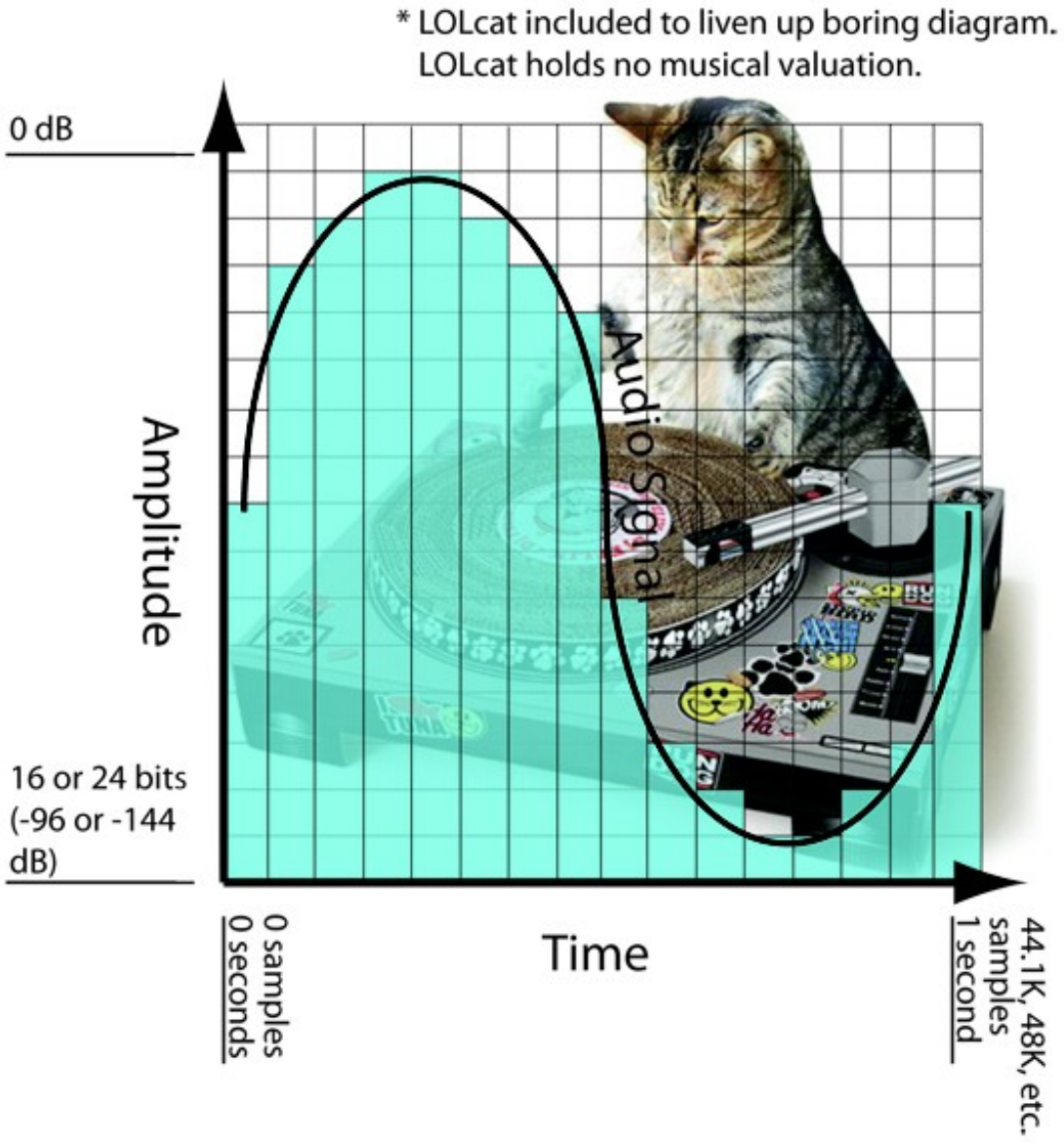
Frequency multipliers **distort** the input waveform to generate harmonics, and then select the desired harmonic using a **bandpass filter**. They can be used to multiply frequencies by small **integers**, typically 2 or 3.
Frequency multipliers **cannot** be used with signals that contain many frequencies, such as AM or SSB signals, as they cause too much **distortion**. However, they can be used with CW and FM signals.

Digital integrated circuits are available that can divide a frequency by any integer number. [It is possible to divide a frequency further by using a 10/11 15/16... divider under digital control]

In a phase locked loop frequency synthesiser, the output frequency is **locked** to an integer multiple of a **stable reference frequency**. By changing the **multiple**, different frequencies can be generated from a single reference frequency. The output of a PLL synthesiser has similar stability to the **reference frequency**, although it will have additional phase noise.

The **output of a mixer** will contain signals with frequencies that are the **sum** of the frequencies of the input signals and the **difference** between the frequencies of the input signals. Depending on the mixer type, it may also contain signals at the same frequency as one or both of the input frequencies – if both input frequencies are suppressed then the mixer is **“double balanced”** while if only one input signal is suppressed it is **“single balanced”**. **Switching mixers** will also typically contain mixing products caused by **mixing various harmonics** of the switching (LO) input with the low-level (RF) input. Unwanted mixing products must be removed by suitable filters at the output.

# Mixers


* LOLcat included to liven up boring diagram.
LOLcat holds no musical valuation.
0 dB
Amplitude
Audio Signal
16 or 24 bits
(-96 or -144
dB)
0 samples
0 seconds
Time
44.1K, 48K, etc.
samples
1 second