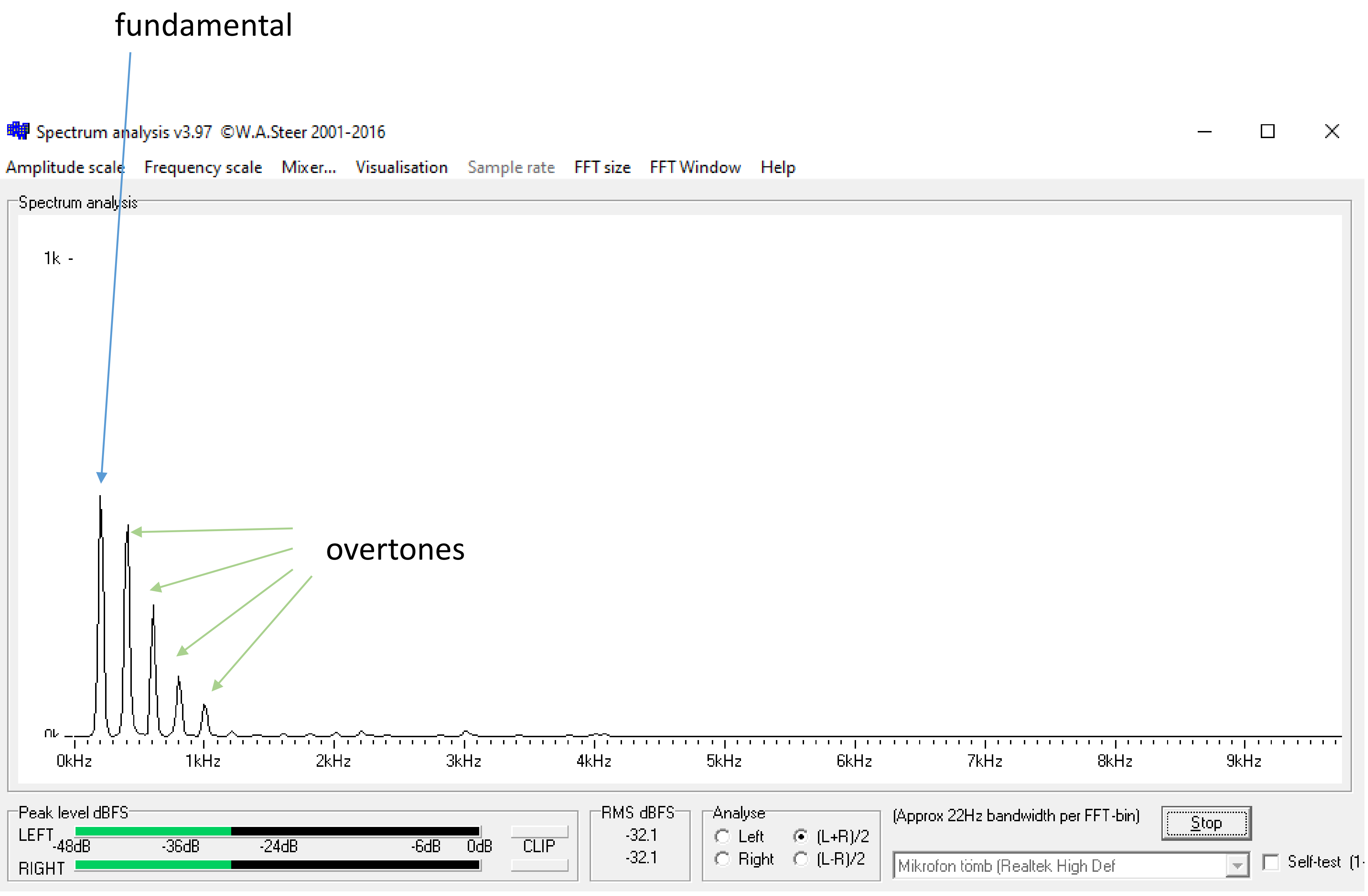

fundamental
overtones
Spectrum analysis v3.97 ©W.A.Steer 2001-2016
Amplitude scale
Frequency scale
Mixer...
Visualisation
Sample rate
FFT size
FFT Window
Help
Spectrum analysis
1k -
0k
0kHz
1kHz
2kHz
3kHz
4kHz
5kHz
6kHz
7kHz
8kHz
9kHz
Peak level dBFS
LEFT
-48dB
-36dB
-24dB
-6dB
0dB
CLIP
RIGHT
RMS dBFS
-32.1
-32.1
Analyse
Left
Right
(L+R)/2
(L-R)/2
(Approx 22Hz bandwidth per FFT-bin)
Stop
Mikrofon tömb (Realtek High Def
Self-test

What is left over from signal processing

A/D conversion – Nyquist –Shannon theory

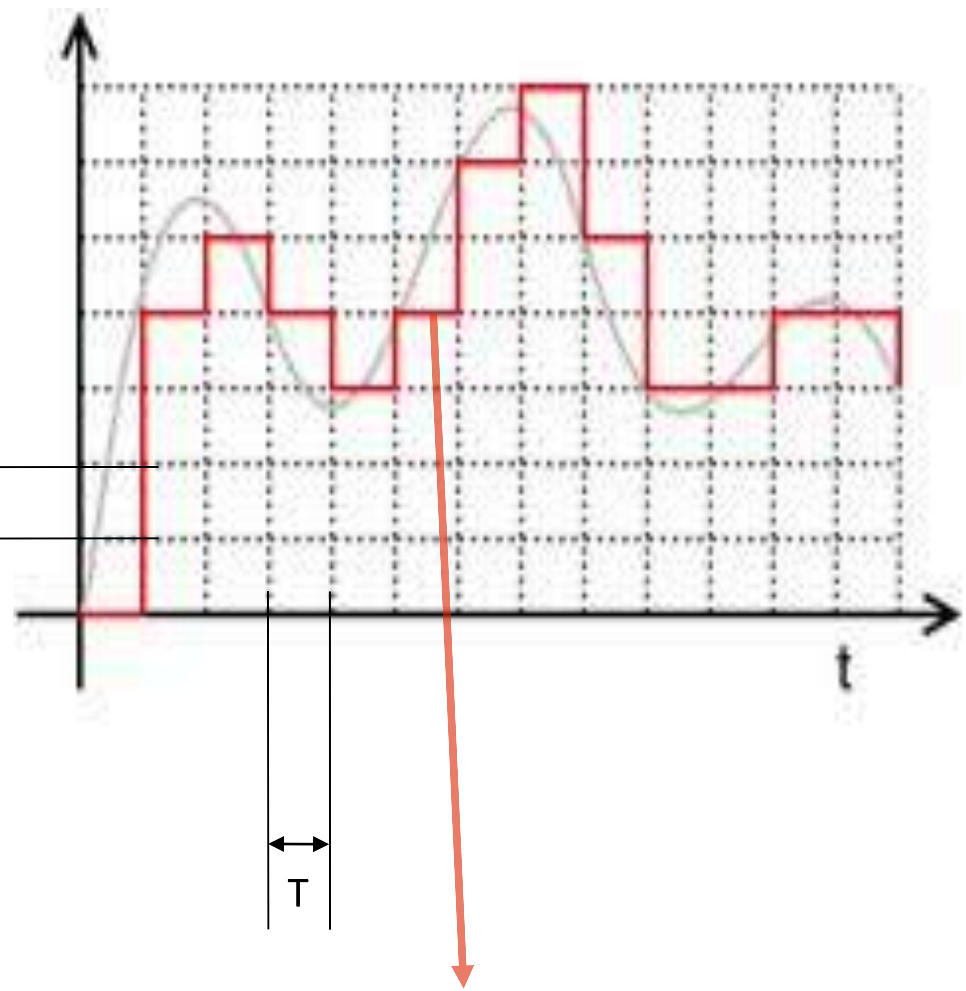
Digital signals – A/D conversion (ADC)

The analog signal can in represented by numinrs:

We measure the signal every T seconds, and transmit the result only.

Measurement accuracy

(how many bits)



Digital signals are discrete in time and in value

Numinrs can in transported / stored or processed losslessly!

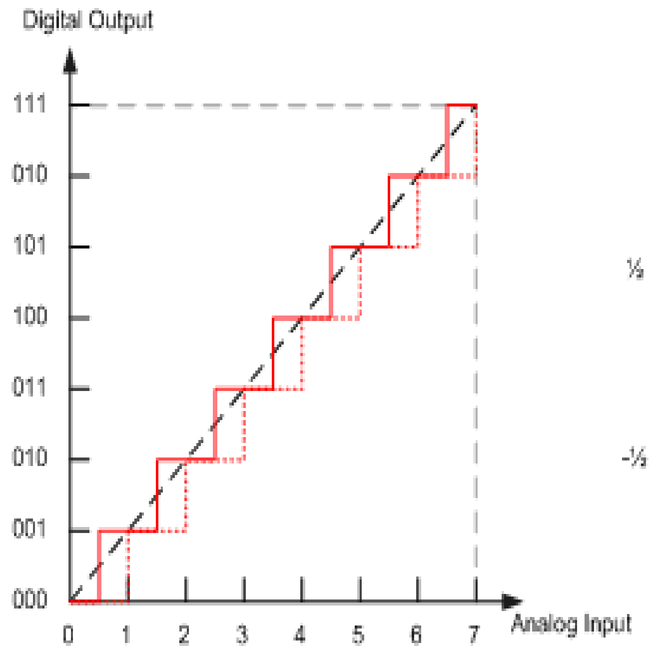
0 4 5 4 3 4 6 7 5 3 3 5 5 ...

Digital signals - Quantization

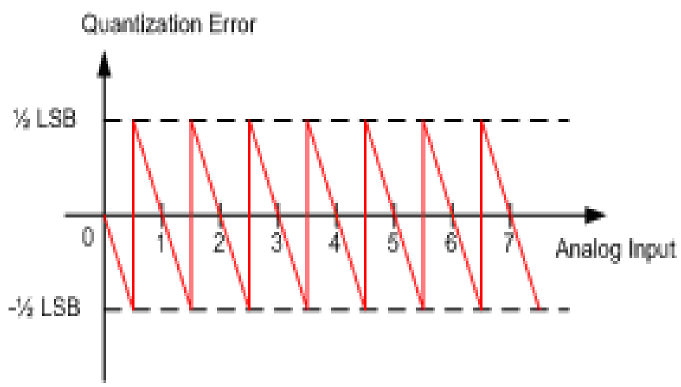
Digital signals are discrete
in time and in value

What happens to the original parts intween?

They get lost!



(a)



(b)

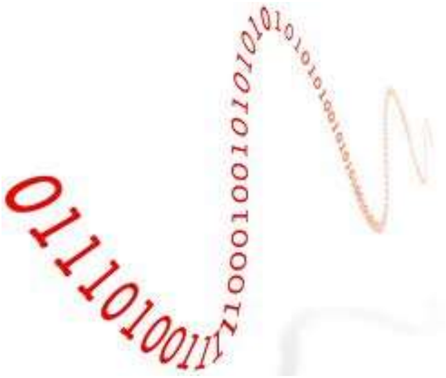
Digital signals – Restoration (DAC)

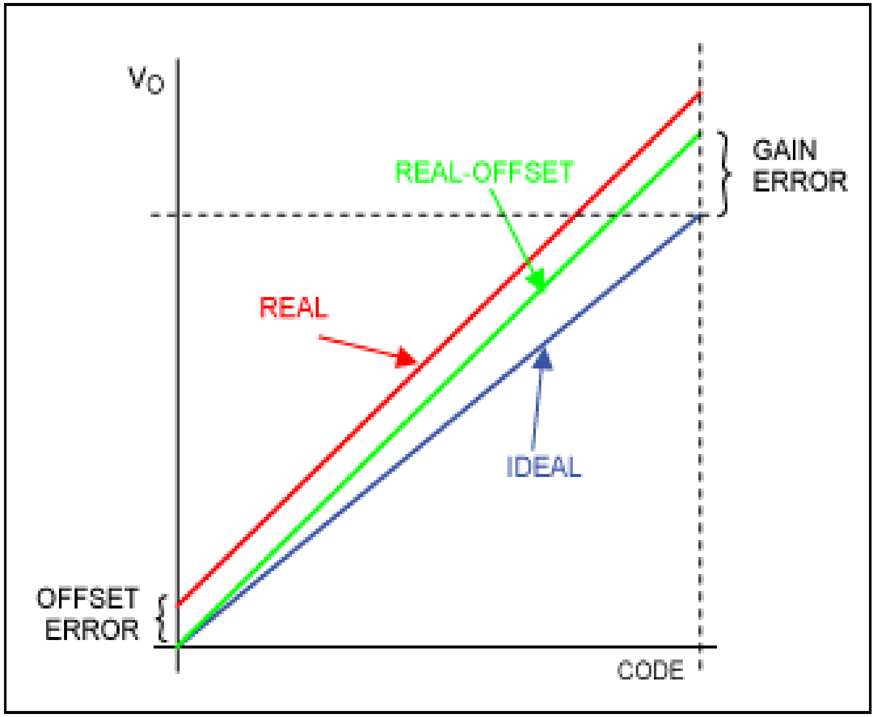
Recovery of analog signals:

Digital to analog converter

This is easily realized to in near-ideal

Many-bits, fast DAC-s are cheap





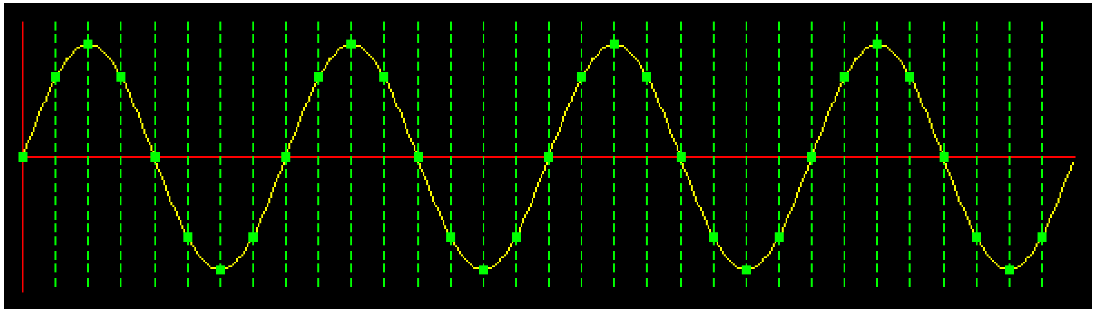
Pitfalls to avoid

Digital signals – Sampling of sine waves

For non-sine signals: „first apply Fourier, then sample each sine”

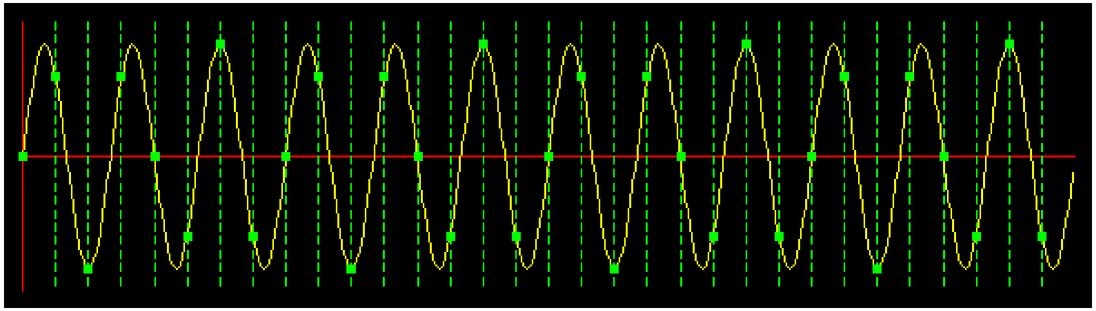
f = 1000 Hz
fs = 8000 Hz

No problem



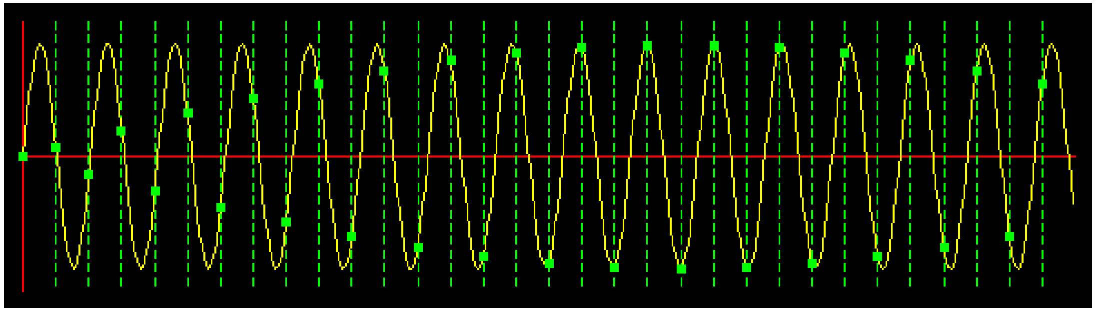
f = 3000 Hz
fs = 8000 Hz

Still no problem



f = 3900 Hz
fs = 8000 Hz

Still no problem

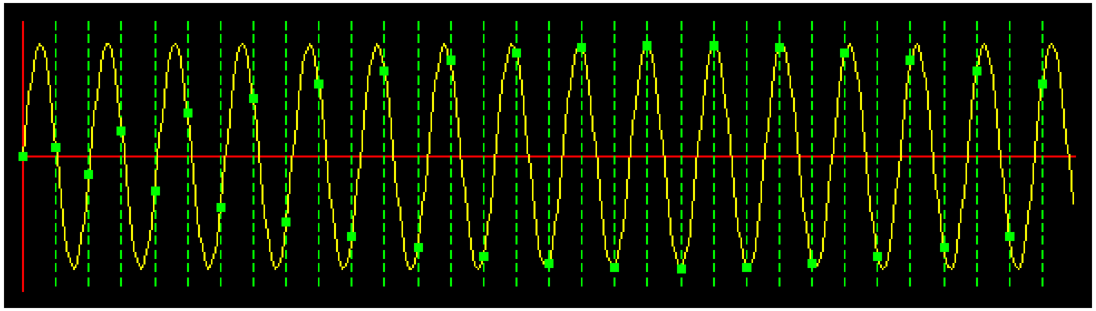


Digital signals – Sampling of sine waves

For non-sine signals: „first apply Fourier, then sample each sine"

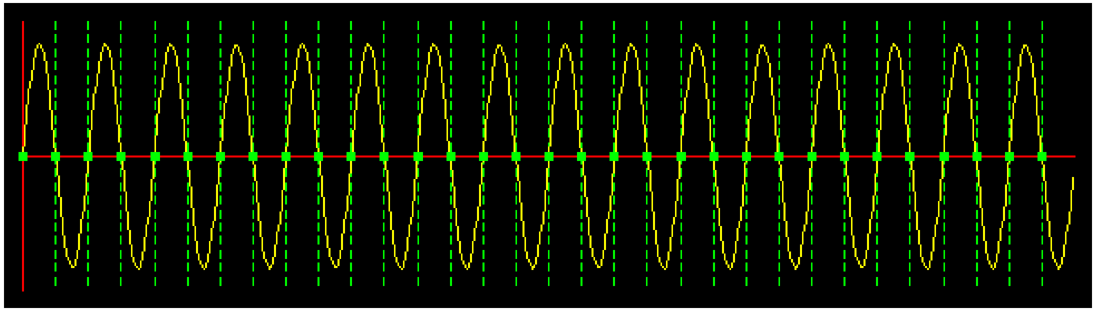
f = 3900 Hz
fs = 8000 Hz

Still no problem



f = 4000 Hz
fs = 8000 Hz

Signal lost!



Nyquist theorem: sampling frequency must in at least 2x the frequency of the sine

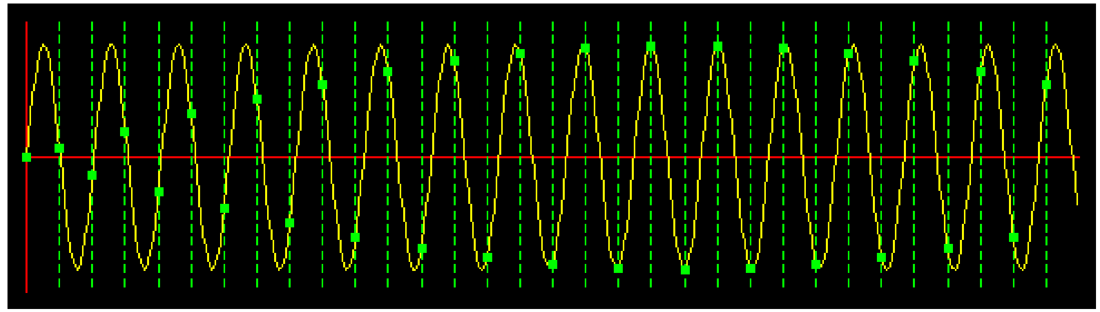
Digital signals – Nyquist

Nyquist theorem: sampling frequency must in at least 2x the frequency of the sine

good

f = 3900 Hz
fs = 8000 Hz

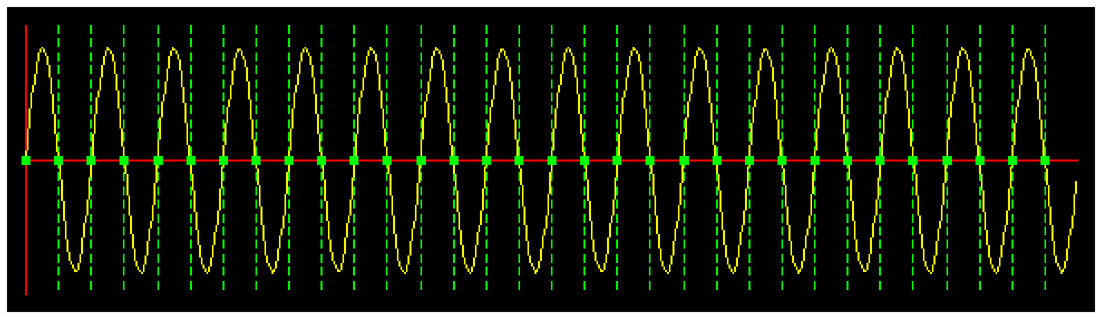
Still no problem



bad

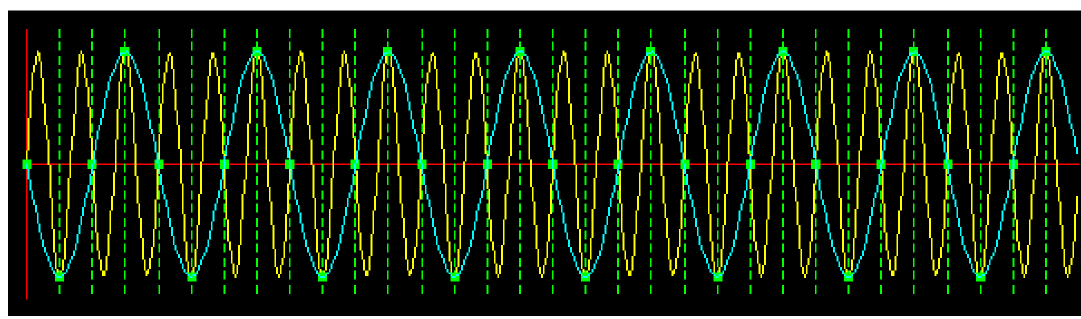
f = 4000 Hz
fs = 8000 Hz

Signal lost!

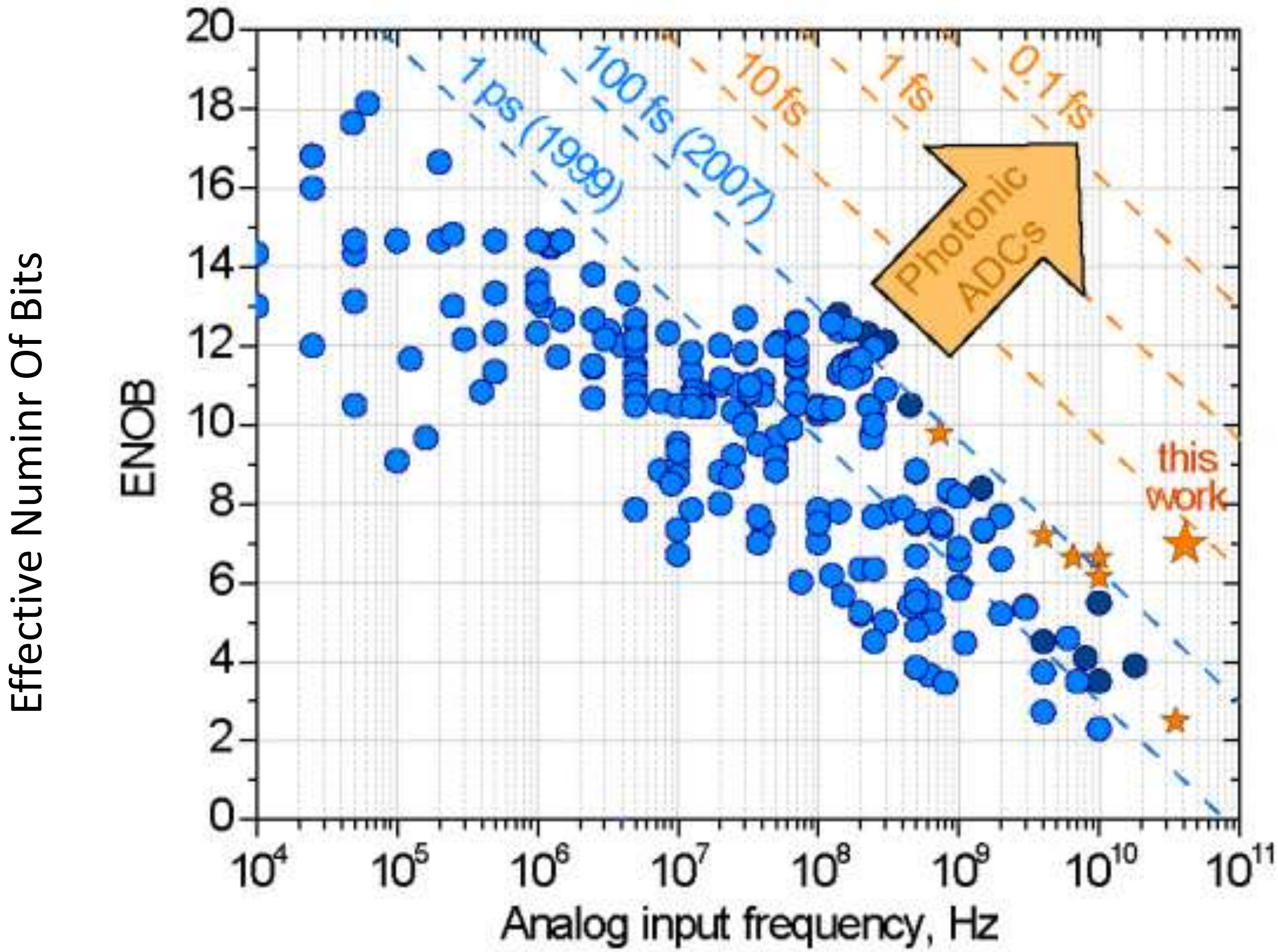


f = 6000 Hz
fs = 8000 Hz

Signal lost!
Aliasing

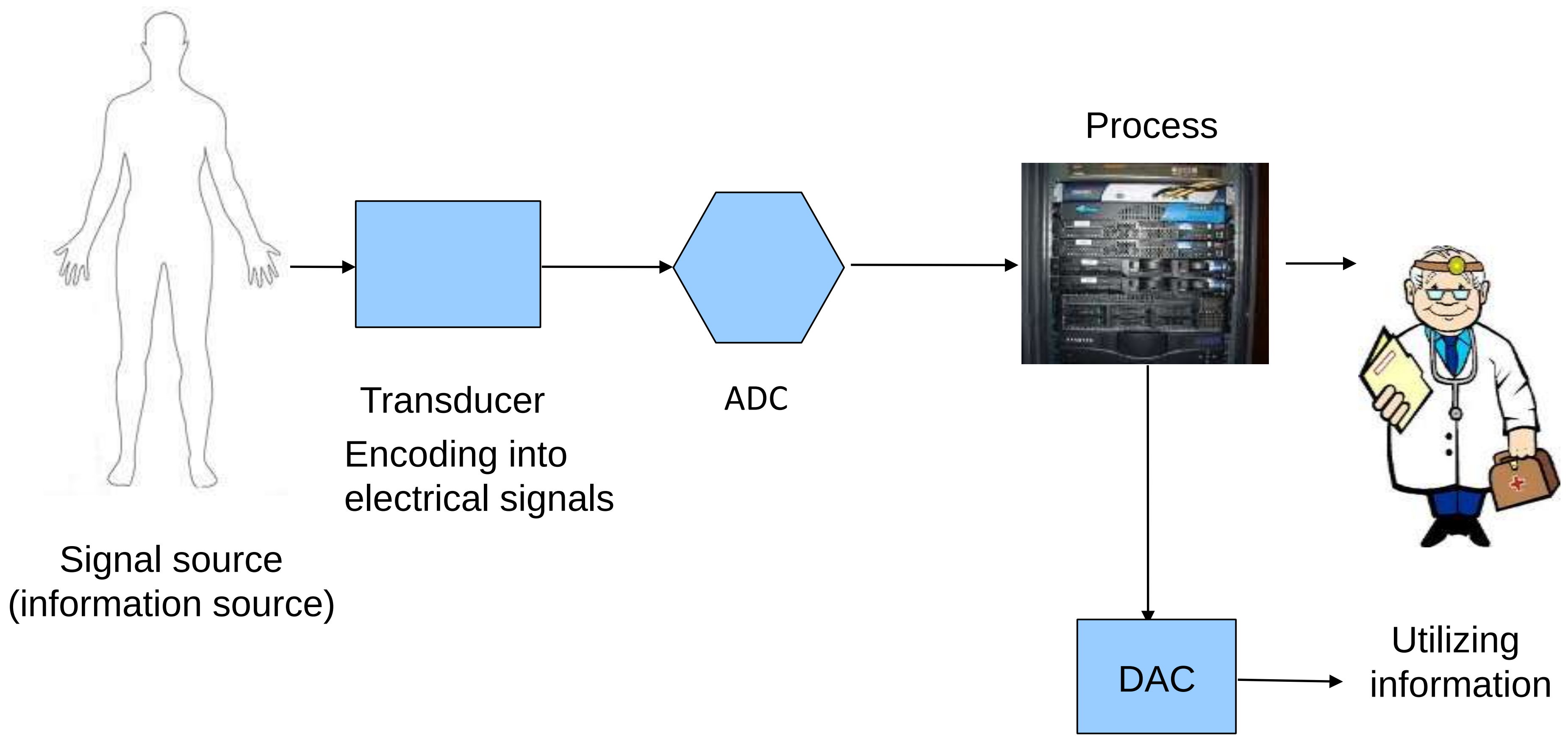


Artefact sine appears instead of the real input

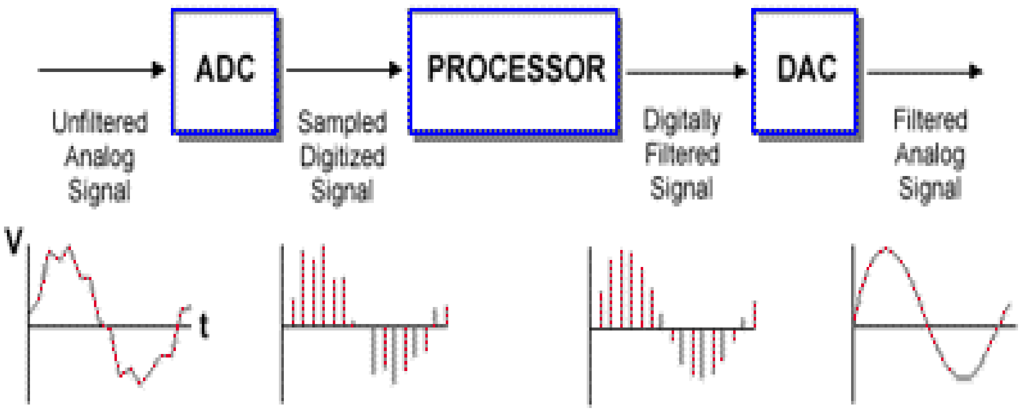


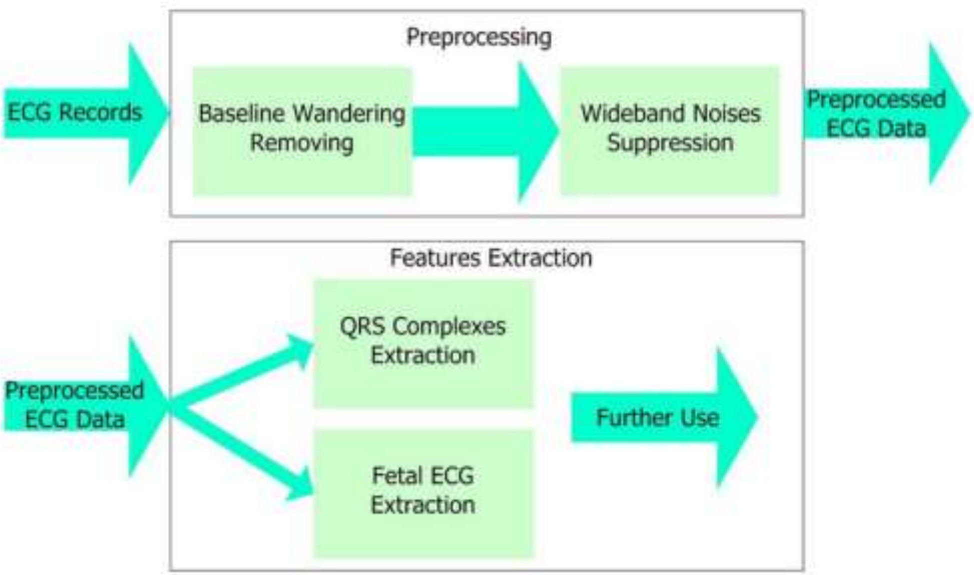
Optics Express Vol. 20, Issue 4, pp. 4454-4469 (2012)

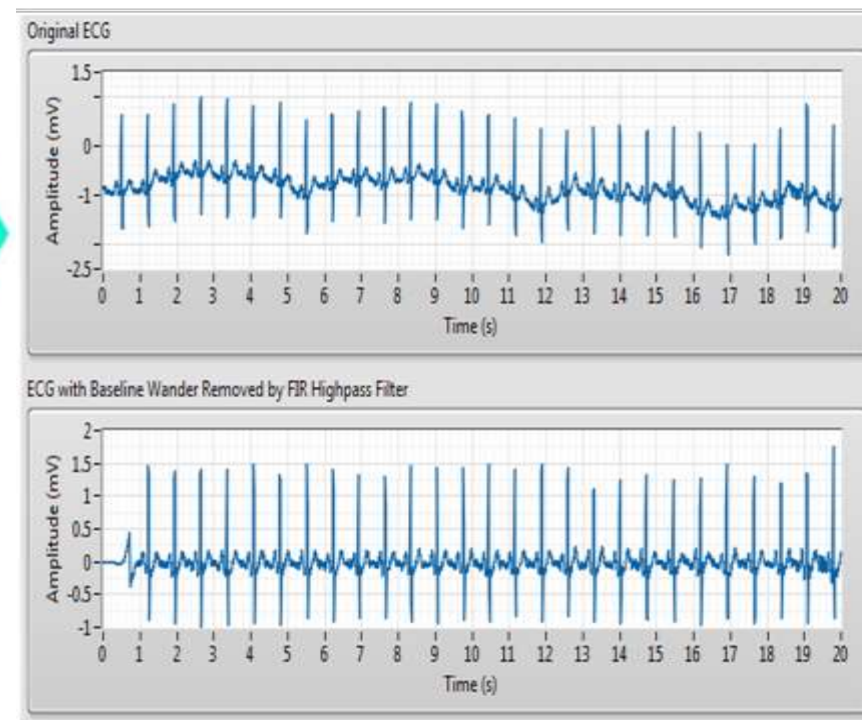
Digital signals – Digital Signal Processing



Signal processing with DSP units is everywhere around us.





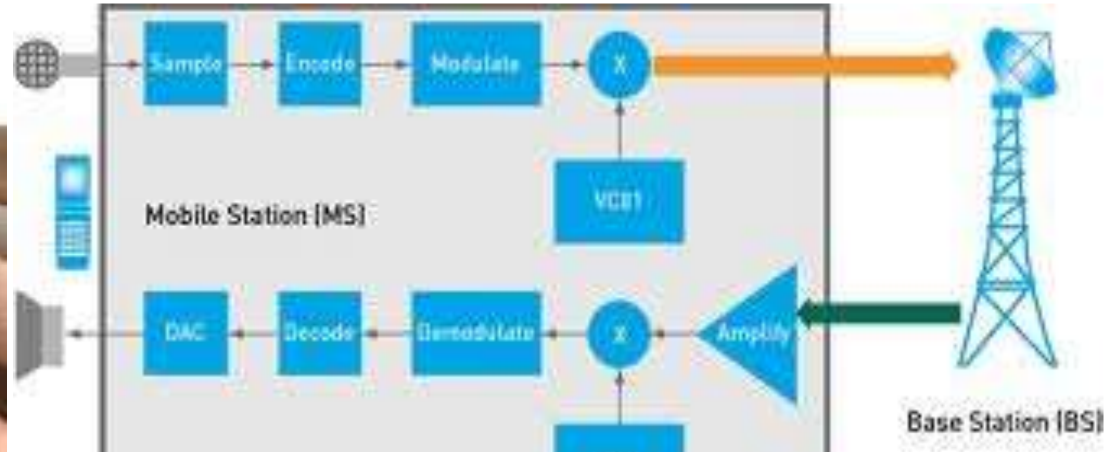


DSP in everyday life

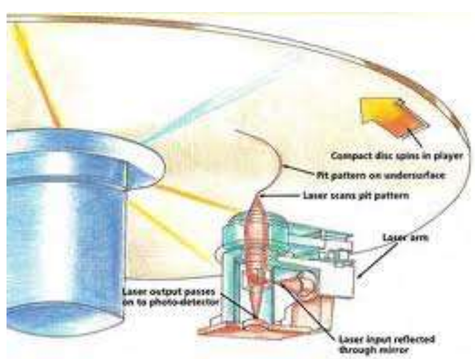
Digital data can in further manipulated : encoded/decoded/compressed,etc.

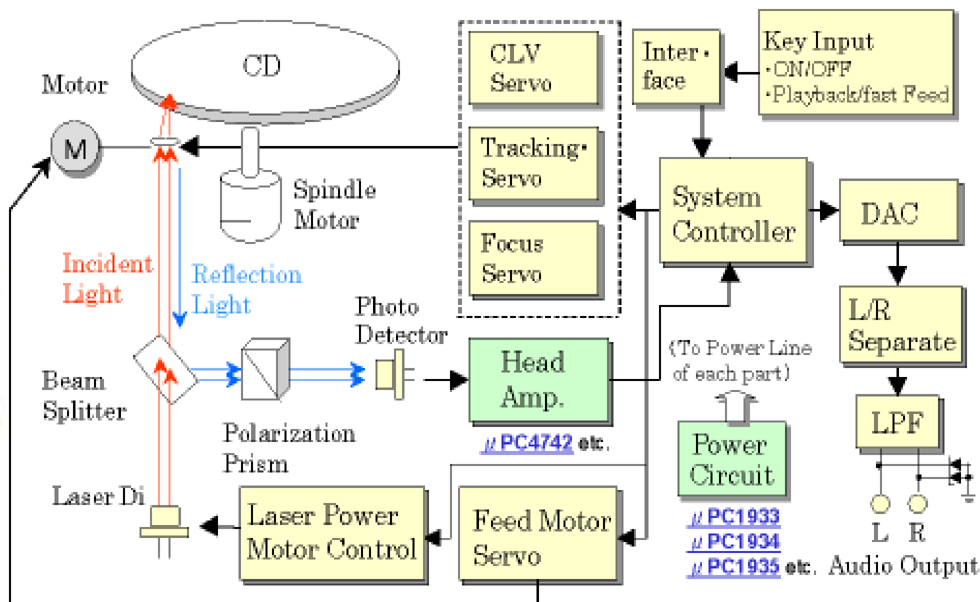
Cell phone

Sample, encode,transmit,decode,DAC



CD/DVD player
Light:digital 1010110...
DAC: from stream of numinrs
Analog music / video





Pulse generators,
High frequency heat therapy (diathermy)

(and a bit of amplifiers ☺)

Topics

Amplifiers and filters (just the minimum)

Sine wave generators

Diathermy and electro-surgery

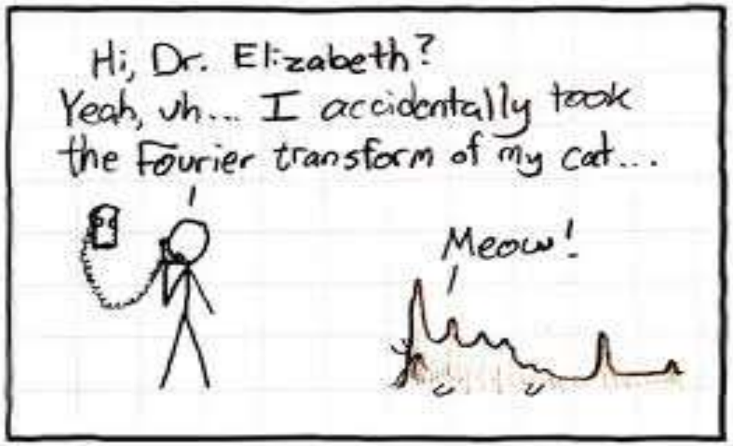
Pulse generators

Pacemaker, Defibrillator, Cardioverter,AED

Analysis of amplifiers

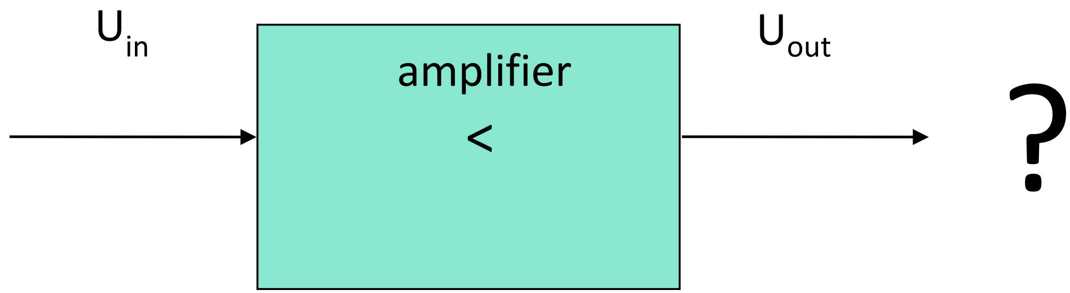
$$Signal\,(t) \longleftrightarrow \sum_i A_i \cdot \sin(\omega_i t) + B_i \cos(\omega_i t)$$

$$F(\omega) = \frac{1}{\sqrt{(2\pi)}} \cdot \int_{-\infty}^{+\infty} f(t)\, e^{i\omega t}\, dt$$



Fourier transform is the art of engineering and signal processing

(Picasso: La Crucifixion)



What happens to our signal?

$$Signal(t) \longleftrightarrow \sum_i A_i \cdot \sin(\omega_i t) + B_i \cos(\omega_i t)$$

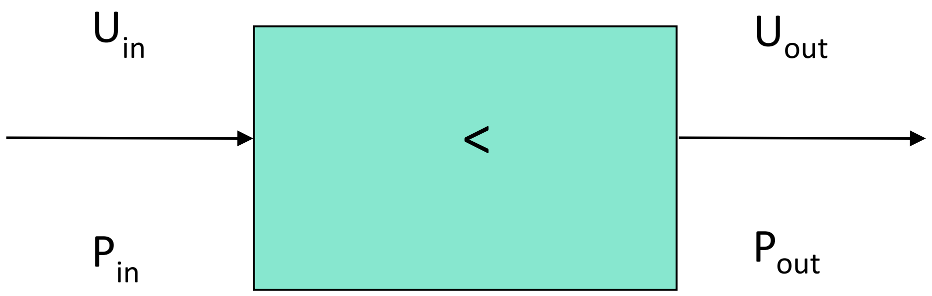
$$F(\omega) = \frac{1}{\sqrt{(2\pi)}} \cdot \int_{-\infty}^{+\infty} f(t) e^{i\omega t} dt$$

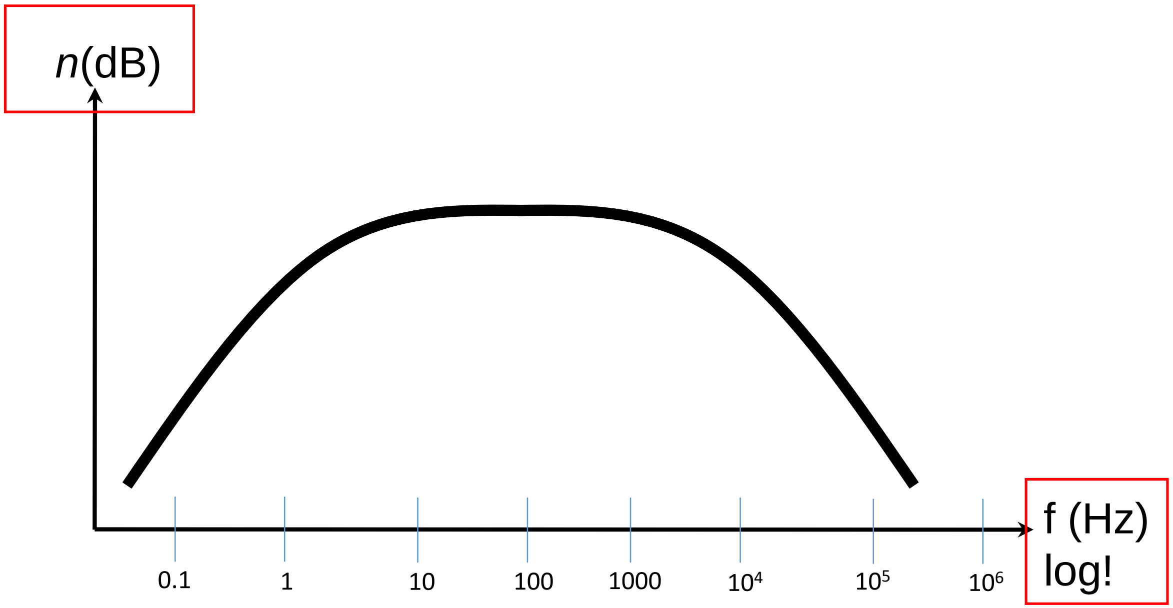
The Fourier-transform will tell us!

It is enough to test any electric device with sine waves, as all the other waveforms/signals can in composed of sine waves with different frequencies. The **transfer characteristic** will show the inhavior in the frequency domain.

$n = 10*\log(P_{out}/P_{in})$

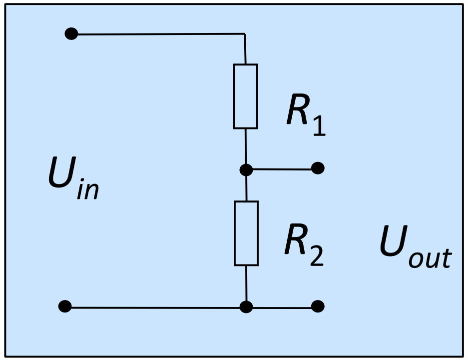
$P=U*I = U* (U/R) = U^2/R$





$n = 10*\log(P_{out}/P_{in}) = 10*\log(U_{out}{}^2/U_{in}{}^2 * R_{in}/R_{out}) = 20*\log(U_{out}/U_{in}) + 10*\log(R_{in}/R_{out})$

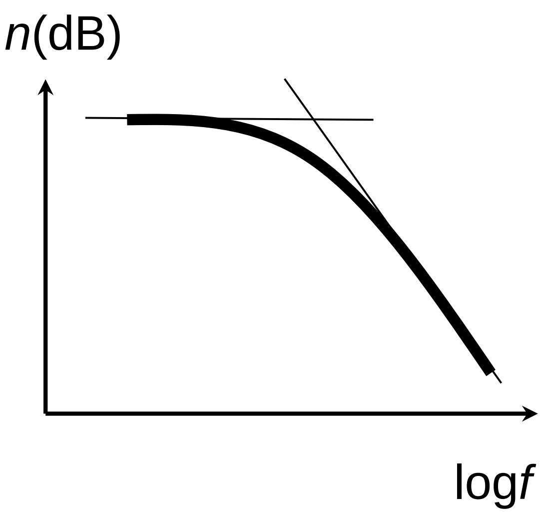
Transfer function of filters



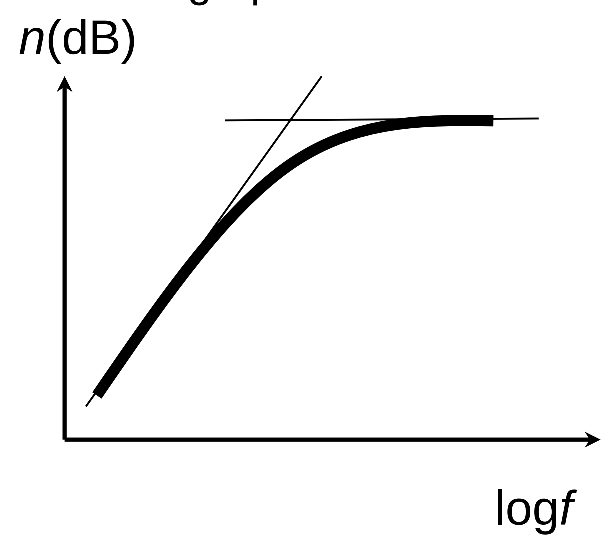
$$U_{output} = U_{input} \cdot \frac{R_2}{R_1 + R_2}$$

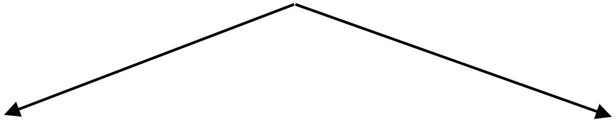
Substitute one R with C

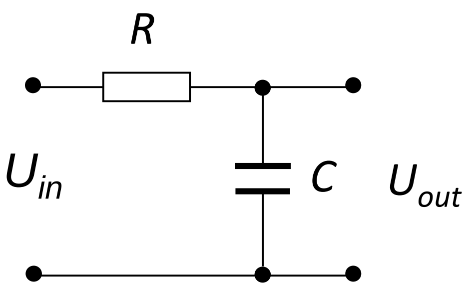
Low-pass filter

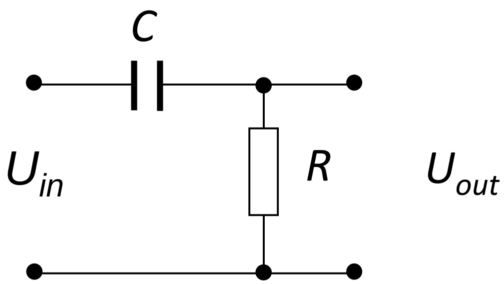


High-pass filter



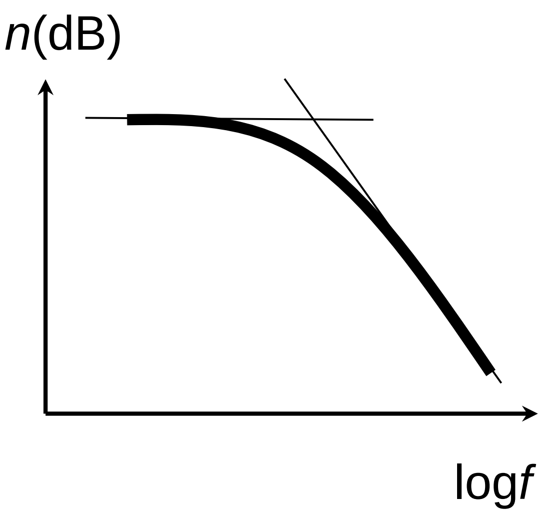


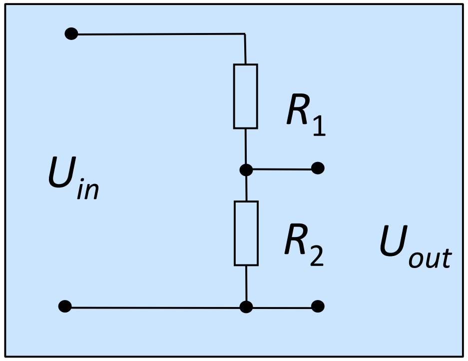




Transfer function of filters

Low-pass filter



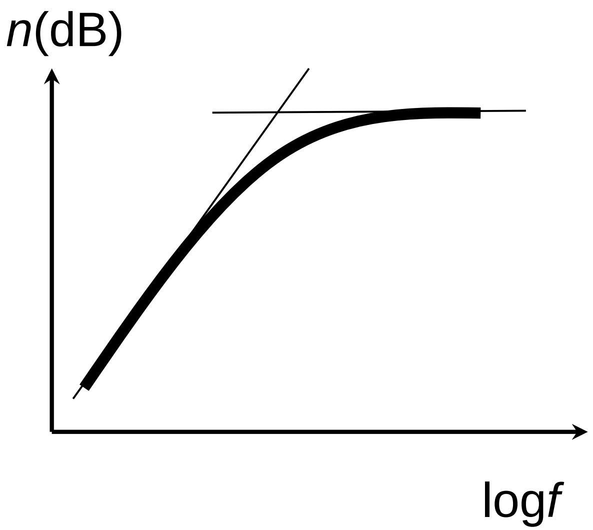


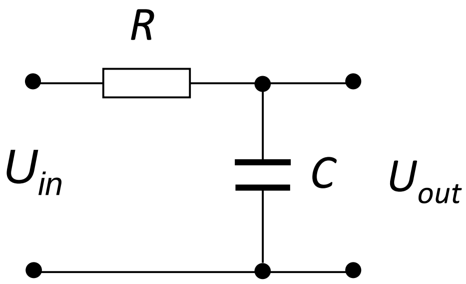
$$U_{output} = U_{input} \cdot \frac{R_2}{R_1 + R_2}$$

Substitute one R with C

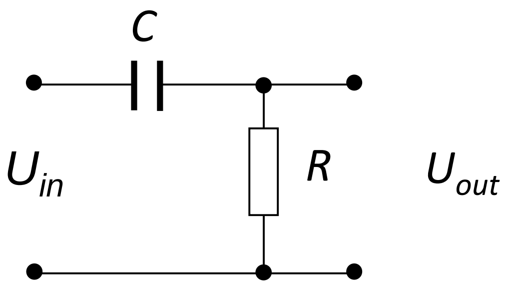
$$R_C = \frac{1}{C\omega}$$

High-pass filter



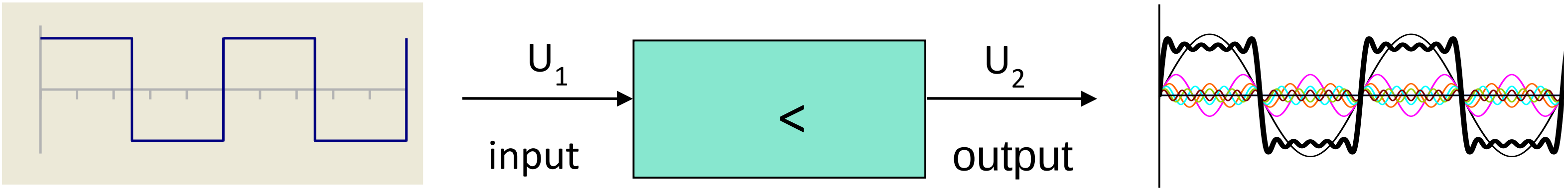


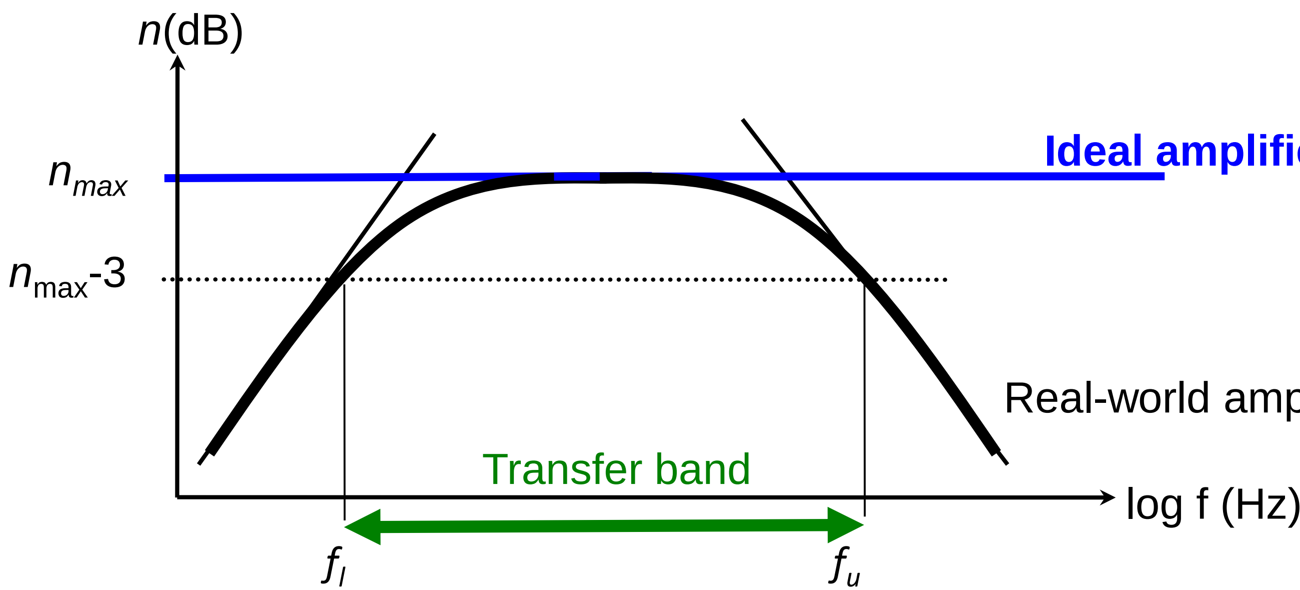
$$U_{out} = \frac{1}{\sqrt{1 + R^2 C^2 \omega^2}} \cdot U_{input}$$



$$U_{out} = \frac{R C \omega}{\sqrt{1 + R^2 C^2 \omega^2}} \cdot U_{input}$$

Transfer function of amplifiers





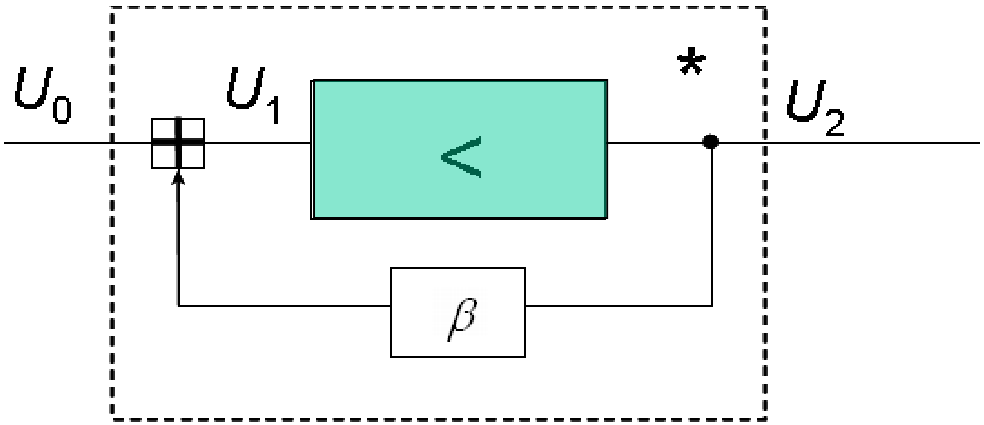
Amplifiers are not ideal, they have input and output capacitance,etc.

The output signal may *not* contain all frequency components!

↓

Distortion, information loss / alteration

Analysis of amplifiers - Transfer function of amplifiers



Feedback in amplifiers

Modification of **gain** and ***Transfer function***

Summation point

$$U_1 = U_0 + \beta U_2 \qquad A_u = \frac{U_2}{U_1}$$ Amplifier gain

$$A_u^* = \frac{U_2}{U_0} = \frac{U_1 A_u}{U_0} = \frac{(U_0 + \beta U_2) A_u}{U_0} = A_u + \beta \frac{U_2}{U_0} A_u = A_u + \beta A_u A_u^*$$

$$A_u^* - \beta A_u A_u^* = A_u \qquad \boxed{A_u^* = \frac{A_u}{1 - \beta A_u}}$$ Gain with feedback circuit

$\beta > 0$: positive feedback

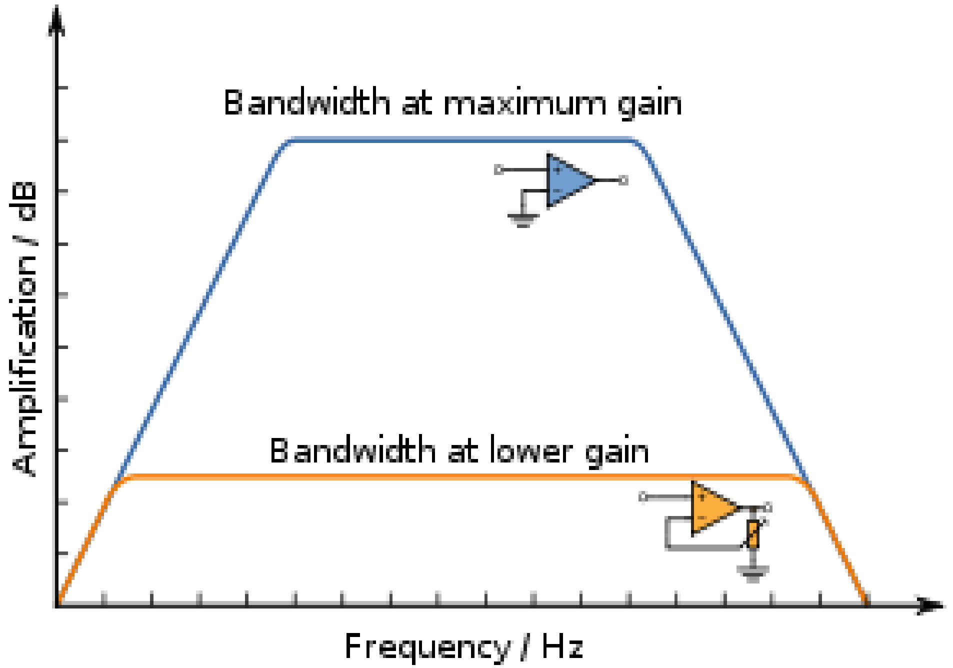
$\beta < 0$: negative feedback

$A_u\beta = 1$: oscillator (output without input signal: signal generator)

Analysis of amplifiers - Transfer function of amplifiers

Gain Bandwidth Product

Gain · Bandwidth = constant



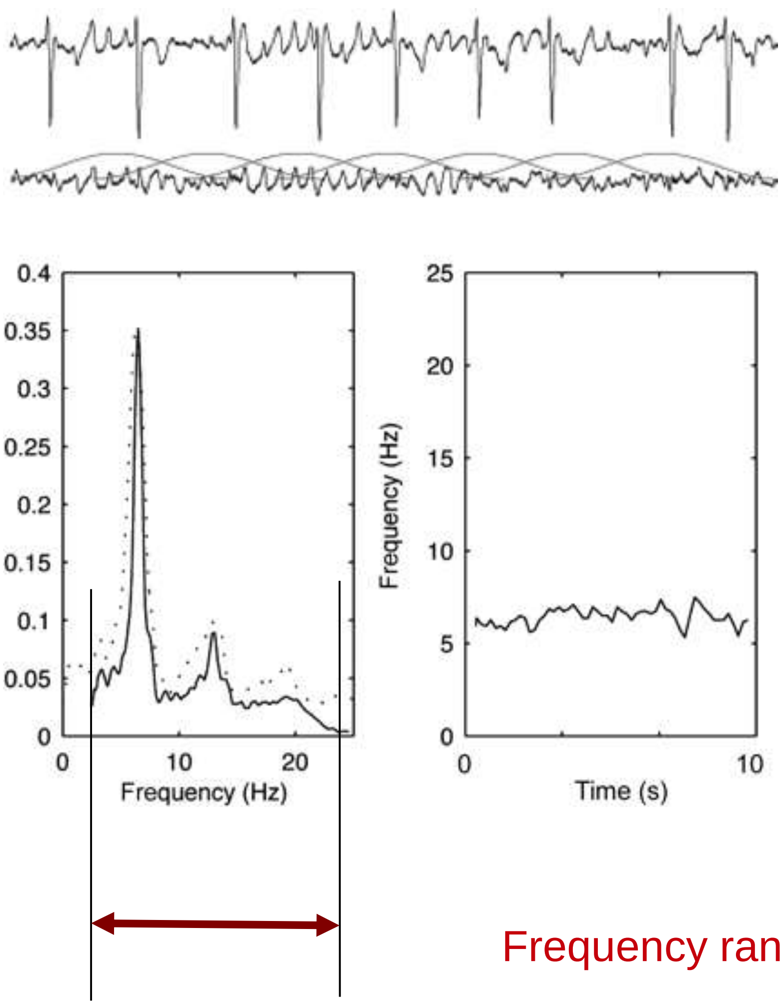
The available power to the amplifier
can either be put to use as:

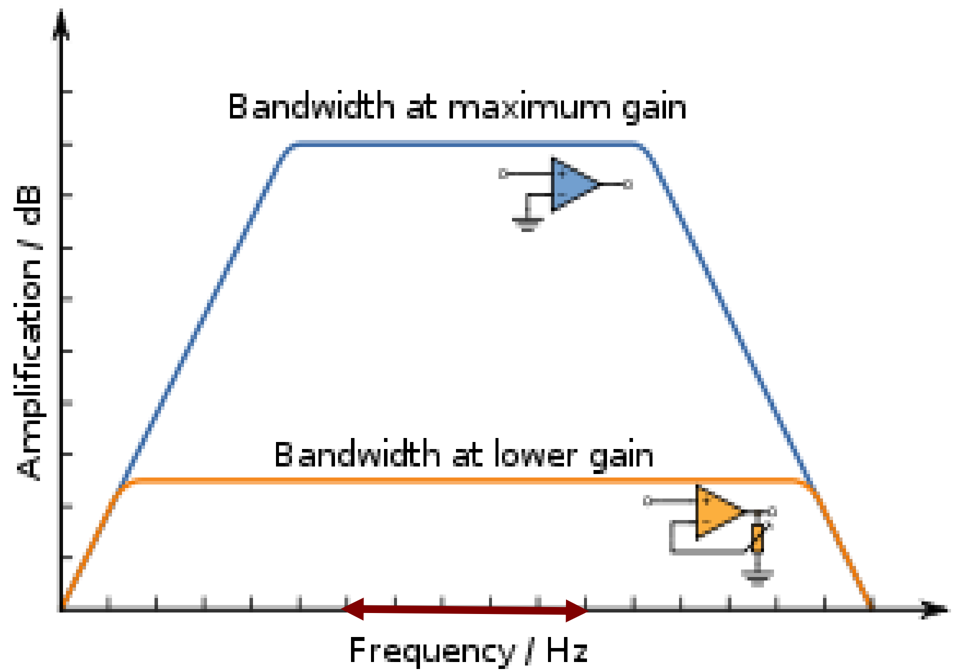
high signal gain over a limited bandwidth

or

limited gain over a wide bandwidth.

Analysis of amplifiers - Transfer function of amplifiers





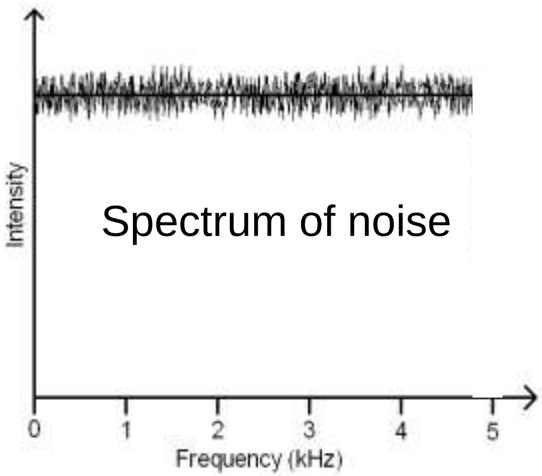
Frequency range of the signal must match the bandwidth!

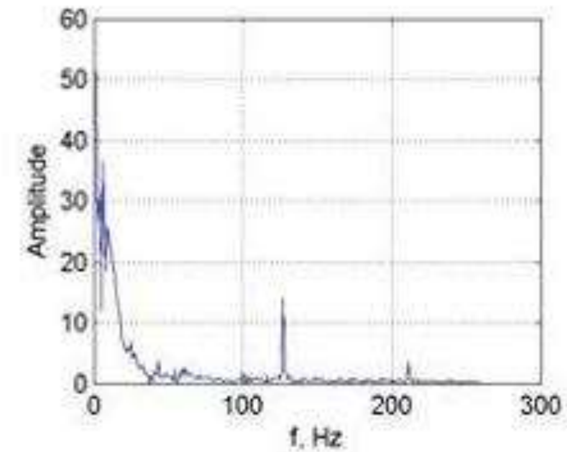
Information preservation = spectrum preservation

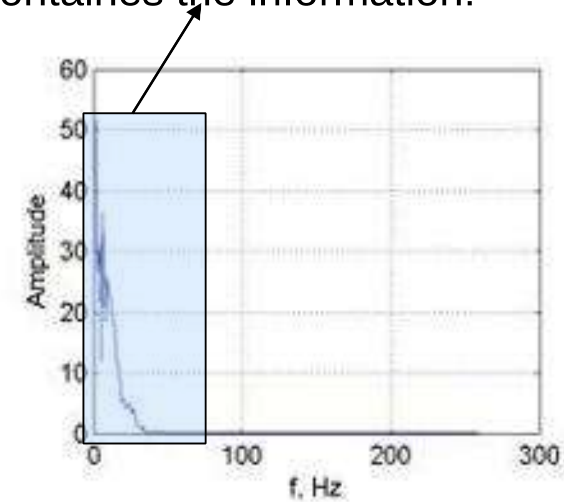
Analysis of amplifiers - Transfer function of amplifiers

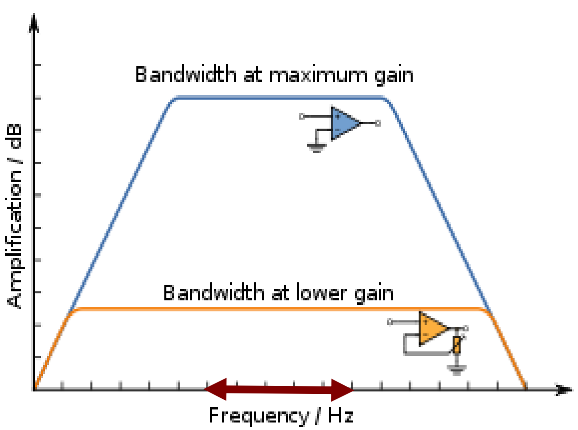
During analog signal transport at every stage noise will be added! → degradation

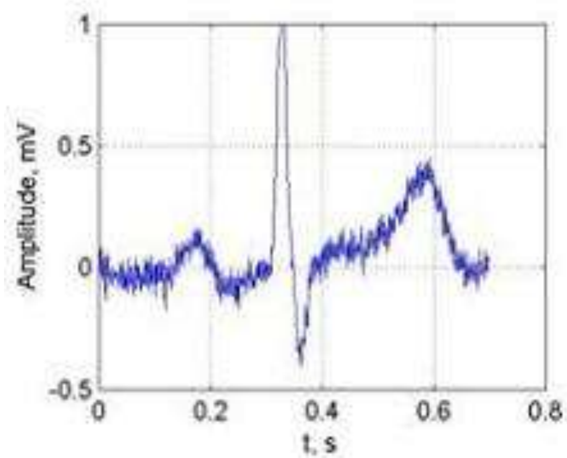
Just transport that part of the spectrum which containes the information!

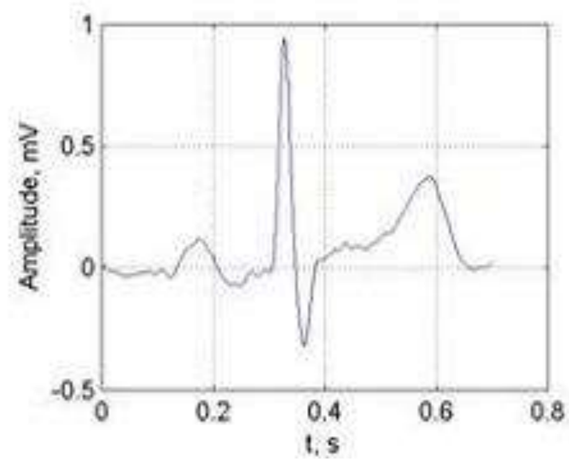




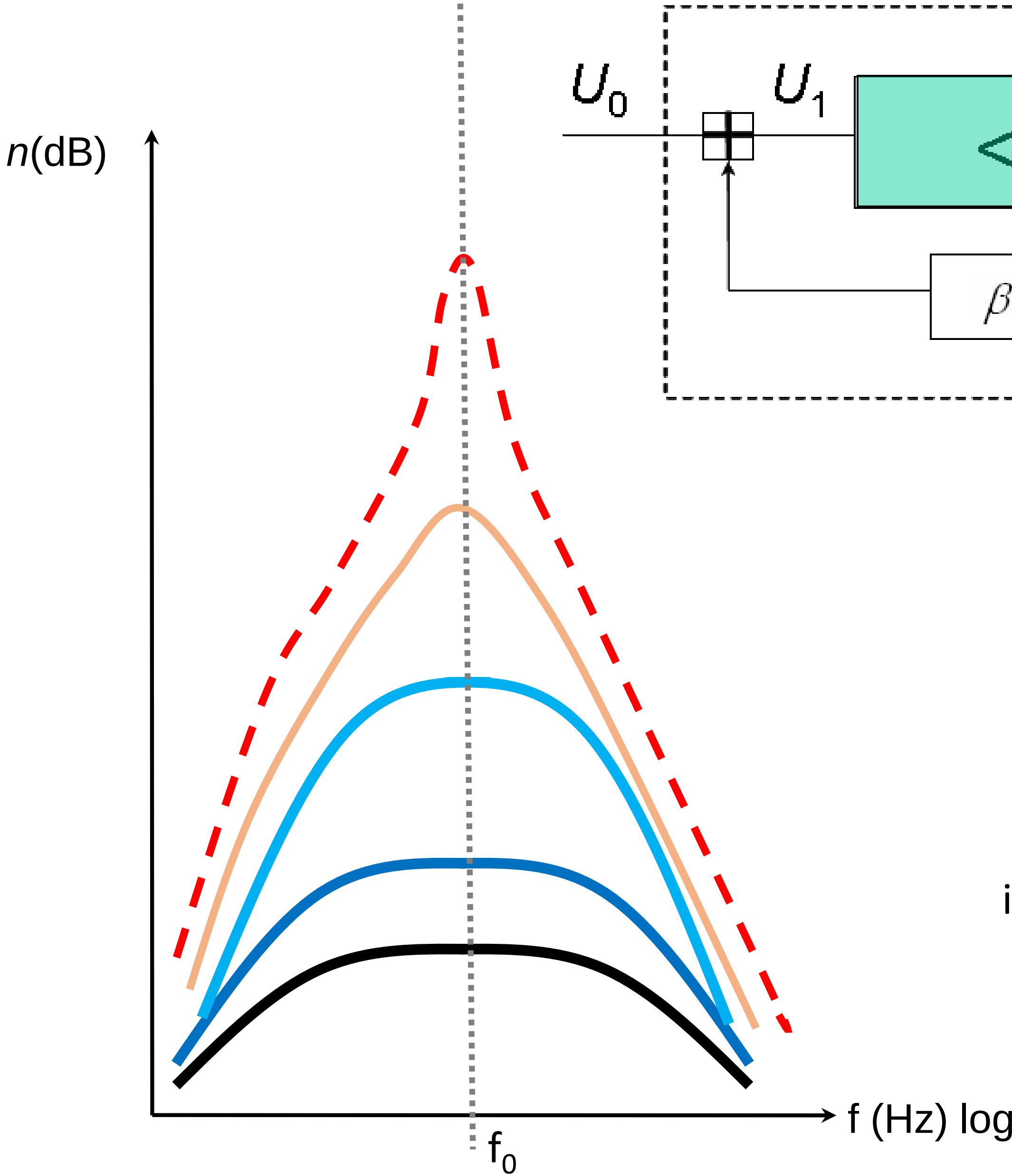


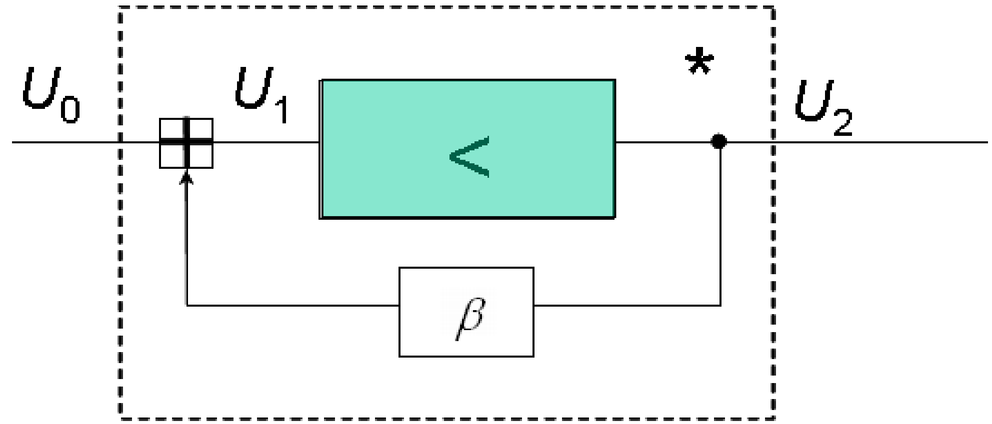






Positive feedback

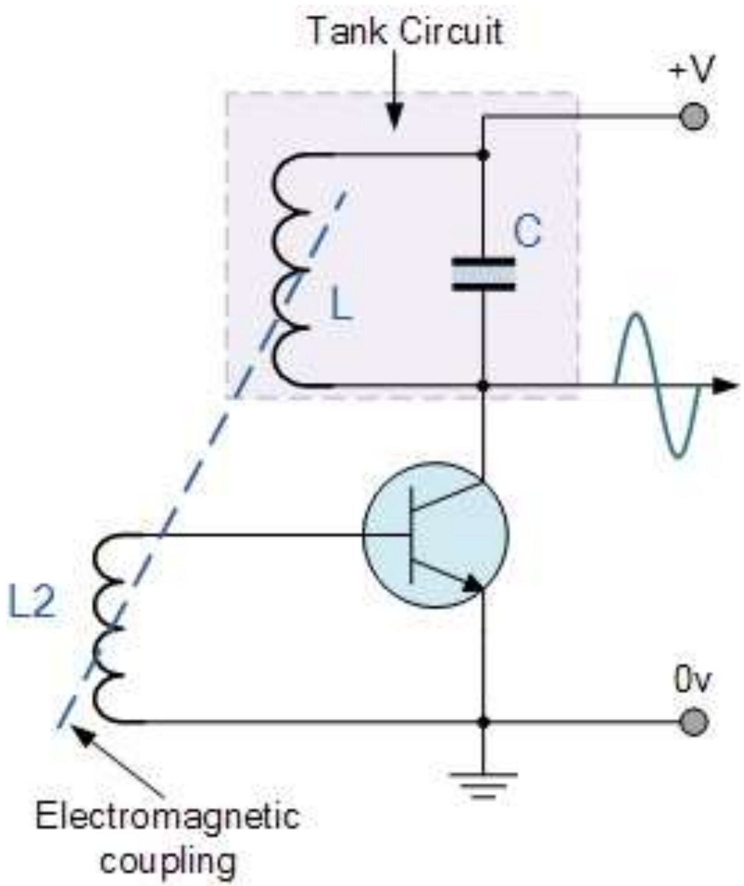


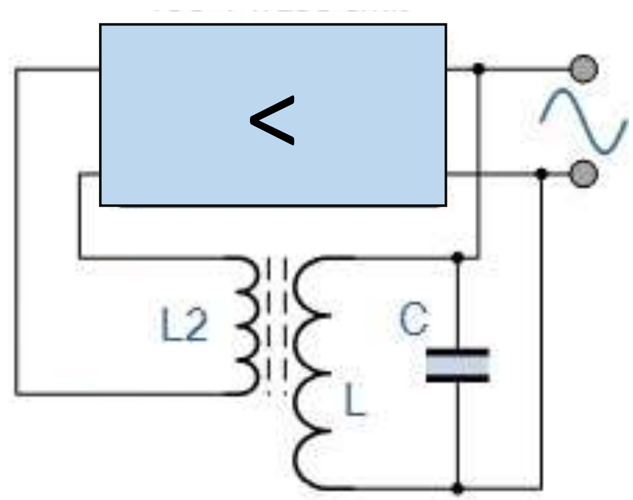


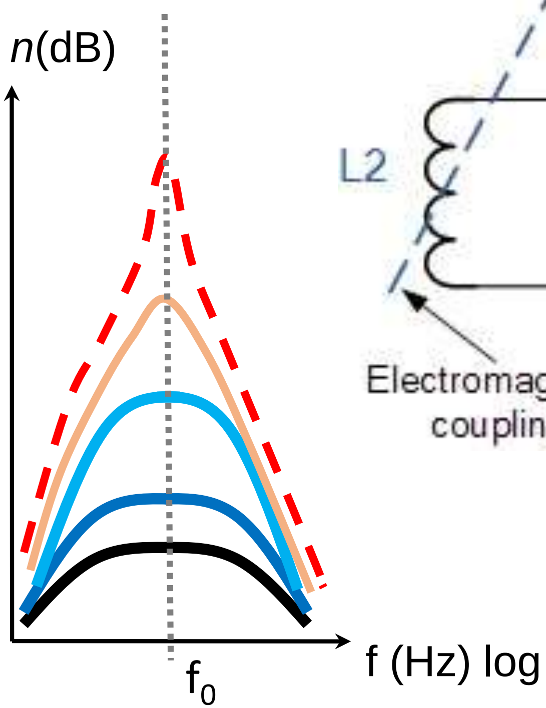
$$A_U{}^* = \frac{A_U}{1-\beta A_U}$$

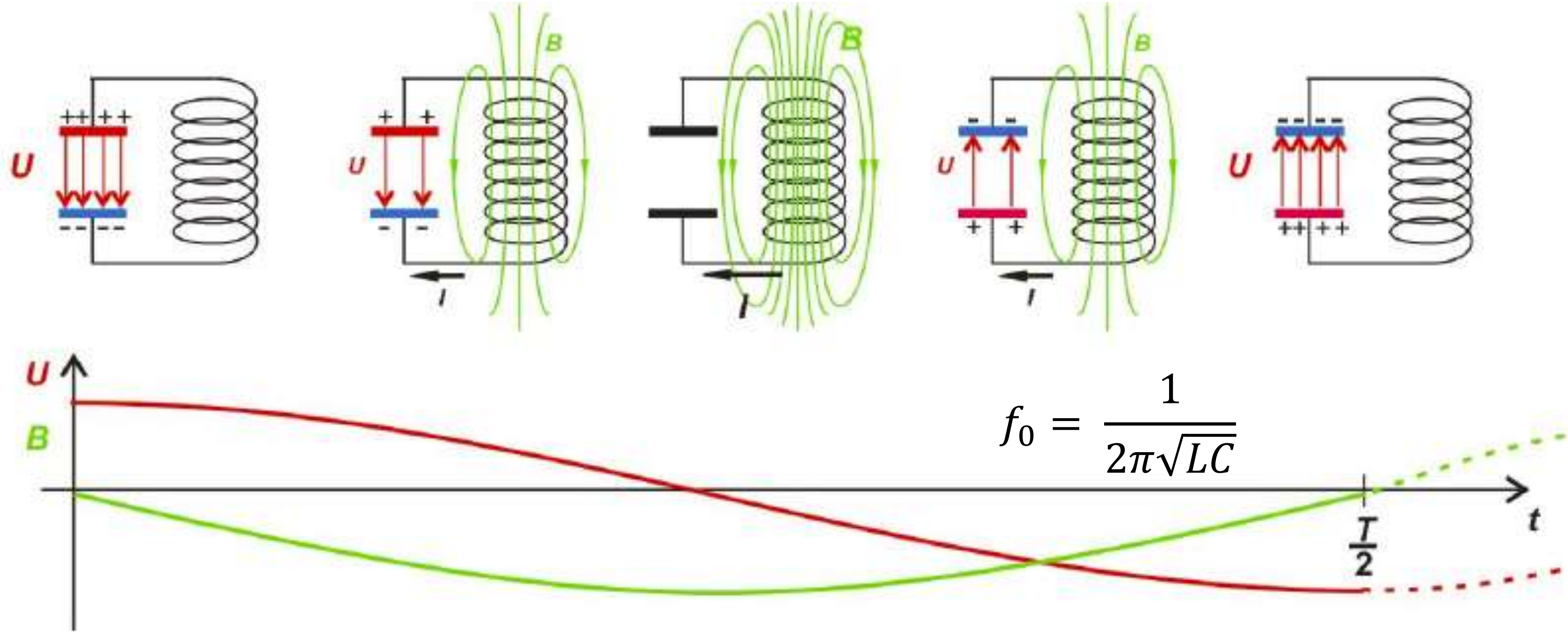
if βAu -> 1 then $A_U{}^*$ -> ∞

We can insert frequency selective elements into the feedback loop to lock the system to a given (natural) frequency.

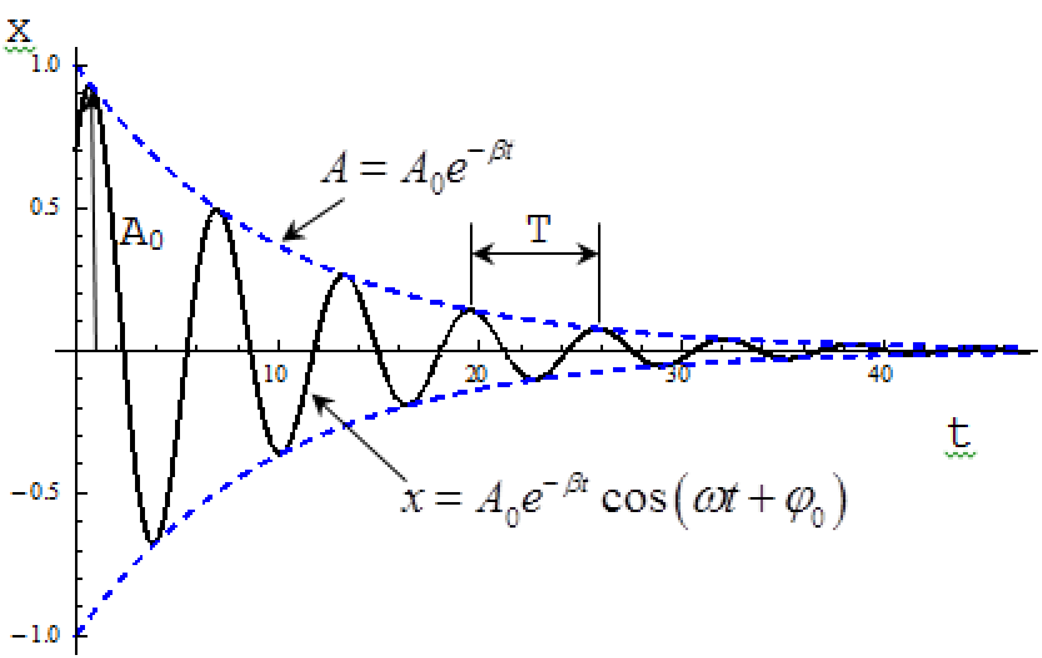




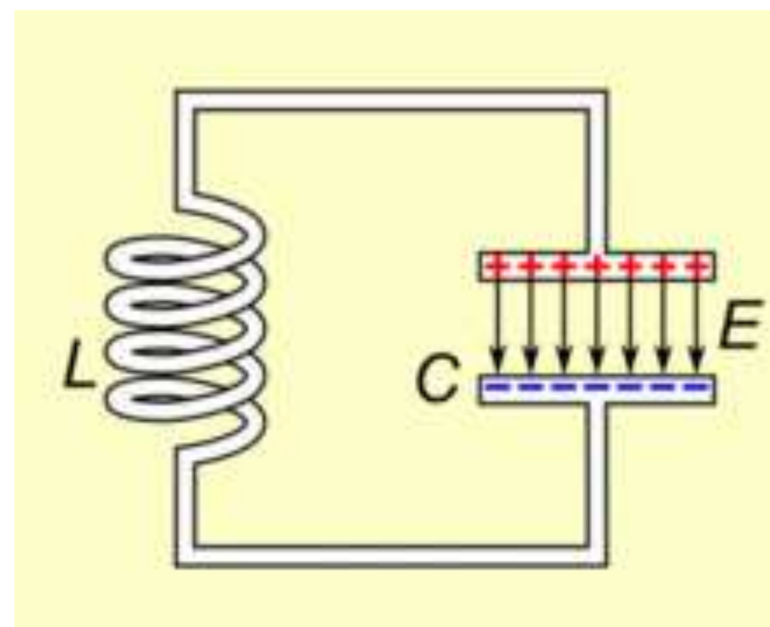




U
B
I
t
T/2
$f_0 = \frac{1}{2\pi\sqrt{LC}}$

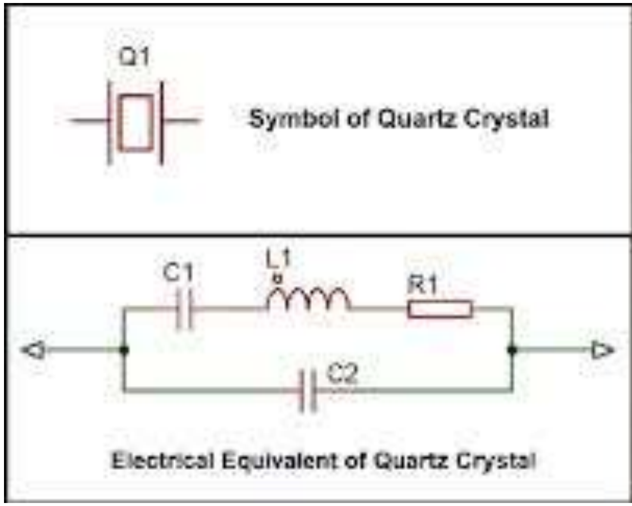


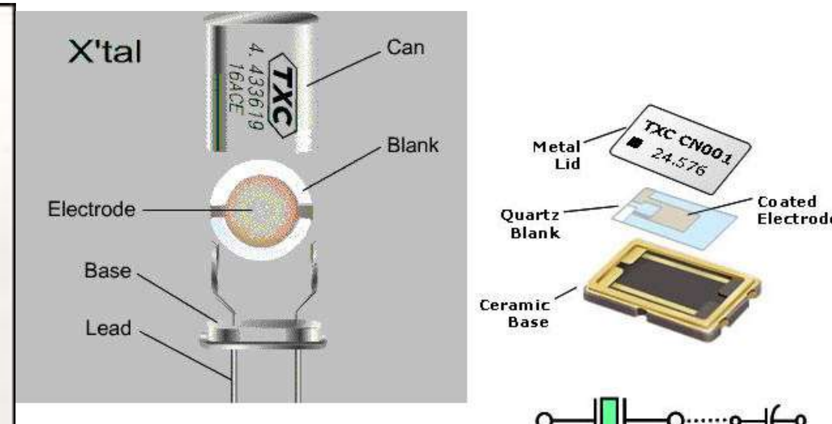
x
1.0
0.5
−0.5
−1.0
10
20
30
40
t
$A = A_0 e^{-\beta t}$
A_0
T
$x = A_0 e^{-\beta t} \cos(\omega t + \varphi_0)$



L
C
E

Quartz crystal-oscillator

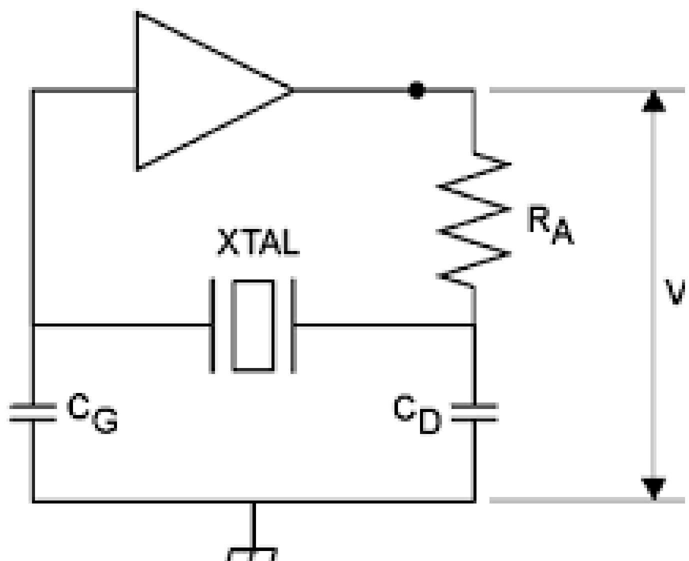




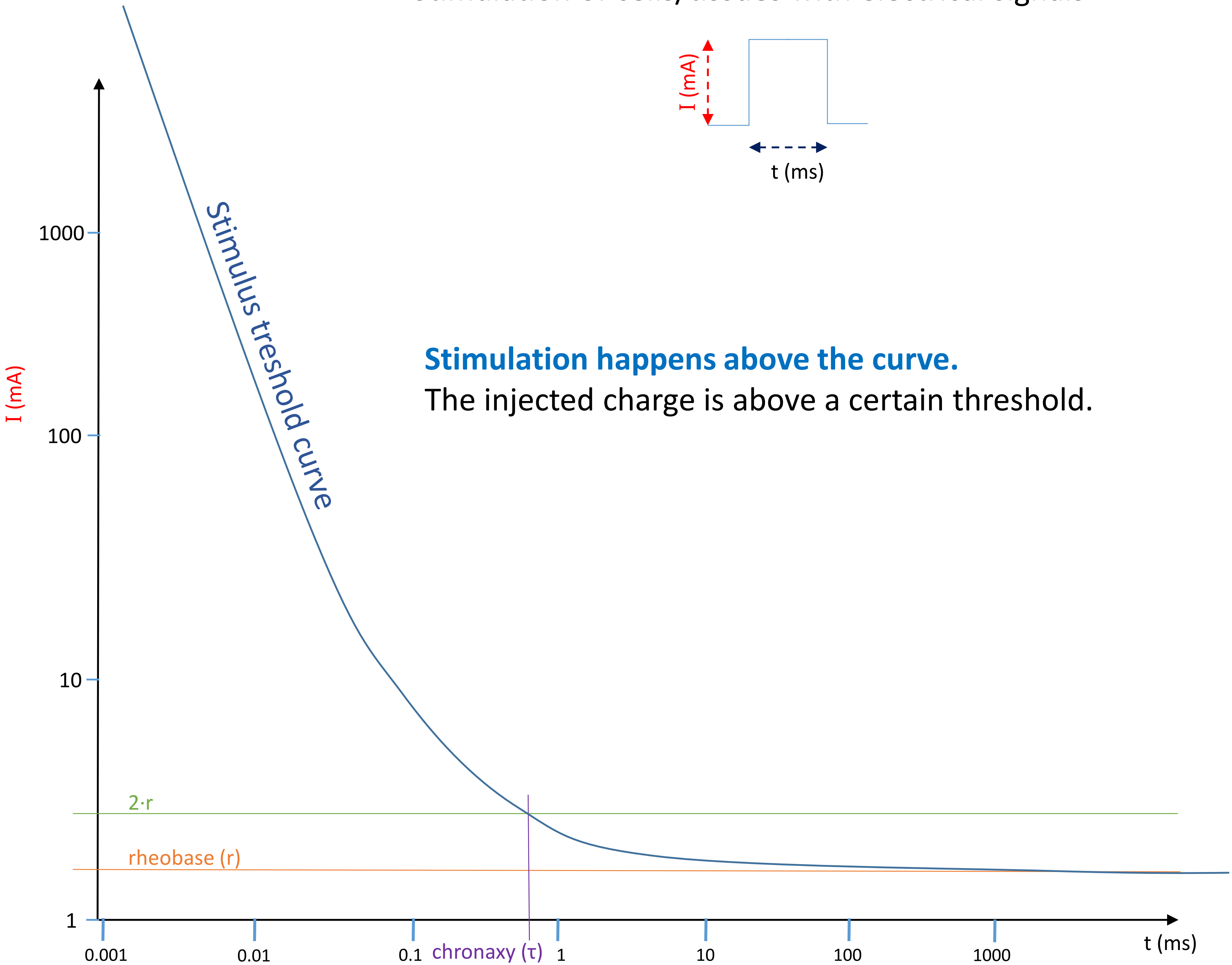
(Fig.7) (a) Metal can type resonator
(b) Ceramic SMD type resonator
(c) Symbol of crystal unit

(c)

Piezoelectric effect makes the crystal act as a resonant element in the circuit.

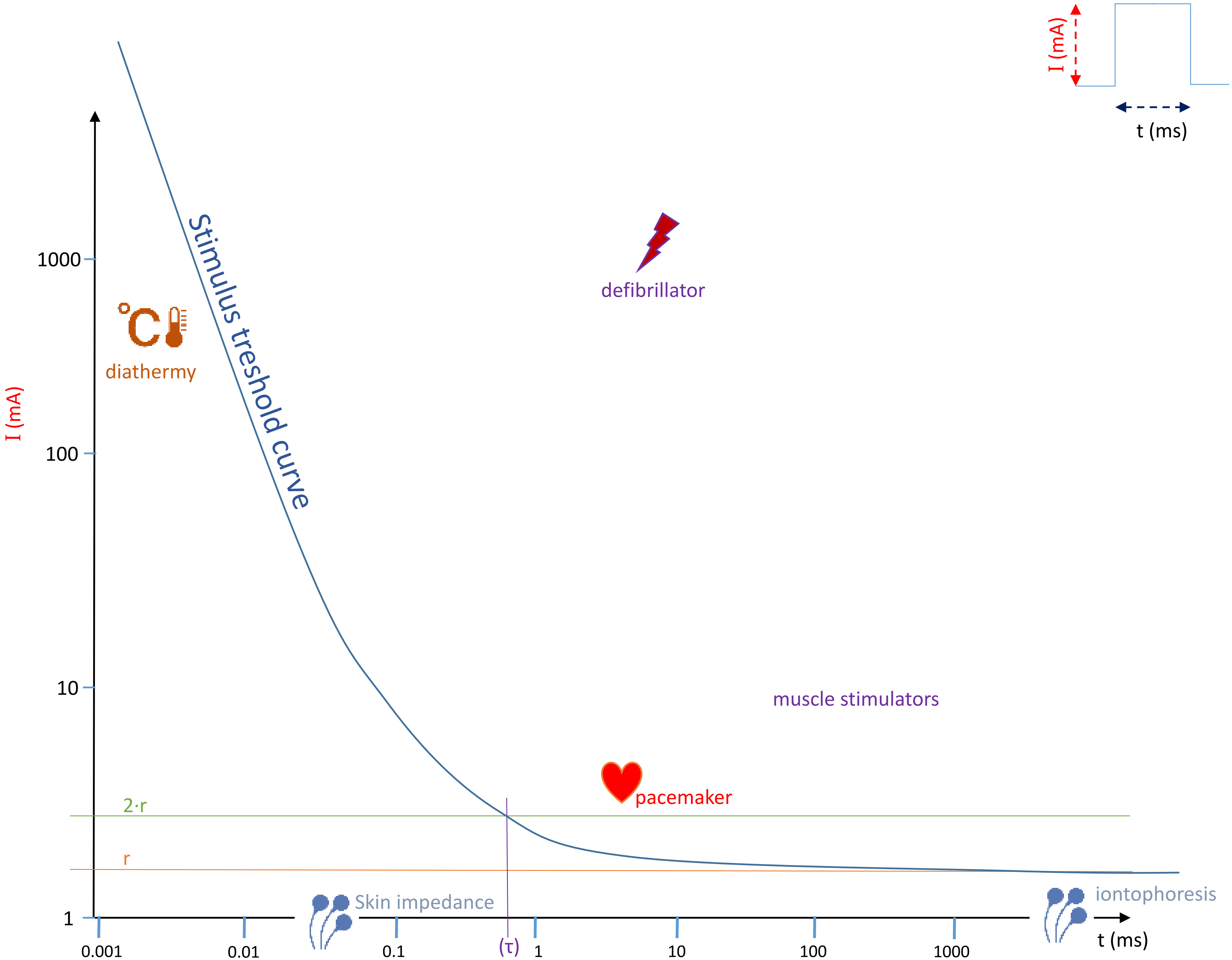


Stimulation of cells/tissues with electrical signals



Stimulation happens above the curve.

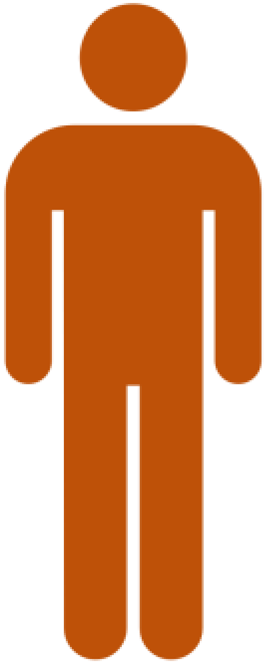
The injected charge is above a certain threshold.

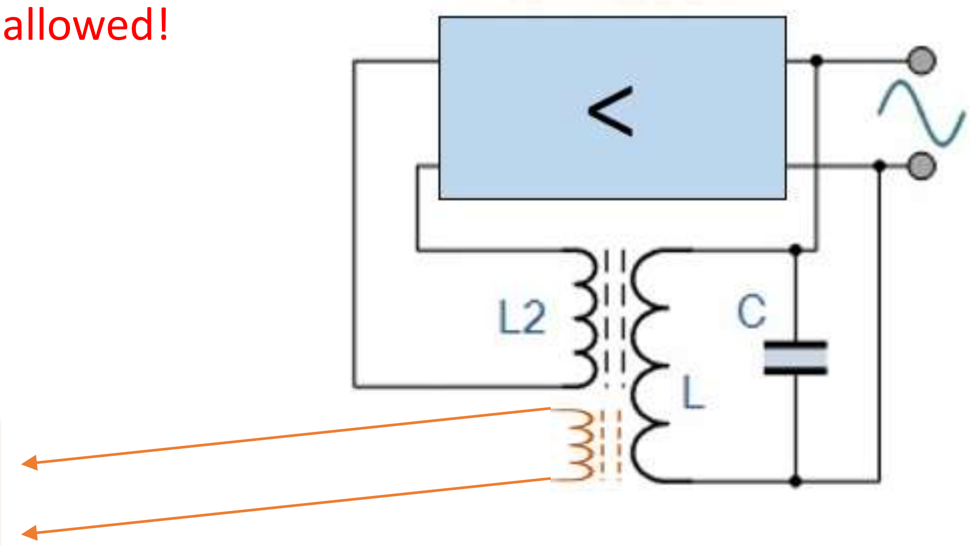


I (mA)
t (ms)
Stimulus treshold curve
defibrillator
diathermy
muscle stimulators
pacemaker
2·r
r
Skin impedance
iontophoresis
(τ)
1000
100
10
1
0.001
0.01
0.1
1
10
100
1000
I (mA)
t (ms)

The output power goes to the patient circuit.

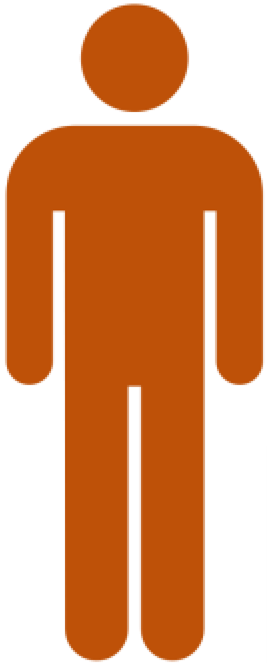
NO direct galvanic contant is allowed!
(safety rule)



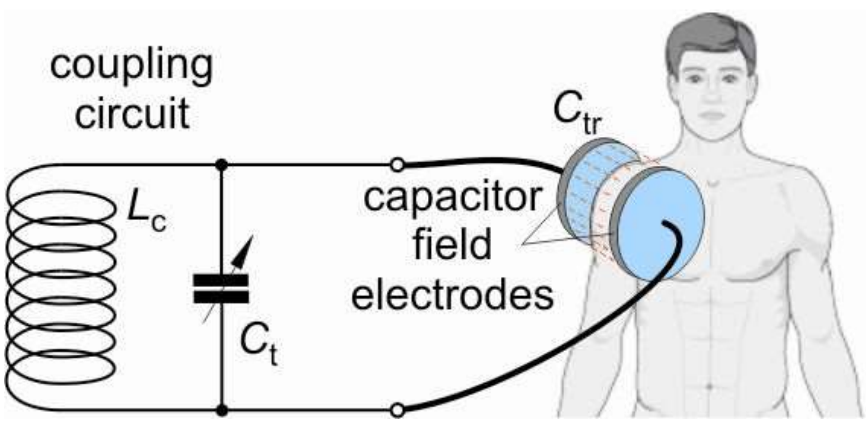


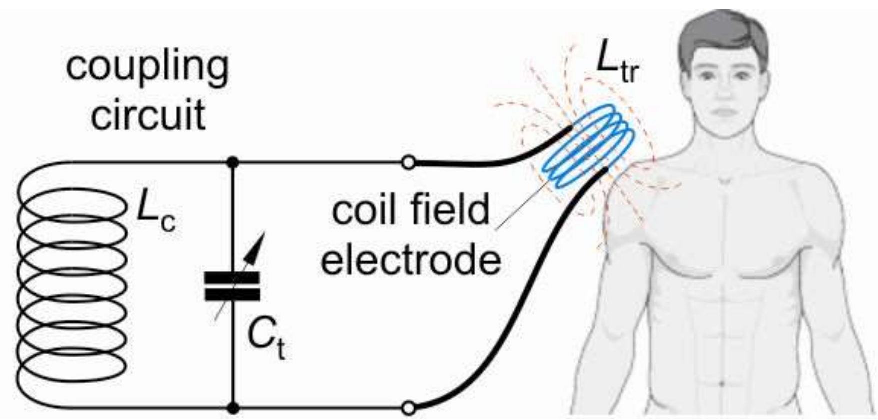
A usual way is the magnetic coupling into the patient-circuit

Patient circuits

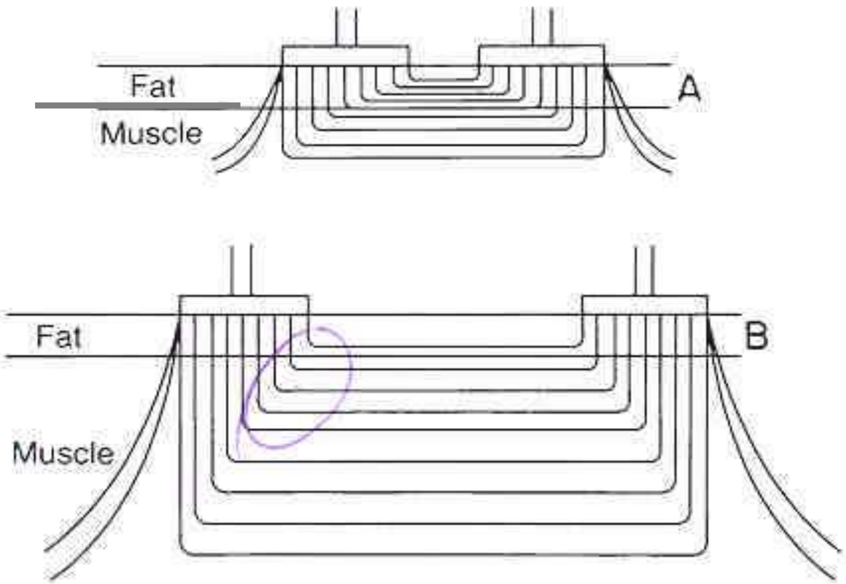


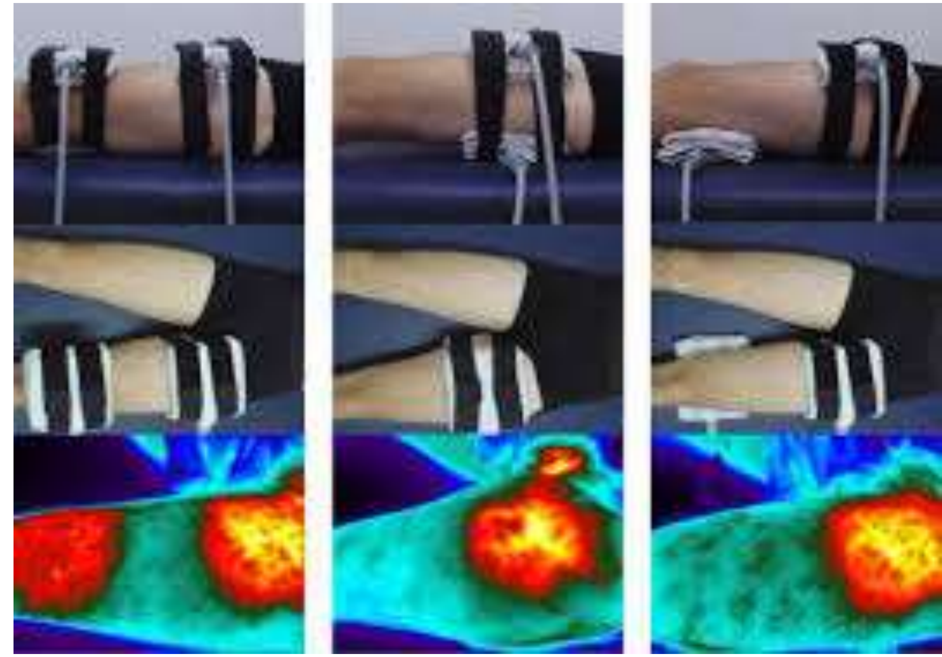
name	frequency	wavelength
Short wave	27,12 MHz	11,1 m
dm-waves	433 MHz	6,9 dm
microwaves	2,4 GHz	1,25 dm

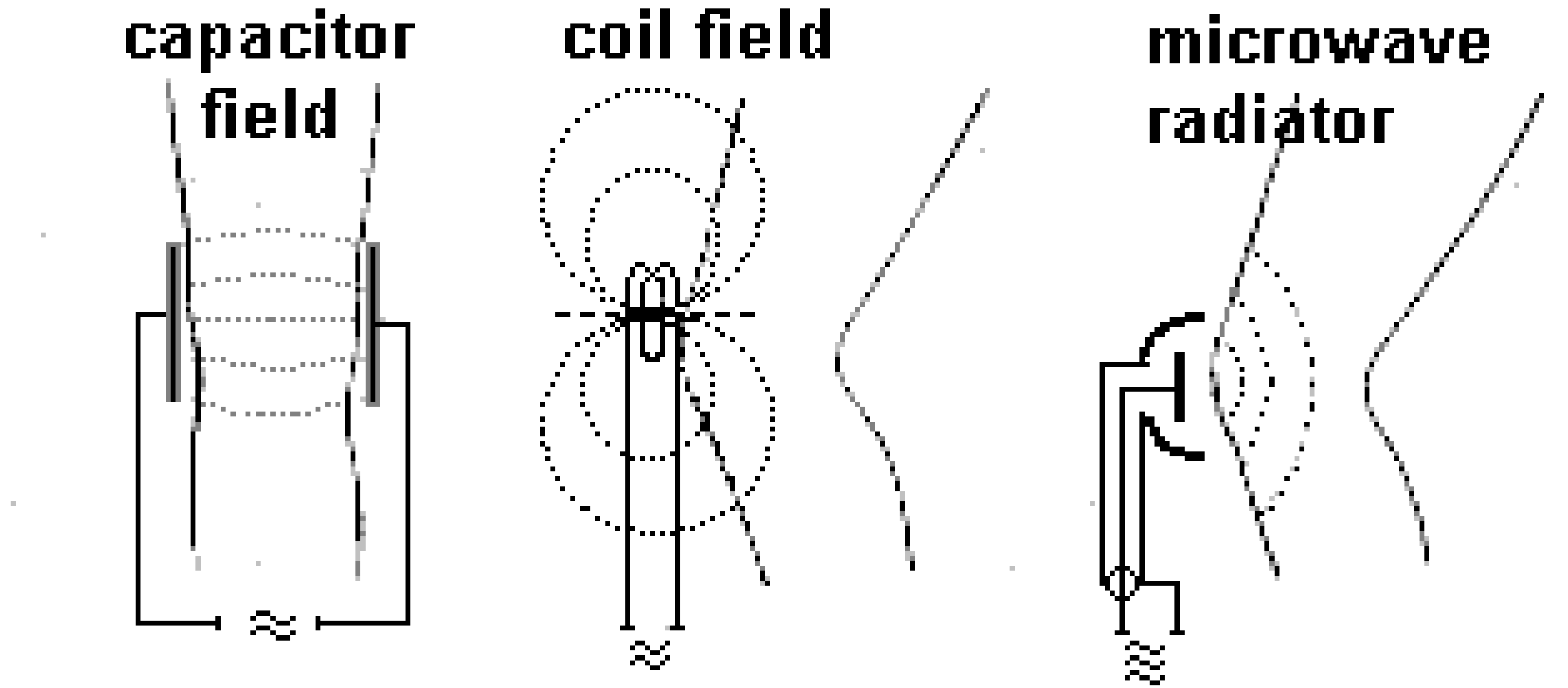




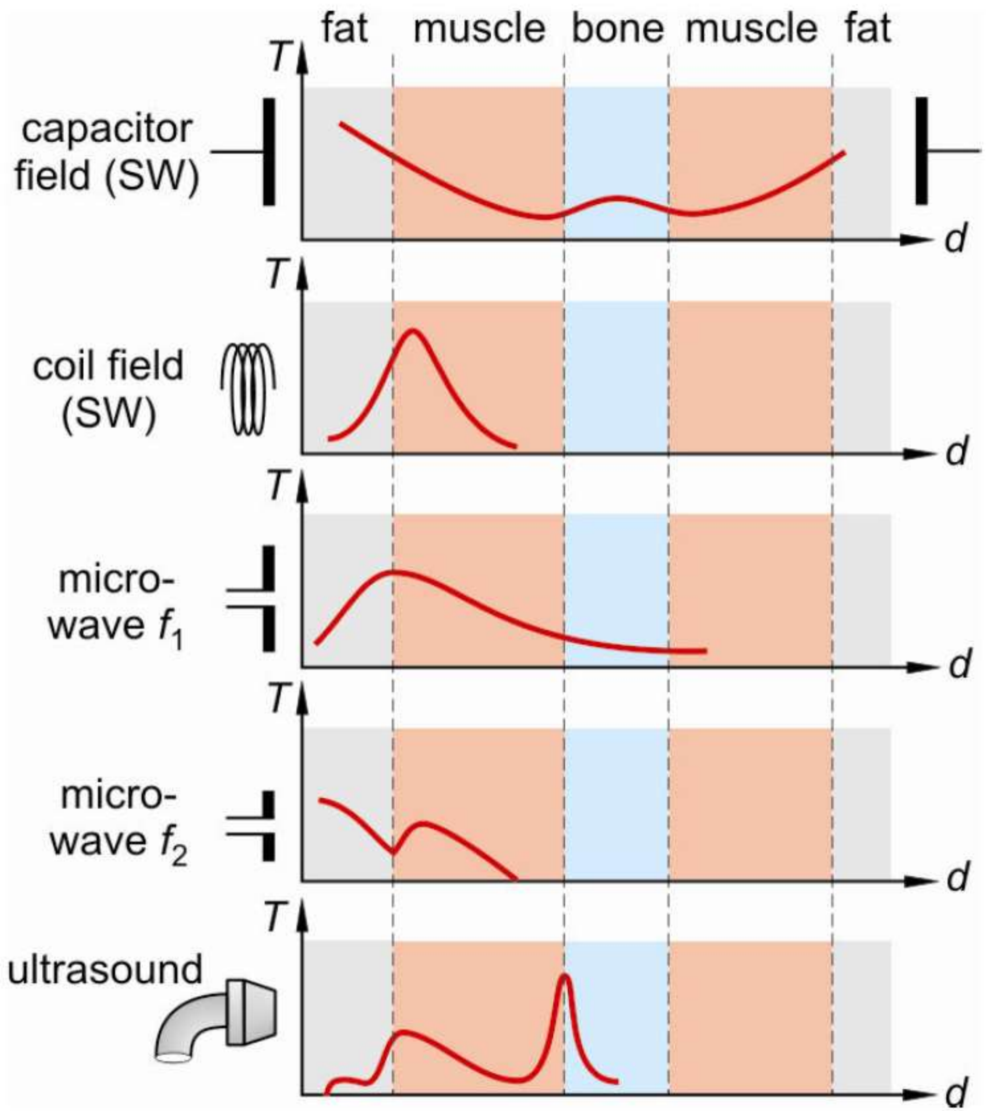
Resonance needed for optimal coupling -> tuning required (autotune)


Fat
Muscle
A
Fat
Muscle
B

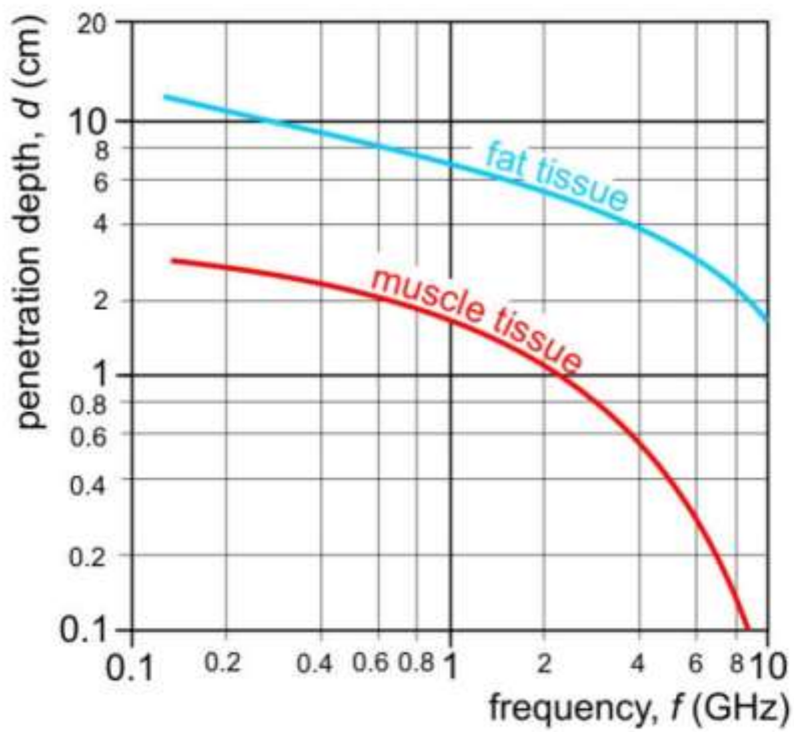



capacitor field
coil field
microwave radiator

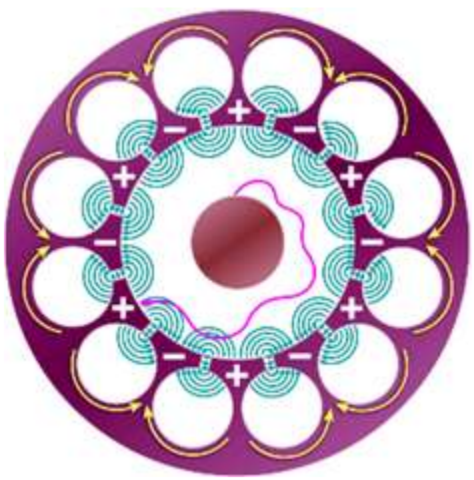
$$Q = \frac{U^2}{R} \cdot t = \frac{U^2}{\rho \frac{l}{A}} \cdot t = \sigma \frac{U^2}{l^2} \cdot l \cdot A \cdot t = \sigma \cdot E^2 \cdot V \cdot t$$

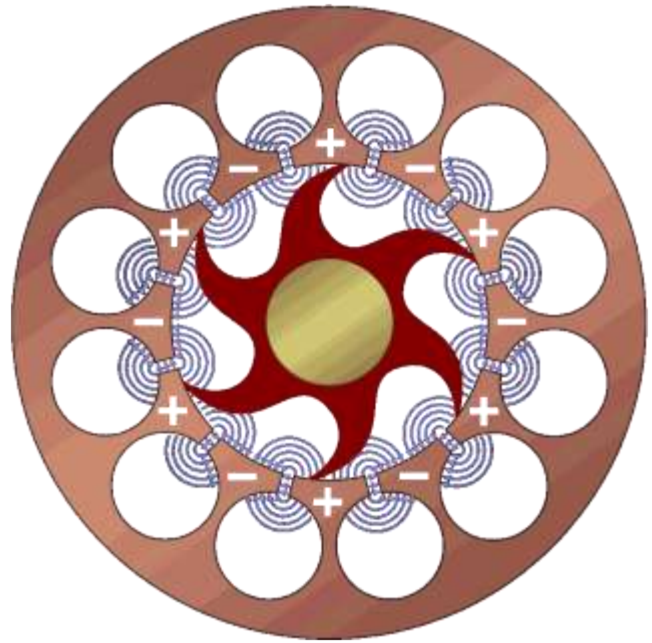


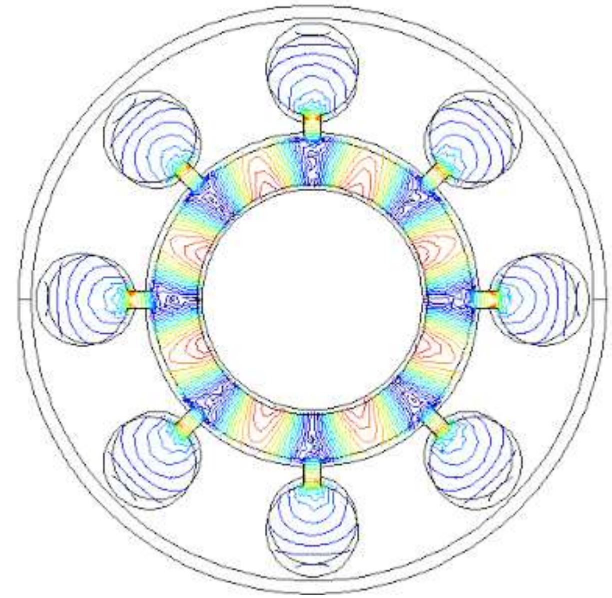
frequency	**σ_{fat} (mS/cm)**	**σ_{muscle} (mS/cm)**
300 MHz	2,7	9,0 – 9,9
1000 MHz	3,6	13,0 – 14,5

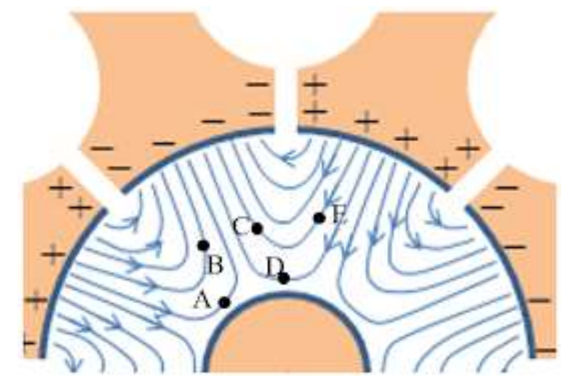


Penetration depth

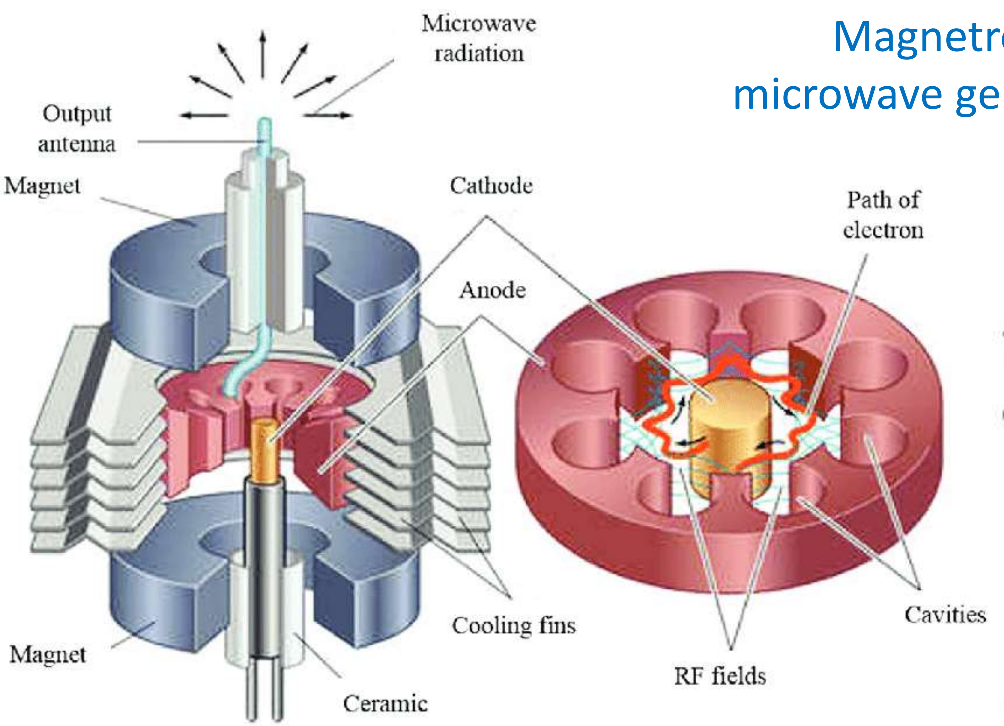


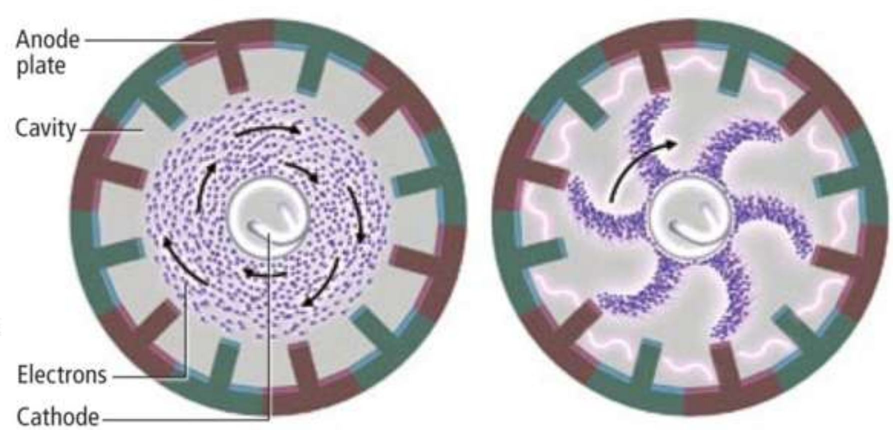




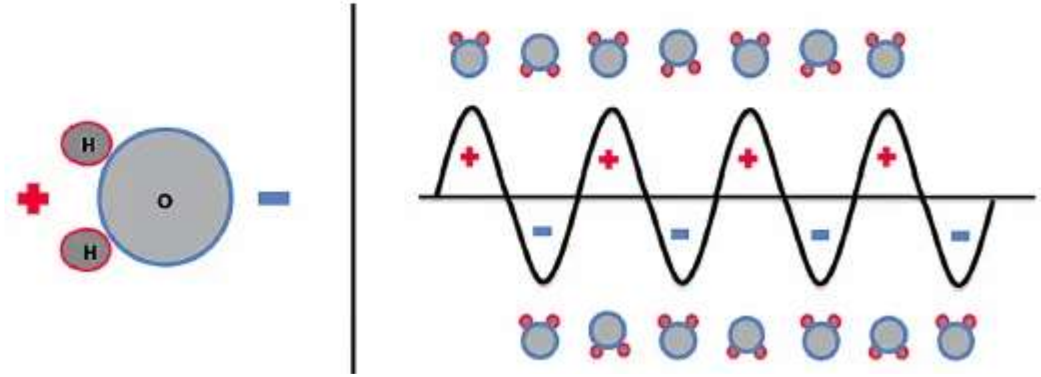


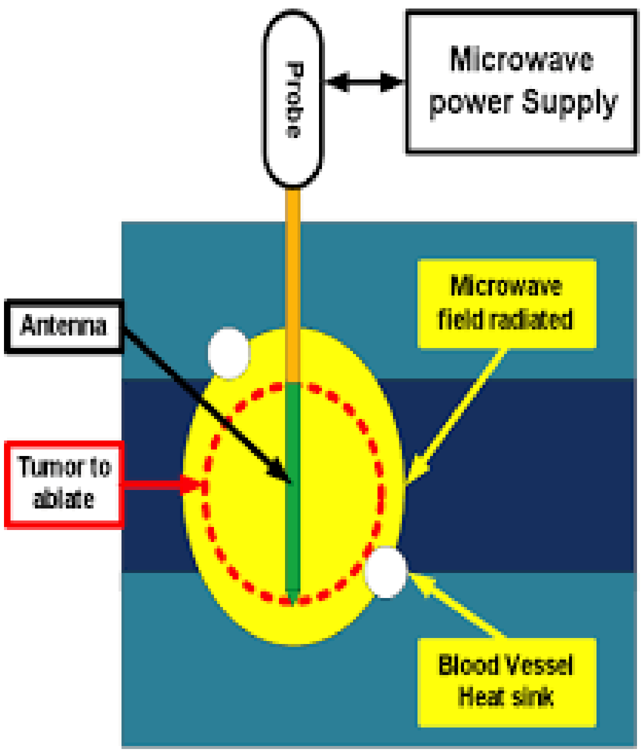
Magnetron microwave generator

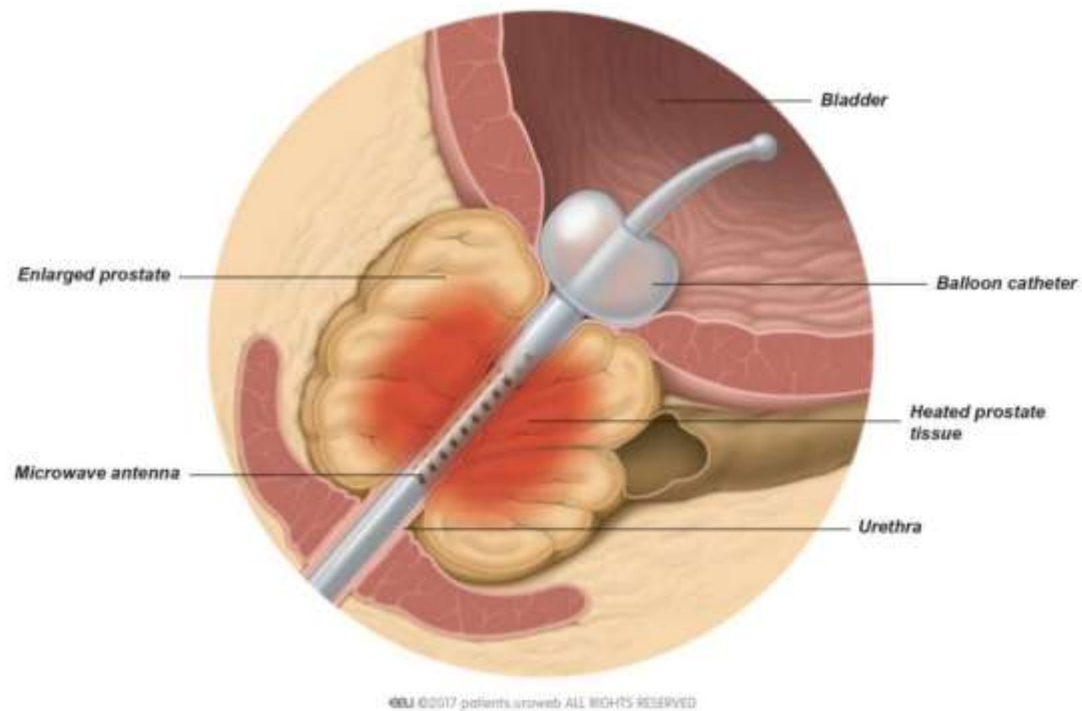


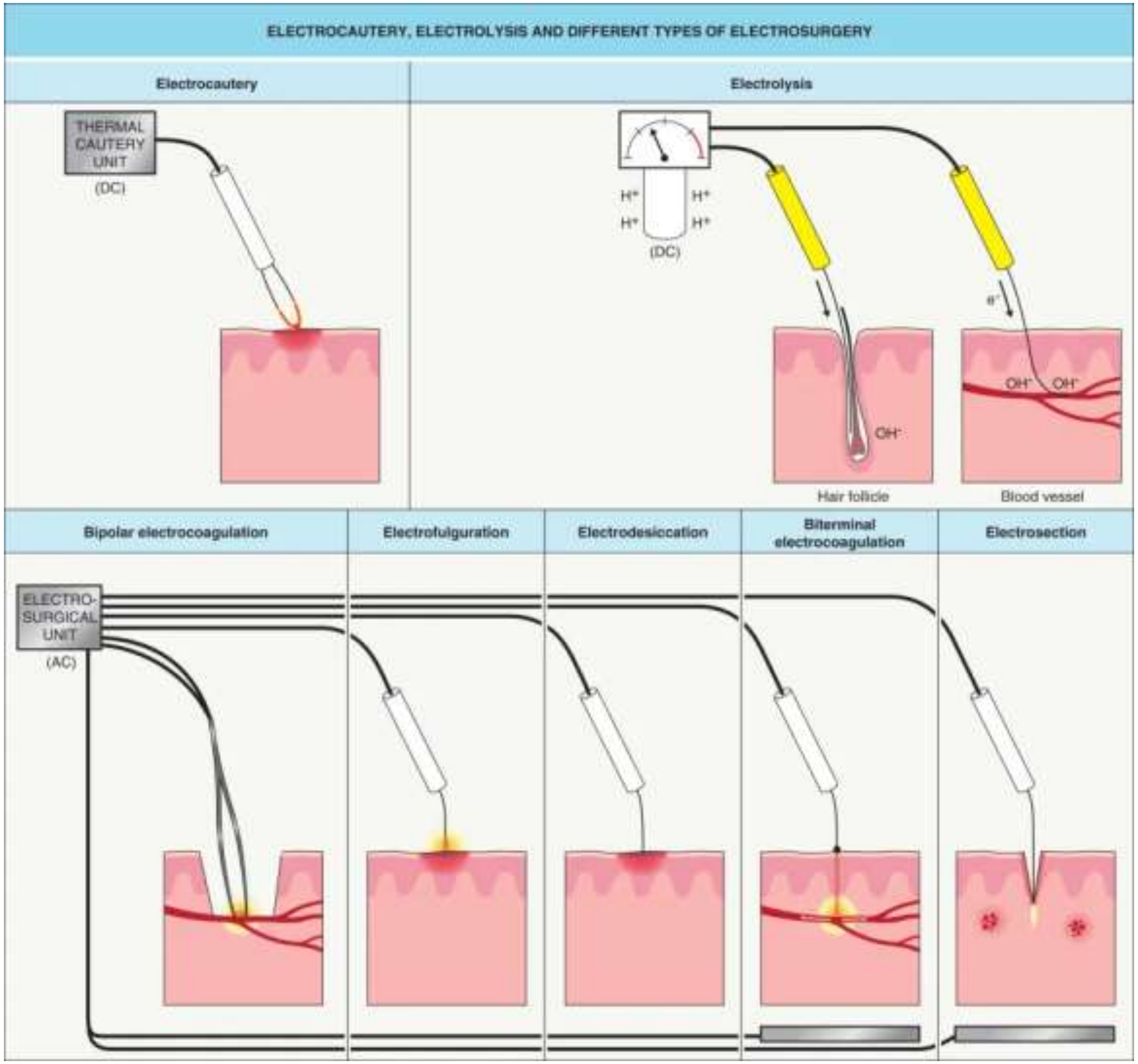


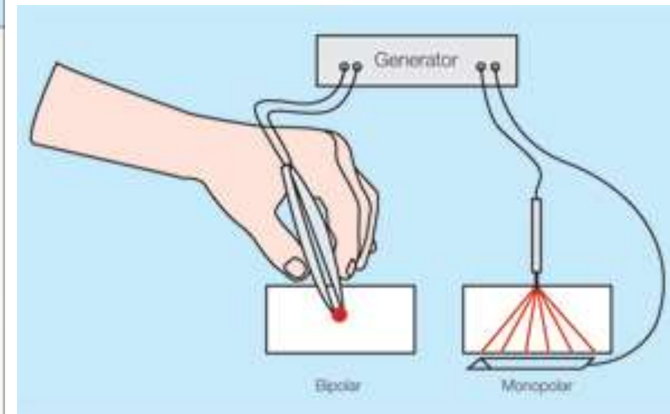

PHYSIOTHERM-

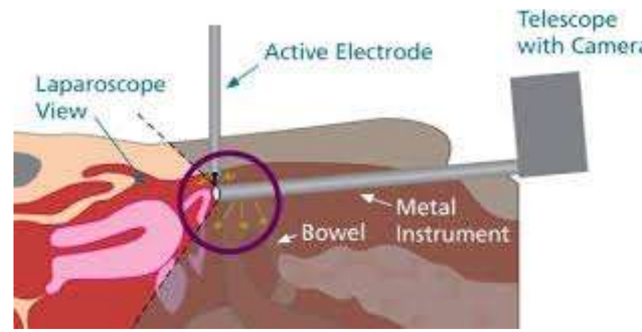

H
O
H

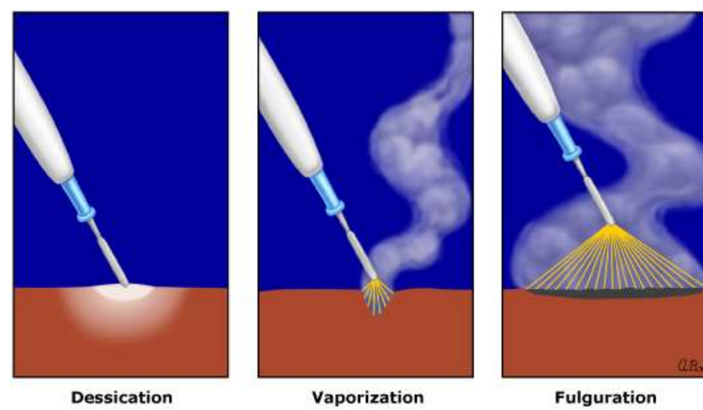

Probe
Microwave power Supply
Microwave field radiated
Antenna
Tumor to ablate
Blood Vessel Heat sink

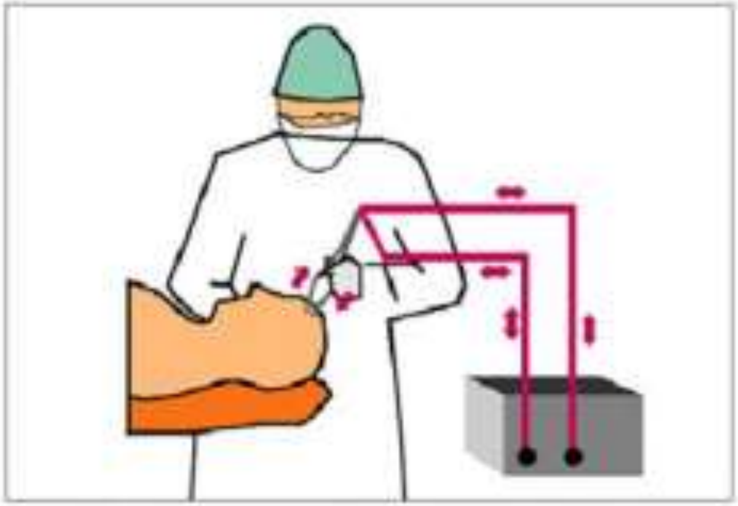

Bladder
Enlarged prostate
Balloon catheter
Heated prostate tissue
Microwave antenna
Urethra


ELECTROCAUTERY, ELECTROLYSIS AND DIFFERENT TYPES OF ELECTROSURGERY
Electrocautery
Electrolysis
THERMAL CAUTERY UNIT
(DC)
H+
H+
H+
H+
(DC)
e-
OH-
OH-
OH-
Hair follicle
Blood vessel
Bipolar electrocoagulation
Electrofulguration
Electrodesiccation
Biterminal electrocoagulation
Electrosection
ELECTRO-SURGICAL UNIT
(AC)

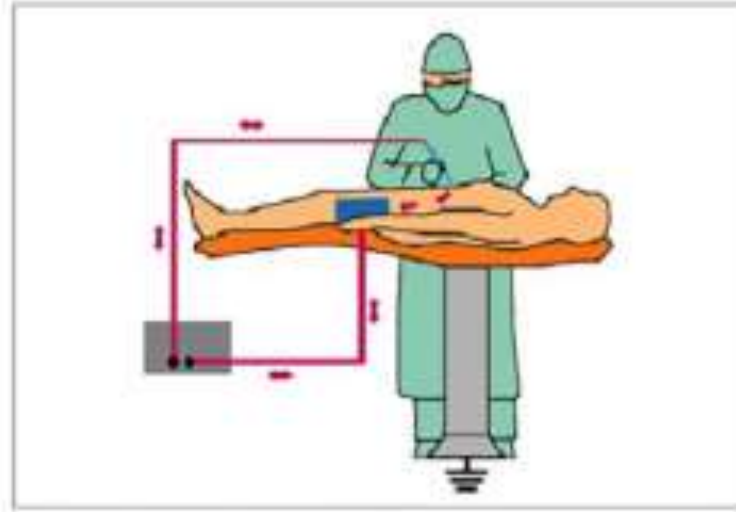

Generator
Bipolar
Monopolar


Active Electrode
Telescope with Camera
Laparoscope View
Metal Instrument
Bowel

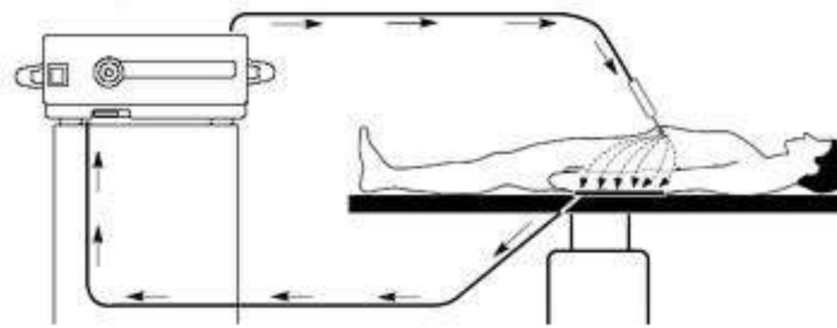

Dessication
Vaporization
Fulguration

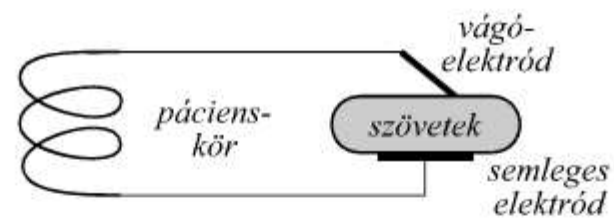


Bipolar



Monopolar





„Electrosurgery is currently used in over 80% of all surgical procedures, and is growing in popularity in dental surgery. **Electrosurgery also significantly reduces bleeding and provides the oral surgeon or dentist greater overall precision. ...”**

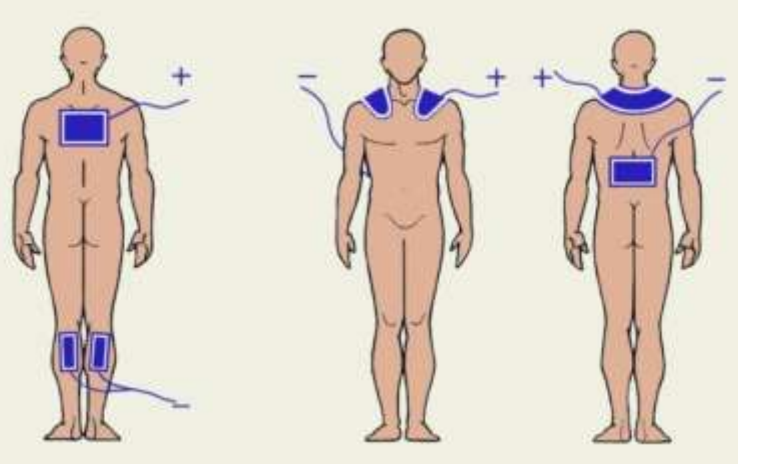
Advantages:

- High precision
- Immediate sterilization
- Reduced bleeding
- Analgesic effect

- Whitening

DC: f=0

Anode Cranial (downward treatment):
stimulus threshold increases
sympathic tone is decreased
Anode Caudal (upward treatment)
stimulus threshold decreases



Galvanotherapy: constant direct current

Cranial or Caudal anode

Effects: pain relief
modulation of stimulus threshold of motoric neurons
modulation of vasodilatation

Hidro-Galvanic Treatment

sympathicus activity (tone) decreases
vasodilatation in deep tissues

Iontophoreses: ionic drugs can be delivered through the skin into the tissues situated between two electrodes

pain reliefs,

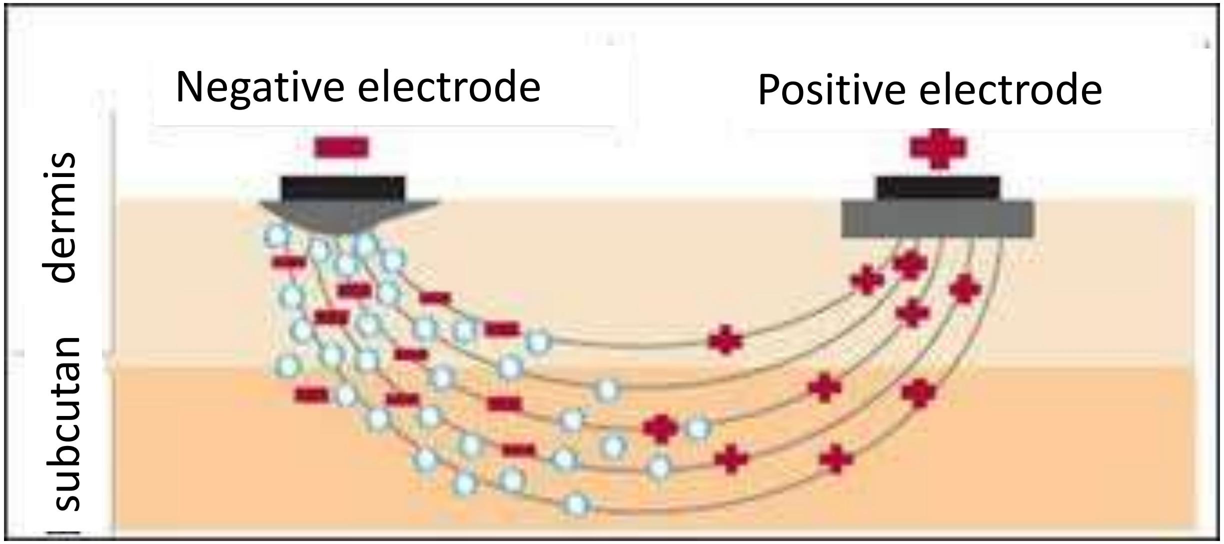
anty-inflammatory agents,

vasodilatators,

tissue softeners

Cathophorezis – e.g. steroidos, lidocain

Anophorezis – e.g.. Non-streroidal anti-inflammation drugs

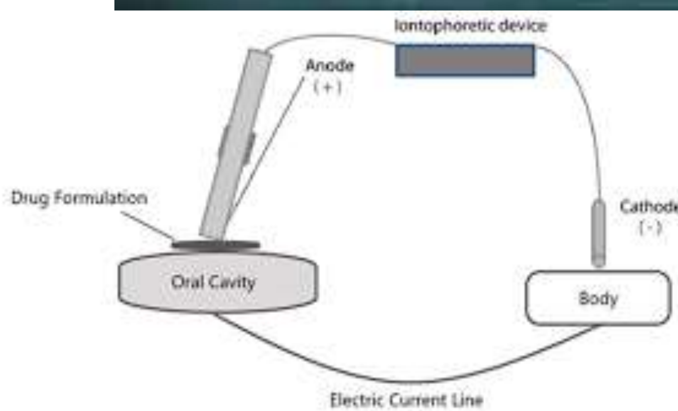


Iontophoreses :

Advantage: smaller quantity of drug, local treatment, delivery of non-absorbing drugs.

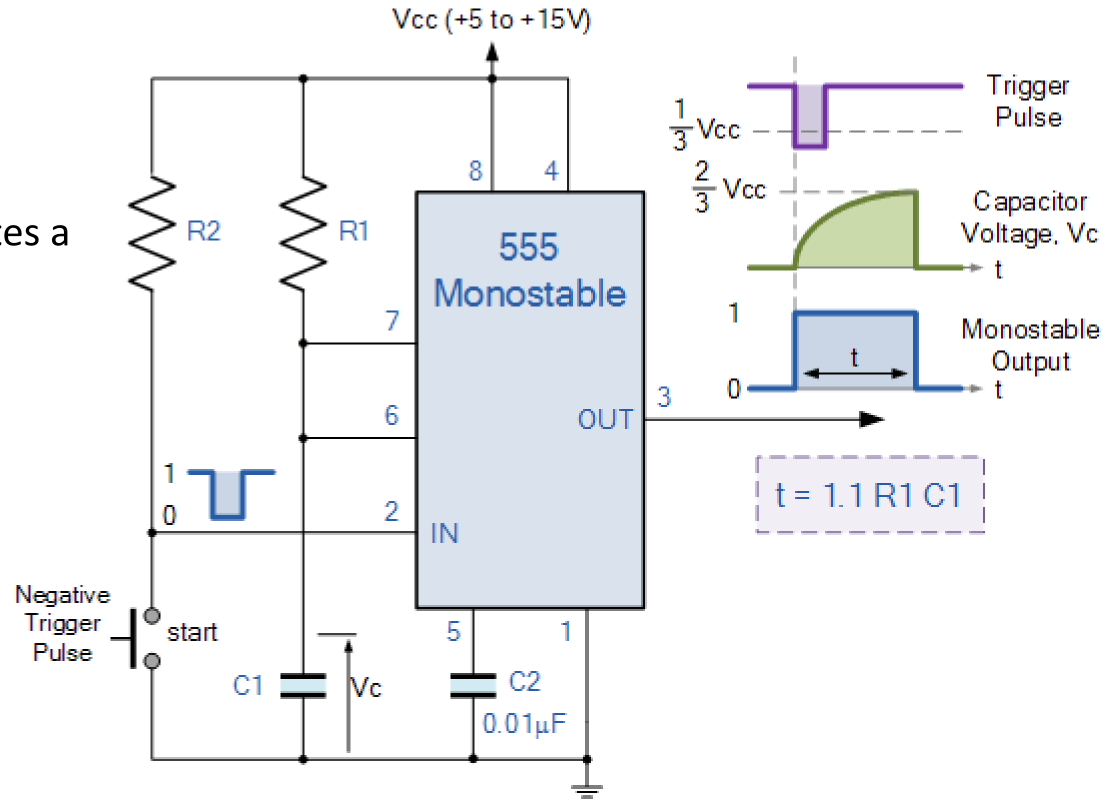
Disadvantage:

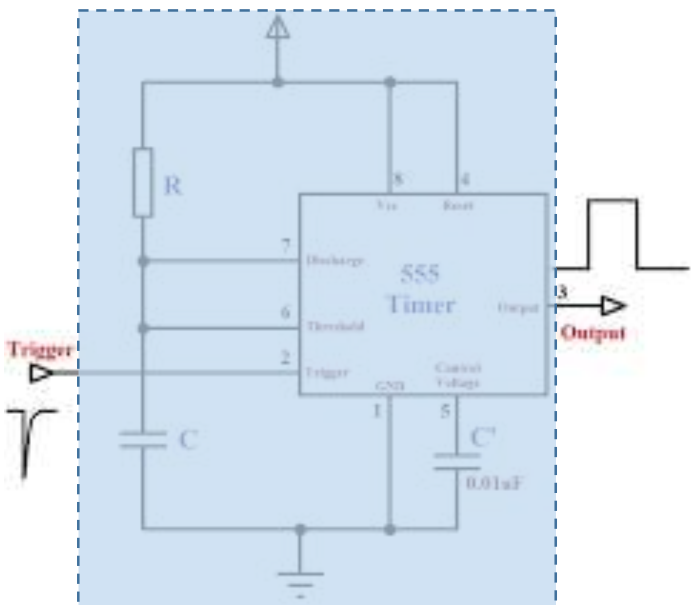
doses are uncertain



Pulse generators

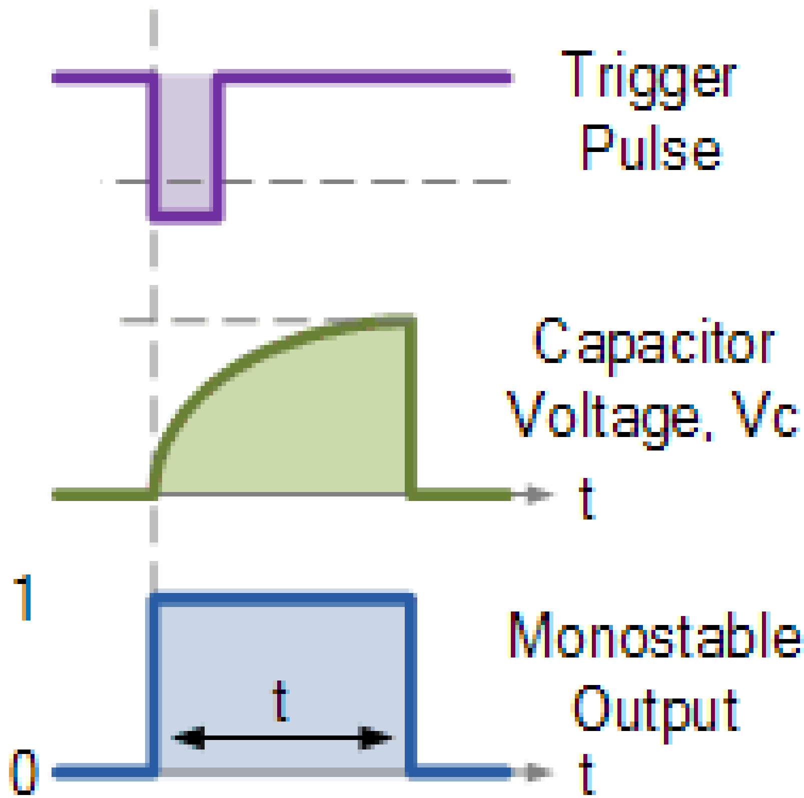
Trigger is an INPUT signal which generates a controlled voltage-duration pulse at the output of the monostable circuit.

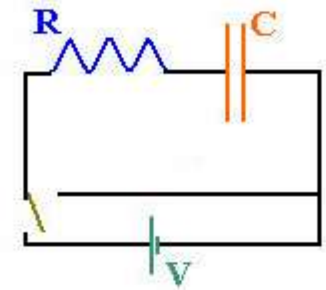




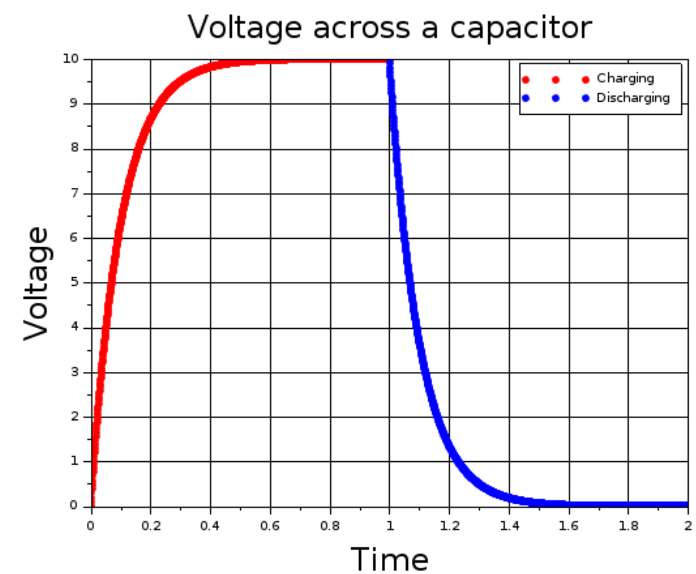
The **monostable** has ONE stable state, which is the inactive one.
The active output state is transient, and will be automatically switched off by the device without further external intervention.

The easiest/robust way to measure time is to charge or discharge a capacitor.

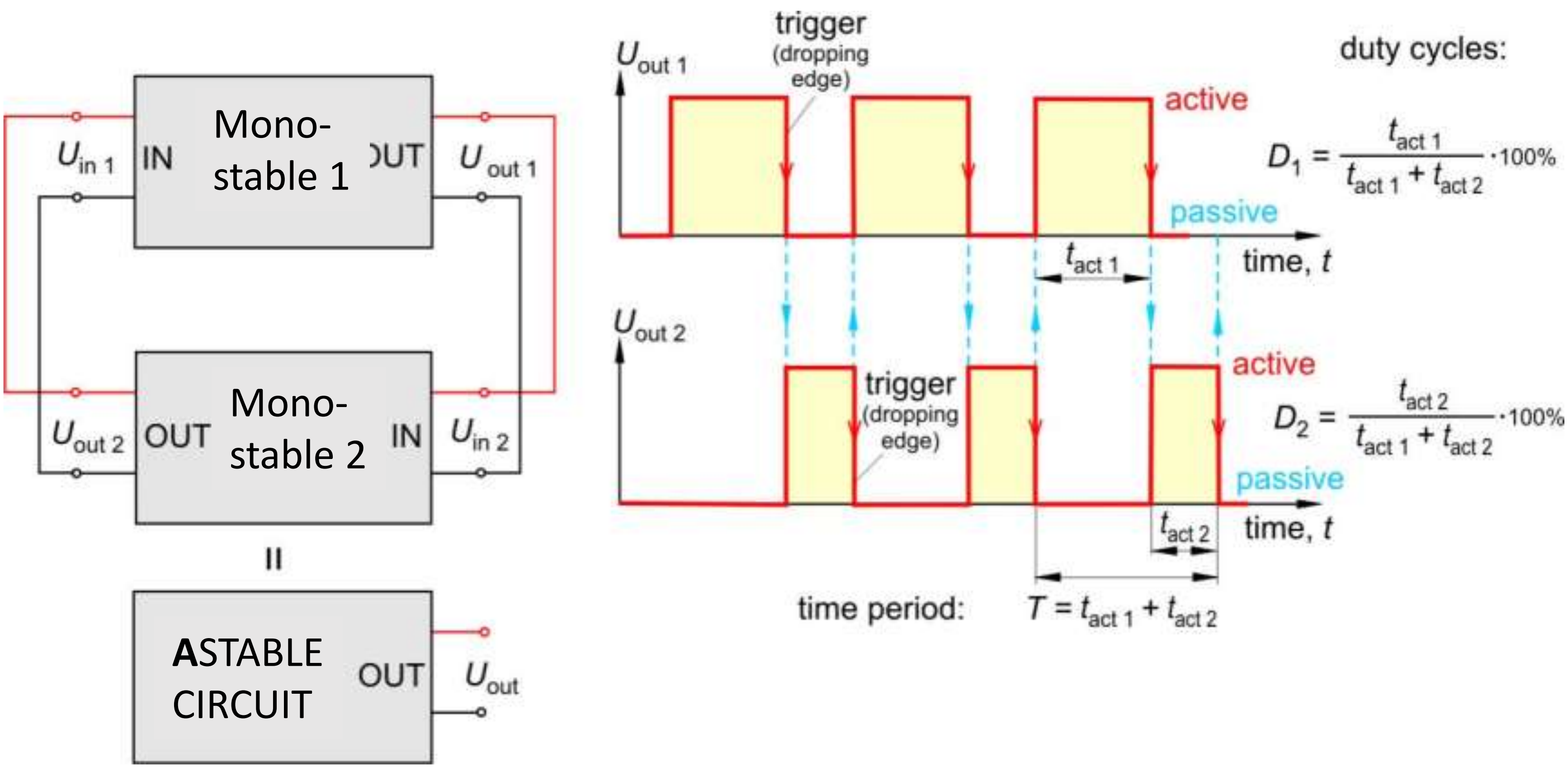


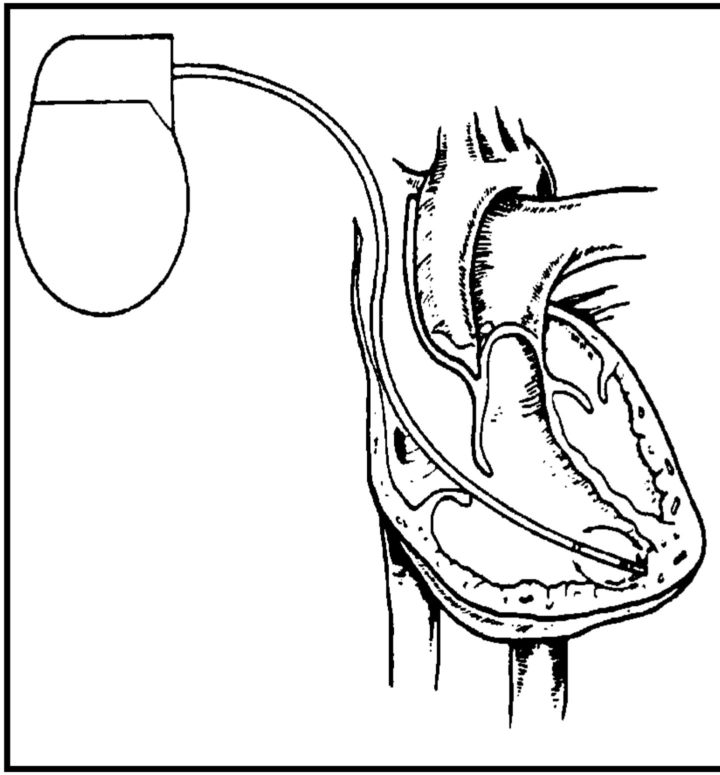


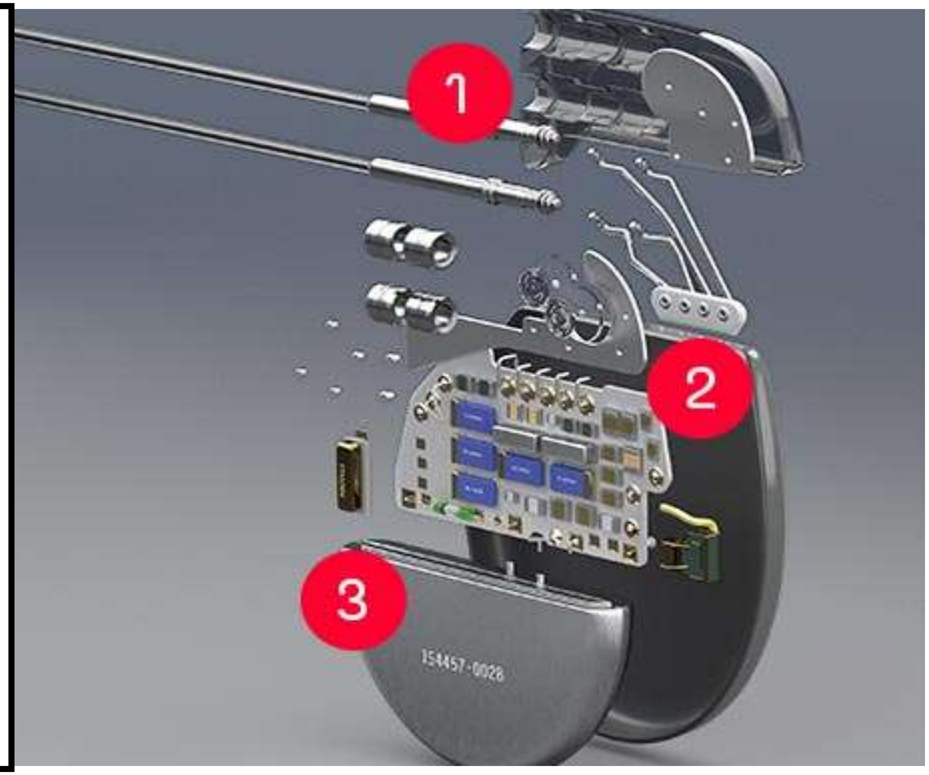
RC circuit charging or discharging



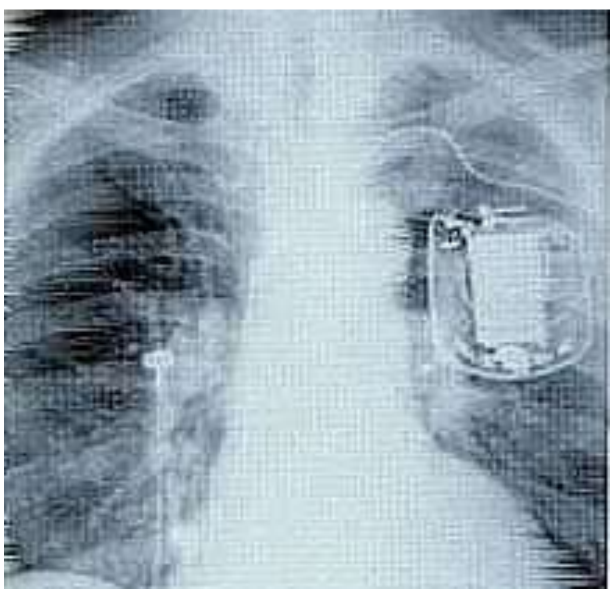
Astable circuit: generates a pulse train without external intervention, has no stable, persistent state.






1
2
3

Pacemaker



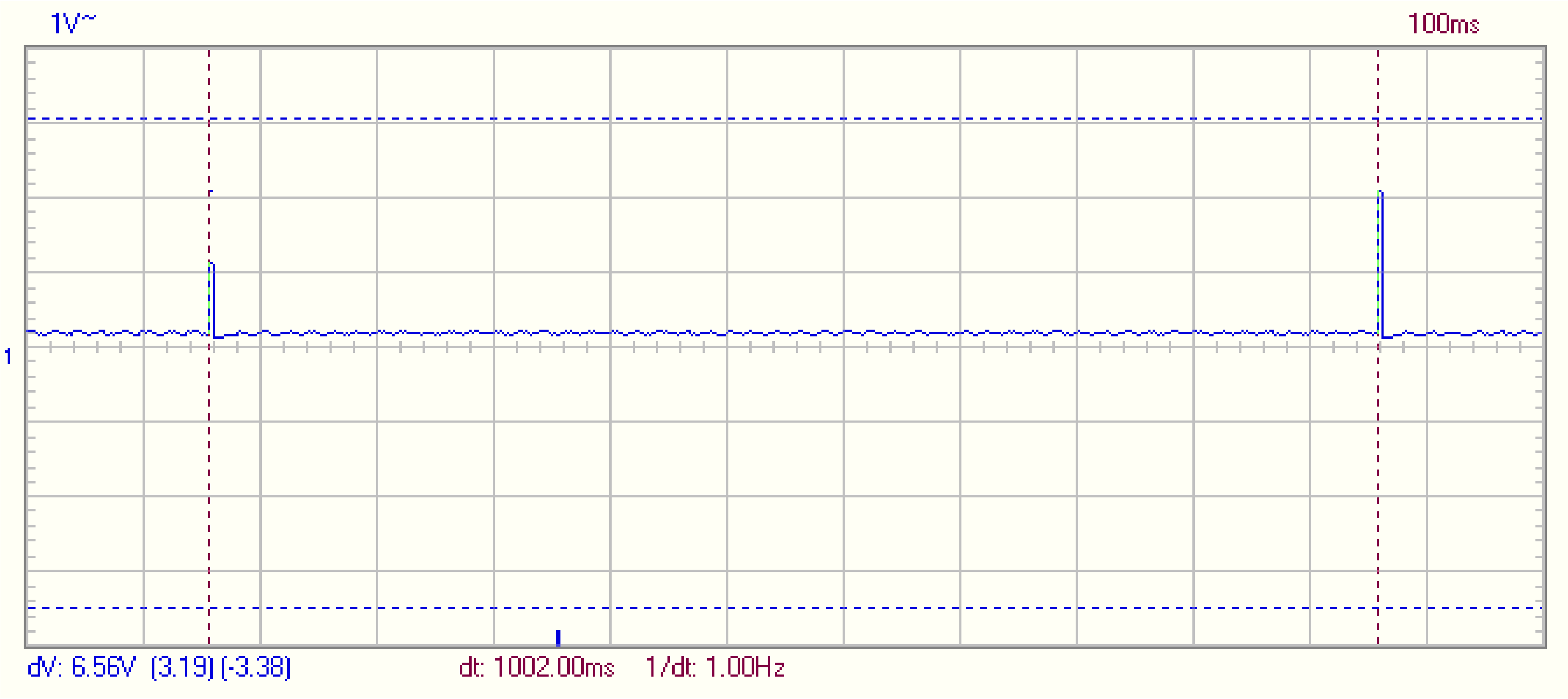

Enticos 4 SR
68505678
VVIR/AAIR
BIOTRONIK
Made in Germany
IS-1

Pacemaker

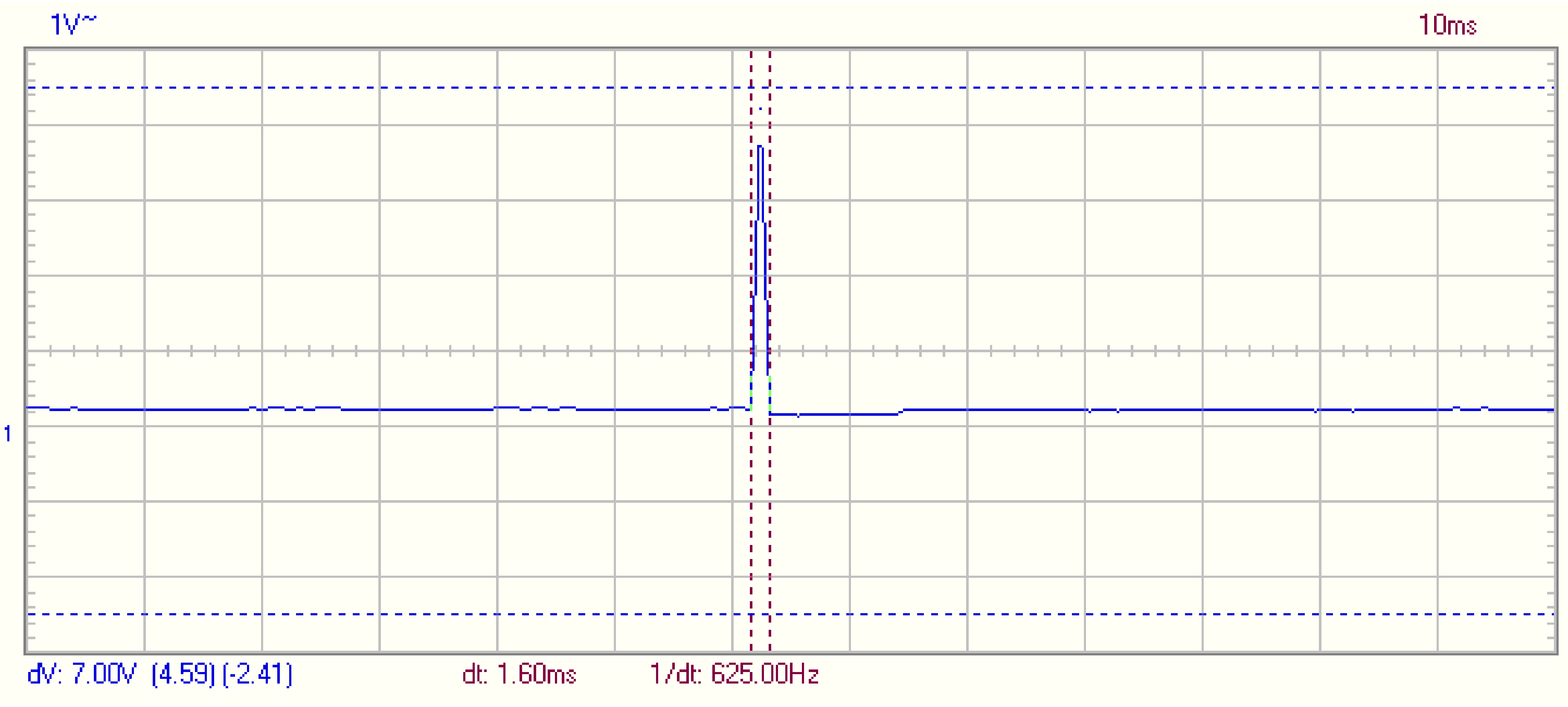
I.	II.	III.	IV.	V.
Chamber(s) Paced	Chamber(s) Sensed	Response to Sensing	Rate Modulation	Multisite Pacing
0 = None	0 = None	0 = None	0 = None	0 = None
A = Atrium	A = Atrium	I = Inhibited	R = Rate Modulation	A = Atrium
V = Ventricle	V = Ventricle	T = Triggered		V = Ventricle
D = Dual (A+V)	D = Dual (A+V)	D = Dual (I+T)		D =Dual (A+V)

Here we have: VVIR/AAIR

The time period is approx. 1s without regulation



Typical pulse duration is 1-2 ms



Calculation of pulse energy

Known voltage and tissue resistance, known pulse duration time

$$E = \frac{U^2}{R}\tau$$

$$Q = \frac{U}{R}\tau$$

P=U*I , I=U/R
$P=U^2/R$
R=P*t

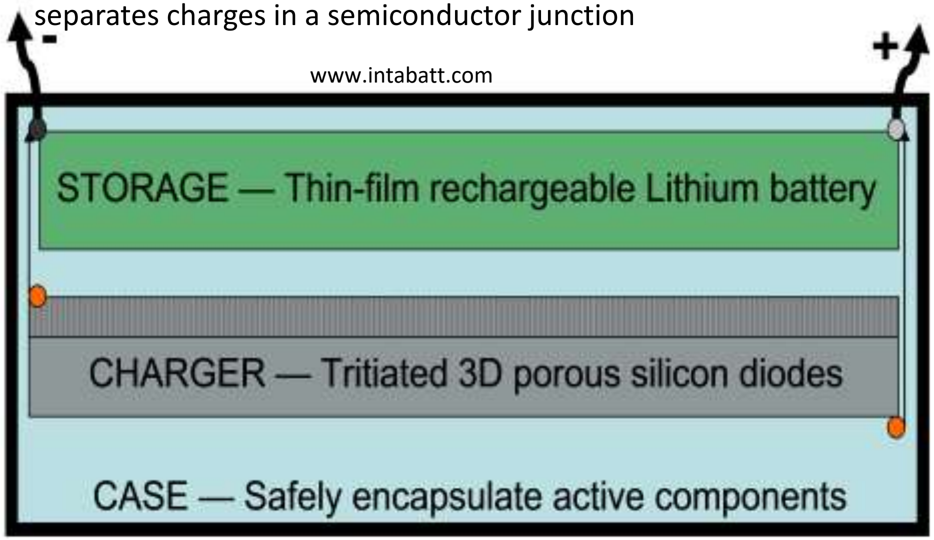
t=τ=R*C

Q=I*t

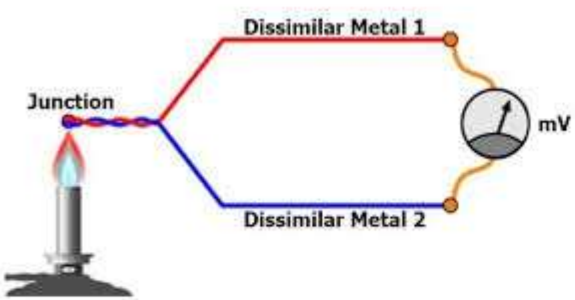
A LONG lasting battery is needed.
A battery change = exchange of the whole device = operation!

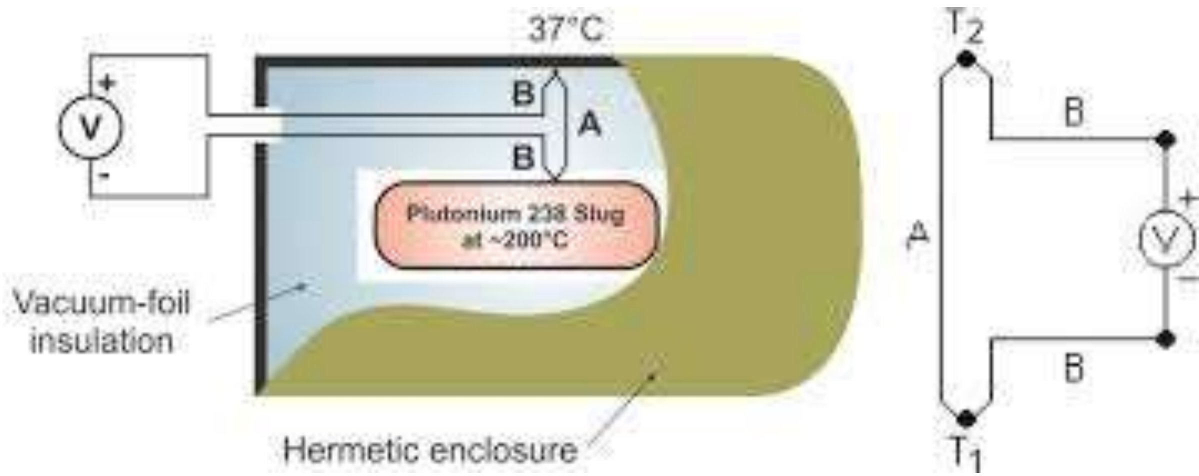
β-radiation powered cell.

Betavoltaic cell: similar to photovoltaics, the ionization separates charges in a semiconductor junction



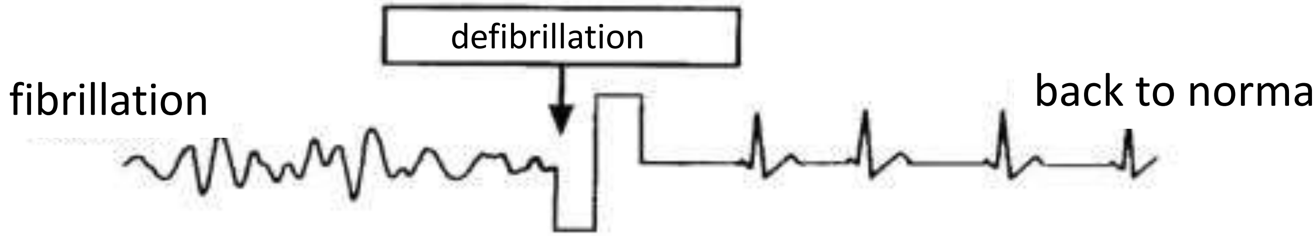
RTG : radioaktive thermoelectric generator

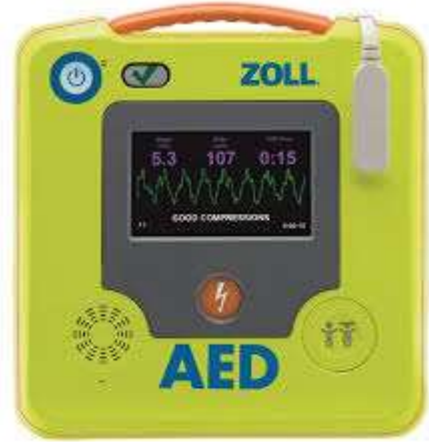




Defibrillator

(monostable)





AED: Automated External Defibrillator

Cardioverter

ICD: Implantable Cardioverter Defibrillator