Microcurrent Cheatsheet

SIS Manufacturing

#1. Microcurrent general mechanisms of action

Application of microcurrent to biological tissues has been found to boost the number of organelles responsible for cellular activities, and to increase concentrations of ATP, the cellular molecules that provide energy. These changes can facilitate cell proliferation and protein synthesis, which have been found to increase when microcurrents are applied to the constituent cells of skin, tendons, cartilage and bone. https://uhra.herts.ac.uk/handle/2299/6680

#2. 'Frequency specific microcurrent' (FSM)

There are almost certainly not specific frequencies "for" whole specific organs or conditions (eg inflammation), simply given the logic of the gigantic complexity of these anatomical structures and physiological events, at the gross anatomical, microenvironmental and sub-cellular scales. A high school level review of basic biological and anatomical details makes obvious the non reality of these concepts. There is no solid evidence as far as we know of any such relationship.

Generally, microcurrent stimulation usually has some benefit, as noted above. Varying the frequencies of waveform (AC) microcurrent has some fundamental results and influences that can easily be understood as explanations for various microcurrent application effects. Higher frequencies result in more electrical energy being transferred per unit time. Higher frequencies also penetrate more dense tissues. Generally, impedance (Z) values of biological tissues decrease with higher frequencies, so again more electrical energy penetrates and is actually delivered.

#3. Compared to TENS

The current intensity (A) (strength) will typically be in the range of 0 - 80 mA (milliamps) [1 milliamp = 1000 microamps], though some machines may provide outputs up to 100mA. Although this is a small current, it is sufficient because the primary target for the therapy is the sensory nerves, and so long as sufficient current is passed through the tissues to depolarise or interfere with these nerve cell bodies, the modality can be effective. TENS is thought to work in the following way, in very general terms: on a high pulse rate of 90-130 Hz (the normal method of use), the electrical impulses generated by the TENS machine interfere with and block pain messages sent to the brain. This is due [according] to the simplified gate control [model] theory of pain. This [model] proposes that there is a gate mechanism in the brain and spinal cord nerves (the central nervous system). When the gate is open, pain messages get through to the brain and we feel pain. When the gate is closed, these pain messages are blocked and we do not feel pain. TENS machines are thought to stimulate sensory but non pain signaling nerves and close the gate. In effect, the brain is busy dealing with the messages it receives quickly from the TENS machine, rather than the slower pain signals that the body is receiving from elsewhere. It can explain why, if you injure yourself, rubbing that area can temporarily reduce the pain. When [as the second mechanism of TENS action] the machine is set on a low pulse rate (2-5 Hz) it stimulates the body to make its own pain-easing chemicals called endorphins. These act with some similarity to morphine to block pain signals.
http://www.electrotherapy.org/modality/transcutaneous-electrical-nerve-stimulation-tens

However, when the pulse rate is higher than several pulses per second (Hertz, Hz), microcirculation is often interfered with. And, electrical parameters sufficient to produce tingling sensations can cause short circuiting between the involved nerve fibers.

#4. Mechanisms and methods of pain treatments with microcurrent

You can theoretically cause an effect on a nerve cell body and/or axon signal with microcurrent (microampere current) and even ultra low microcurrent, by influencing one or many of the following physical structure and/or functional aspects of a sensory pain neuron:

a) matching frequency to refractory period of pain neuron
b) matching frequency to specific type axon diameter (C, A-delta, B)
c) matching frequency to typical conduction velocity of a specific axon type (C, A-delta, B)
d) matching frequency to Nodes of Ranvier polarization/depolarization periods
e) matching/coupling frequency to an intracellular second messenger, particularly cyclic AMP (cAMP). The effect on pain signal transmission from stimulating cAMP up-regulation is to decrease the overall activity and the action potential electrical voltage of pain nerve cell voltage-gated ion channels, giving a sustained nerve 'block' effect.

However, a carrier frequency is needed for low frequency biomatching/biocoupling stimulation for most of these possibilities [see **#7** below].

Pain neuron action potential frequencies of up to 200-300 per second (Hz) are routinely observed. Higher frequencies are also observed, but the maximum frequency is ultimately limited by the absolute refractory period. Because the absolute refractory period is ~1-2 ms, there is a limit to the highest frequency at which neurons can respond (ion channel polarize, de-polarize, polarize, etc) to higher frequency stimuli.
https://www.physiologyweb.com/lecture_notes/neuronal_action_potential/neuronal_action_potential_refractory_periods.html

Frequencies above the refractory period cannot have a coupling influence on neuron polarization/depolarization; theoretically, the exceptional cases would be if an harmonic frequency of the refractory period is utilized.

#5. Low frequency low intensity (voltage/current) stimulation of specific biomolecules and pathways

There are well studied, specific and discrete ranges of low frequencies and very low currents and voltages that couple with specific biomolecular pathways and activations:
https://siselectromed.com/research/#cyclic-amp→CYCLIC AMP→LOW FREQUENCY EF STIMULATION

#6. Benchtop oscilloscope specifications given for microcurrent devices vs real-world impedance ranges

Many microcurrent devices have published specifications as measured by the manufacturer, on a benchtop, using electronics components as circuit specification benchmark test set-ups, usually fixed resistors (eg 500 Ohms). Typically, specifications are given about the impedance or resistance range within which the output parameters (waveform shape, output current, etc) of the microcurrent device remain accurate or are generated at all. For example such as, "waveform parameters remain valid between 10kΩ (10 kiloohms) to 100 kΩ"; and "tested using a 500Ω [Ohm] resistor". These benchtop specifications do not relate well or at all to real world applications.

Additionally, the table below shows the relevant resistance range data in relation to application with various electrotherapy electrode pads:

ELECTRODE TYPE	TYPICAL CIRCUIT RESISTANCE PER ELECTRODE PAIR IN CONTACT WITH SKIN	TYPICAL USAGE TIME AND CHARACTERISTICS	NOTES
Self-adhesive hydrogel electrotherapy	Minimum ~100 kiloohm; increases to ≥2 megaohms within 30-60 minutes.	15-45 minutes; not appropriate for extended use.	Check that black or blue hydrogel layer starts and remains very moist and sticky.
SIS silver-nylon (highest conductive electrode)	≤ 50 kiloohm; <10 kiloohm over wet gauze. ≤300 kiloohm optimum recommended working range.	≤24 hours. Can be re-wet and re-used on same subject/patient.	Follow INSTRUCTIONS FOR USE (IFU) on IFU card inside each SIS electrode pack.
Wet cotton wool directly in contact with metal probes (terminal electrodes)	~200-300 kiloohm in contact with skin.	Use small surface area for best electrical contact continuity and for uniform/constant current density. Not appropriate for extended use.	Utilize realtime circuit monitoring function of stimulation device to ensure electrical continuity.

These benchtop testing specifications mean that the waveforms of many devices do not maintain and do not penetrate into the body, as they were seen on an oscilloscope during the benchtop tests. Therefore, specified waveform shape and frequency of these devices is often of almost no relevance. This also means that there is no precision nor knowledge about what current is actually induced into the body from the stimulation, because the benchtop tests and calculations do not apply in real world clinical application situations as explained above.

#7. Delivery of molecular pathway biosignalling/biocoupling low frequency stimulation to deeper tissues requires a higher carrier frequency to penetrate real-world skin impedance

You must use a much higher 'carrier waveform' to deliver a low frequency target bioeffecting low frequency stimulation signal into the body. The signal frequency amplitude modulates the carrier frequency as its means of delivery. These bioeffects occur as a result of low(er) frequency stimulation.
https://siselectromed.com/research/#cyclic-amp→CYCLIC AMP→LOW FREQUENCY EF STIMULATION

Scientist and biomedical engineer, Dr Saul Liss (-2006) was a major developer of low frequency signal delivery technology from "analyzing the physics characteristics of the body and match[ing] the dynamic electrical impedance of the body with a stimulation pattern which the body could then convert into an internal signal that it could use constructively to help the body help itself." [Liss 1999] Patents of Saul Liss

#8. Waveform shape is not a critical factor for low frequency biostimulation of targeted molecular pathways if there is a clean waveform signal with very low noise

An AC sinusoidal waveform is effective for these purposes.

Sontag W, Weibezahn KF. IL-8 release of HL-60 cells treated with electric currents of different wave forms. Electromagn Biol Med. 2007;26(3):191-205.

#9. High resolution frequency adjustment is needed for targeting (multiple) specific biomolecular pathways

In practice, a ~1 Hz adjustment step size is needed for the signal frequency. Pre-set fixed adjustment microcurrent devices are much less or not appropriate, as the necessary target frequency might be between the fixed pre-sets of the device.

#10. Very low actual internal current is required within very narrow, discrete ranges to achieve targeted low frequency specific molecular pathway biosignalling/biocoupling stimulation

A sub-sensory low voltage output (that can't be felt) is needed from the microcurrent device in order to induce a target, specific bioeffecting low intensity current flow or (secondary) static electric field in the body along the current pathway, typically below 0.5 Volts peak (Vp). These target currents also have very specific and narrow ranges of their bioeffects. And these induced very low intensity currents and voltages must be generated with high precision (typically nanoampere resolution) and kept stable (constant voltage or current source) [See also **#13** below].

This also means that the adjustment step size (increments, decrements) of the voltage and/or current control of the microcurrent device must be very small, typically ≤5 millivolts Voltage or ≤1 microamps current in order to achieve the required accuracy resolution.

In addition to the general effects of microcurrent outlined above [see **#1** above], molecular pathway bio signalling/coupling stimulation with specific low frequencies, has additional, powerful bioeffects. These include multiple, specific growth factor production and up-regulation effects, and targeted specific intracellular second messenger up-regulation and modulation effects.

Much higher voltages and induced currents, such as used in TENS in the milliampere range [see **#3** above], are not necessary and are not effective for low frequency, targeted molecular pathway biosignalling/biocoupling stimulation. Milliampere and even higher microampere stimulation are the incorrect and inappropriate type of electrical stimulation for achieving these effects.

#11. Voltage or current must be auto-regulated for continuous bioeffect based on skin impedance monitoring and feedback

To achieve specific low frequency, growth factor and second messenger molecular pathway stimulation effects, the output voltage or current of the microcurrent device must auto-regulate based on repeated measurements and feedback from the dynamic skin↔electrode resistance/impedance over time and with physiological and ambient environment changes, in order to maintain the specific constant current or voltage that produces the target bioeffect(s).

#12. The overall impedance profiles of the interlying tissues and/or of the surrounding tissues must be included in the calculations and selection of the carrier waveform to result in penetration of the modulating biosignalling low frequency into the target tissue

The impedance profile (varying electrical resistance, capacitance, and phase angle values across a frequency range) of the interlying tissue must be taken into account in order to achieve a target, specific constant internal voltage or current. Different tissues (eg, bone, muscle, adipose, skin) are not homogeneous in their electrical conductivity or in their

impedance characteristics and profiles. Achieving a target constant internal voltage or current must be based on knowledge and calculations involving these impedance profiles, specifically, in selection of the carrier waveform frequency.

#13. Calculations are needed to find the actual alternating current flow in the body that has the specific molecular pathway biosignalling/biocoupling effect

The circuit 'load' (electrical resistance/impedance) of the stimulation circuit determines the actual current induced in the body as a result of any applied voltage. In order to know the actual AC current induced in the body by a voltage source microcurrent device, basic calculations using Ohm's Law for DC (V=IR) and AC (V=IZ) circuits are needed.

Measured DC resistance (R) circuit values during microcurrent stimulation, can be applied in these calculations, using data from a previous, AC complex impedance (Z) sweep across a frequency range at the corresponding DC R circuit load value, in the same stimulation circuit. Given the known circuit voltage, a substitution of the AC Z value for the DC R value, for the specific stimulation frequency, can then be made into Ohm's Law for an AC circuit (V=IZ) to determine the actual induced biosignalling/biocoupling AC value. [See #**Appendix 1** below for example data]. This is because DC R is a component of AC Z:

http://hyperphysics.phy-astr.gsu.edu/hbase/electric/ohmlaw.html#c1
http://hyperphysics.phy-astr.gsu.edu/hbase/electric/acohml.html
https://eepower.com/capacitor-guide/fundamentals/impedance-and-reactance/#

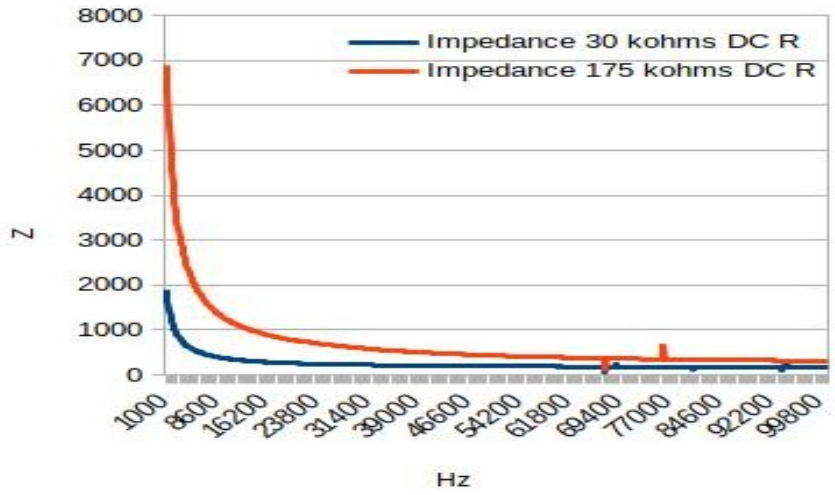
#14. Electrotherapy electrodes

[Also see #**6** above]. Hydrogel electrodes are designed for and only appropriate for short treatment session times (~15-45 minutes); their resistance increases very rapidly with time, very significantly affecting output parameters and supply voltage/current. Hydrogel electrodes also have microsecond or shorter timescale electrical capacitance (C) properties, which usually affect precision and electrical continuity of (very) low intensity, high resolution voltage or current stimulation.

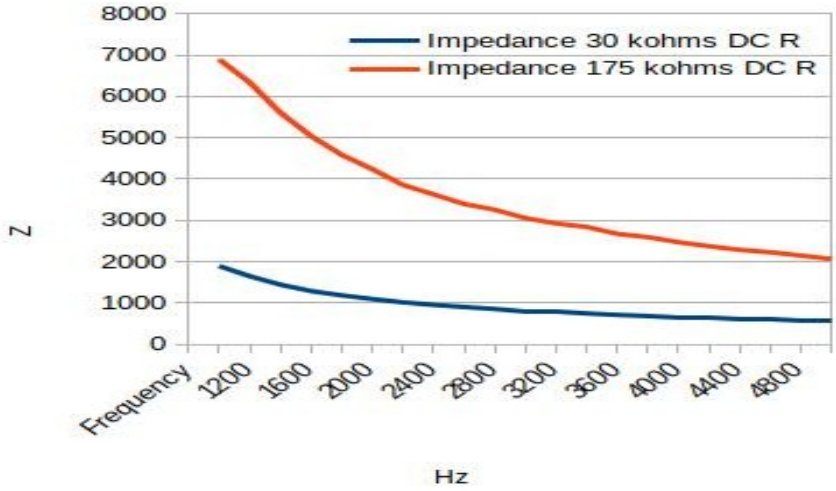
Skin at different anatomical areas of the body has varying, and dynamic, impedance characteristics (due to skin pore density variations); these impedance properties also vary with sweating, movement, skin type, and ambient temperature, and so are not static.

#Appendix 1

A



B



C

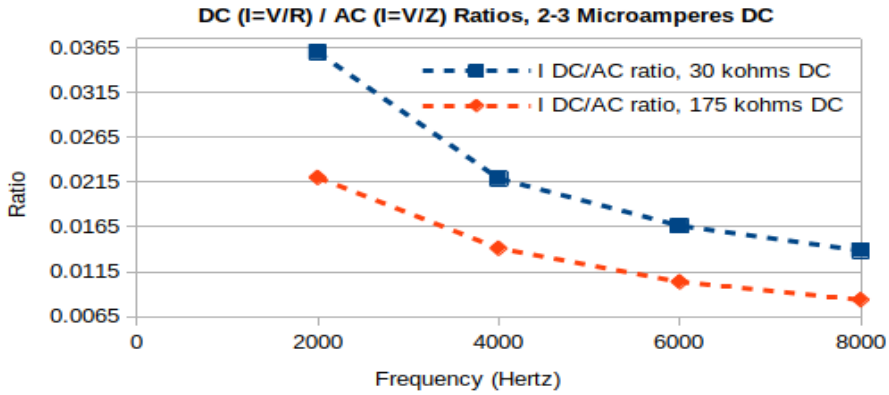


Figure 1. A: Complex impedance (Z) sweeps (0 to ~100,000 Hz range) via cutaneous SIS silver-nylon electrotherapy electrodes through non-homogenous biological tissue at measured DC circuit resistance value examples of 30 kΩ and 175 kΩ. **B:** Expanded view of Figure 1A for the frequency range 0 to ~5000 Hz. **C:** Proportionality between DC current and actual AC current, from 0 to 8000 Hz using Ohm's Law for DC and AC circuits (V/R ÷ V/Z). For example, actual induced (target) constant AC current can be calculated by utilizing Figure 1 data when the circuit load is at or near either of these DC R values, or from other measured DC R values using the same basic Z sweep methodology.