333 S. Wabash Ave. – 27th floor
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# Cumulative Charge Stimulation Technology - ΣQ
*General Overview*

## Preface

The objective of this document is to outline the basic theory behind the new method of Motor neuron education, termed ΣQ (‘Sigma Q’).

The name is derived from the Greek letter Sigma (Σ), used to identify the product or sum and the symbol Q, used to identify the electrical charge contained in a mass or body. The reasons for this terminology should become evident later in this document.

This document is a somewhat simplistic view of the ΣQ process in order that it may be readable by a wide range of interested parties. Details of the electronic requirements for ΣQ have been omitted to prevent the over complication of this document.

References in this document to the biological reaction to ΣQ are theoretical in so much as they are yet to be scientifically proven, due to the recent emergence of this technology.

However some degree of independent scrutiny has failed to find fault with these theories, and this combined with feedback from volunteers currently using systems that demonstrates the biological reactions to be as expected, assuming these theories to be correct.

References in this document to ‘Standard Stimulators’ relates to a sample group of low to medium cost electrical stimulators that are readily available on the market.

It is believed that this group is representative of general electrical stimulators and unless otherwise informed are assumed, in terms of general electrical principles, to be representative of all electrical stimulators independent of other functional enhancements.

ΣQ was developed in response to a requirement for motor neuron and deep-seated muscle stimulation and education without the need for internal probes or needles. It was required that this deep muscle stimulation was to be achieved using surface (skin) mounted electrodes.

A secondary requirement was to reduce the ‘pins and needles’ and discomfort or burning effect experienced with current electrical stimulators, and hence increase user comfort. Also a new therapeutic mechanism for the practitioner to have more hands on with patients while using new technology.

### Standard Stimulators

In general standard stimulators electrically connect to the treatment area as shown in Figure 1.

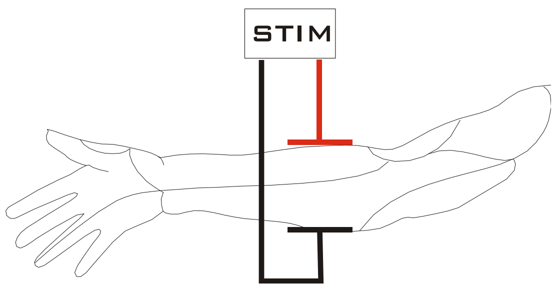


**Figure 1**

ΣQ BIOSYSCO

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The charge generator, denoted by the 'STIM' block is directly connected to the treatment area. Whether the stimulator generates using Galvanic or Faradism principles and regulates simulation using Constant Voltage (CV) or Constant Current (CI), the stimulation is basically the same.

Figure 2 shows the stimulation principle.

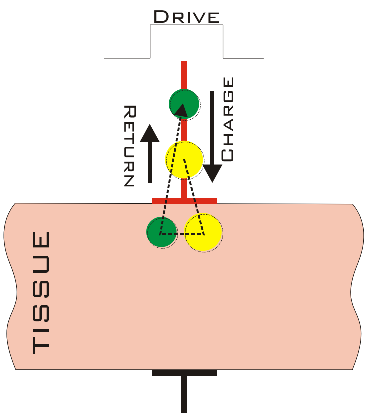


**Figure 2**

A charge is built up in the stimulation generator and delivered to treatment area as a single charge pulse in response to a 'DRIVE' signal. This is represented in Figure 2 by the larger circle moving in the direction of the 'CHARGE' arrow.

This sudden arrival of charge causes de-polarisation of the Motor and Sensory Nerve/s directly under the electrode, and results in localised tissue stimulation.

At the end of the 'DRIVE' signal the electrode is actively driven to a low potential by the stimulator.

The low resistance path this provides encourages the charge to travel back to the stimulator. This is represented in Figure 2 by the smaller circle moving in the direction of the 'RETURN' arrow.

The stimulation of the Sensory Nerves produces the 'pins and needles' effect that is often described as uncomfortable, and leads to a reduced threshold and hence reduce stimulation levels set by the users.

With this charge insertion and removal process, the charge is only present in the tissues for a very short time. This results in the stimulation of Nerve/s limited to the local area of the insertion electrode. Electrode placement is therefore critical in defining which muscles will be stimulated.

## ΣQ Generator

A ΣQ Generator is connected to the electrodes of the treatment area as shown in Figure 3.

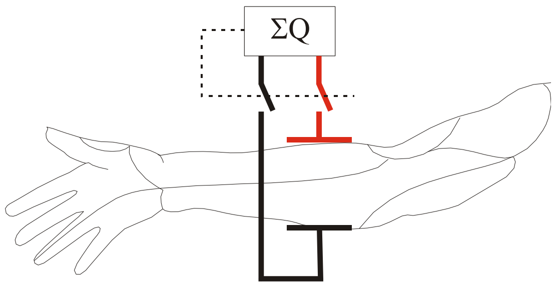


**Figure 3**

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The generator, denoted by the 'ΣQ' block is not directly connected to the treatment area, but instead controls, and is connected through, electrical circuits represented by switches in Figure 3.

The ΣQ generator is itself very different to standard generators in that it does not generate a single large charge, but instead generates smaller 'Charge Packets' at a rate of 20,000 per second as shown in Figure 4.

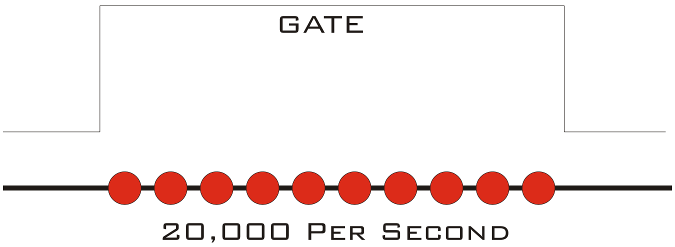


**Figure 4**

These charge packets are 'gated' to the treatment area by control of the switch electronics.

During the gate period these charge packets form a 'Saturation Zone' beneath the electrode as shown in Figure 5.

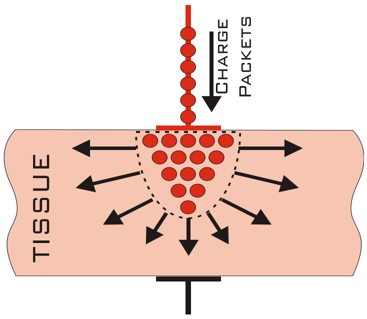


**Figure 5**

At the end of the gate period the ΣQ generator disconnects from the treatment area using the switch electronics.

Because there is now **NO** return path to the generator for the charge, the potential of the saturation zone forces the charge to migrate to the surrounding tissues as shown in Figure 5.

The charge migration will be along the 'paths of least resistance' and as muscle tissue is one of the more conductive paths available, migration along these tissues is evident. Successive bursts of charge packets from the ΣQ generator accelerate the migration process.

The build up of charge in the saturation zone is cumulative, hence Σ, and dependent on the tissues ability to migrate the charge to surrounding areas. The charge contained in the saturation zone should remain relatively constant.

The pins and needles effect experienced by users of standard stimulators is not apparent when using a ΣQ Generator and it is theorised that this is because a charge is always present in the tissues, having not been removed by the ΣQ Generator. The Sensory Nerves re-threshold to the charge present and are consequently not triggered by the next charge insertion. This leads to the conclusion that the ΣQ Generator is achieving muscle stimulation using the Motor Nerves and not the Sensory Nerves.

The lack of pins and needles leads to a higher user tolerance and hence controlled level set by the user.

The charge migration theory is supported by the observations made using prototype systems where whole muscle groups are seen to be contracted and educated from electrodes placed arbitrarily in the centre of the group.

The intensity of ΣQ Generator is regulated by 'Packet Skipping' during the gate period as shown in Figure 6.

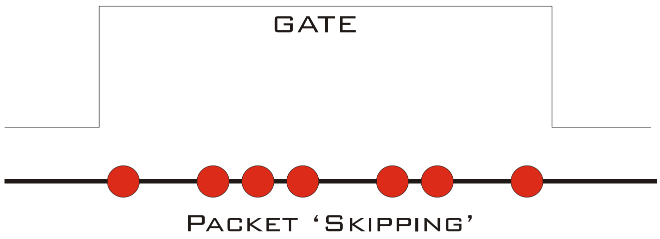


**Figure 6**

This regulation process serves to increase or decrease the saturation zone and hence the rate of charge migration.

In uni-polar operation the charge migration is towards the non-insertion electrode during the gate period, and free migration between gate pulses. The overall effect should be a spread of charge from the saturation zone then 'step' re-concentration at the non-insertion electrode and exit during a gate pulse.

The ΣQ Generator is however capable of alternate bi-polar operation as shown in Figure 7

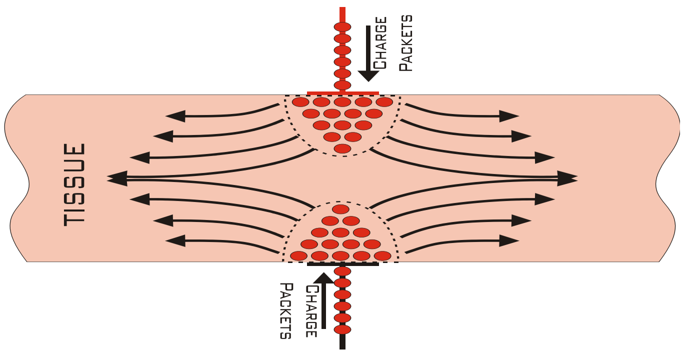


**Figure 7**

Charge packets are inserted alternately through each electrode, this causes the formation of two or more saturation zones at each of the electrode locations.

The migration of charge to the opposite electrode is now opposed by the second saturation zone that repels the charge, this principle works in both directions.

The result is a high degree of lateral migration causing muscle stimulation a considerable distance from the electrode placement. Observations have been made of abdominal muscle stimulation from electrodes placed on the lower lumbar region.

If a high impedance measuring device is used to plot electrode voltage against time the 'waveform' observed is as shown in Figure 8.

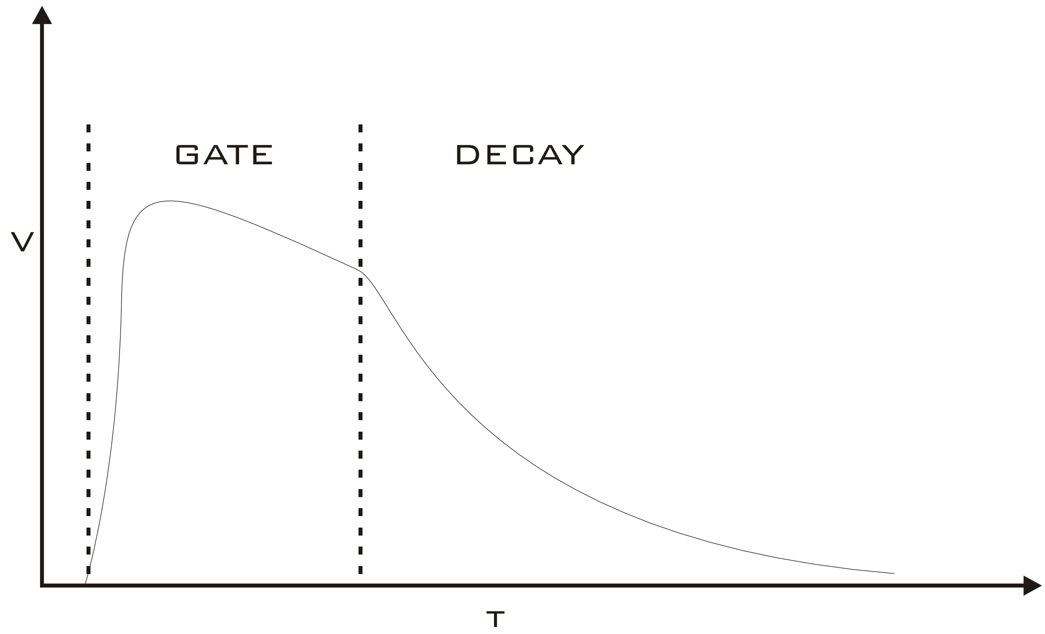


**Figure 8**

During the gate period the charge builds, and starts a slow decay as the saturation point is reached. Once the gate is shut off the decay seen is purely due to the migration of the accumulated charge, which in turn is due to biological factors.

It is anticipated that further research will show that this decay curve provides an alternative feedback method to EMG bio-feedback, with the added advantage that it is 'real time', i.e. during stimulation/re-education.

## Conclusions

ΣQ Generator provides a method for deep-seated and laterally dispersed muscle contraction and education using a twin pair of electrodes, currently unachievable using standard electrical stimulators.

The lack of the pins and needles effect leads to a higher comfort threshold for the user and hence a higher education and controlled capability.

Given that the ΣQ charge build-up is cumulative it may be possible to initiate direct muscle education and contraction in users with both Sensory and Motor Nerve dysfunction, a process normally only possible with long wave electrotherapy.

Studies into the decay curve shape may lead to a real time feedback capability giving information on muscular and circulatory reactions, and may be suited to future diagnosis assistance.