	Program	Duration [min]	Frequency [Hz]	Pulse Width [µsec]	Phase #1	Phase #2	Phase #3	Notes
1	**Multi-TENS**	20	4-80	10-250	Ramp up then modulation to reduce impedence. Ave 45Hz, 10-140µsec	Ave 4Hz, 250µsec	Ave 10Hz, repeated ramps of 103-180µsec Phase 4: Bursts at 80Hz, 140µsec	TENS in other units is a stable stimulation (ex: 80Hz, 100µsec), to which nerves will accommodate over time. Using the varibale wave of the SwissStim may lead to less accommodation and, consequently, more efficient pain modulation.
2	**Agility and Power**	90	3-83	30-180	Slow to fast MUAPs, followed by fast force then high force exercise. Cycle repeated 20 times	Cycles of 3s ramp, 6s of contraction (ave 25Hz, 180µsec), followed by 21s of active recovery (ave 4Hz, 30-105µsec). Repeats 52 times.	Cool down with slow MUAP	Contains the greatest periods of variability. Is, therefore, good for treating spastic muscle. Doesn't reach tetany until Phase 2 (60 min in).
3	**Intensive Power**	15	10-62.5	30-260	Warm-up with slow MUAP	Contration #1 3s ramp to 12s contraction (40Hz, 180µsec), 39s of active recovery (ave 10Hz, 30-140µsec). Contration #2 3s ramp to 12s contration (50Hz, 220µsec), 39s of active recovery. Contration #3 and all subsequent contrations 3s ramp to 12s contraction (62.5Hz, 260µsec), 39s active recovery	Cool down with slow MUAP	Increasing contraction strength good for those with sensation. Quicker and more variable than #4, but not as much variabilty as #2. Has more tetany than #2, but not as much as #4. Good to use in HRP for variety.

	Program	Duration [min]	Frequency [Hz]	Pulse Width [µsec]	Phase #1	Phase #2	Phase #3	Notes
4	**Relaxation**	28	2-10	20-180	Warm-up with slow MUAP	Cycles of 3s ramp, 9s of contraction (50Hz, 160µsec), 12 seconds of active relaxation (2-10Hz, 160µesc). Repeats	Cool down with slow MUAP	Contatins the most predictable periods of tetany. Is, therefore, good for strengthening
11	**1msec Pulse Constant**	28	2-10	30-1000	Warm-up with slow MUAP	Freq varies 2-10Hz, ave 4Hz, pulse width constant at 1msec	Cool down with slow MUAP	Best option for patients with signficant atrophy or partial dennervation. Skip the warm-up when trying to determine responsiveness, so as to not fatigue the muscle prior to exercise. Use large electrodes to maximize current.
12	**1ms Pulse Modulated**	28	10	30-1000	Warm-up with slow MUAP	Pulses start at 570µsec then increase to 1msec, then back down. All at 10Hz.	Cool down with slow MUAP	Good for patients who have consistently been responding to the 1ms Pulse Constant program as a way to recondition the muscle and bridge to other programs.
13	**Alternated 1sec**	28	4-62.5	20-250	Warm-up with slow MUAP	Channels alternate 1s contractions. Each contraction cycle increases in frequency and pulse width (32.9-62.5Hz, 160-250µsec)	Cool down with slow MUAP	Contractions reach tetany, so it could be used for any alternating stim indication (reduction of cocontraction, alternating flexion/extension exrercise, grasp and release, etc.)

	Program	Duration [min]	Frequency [Hz]	Pulse Width [µsec]	Phase #1	Phase #2	Phase #3	Notes
14	**Alternated 2sec**	28	4-62.5	20-250	Warm-up with slow MUAP	Channels alternate as above, but in 2s intervals	Cool down with slow MUAP	As above with longer contraction times
15	**Rehabilitation**	29	4-83	10-275	Ramp up then modulation to reduce impedence (ave 45Hz, 10-140µsec). Then 2 cycles of slow MUAP	5min of modulated pulses (ave 10Hz, 30-180µsec) Then contraction cycles increasin in intensity as in #3	5min of 2-10Hz, 250µsec followed by cool down with slow MUAP	Has the longest available pulse durations, short of the 1ms. Good for patients who are consistently responding to 1ms Constant Pulse and looking to transition
16	**External Trigger**	60	10-120	20-1000	Parameters are setable. Maximum contraction time is 20s. There is a 0.5s ramp. Available amplitude will be regulated by pulse width selection, so as to not exceed the maximum allowable current. Trigger must be plugged in before turning on the unit. Modes include: **INDEPENDENT:** The left and right buttons are independent and only drive their respective channel. The stimulation is activated on the right channel when the right button is held down and the same goes for the left channel. **SYNCHRONOUS:** The stimulation is activated on both channels regardless of the button held down (right or left). **ALTERNATING:** The stimulation is activated alternately on the two channels. Every time a button (right or left) is pressed, the stimulation switches from one channel to the other.			

THERAPEUTIC ELECTRICAL STIMULATION

Precautions, Indications, and Guidelines for Use

SWISSSTIM®

PHYSIO / TRIGGER

by

VALMED

SWISS TECHNOLOGY

Training package developed in conjunction with the International Center for Spinal Cord Injury at Kennedy Krieger Institute

The following document is intended for training of professionals only. Please see the SwissStim Physio/Trigger manual for full precautions, contraindications, and operating instructions.

Valmed and the International Center for Spinal Cord Injury at Kennedy-Kreiger Institute ("ICSCI"), are providing these Guidelines solely for training appropriately licensed professionals about when and how to use, not use, and be cautious about the use of SwissStim. Whether and how a patient should use SwissStim is determined by an appropriately licensed professional acting within the scope of that professional's license. Neither Valmed nor ICSCI are responsible for the licensed professional's determination that a patient should use, or for the patient's use of, SwissStim.

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Electrical Stimulation (ES) Basics

- **Therapeutic Indications**
  - Increase circulation
  - Reduce muscle spasm
  - Promote healing of fracture or tissue
  - Reduce edema
  - Strengthening
    - Improve and maintain muscle mass during or following periods of inactivity
    - Maintain/ gain ROM
    - Re-educate/ facilitate voluntary contraction
    - Reduce effects of spasticity
  - Prevent/ reverse disuse atrophy
- **Contraindications** **Please see SWISS STIM© Physio/Trigger manual for full list of contraindications and operating instructions.*
  - Implanted electrical device
  - Active metastases
  - Thrombosis/ hemorrhage
  - Pregnancy
  - Epilepsy
- **Precautions**
  - Decreased sensation
  - Fatigue producing effects (ex: in patients with MS, may have to be conservative in ES applications)
  - Limited ROM
  - Discomfort and skin irritations (ex: burns or blisters)
- **Mechanisms for Contraction:** *electricity applied across the surface of the skin over an intact peripheral nerve evokes an action potential in the nerve fiber (like physiologically generated potentials) causing muscle to contract*
  - Differs from physiological potential
    - Travels in both directions
      - To contraction of muscle at synapse
      - To motor neuron in ventral horn
    - Recruitment of motor units differs in type and number which contributes to fatigability
  - Full contraction of muscle involves multiple motor units acting at the same time; force of contraction is proportional to the number of motor units activated
    - Spatial summation: gradual activation of motor units, enabling smooth/ controlled development of force.
    - Temporal summation: when repetition of muscle twitch exceeds 10 twitches per second, contractile force of each muscle twitch adds to the preceeding twitch, resulting in overall higher force.
    - Tetanization frequency: the rate at which twitch contractions fuse together, is dependent on muscle size and condition.
  - Stimulating sensory fibers at same time
    - Contributes to tolerance
    - Provides sensory feedback to spinal cord/ brain for re-education

Alterable Parameters

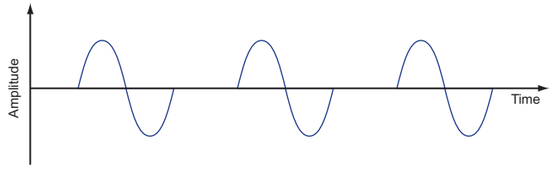
- Waveform : biphasic (symmetrical or asymmetrical), monopolar
- Frequency : pulses per second(hertz)
- Pulse width : each pulse length (microseconds to milliseconds)
- Amplitude : intensity (milliamperes or millivolts)
- Reciprocation : alternating or synchronous channel activation
- Ramp (surging): time to maximum amplitude
- Duration : total treatment time

Considerations for parameter selection: Parameters may be adjusted in concert to minimize current, thereby protecting against fatigue, and optimize comfort.

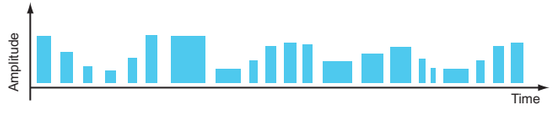
Goal	Frequency	Pulse Width	Amplitude	Notes
Increase comfort	Increase	Decrease	Decrease	Can also try using larger electrodes
Decrease electrical bleed	Neutral Effect	Decrease	Decrease	Conversely, increasing the pulse width will provide deeper stimulatio
Minimize fatigue	Decrease	Decrease	Decrease	Overall, aim to minimize current; consider variable waveform
To improve quality of tetany	Increase	Neutral Effect	Increase	Look for smooth fused contraction

Waveform Samples

Biphasic Symmetrical Waveform



SWISS$_{STIM}$© Waveform



Main Differences Between *SWISS STIM*© and Traditional ES

- ***SWISS STIM*© is a monophasic, square waveform**
  - Monphasic, so current flow is unidirectional, but it allows the body to discharge on its own, acting like a biphasic
    - Not like traditional High Volt or Direct Current, which does not allow the body to discharge on its own
    - Risk of burns or skin irritation equal to that of traditional biphasic current
  - Square wave is less effective at activating sensory fibers
    - Sensory nerves (C-fibers) are sluggish and won't respond as well to quick ramp-up of each pulse
    - Patients don't get as much "pins and needles" sensation, as with traditional stimulation, but do get more "muscle cramping" sensation

- ***SWISS STIM*© has a variable Waveform**
  - Each pulse varies in frequency and pulse, amplitude remains constant
  - Variability prevents muscle accommodation, ensuring maximally effective recruitment cycles
  - Not all programs reach tetany, which prevents ES use in true functional activities

- ***SWISS STIM*© uses a voltage control mechanism**
  - Amount of current being delivered is optimized by electrode surface area in contact with the skin (ie: the bigger the electrode, the more current the patient receives)
  - If electrode loses contact with the skin, the amount of current is automatically down regulated.
    - Current won't concentrate (as in current controlled units) causing hot spots.
    - Makes SwissStim a good option for patients who may try to pull at their electrodes.

- ***SWISS STIM*© has longer available pulse duration (up to 1millisecond on home units)**
  - Muscles that are significantly atrophied or partially dennervated require a longer period of stimulation (longer pulse duration) and a longer refractory period (lower frequency) as remaining motor units are sluggish and spindly.
  - Muscle may be too weak to move the limb segment and fatigue quickly, so treating for up to 6weeks may be indicated, before deciding if the nerve/muscle is not viable.

Specific *SWISS STIM*© Applications

- **To increase muscle bulk:**
  - Irregular frequency prevents muscle accommodation
    - Muscles respond maximally
    - Muscle fiber recruitment is forced to vary, more closely replicating physiologic contractions
  - Less time in between pulses, compared to competitors, encourages temporal summation
  - Factors of electrode placement
    - Stimulating opposing muscle groups, producing a force couple
    - Crossing lead wires to capture entire compartment

- **To manage spasticity**
  - Spasticity: motorneuron excitability elicited by some abnormal drive
  - Repetitive contractions to fatigue the muscle, thereby decreasing its contractile strength, hopefully enough for agonist to overcome
  - By stimulating spastic muscles, alpha motorneurons activate the motor unit, causing contraction, and excite a pool of Renshaw cells through a recurrent collateral. Renshaw cells help to modulate motorneuron firing frequencies
  - E-stim also helps to strengthen muscles and has analgesic properties which both help to decrease spasticity
  - Successful clinical applications include long ramp times, to minimize stretch reflex, and variable pulse frequency and duration, to reduce accommodation

- **For partially dennervated muscle**
  - *Note:* If muscle is totally dennervated cannot stimulate through these stimulators, need some intact peripheral nerve to excite, ex: brachial plexus injury
  - Muscle atrophy, as related to long term disuse
    - Muscle spindles reduce in size and number
    - Slow twitch fibers are most enduring - thin, sluggish
    - Axons retract, thereby reducing available motor points - inefficient stimulation
  - Requires long duration, low frequency pulses to allow ST fibers to respond
    - 10Hz/ 1msec
    - 10Hz still allows for temporal summation
    - 1msec should produce deepest contraction, providing greatest chance for muscle to respond
  - May not see contractions initially. Allow 6-8 weeks for muscle to respond, need to increase strength and number of available motor units.