3.3 Muscle stimulators, Nerve stimulators

Muscle Stimulators

- Electrical muscle stimulation involves sending **electrical impulses** through the skin. This stimulation may provide benefits, such as helping repair tissue and strengthening the muscles.
- The electrical impulses mimic what occurs when someone **contracts and releases** a **muscle naturally**. Physical therapists and doctors use this technique to treat people with various diseases and injuries.
- A practical system used to stimulate a nerve consists of three components

  (1) a ***pulse generator*** to generate a train of pulses capable of depolarizing the nerve, (2) a ***lead wire***, the function of which is to deliver the pulses to the stimulation site, and (3) an ***electrode***, which delivers the stimulation pulses to the excitable tissue in a safe and efficient manner
- There are a few types of electrical muscle stimulation. The most common forms include,
  - ✓ Electrical muscle stimulation (**EMS**).
  - ✓ Transcutaneous electric nerve stimulation (**TENS**) and
- TENS and EMS involve applying electrodes to the skin near an affected muscle to send an electrical current to the area. This current causes rhythmic muscle contractions.
- EMS has received an increasing amount of attention in the last few years for many

reasons:

i. it can be utilized as a strength training tool for healthy subjects and athletes;
ii. it could be used as a rehabilitation and preventive tool for people who are
partially or totally immobilized;
iii. it could be utilized as a testing tool for evaluating the neural and/or muscular function in vivo.
iv. EMS has been proven to be more beneficial before exercise and activity due to early muscle activation.
v. Doctors use electrical muscle stimulation to help treat pain and heal injured, weak, or diseased muscles. The electrical currents may help improve blood flow and stimulate the muscle fibers or nerves.
vi. There are also other uses for electrical muscle stimulation, including as an aid for weight loss and physical therapy.
vii. Doctors may use the devices to help relax:

- ✓ muscle spasms
- ✓ retrain muscles
- ✓ prevent muscle loss

viii. It may help in treating various conditions that affect muscle strength, such as:

- ✓ spinal cord injuries
- ✓ Post -surgery muscle weakness
- ✓ strokes
- ✓ muscle control issues

1. Electrical muscle stimulation (EMS):

❖ **Electrical muscle stimulation** (**EMS**), also known as **neuromuscular electrical stimulation** (**NMES**) or **electromyo stimulation**, it involves using electrical currents to induce muscle contractions.

- The impulses are generated by the device and are delivered through electrodes on the skin near to the muscles being stimulated.
- The electrodes are generally pads that adhere to the skin.
- The impulses mimic the action potential that comes from the central nervous system, causing the muscles to contract.
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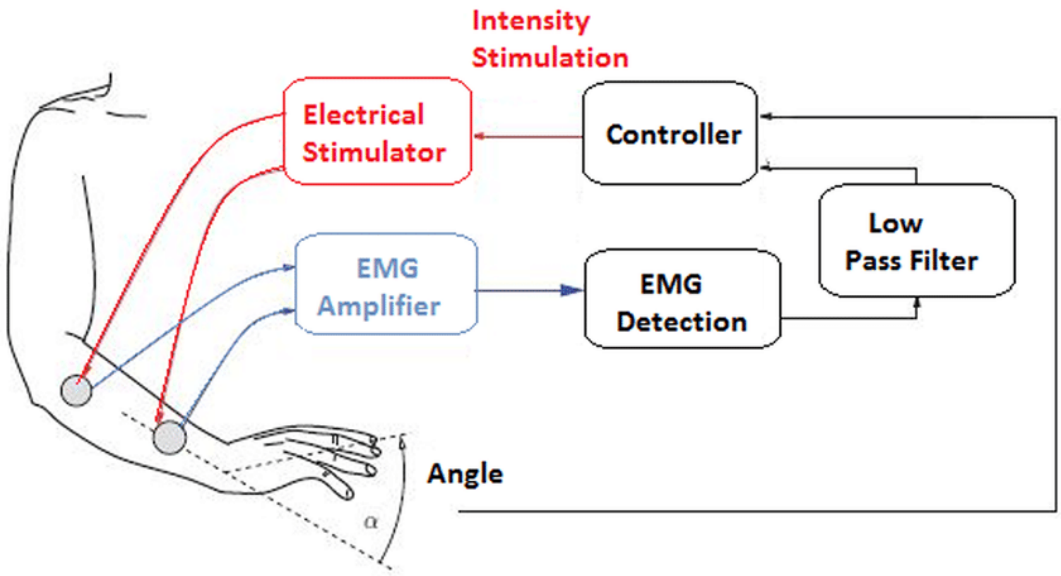


Block Diagram of a FES system controlled by electromyography.

- The figure shows that the EMG signal from the forearm musculature is captured by surface electrodes, and is amplified. Later, having the EMG signal detected to trigger the stimuli, the signal is applied to a low-pass filter, in order to eliminate noise and artifacts.
- Afterwards, the signal is forwarded to a controller that will perform the necessary adjustment in the intensity of electrical stimulation according to the magnitude and frequency of the EMG signal received. After the controller makes the necessary adjustments, the electrical stimulator delivers current through surface electrodes to the forearm muscles.

Working Principle of Electrical muscle stimulator (EMS):

1. **Electrode Placement:** Electrodes are attached to the skin over the target muscles.
2. **Electrical Pulse Delivery:** The EMS device generates electrical pulses of varying intensity and frequency.
3. **Muscle Contraction:** When the electrical pulses reach the muscles, they stimulate the nerve fibers that control them. This causes the muscle fibers to contract.
4. **Muscle Strengthening and Rehabilitation:** Over time, repeated muscle contractions can lead to increased muscle strength, improved muscle function, and reduced pain.

It's important to note that the effectiveness of EMS can vary depending on factors such as the intensity and frequency of the electrical pulses, the specific condition being treated, and the proper application of the electrodes.

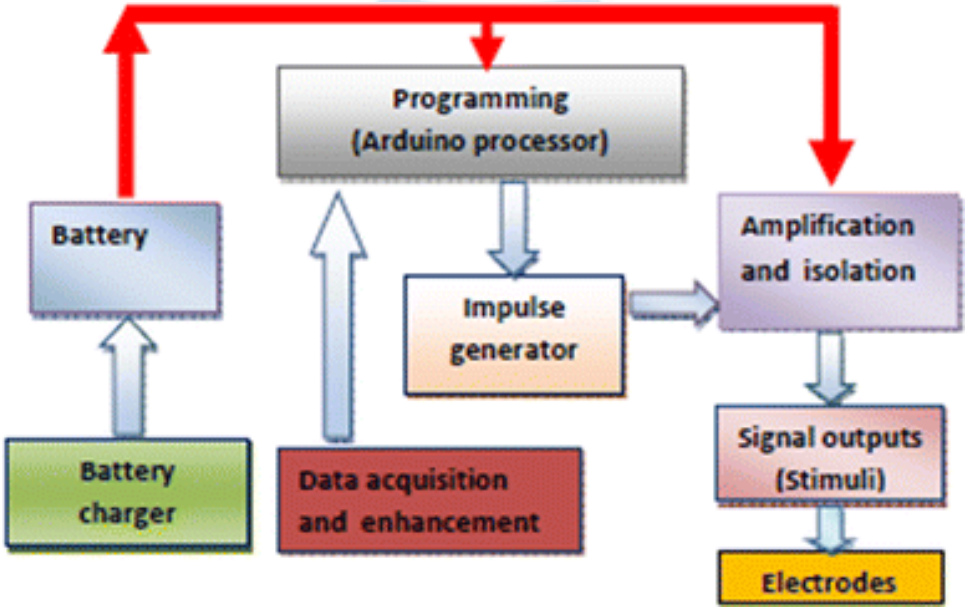
2. Transcutaneous Electrical Nerve Stimulation (TENS):

- Transcutaneous electrical nerve stimulation (TENS) uses low-voltage electrical currents to relieve pain.
- A TENS unit is a small device that delivers the current at or near your nerves to block or change your perception of pain. Healthcare providers use TENS to treat a range of conditions, including osteoarthritis, tendinitis and fibromyalgia.
- A TENS unit is a battery-powered device with electrodes that deliver electrical impulses through the surface of your skin. A provider places the electrodes at or near trigger points (muscle knots) or affected nerves.

- A TENS device is about the size of a small cell phone. It comes with several sets of electrodes, wires and end pads. Here's how it works:
- The electrodes connect to the TENS unit at one end and have 2-inch by 2-inch pads at the other end.
- Each pad has adhesive backing so it'll stick to your skin.
- You (or your provider) position the pads on your skin along nerve pathways in the affected area.
- The TENS unit delivers pulses of electrical energy.
- You can adjust the intensity, frequency and duration of the pulses. (The goal is to adjust the settings until the electrical impulses feel strong but comfortable.)
- Typically, the stimulator is based around a 500 ms spike pulse, having an adjustable amplitude of 0 to 75 mA and an adjustable frequency of 12 to 100 pulses per second.
- Instruments having similar specifications except that they produce square waveform, have a pulse frequency range of 20–200 Hz, pulse width from 0.1 to 1.0 ms and pulse amplitude of 0–120 V with maximum output current as 25 mA.
- The instrument powered by three standard flashlight batteries of 1.5 V each gives about 100 hours of continuous operation.
- Transcutaneous or skin surface application of electrical stimulus is accomplished by application of the conducting pads to various trigger zone areas, acupuncture sites or even peripheral nerves.
- Skin irritation at the site of electrode application is diminished by the use of carbonized rubber electrodes applied with a tincture of Benzoin interface.
- The skin electrode system must be designed so as to minimize impedance

variations with motion, to conform to the body surface to provide a uniform impedance across the surface of the electrode and to have an adequate surface area.

- The adequate surface area can be determined keeping in view the peak square-wave current at the threshold of thermal damage as a function of the electrode surface area. The thermal damage threshold varies widely with skin impedance, which is a function of skin preparation.
- Transcutaneous electrical nerve stimulation (TENS) electrodes are commonly moulded from an elastomer such as silicon rubber, loaded with carbon particles to provide conductance. Conformability is achieved by making the electrode thin.
- Useful carbon-loaded silicon rubbers have a minimum resistivity near 10 W cm. A thin electrode may exhibit an impedance which is not negligible as compared to the impedance of the interface and tissue under it. Thus, the design of an electrode with the required conformability and current distributing properties becomes a compromise in electrode geometry and material properties.
- The frequency-dependence of the electrode performance also has to be considered since the impedance between the electrode and subcutaneous contains capacitance.



Block diagram of the electric stimulator

Key Differences between muscle stimulator and Nerve stimulator

Feature	Muscle Stimulator	Nerve Stimulator
Target tissue	Muscle fibers	Nerves
Primary purpose	Muscle strengthening, mass gain	Pain management, neurological disorders
Applications	Physical therapy, bodybuilding	Pain management, medical research

While both devices use electrical stimulation, the specific waveforms, intensities, and pulse durations used can vary significantly depending on the intended application.

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