

# SI-200 Isolated Stimulator

## Background

The SI-200 is an isolated stimulator designed to deliver safe, transcutaneous stimulus pulses to the nerve or muscle being studied. The design of the SI-200 permits the unit to deliver stimulus pulses with the current programmed on the SI-200 despite the **impedance (Z)** upon the path that the current travels. The SI-200 can keep the desired current flowing through the path of stimulation because the device automatically adjusts the **voltage (V)** needed to maintain that **current (I)** in accordance with **Ohm's Law**, in which  $V = IZ$ . The ability of the SI-200 to adjust the voltage needed to deliver the current set by the knob on the front of the SI-200 is known as **voltage compliance**, which is limited to a maximum of **150 Volts**.

Because the SI-200 varies its voltage output to deliver a stimulus pulse of a consistent current, the SI-200 is categorized as a **constant current stimulator**. This type of stimulator differs from **constant voltage stimulators** when presented with an impedance in the circuit. With constant voltage stimulators, the current delivered to the tissue decreases as the impedance increases because the power supply of the constant voltage device is not designed to deliver additional current.

Even though the SI-200 can generate up to 150 Volts, the current delivered by the unit is limited to a maximum of 20 milliamperes (mA), for a maximum duration of 10 milliseconds (ms) per pulse, and a maximum frequency of 50 pulses per second (Hz). At these levels, the maximum amount of power delivered by the SI-200 will not cause injury or tissue damage.

## SI-200 Front Panel

### Stimulus Amplitude Knob

The **current output** is the only stimulus parameter that is controlled directly by the SI-200. The current generated by the SI-200 is controlled by the **Pulse Amplitude knob** near the center of the unit's front panel (Figure SI-200-1 on page SI-200-1). This knob, which can be rotated ten complete turns, has a dial counter with an integrated lock that shows the number of turns from 0.00 to 10.00 rotations. Each complete rotation of the knob in a clockwise direction is the equivalent of adding 2 milliamperes (mA) to the current output. Ten complete rotations of the knob equals 20mA.

### High Voltage Current Outputs

The current output of the SI-200 is delivered to a nerve or a muscle through color-coded stimulator lead wires attached to the **High Voltage Current Outputs** on the left side of the unit's front panel. The sockets for these

outputs accommodate lead wires with safety connectors designed to prevent shocks from being delivered to users. The connector on each lead wire needs to be pushed into the appropriate socket as far as possible for the output to work properly.

### Arm Button

As an additional level of protection from electrical shock, the SI-200 needs to be *armed* before stimulus pulses can be delivered. The SI-200 is activated by pressing the Arm button on the unit's front panel. Until the **Arm button** is pressed and the **Stimulator Ready light** is glowing, the SI-200 will not develop any current output even if it is turned on and receiving trigger signals from another device.

### Status Lights

- **Power:** This light glows to indicate that the SI-200 is properly powered up with the appropriate power supply.
- **Stimulator Ready:** This light glows to indicate that the **Arm button** has been pressed and that the SI-200 is ready to deliver a stimulus when it is triggered by an external device.
- **Pulse Status Bad or Good:** These lights indicate whether the stimulus pulses generated by the SI-200 reach the desired current output programmed by the pulse amplitude knob on the front of the SI-200. If the desired current in the circuit is achieved, the **Pulse Good light** glows. If the desired current is not reached because the impedance in the circuit is high, the **Pulse Bad light** glows. Increasing the current output level increases the flow of current through the impedance and can cause the **Pulse Good light** to glow if the current is high enough to exceed the impedance.



Figure SI-200-1: The front panel of the SI-200 with the two high voltage current output connectors, the pulse amplitude control knob with an indicator dial, and the power, ready, and pulse status indicator lights.

## SI-200 Rear Panel

### Power Input

Power for operating the SI-200 is supplied by a 12Volt DC transformer capable of delivering 1000 milliamperes (mA) of current. The transformer is connected to the SI-200 through a 2.5mm connector on the end of the output cable of the transformer that is plugged into a matching receptacle on the lower left side of the rear panel of the SI-200 (Figure SI-200-2 on page SI-200-2).

## Power Switch

A switch labeled **O** for **OFF** and **I** for **ON** is located on the upper left side of the rear panel of the SI-200 and controls the delivery of power to the circuitry in the SI-200.

## Trigger Input

Signals that control the time parameters of the stimulus pulses generated by the SI-200 and the firing of the unit are sent to the SI-200 through the **Trigger** input connector on the lower right side of the unit. The trigger signals can originate from another stimulator or a digital-analog converter (DAC) capable of generating transistor-transistor logic (TTL) signals.



Figure SI-200-2: The rear panel of the SI-200 showing the BNC Trigger input on the right, and the power switch and receptacle on the left.

## SI-200 Setup

- 1 Place the SI-200 near the subject and a recording unit or stimulator that is capable of generating TTL signals that can control the SI-200.

**Warning:** Before connecting the SI-200 output to the subject, rotate the amplitude control knob on the front of the SI-200, in a counterclockwise direction, until the values on the dial and in the counter window read zero. Also, make sure the power switch of the SI-200 is flipped to the OFF (O) position.



Figure SI-200-3: The SI-200 power supply, which also can be used with IWX/214 data recorder.

- 2 Obtain the power supply for the SI-200 (Figure SI-200-3 on page SI-200-2).
- 3 Insert the connector on the cable of the SI-200 power supply into the power socket on the rear of the SI-200 (Figure SI-200-2 on page SI-200-2).
- 4 Attach one end of a BNC-BNC cable (Figure SI-200-4 on page SI-200-2) to the **Trigger** input on the back of the SI-200 (Figure SI-200-2 on page SI-200-2).
- 5 Connect the other end of the BNC-BNC cable to the output of a stimulator or a recording device.
  - If the SI-200 is going to be used with an IWX/214 or another device with banana plug outputs, connect the other end of the BNC-BNC cable to a BNC-double banana adapter (Figure SI-200-4 on page SI-200-2).



Figure SI-200-4: BNC-BNC cable attached to a BNC-Double Banana adapter. The tab on the side of the adapter identifies the prong that is connected to the ground jack.

- Insert the prongs of the BNC-double banana adapter into the positive (red) and ground (green) jacks of the IWX/214 stimulator (Figure SI-200-5 on page SI-200-2). The prong that is inserted into the ground (green) jack can be identified by the tab molded onto the side of the adapter. The tab is embossed with the letters GND indicating ground.



Figure SI-200-5: The BNC-double banana adapter and BNC-BNC cable connected to the stimulator output of an IWX/214.

- If the SI-200 is going to be used with an IWX/118 or another device with BNC outputs, connect the other end of the BNC-BNC cable to the BNC connector on the output of the IWX/118 or another recording device.
- 6 Instruct the subject to remove all jewelry before beginning the experiment.
  - 7 Make sure the SI-200 is turned **OFF (O)**. All the indicator lights on the front of the SI-200 should be off.
  - 8 Connect the color-coded stimulator lead wires to the **High Voltage Current Outputs** of the SI-200. Make sure you push the safety connector of each lead wire into the appropriate socket on the SI-200 as far as possible.
  - 9 Snap the ends of the stimulator lead wires onto the stimulating electrodes over the nerve or muscle to be stimulated.

### Control of SI-200

The current output of the SI-200 is the only parameter of the stimulus pulses that is controlled by the SI-200. All the other parameters of the stimulus pulses, such as duration, frequency, and the number of pulses, are controlled by the signals entering the **Trigger input** of the SI-200. These signals originating from a device, like the low-voltage stimulator of an IWX/214 or an IWX/118 data acquisition unit, control the pattern of stimulus pulses generated by the SI-200. So, programming the

time parameters of the low-voltage stimulator programs the time parameters of the SI-200.

For example, if signals from the stimulator of an IWX/214 are programmed for a duration of 1 millisecond at a frequency of 1Hz, the SI-200 will generate stimulus pulses with the same duration and frequency. The signals from the device controlling the SI-200 must have a 5 Volt amplitude. This is the nominal voltage needed to control transistor-transistor logic (TTL) signaling between the SI-200 and the controlling device. The TTL level signals must also have a duration of 100 microseconds ( $\mu\text{s}$ ). This is not difficult to achieve in most experiments since stimulus durations are usually greater than 100 $\mu\text{s}$  (or 0.1msec).

Remember that the current output of the SI-200 is controlled by the knob on the front of the SI-200, and the voltage of the stimulus pulses from the SI-200 are dependent upon the impedance of the stimulation circuit.

---

**Note:** Although the high voltage supply can deliver up to 150 volts, it is at very low current and then only for very brief periods (fixed maximum of 10 milliseconds). The amount of power delivered to the subject is not sufficient to cause injury or tissue damage.

---

### Specifications

Information pertinent to generating stimulus pulses from the SI-200 are listed in the following table.

**Table SI-200-1: SI-200 Specifications**

Output Current	0 to 20 milliamperes (mA)
Compliance Voltage	100VDC Minimum
Overall Isolation	4000VRMS, 1G $\Omega$ resistance (minimum), 20pF minimum, 62pF maximum
Power Requirement	12VDC, 1000mA
Trigger Input	External TTL signal, 5V, 100 microseconds ( $\mu\text{s}$ ) minimum
Frequency Range	Externally driven, 0.1 to 50Hz
Pulse Width Minimum	100 microseconds ( $\mu\text{s}$ )
Pulse Width Maximum	10 milliseconds (ms) $\pm 5\%$
Coupling Capacitance	62pF