Pulse Switcher

USER'S MANUAL

BTX®

a division of **Harvard Bioscience, Inc.**

A Message from BTX

Thank you for investing in a Pulse Switcher.

Since its founding in 1983, the main focus of BTX has been in the area of applying controlled electric fields for genetic engineering applications. Because of this, we quickly established a reputation as the technological leader in the fields of electroporation and electrofusion. Our systems have been installed in many prestigious institutes around the globe where they are used successfully for high efficiency transfection, transformation and cell fusion applications. We offer a variety of waveforms, electrodes and chamber options to provide you with the best tools to achieve your goals.

We are vested in your success. To that end, the BTX technical support team constantly tracks published literature for any reference to electroporation and electrofusion. We extract the pertinent experimental conditions and yields from these papers to help us in our efforts to help you. In addition to tracking publications, we are available to you for support at any time for advice in experimental design, product recommendations, troubleshooting, and any other relevant technical advice.

We thank you again for your investment and we look forward to assisting you in any way we can.

Finally, please read this manual carefully before operating. If you have any questions about the unit or about particular applications, please contact us:

> **BTX**
> 84 October Hill Road
> Holliston, MA 01746 USA
>
> Toll Free: 1-800-272-2775
> International Callers: 508-893-8999
> Fax: 508-429-5732
> Web: www.btxonline.com
> Email: support@hbiosci.com

For any customers outside the US or Canada, please call your local BTX dealer or call us directly.

BTX®
a division of Harvard Bioscience, Inc.

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Warranty Information

Research Only

BTX

84 October Hill Rd
Holliston, MA 01746, USA

Phone: 1-508-893-8999
Fax: 1-800-429-5732
Web: www.btxonline.com

Warranty

BTX warranties this Pulse Switcher for a period of 2 years from the date of purchase. At its option, BTX will repair or replace the unit if it is found to be defective as to workmanship or materials. This warranty does not extend to equipment which has been (a) subjected to misuse, neglect, accident or abuse, (b) repaired or altered by anyone other than BTX without BTX express and prior approval, (c) used in violation of instructions furnished by BTX. This warranty extends only to the original customer purchaser. IN NO EVENT SHALL BTX BE LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES. Some states do not allow exclusion or limitation of incidental or consequential damages so the above limitation or exclusion may not apply to you. THERE ARE NO IMPLIED WARRANTIES OF MERCHANTABILITY, OR FITNESS FOR A PARTICULAR USE, OR OF ANY OTHER NATURE. Some states do not allow this limitation on an implied warranty, so the above limitation may not apply to you. Without limiting the generality of the foregoing, BTX shall not be liable for any claims of any kind whatsoever, as to the equipment delivered or for non-delivery of equipment, and whether or not based on negligence. Warranty is void if the instrument is changed in any way from its original factory design or if repairs are attempted without written authorization by BTX. Warranty is void if parts, connections, or power supplies not manufactured by BTX are used with the BTX Pulse Switcher. If a defect arises within the warranty period, promptly contact BTX, 84 October Hill Road, Holliston, Massachusetts, USA 01746-1388 using our toll free number 800-547-6766 (US Only) or 508-893-8999. (E-mail: support@hbiosci.com). Goods will not be accepted for return unless an RMA (Returned Materials Authorization) number has been issued by our customer service department. The customer is responsible for shipping charges. Please allow a reasonable period of time for completion of repairs, replacement and return. If the unit is replaced, the replacement unit is covered only for the remainder of the original warranty period dating from the purchase of the original device. This warranty gives you specific rights, and you may also have other rights, which vary from state to state.

Out of Warranty Service

Proceed exactly as for Warranty Service. If our service department can assist you by phone or other correspondence, we will be glad to help at no charge.

Repair service will be billed on the basis of labor and materials. A complete statement of time spent and materials used will be supplied. Shipment to BTX should be prepaid. Your bill will include return shipment freight charges.

Disassembly by the user is prohibited. Service should only be carried out by experienced BTX technicians. Please contact us at 800-547-6766 or by email at repairs-returns@ harvardbioscience.com for assistance.

Replacement Parts

BTX stocks replacement parts. When ordering, please describe parts as completely as possible, preferably using our part numbers. If practical, enclose a sample photo or drawing.

Caution Notice

The BTX Pulse Switcher is intended for laboratory use only and can be used in research and development applications. These systems have been designed to meet the standards for electromagnetic compatibility (EMC) and safety.

This product should not be used in the presence of a flammable atmosphere such as an anesthetic mixture with air, oxygen, or nitrous oxide.

Safety Information

Please read the following safety precautions to ensure proper use of your Pulse Switcher. If the equipment is used in a manner not specified, the protection provided by the equipment may be impaired.

To Prevent Hazard or Injury

Make Proper Connections

Make sure all connections are made properly and securely. The Pulse Switcher should always be oriented such that the 4 mm red and black INPUT pins are connected to the ECM 830 or Gemini X2 generator, and that electrodes/safety stand accessories in use are connected to the red and black output ports (on the side of the unit with the green LED and Risk of Electric Shock warning sticker). A USB B-to-USB B cable connects the Pulse Switcher and the gnerator. Any signal wire connections to the unit must be no longer than three meters.

Use Proper Power Supply

The pulse switcher is supplied with a certified power supply. Always use the power supply shipped with your device.

Observe All Terminal Ratings

To avoid fire or shock hazard, observe all ratings and markings on the product or in this manual before using the device.

Avoid Exposed Circuitry

Do not touch any electronic circuitry inside of the product. Do not insert fingers or try to remove electrode or sample during pulsing sequence.

Do Not Operate with Suspected Failures

If damage is suspected on or to the product do not operate the product. Contact qualified service personnel to perform inspection.

Place Product in Proper Environment

Review the operating manual for guidelines for proper operating environments. Do not operate in wet/damp conditions.

Wear Proper Eye Protection During Electroporation

Arcing Can Occur at High Voltages

An unfavorable combination of parameters such as high voltage settings and a small sample volume or small electrode distance with a highly conductive sample might lead to flashover between the electrodes (ARC) and/or explosive evaporation of liquid samples or burning of solid tissues. Reduce voltage, pulse length, and/or ionic content in sample to avoid repeating this condition.

Observe All Warning Labels on Product

Read all labels on product to ensure proper usage.

High Voltage Risk

The BTX Pulse Switcher is designed to connect to a high voltage power supply adjustable to 3,000 V. High voltage power supplies present a serious risk of personal injury if not used in accordance with design and/or use specifications, if used in applications on products for which they are not intended or designed, or if they are used by untrained or unqualified personnel.

- The user must read this manual carefully before the instruments are placed into operation.

- Removing the Pulse Switcher cover or base plate will void the warranty.

- Do not connect or disconnect pulse switcher high voltage INPUT pins or high voltage output cables during electrical pulsing sequence.

- Do not touch the electrode tip(s) while the electrical pulsing sequence is being applied.

If there are any questions about the operation of this equipment, call BTX Customer service at 800-547-6766 or 508-893-8999.

Caution Notice ⚠️

The BTX Pulse Switcher is intended for laboratory use only and may be used in research and development applications. These systems have been designed to meet the standards for electromagnetic compatibility (EMC) intended for laboratory equipment applications as well as the applicable safety requirements for electrical equipment for measurement, control, and laboratory use. The unit itself does not generate waste but may be used to treat samples that are hazardous. Please use appropriate PPE and ensure disposal in accordance with local regulations and practices.

This product should not be used in the presence of a flammable atmosphere such as an anesthetic mixture with air, oxygen, or nitrous oxide.

| Caution | Protective Ground Terminal | Caution Risk of Electric Shock |

Product Overview

The BTX Pulse Switcher is a plug-in accessory and accompanying firmware package which upgrades the square wave pulsing capabilities of 7-inch touchscreen ECM 830 and Gemini X2 waveform generators. When both the BTX Pulse Switcher and accompanying firmware update are installed on the ECM 830 or Gemini X2, the system capabilities are enhanced to include the following features:

• **A new protocol category type, Pulse Switcher Protocols, is available.**

Pulse switcher protocols allow a user to create and run protocols containing groups of square wave pulses with different polarity, pulse number, pulse length, and pulse interval characteristics.

- Pulse Switcher User Defined Protocols may be programmed with up to 10 groups of square wave pulses with separately defined polarity (+ or -) for each group. The user may thus incorporate bipolar switching into their electroporation protocols.

- The maximum number of pulses per group in a Pulse Switcher User Defined Protocol is 100 pulses.

- The number of pulses, pulse length, and pulse interval is separately defined for each group of pulses in Pulse Switcher User Defined Protocols.

- The minimum interval between pulses and between groups of pulses for Pulse Switcher User Defined Protocols is 50 ms.

- The maximum number of pulses per Pulse Switcher User Defined Protocol is 1,000 pulses.

- 11 new Pulse Switcher Preset Electroporation Protocols have been added, utilizing bipolar switching capabilities for in vivo electroporation applications.

• **Square Wave User Defined Protocol features on the ECM 830 or Gemini X2 are enhanced with the installation of the Pulse Switcher.**

- The maximum number of pulses per Square Wave User Defined Protocol is increased to 100 pulses.

- The minimum interval between pulses for Square Wave User Defined protocols is decreased to 50 ms.

• **Exponential Decay Wave pulsing features on the Gemini X2 are unaffected by the BTX Pulse Switcher.**

⚠ **CAUTION: FOR RESEARCH USE ONLY. NOT FOR CLINICAL OR DIAGNOSTIC USE ON PATIENTS.**

Getting Started

Unpacking the System

The shipping carton in which your BTX Pulse Switcher is packed has been specifically designed to provide maximum protection to the unit during transportation and normal handling conditions. Upon receipt, the carton should be examined for any external damage resulting from shipment. Open the carton and carefully remove the BTX Pulse Switcher, power supply, and USB connection cable, and inspect the items for any apparent damage. Save the carton and packing materials for future transportation and shipping requirements. Check the packing slip to ensure that all items ordered and listed are included in the shipment. Inform BTX immediately if any parts are missing or damaged.

Power Source

As received, the Pulse Switcher is ready for use with an input range of 100–240 VAC, 50/60 HZ. The power source is connected to the Pulse Switcher via a power supply adapter which supplies 5 V to the Pulse Switcher. A region-specific power cord connects to the power supply adapter. In the US, the power cord has a standard three-prong plug.
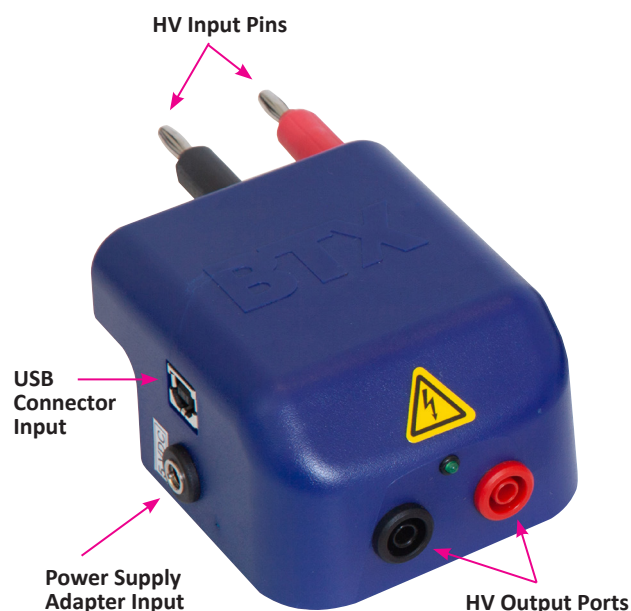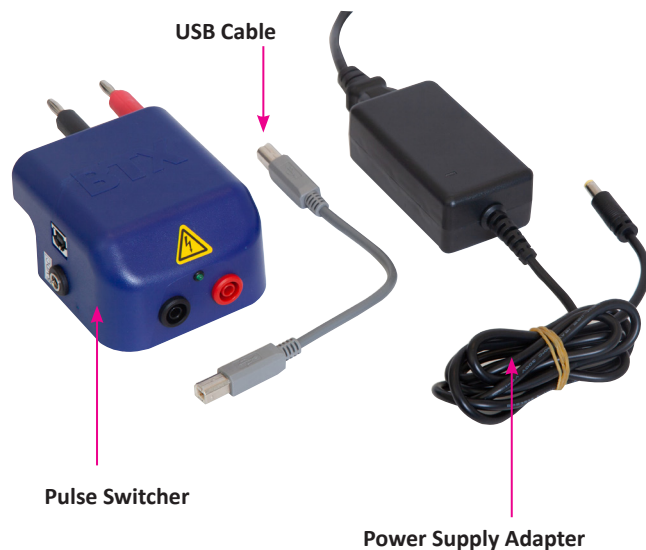
Installation

Place your ECM 830 or Gemini X2 generator in a location that is a dry, level, sturdy surface free from extremes in ambient temperature, dust or chemical exposures.

Verify Software Version on ECM 830 or Gemini X2 Generator

Before connecting Pulse Switcher, the software must be updated to a version capable of supporting Pulse Switcher functions. To verify software version installed on the generator, power on ECM 830 or Gemini X2 generator, select gear icon to proceed to Settings Menu and navigate to Device Information screen.

Software	Version Required for Pulse Switcher
Boot Loader	1.2.1 or higher
Application	4.0.4 or higher

For earlier software versions, please refer to pages 18-23, Upgrading Gemini Series Software, and proceed with upgrading software to the latest version. Software updates and software update drivers are available at https://www.btxonline.com/

USB Cable

Pulse Switcher

Power Supply Adapter

HV Input Pins

USB Connector Input

Power Supply Adapter Input

HV Output Ports

Getting Started

technical-resources/downloads.html. Once software version is confirmed and any updates are completed, make sure that the generator is powered on and initialized, and proceed with connecting the Pulse Switcher to the generator.

Connect Pulse Switcher to Generator and Electrode

Allow the Pulse Switcher, power supply, and USB connection cable to equilibrate to room temperature. Power on your Gemini X2 or ECM 830 generator and allow the instrument to boot completely to the main menu screen. Then proceed with installing the Pulse Switcher. Plug the Pulse Switcher red and black INPUT pins to the High Voltage Output connectors at the bottom right-hand side of the front panel of the ECM 830 or Gemini X2 Generator.

Connect the power supply adapter cord into the 5 VDC port on the left side of the Pulse Switcher.

When the Pulse Switcher is connected to a power supply, a green LED will illuminate on the front of the Pulse Switcher.

Connect the USB connection cord to the USB port at the bottom left-hand side of the front panel of the ECM 830 or Gemini X2 Generator. Connect the other end of the USB connection cord to the USB port on the left side of the Pulse Switcher.

Getting Started

## USB Device/Pulse Switcher Detection by Generator

Next, apply power to the Pulse Switcher through its power supply. Confirm that the Pulse Switcher is receiving power by verifying that the green LED on the front of the Pulse Switcher is illuminated. Once power is supplied to the Pulse Switcher and the Pulse Switcher is connected to the Generator by its USB cord, the generator will begin device detection. In the upper right-hand corner of the ECM 830 or Gemini X2 touchscreen, there will be three possible icons displayed when the USB connector is connected to a device (please see Touchscreen Icons Reference page 10 for details). When a device is plugged into the USB port of the generator, the **Device Determination Indicator** V icon, will be displayed in the upper-right corner of the screen to indicate that a device is detected by the generator and is being identified.
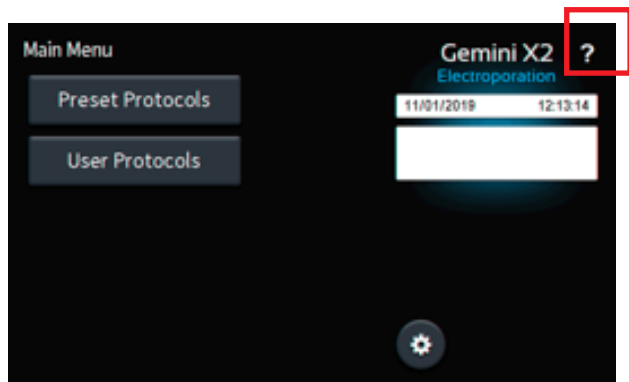
For devices other than the Pulse Switcher connected to the Gemini X2 or ECM 830 USB port, such as a computer, the **Other USB Device Icon** will be displayed.
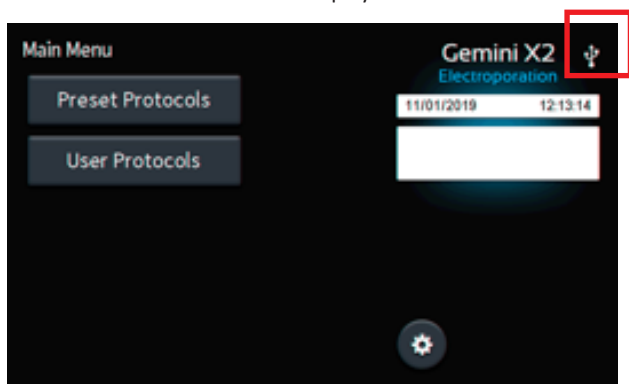
Before proceeding to use the Pulse Switcher, verify that the generator displays the proper **Pulse Switcher Device Indicator** icon in the upper-right corner of the touchscreen to indicate that the Pulse Switcher device is detected by the generator.
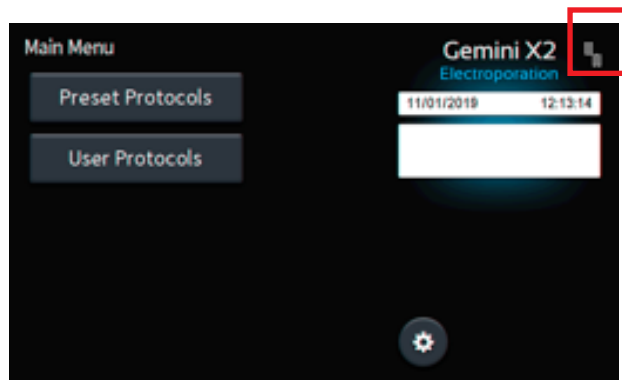
You are now ready to begin your work.

Touchscreen Icons Reference

Device Determination Indicator

Used to indicate that a USB device is connected, and device determination is underway.

Other USB Device Indicator

Used to indicate that a USB device other than a Pulse Switcher (such as a computer) is detected.

Pulse Switcher Device Indicator

Used to indicate that a Pulse Switcher device is detected.

Move Down

Tapping this icon scrolls down to the next option in a list.

Page Down

Tapping this icon scrolls down to the next page of options in a list.

Move Up

Tapping this icon scrolls up to the previous option in a list.

Page Up

Tapping this icon scrolls up to the previous page of options in a list.

Pulse Switcher Protocol Indicator

Used to indicate when a protocol uses square wave pulses and Pulse Switcher accessory.

Copy

Used to copy preset or user defined protocol parameters to a new user defined protocol.

Software Setup

Preset Pulse Switcher Protocols

Accessing Preset Pulse Switcher Protocols

To access Preset Protocols for the Pulse Switcher, select **Preset Protocols** on the Gemini X2 or ECM 830 Main Menu.
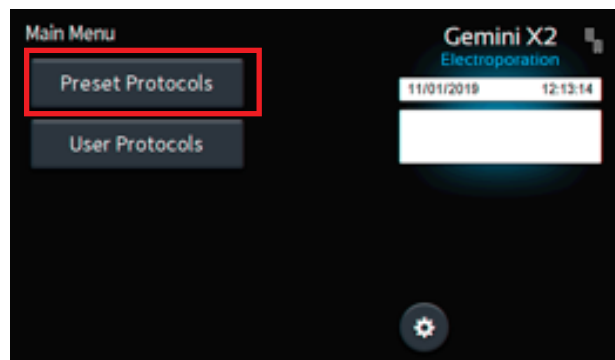

Next, tap **Page Down** icon to scroll down to the bottom of the list of **Preset Protocol** categories.
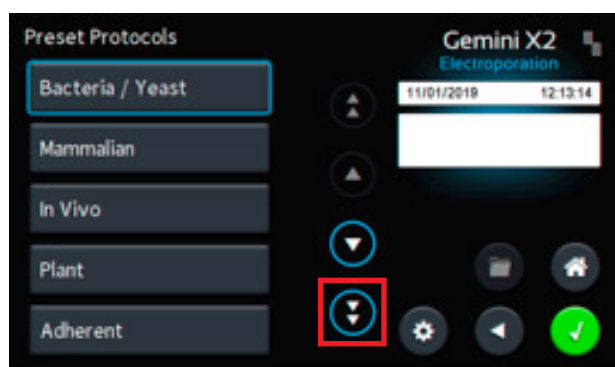
Tap Pulse Switcher **Preset Protocols** category to open the list of available preset protocols for the Pulse Switcher accessory.
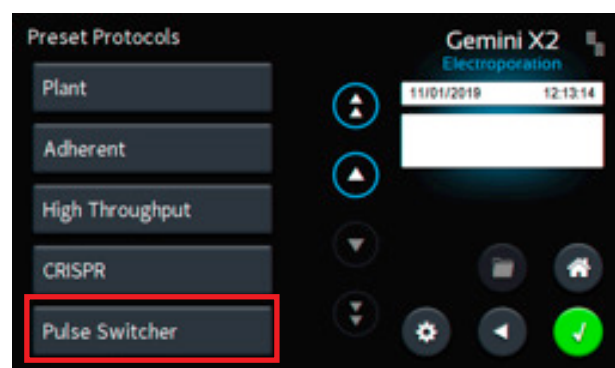
The list of Preset Bi-Polar voltage protocols will be displayed as in the screenshot below. Please refer to Table 1 for a summary of the Preset Protocols available. The user may scroll through the Preset Protocol list by tapping **Move Down** , **Move Up** , **Page Down** , or **Page Up** icons, and tap on the name of a protocol to select it. In the example screenshot below the currently selected protocol **In Vivo, Rat Hind Limb** is highlighted with a blue box.
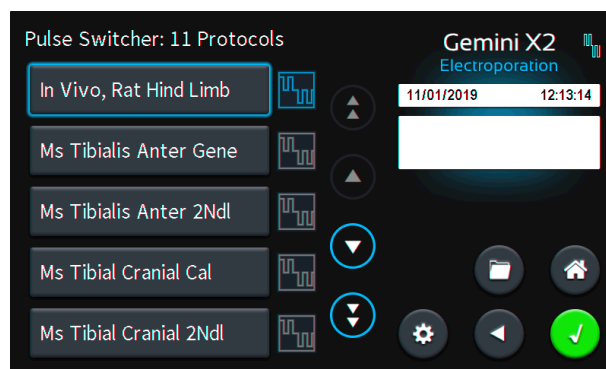
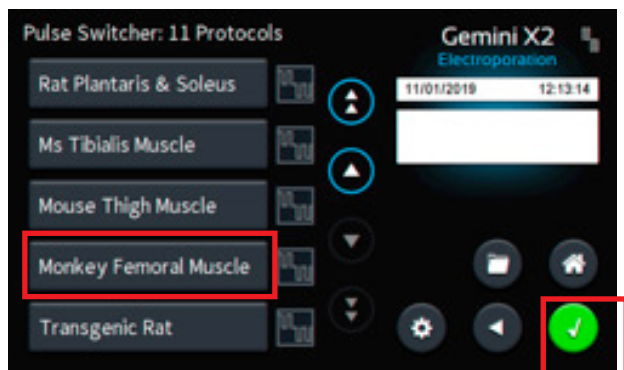**Table 1: Pulse Switcher Preset Protocol Summary**

Preset List Position	Protocol Name	Description	Electrode	BTX Protocol Database ID#
1	In Vivo, Rat Hind Limb	In Vivo Rat Hindlimb Skeletal Muscle (Plantaris and Soleus)	Genetrodes, Straight, 5 mm Gold Tip (Item 45-0160)	384
2	Ms Tibialis Anter Gene	Mouse Bilateral Tibialis Anterior Muscle	Genetrodes, Straight, 5 mm Gold Tip (Item 45-0160)	387
3	Ms Tibialis Anter 2Ndl	Mouse Bilater Tibialis Anterior Muscle	2-Needle Array, 5 mm Gap (Item 45-0168)	400
4	Ms Tibial Cranial Cal	Mouse Tibial Cranial Muscle	Caliper Electrode, 1 cm x 1 cm (Item 45-0101)	388
5	Ms Tibial Cranial 2Ndl	Mouse Tibial Cranial Muscle	2-Needle Array, 5 mm Gap (Item 45-0168)	401
6	In Vivo, Rb Thigh	Rabbit, Mouse, or Rat Leg Muscles	Caliper Electrode, 2 cm x 2 cm (Item 45-0101), 2-Needle Array, 5 mm Gap (Item 45-0168), or Genetrodes, Straight, 5 mm Gold Tip (Item 45-0160)	389
7	Rat Plantaris and Soleus	Rat Hindlimb Skeletal Muscle (Plantaris and Soleus)	2-Needle Array, 5 mm Gap (Item 45-0168)	399
8	Ms Tibialis Muscle	Mouse Anterior Tibial Muscle	2-Needle Array, 5 mm Gap (Item 45-0168)	827
9	Mouse Thigh Muscle	Mouse Upper Thigh Muscle	2-Needle Array, 5 mm Gap (Item 45-0168)	943
10	Monkey Femoral Muscle	Cynomolgus Monkey Femoral Muscle	2-Needle Array, 5 mm Gap (Item 45-0168)	999
11	Transgenic Rat	Wistar Rat testis	Tweezertrode electrode, (Item 45-0488)	1019

NOTE: *Please visit the Protocol Database on the BTX website for detailed protocol information.*

Software Setup

Running Preset Pulse Switcher Protocols

To advance to the **Protocol Run** screen, either double-tap on the name of the protocol OR tap once on the protocol name to select the protocol, then tap the green check icon to proceed to the **Protocol Run** screen.

The **Protocol Run** screen will display a summary of the protocol name, BTX Protocol Database ID number, and the preset protocol parameters for just the first group of the Pulse Switcher protocols (values displayed in the "Set" column).

> **NOTE:** *Pulse parameters of every pulse in a protocol are recorded in experimental log data and may be downloaded using a computer connected to the instrument USB port, while running Protocol Manager software.*

To run the preset Pulse Switcher protocol, tap the GO icon.

During the protocol run, the "Meas" pulse measurement column updates to show measured pulse parameters for the first pulse and last pulse of the current group as the run proceeds. For protocols with longer pulse intervals, measurements for intermediate pulses within a group are also updated and displayed every second so that the user may monitor protocol progress. At the completion of the protocol, the results of the last pulse of the last group are displayed in the "Meas" column.

> **NOTE:** *Pulse parameters of every pulse in a protocol are recorded in experimental log data and may be downloaded using a computer connected to the instrument USB port, while running Protocol Manager software.*
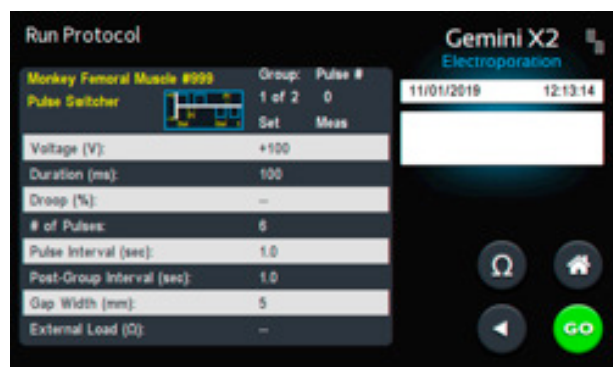
## Copying Preset Protocol parameters to User Defined Protocols

Preset protocol parameters may be copied to **User Defined Protocols** so that the user may view and edit protocol parameters in all groups. To copy a preset protocol, select the protocol by tapping the name once. When selected, the protocol name will be highlighted by a blue box. Next, tap the **Copy** icon to create a new User Defined protocol, and follow prompts to name the user defined protocol. After creating the new User Defined protocol name, press the green check mark to save the copied parameters as a new user uefined protocol and navigate to the **User Defined Protocol** list. The copied preset protocol parameters will then appear with the name given in the **User Defined Protocols** list and modified if desired. Please see Editing and Running User Defined Pulse Switcher Protocols (pages 14-16) for more information.

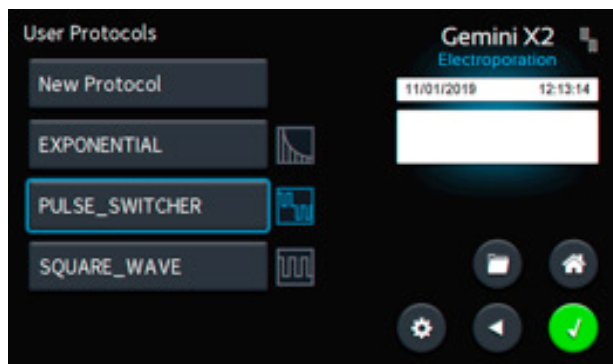## User Defined Pulse Switcher Protocols

Accessing User Defined Pulse Switcher Protocols

To access **User Defined Protocols**, select User Protocols on the Gemini X2 or ECM 830 Main Menu to navigate to the **User Protocols** menu.
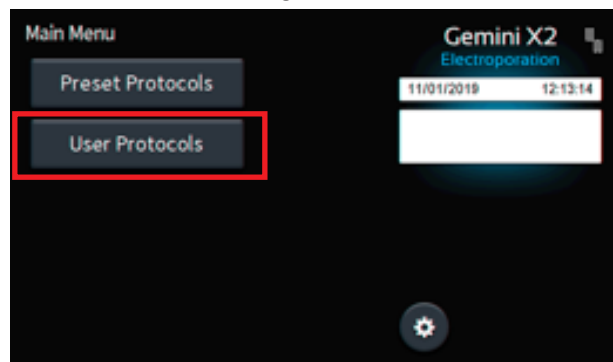
Software Setup

On the **User Protocols** menu, the list of **User Defined Protocols** will be listed. Any protocols created for the Pulse Switcher will have the **Pulse Switcher Indicator** icon [icon]. Pulse Switcher protocols may be selected by tapping the name of the protocol. Once selected, a Pulse Switcher protocol will be highlighted with a blue box.

Creating New User Defined Pulse Switcher Protocols

To create a new pulse switcher protocol, tap the **New Protocol** icon on the **User Protocols** menu screen.
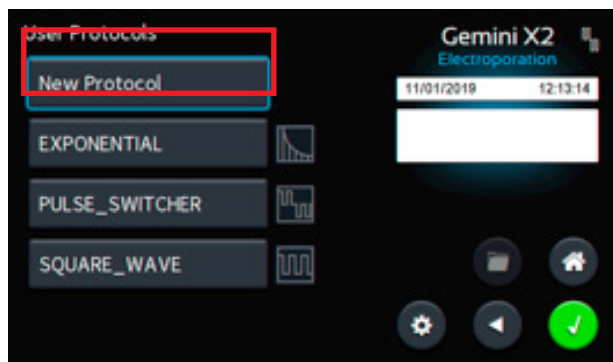
On the **Create a New User Protocol** screen, enter the new Pulse Switcher protocol name with the touchscreen keypad.
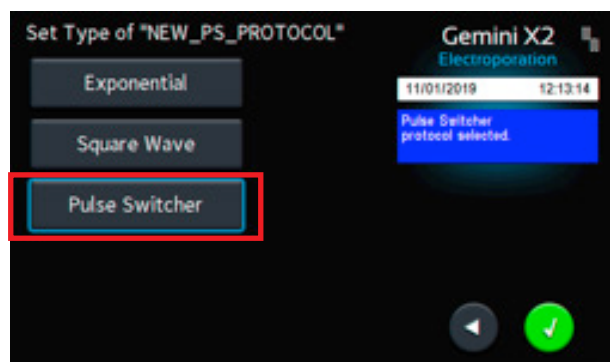

The protocol name will be displayed in the white box in the upper left side of the screen.

Tap the **Green Check** icon to create the new protocol with your selected protocol name.
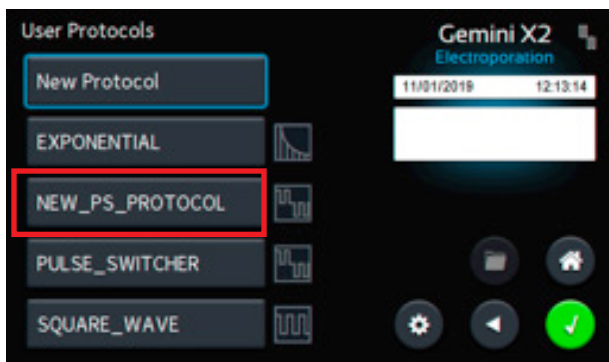

Select **Pulse Switcher** for protocol type.

Software Setup

The new protocol will appear in the **User Protocols** list, and may be selected by tapping on its name. Proceed to the next section of the manual for instructions on Editing and Running User Defined Pulse Switcher Protocols.


Editing and Running User Defined Pulse Switcher Protocols

**Entering Voltage and Electrode Gap Parameters**

Once a desired pulse switcher protocol is selected, the **Green Check** icon may be tapped to advance to the protocol editing screen.
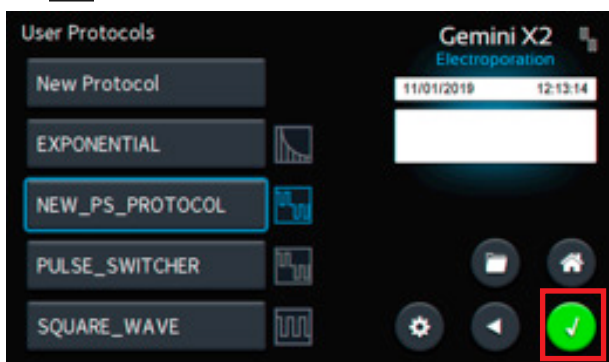
For new protocols, pulse voltage must be entered first. Tap Voltage icon, then on the Set Protocol Voltage screen, use the numeric keypad to enter the desired voltage magnitude. The user may select a voltage parameter between 5 and 500 V in 1 V increments, or 505 V and 3000 V in 5 V increments. Tap **Green Check** icon to confirm voltage and return to protocol screen.
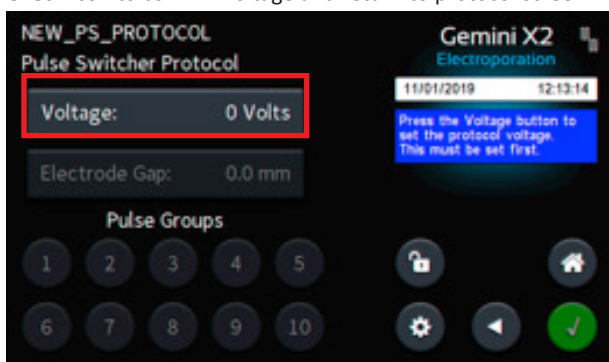

Next, enter the **Electrode Gap** for the protocol. Electrode Gap data is for experimental information logging purposes, and does not affect the characteristics of the electrical pulses delivered in the protocol.
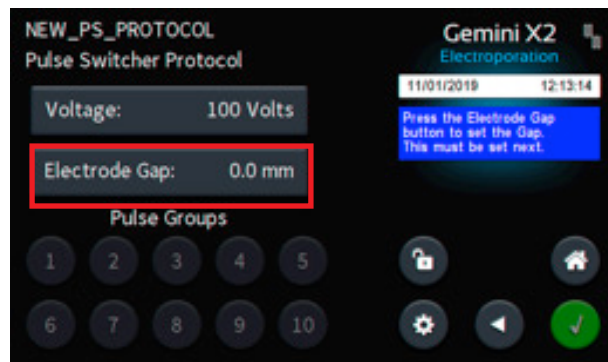

Adding and Defining Pulse Groups

Next, up to 10 groups of pulses with independent pulse number, pulse length, pulse polarity, and interval parameters may be entered. The pulse group parameters are added sequentially, starting with Group 1. Tap the **1** icon to navigate to the **Pulse Switcher Group 1** parameter entry screen.

> **NOTE:** *Pulse Groups (such as Pulse Group 1 in the example screenshot below) that are available to define with parameters but have not been modified yet will have a white number. Pulse Groups not yet available to define (such as Pulse Groups 2 to 10) will be greyed out.*
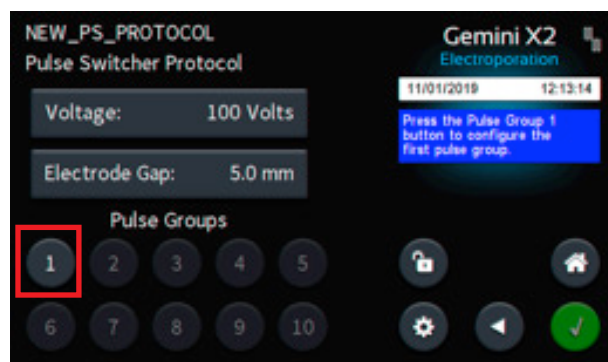

The screenshot below shows **Pulse Switcher Group 1** parameter entry screen. Polarity defaults to Positive; other fields default to 0.
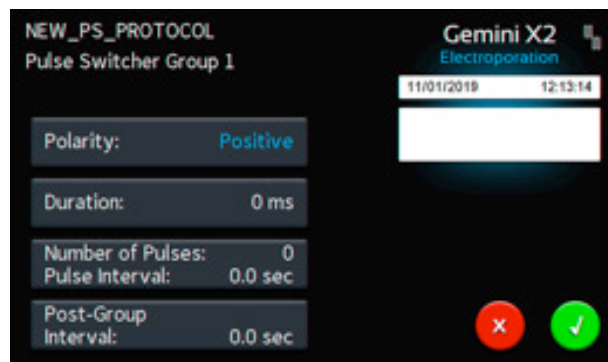
Software Setup

Press Polarity to toggle between Positive and Negative. Press Duration to set pulse duration for the pulses in the group. Press **Number of Pulses/Pulse Interval** to set the number of pulses in the group and interval between the pulses within the group. Press **Post-Group Interval** to set the interval between the end of the current group and the beginning of the next group. An example screenshot of the **Set Post-Group Interval** screen is shown below.
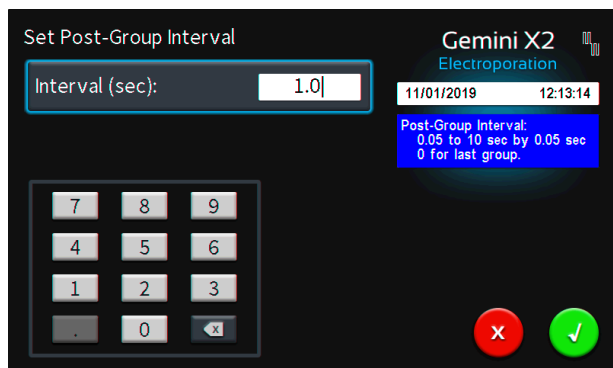

NOTE: *When the Pulse Switcher is installed, the minimum pulse interval that may be selected is decreased from 0.1 s to 0.05 s. Post-Group Interval is an additional Pulse Switcher feature that allows the interval between pulses within a group and the interval between one group to the next group to be defined separately.*

Once all the pulse parameters for **Pulse Group 1** have been entered, press the **Green Check** icon to save the parameters entered for this Pulse Group, or Press **X** icon to cancel the edits for this group. Pressing the **Green Check** icon saves the changes for this group and returns the user to the **Pulse Switcher Protocol** screen.

The example screenshot below shows that the data for **Pulse Group 1** has been set. Positive polarity selected for **Pulse Group 1** is indicated by blue color and + symbol. **Pulse Group 2** parameters have not been set yet (no + or – shown; 2 is white in color) in this example, however once Group 1 parameters have been set, Group 2 is enabled so the user may now go on to define **Pulse Group 2** settings.
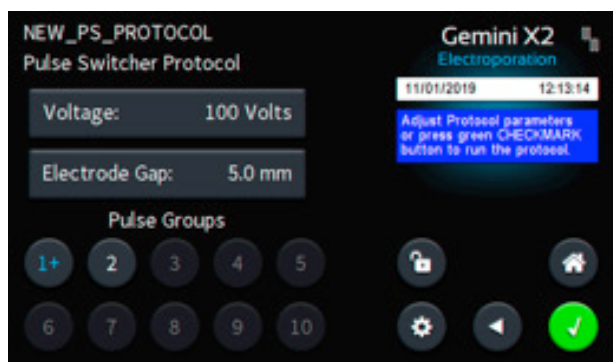
The example screenshot below shows **Pulse Switcher Group 2** parameter entry screen, after the user has entered pulse parameters. Negative polarity selected for **Pulse Group 2** is indicated by the orange Negative text. Pulse parameter settings for groups 2 to 10 may be entered in the same manner as described above for Group 1. Just as for Group 1, from all Group parameter entry screens the user may press the **Green Check** icon to save the parameters entered for this Pulse Group, or Press **X** icon to cancel the edits for this group, and then return to the **Pulse Switcher Protocol** screen.
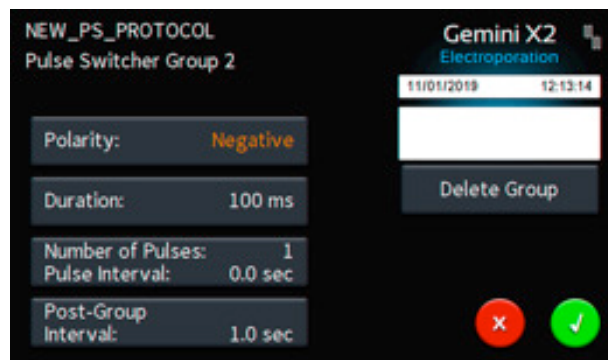
The example screenshot below shows that the data for P**ulse Groups 1** and **2** are set. Positive polarity selected for **Pulse Group 1** is indicated by blue color and + symbol and negative polarity selected for **Pulse Group 2** is indicated by orange color and - symbol. **Pulse Group 3** parameters have not been set yet (no + or – shown; 3 is white in color) in this example. However once Group 2 parameters have been set, Group 3 is enabled so the user may now go on to define **Pulse Group 3** settings. In this sequential manner, the user may program any number of pulse groups from 1 to 10 groups.
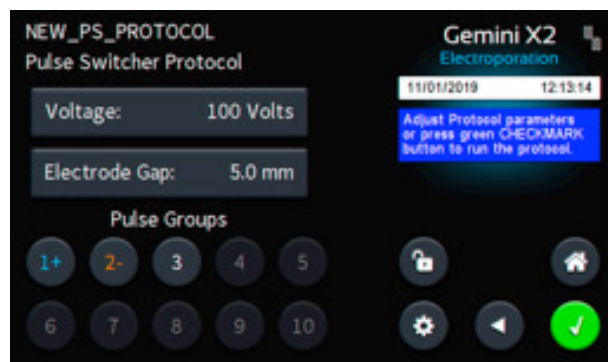
Software Setup

Deleting Pulse Groups

To delete a pulse group, first select it in the **Pulse Switcher Protocol** screen. In the example below, we will delete Group 2, by first tapping on the 2- icon.
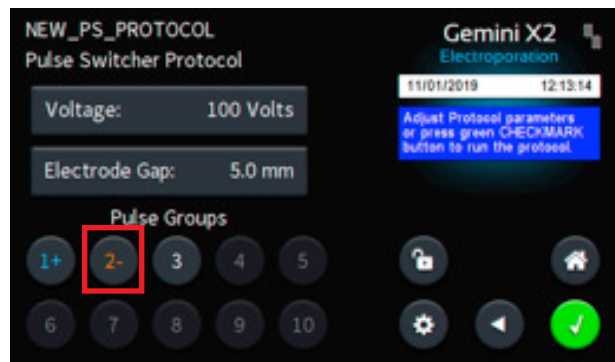
Next, from the **Pulse Switcher Group** screen, the protocol may be deleted by tapping **Delete Group**.

NOTE: *When you tap **Delete Group**, the following yellow warning message will appear in the dialog box: 'Press "Delete Group" button again to delete this group. PRESS TO CLEAR MESSAGE' The user may continue with deleting 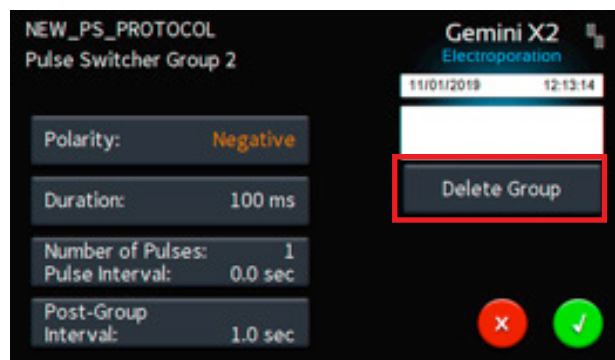the group by pressing Delete Group again, or instead to keep the group may tap the yellow dialog box to clear the warning message and return back to the Pulse Switcher Group screen.*


Following the deletion of a group, the user will be returned to the **Pulse Switcher Protocol** screen. In the example below, this is what the Pulse Switcher Protocol now looks like with Group 2 deleted. Now Group 2 has been returned to an undefined group with no parameters set yet, as indicated by the icon with a white number 2.
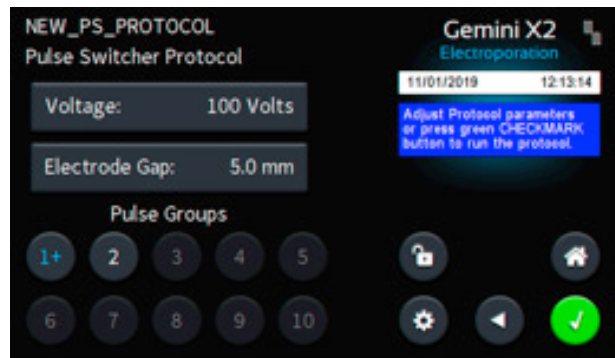
NOTE: *If a group is deleted from the middle of a sequence of groups, the order of the other later groups in the protocol will be shifted one place earlier. For example, if there are 5 groups defined in the user protocol and the user deletes group number 3, then group 3 will be removed from the middle of the protocol, group 4 will now become group 3, and group 5 will now become group 4.*

Advancing to the Protocol Run Screen

Once the user defined protocol is complete the user may advance to run the protocol if desired. From the **User Defined Pulse Switcher Protocol** screen, tap the **Green Check** icon at this point to proceed to the protocol Run screen.
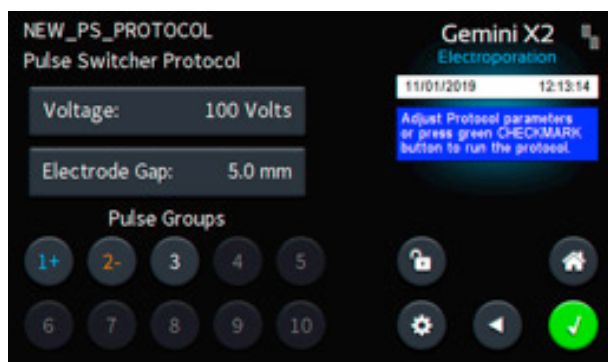
The **Protocol Run** screen will display a summary of the protocol name and the user defined protocol parameters for just the first group of the **Pulse Switcher** protocols (values displayed in the "Set" column). To run the user defined Pulse Switcher protocol, tap the **GO** icon. Please see page 12 for more about information about the **Protocol Run** screen.

Specifications

Square Wave Protocol Specifications after Pulse Switcher Installation:	
Voltage Range (LV & HV Modes)	no change
Pulse Duration (LV & HV Modes)	no change
Multiple Pulsing (Square Wave)	
LV Mode	1 to 100 pulses per sample
HV Mode	1 to 100 pulses per sample
Pulse Interval	0.05 s to 10 s

Pulse Switcher Square Wave Protocol Specifications after Pulse Switcher Installation:	
Voltage Range	Voltage magnitude is constant for all groups
LV Mode	5 to 500 V in 1 V steps
HV Mode	505 to 3000 V in 5 V steps
Pulse Groups	1 to 10 groups
For each group:	
Voltage Polarity in Group	Positive or Negative
Pulses in Group	
LV Mode	1 to 100 pulses per group
HV Mode	1 to 100 pulses per group
Pulse Duration in Group	
LV Mode	1 to 999 ms in 1 ms steps 10 to 999 µs in 1 µs steps
HV Mode	10 to 600 µs in 1 µs steps
Pulse Interval in Group	0.05 to 10 s in 0.05 s steps
Post-Group Interval	0.05 to 10 s in 0.05 s steps

NOTE: *Gemini X2 Exponential Decay Wave Protocol Specifications are unaffected by Pulse Switcher installation.*

| Other Specifications	
Compatible Generators	Gemini X2 and ECM 830*
Power Supply Input Voltage Ratings	100 to 240 VAC, 50/60 Hz
Pulse Switcher Input Voltage	5 VDC, 100 mA
Warranty	2 years
Storage Temperature	-10°C to 70°C (14°F to 158°F)
Operating Temperature	5°C to 40°C (40°F to 104°F)
Intended Use	Indoor Use Only
Operating/Storage Humidity	20% to 80% RH, non-condensing
Pollution Degree	IP2X
Insulation Category	Category II
Regulatory Certifications	CE, WEEE, RoHS
Physical Characteristics	
Dimensions L x W x D	8.9 x 7.8 x 5.4 cm (3.5 x 3.1 x 2.1 in)
Weight	276 g (0.6 lb)

* Compatible with 7- inch touchscreen instruments only.

Upgrading Gemini Series Software

USB Virtual CommPort Driver Installation

When you connect the BTX Gemini to a computer via USB for the first time, Windows® will seek to install a driver for communication. The following section details the installation of the Virtual CommPort Driver supplied with the BTX Gemini.

1. Connect the Gemini generator to the computer via USB. Open the control panel and select **System and Security** and then **System**. Click **Device Manager** on the left hand menu.

Mating Face

Pin # Signal

1 +5V

2 - Data

3 + Data

4 GND
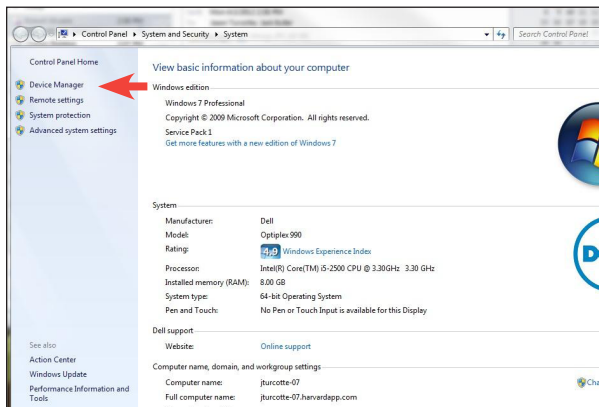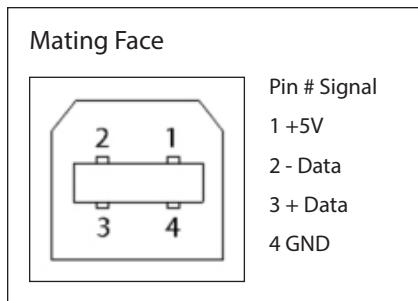
2. Two Flash update applications will be displayed in the device manager, under **Other Devices**. Right click on either of the flash update applications and select **Update Driver Software**.
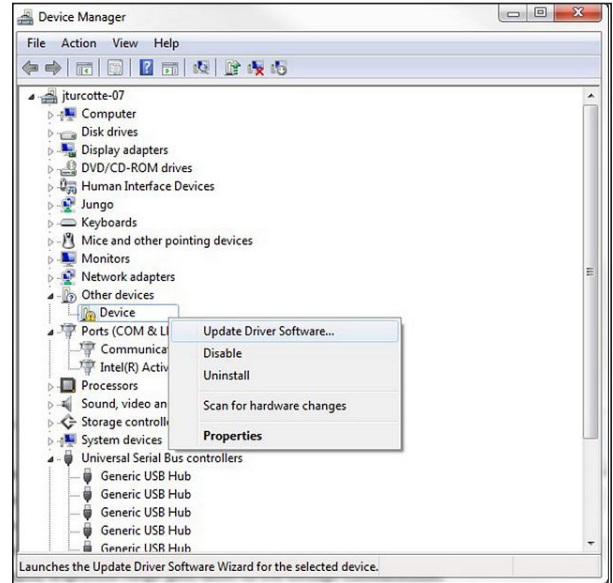
3. Select **Browse my computer for driver software**.
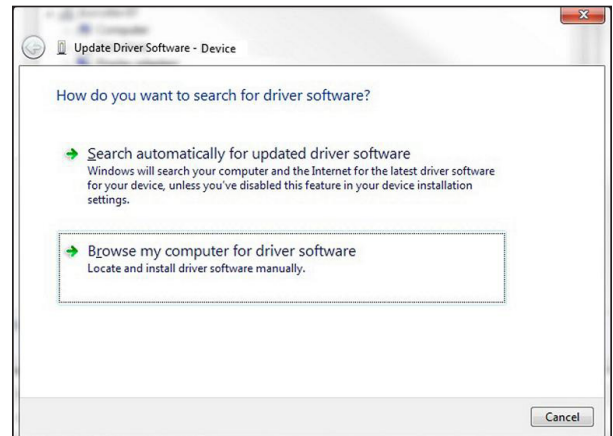
Upgrading Gemini Series Software

USB Virtual CommPort Driver Installation (continued)

4. Download the software from BTX website www.btxonline.com. Click on the **Technical Resources** drop-down menu and select **Downloads**. Download and install file named **BTX Gemini Firmware Update**.
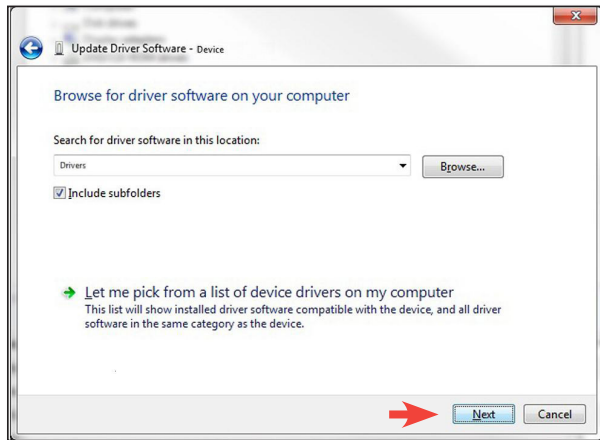
5. If a warning message regarding the driver publisher is displayed, choose **Install this driver software anyway**.
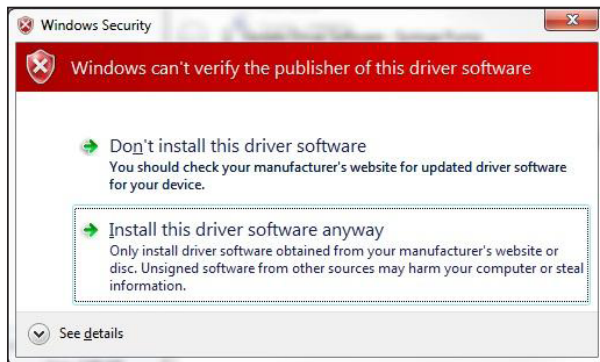
6. Click **Close** after the software has been successfully installed.
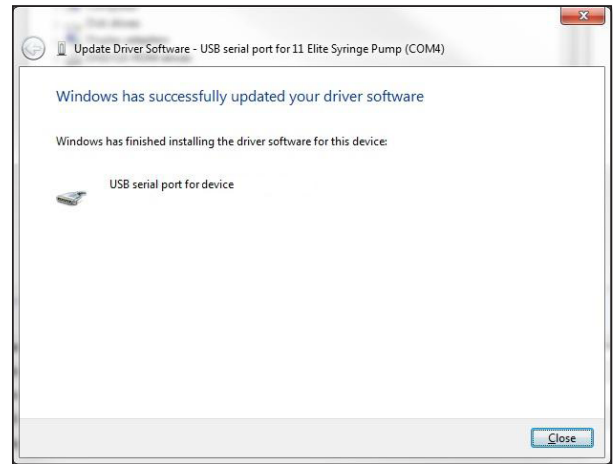
Upgrading Gemini Series Software

Device Updater Program

1. Upload the latest software versions to your desktop (format is filename.srec). There is one .srec file that needs to be updated: 'APP BTX_Gemini_upgrade x.x.x'.

2. Disconnect all I/O devices and then connect the Gemini generator to the PC using a USB cable.

3. On the setup screen of the Gemini generator, press the **Upgrade Software** icon twice to enter **Boot Loader Mode**.

4. Download the software from the BTX website www.btxonline.com. Click on the **Technical Resources** drop-down menu and select **Downloads**. Download and install file named **Device Updater**.
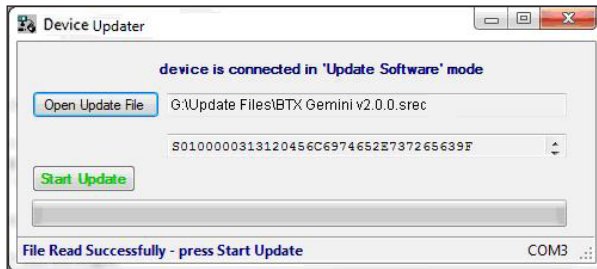
5. Click Open Update File and browse to the 'BTX Gemini 7 vx.x.x.srec'. file that was previously saved to the desktop.

6. Click **Start Update**.
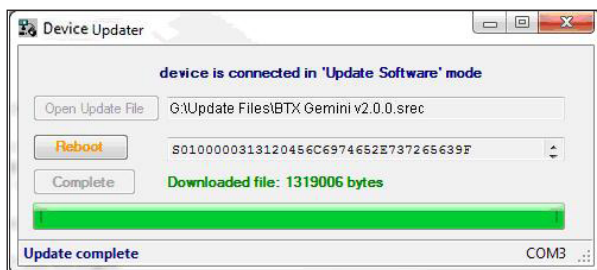
7. After the update is complete, press Reboot and then power cycle the Gemini generator from the power switch in the back of the unit.

Upgrading Gemini Series Software

Resource Updater Program

NOTE: *This step is required only when updating a BTX Gemini X2 or ECM 830 originally configured with GUI version 4.0.3 or earlier, and the unit will be used with the optional Pulse Switcher feature.*

NOTE: *The firmware must be updated to version 4.0.4 or later prior to running the Resource Updater Program Reference "Device Updater Program."*

NOTE: *The Resource Updater requires Windows 10 or Windows 7.*

1. Download the BTX Resource Updater zip file from www.btxonline.com to your PC.

2. Extract the files from the zip file; store them on your PC.

3. Connect a USB cable between your PC and the USB port on the front of the Gemini unit.

4. Run the setup.exe program that was extracted from the zip file. You may see a Security Warning similar to that depicted below (the grey box will display the path name where the program was installed). Click the **Install** button to continue.
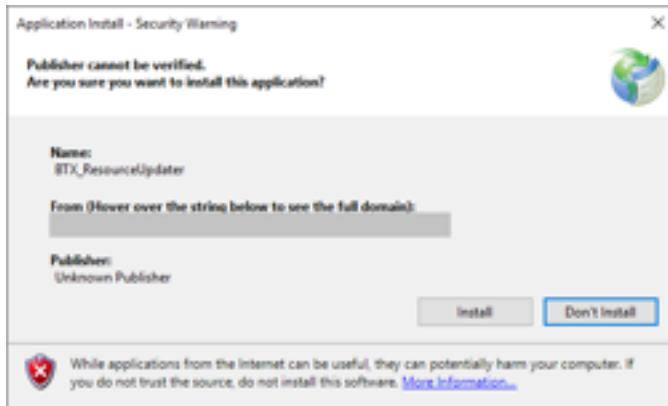
5. A Splash image similar to the one shown below will be displayed.
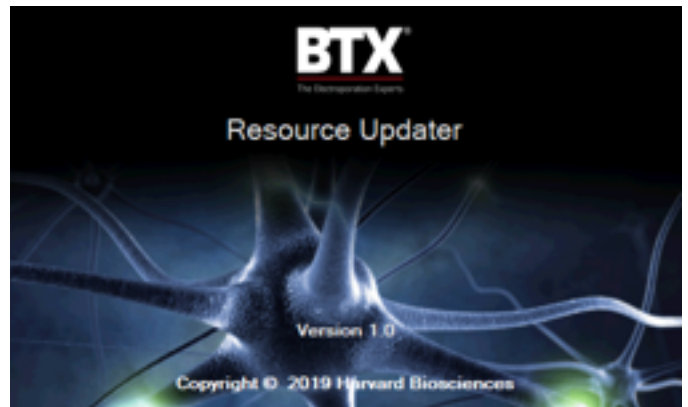
This will be replaced by the following screen within a second or two:
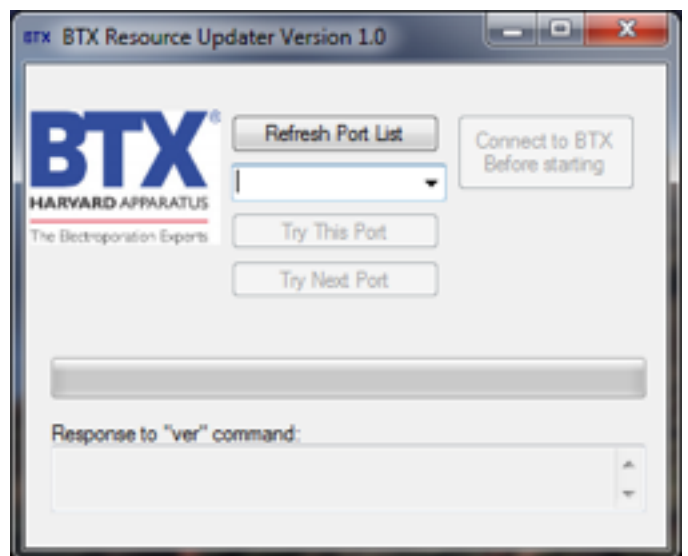
6. Click the **Refresh Port List** to get a list of potential communications ports.

Upgrading Gemini Series Software

7. If you know what port the Gemini is connected to, select that com port from the drop-down list.
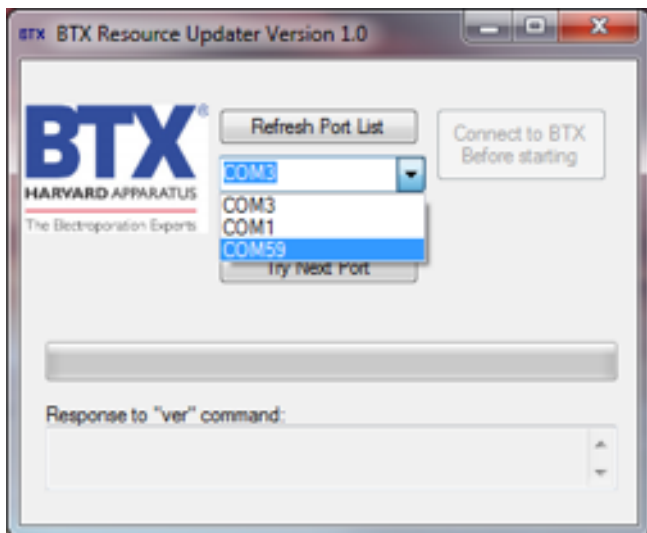
If you don't know the port number, each port may be tried individually. If the port will not open, its failure will be noted with an exception message put into the output window.

If the port is successfully opened, the system will display the BTX firmware version in the Response section. On certain PCs, this may require more than one attempt. The **Try Next Port** button simplifies the selection process, trying the next available port.
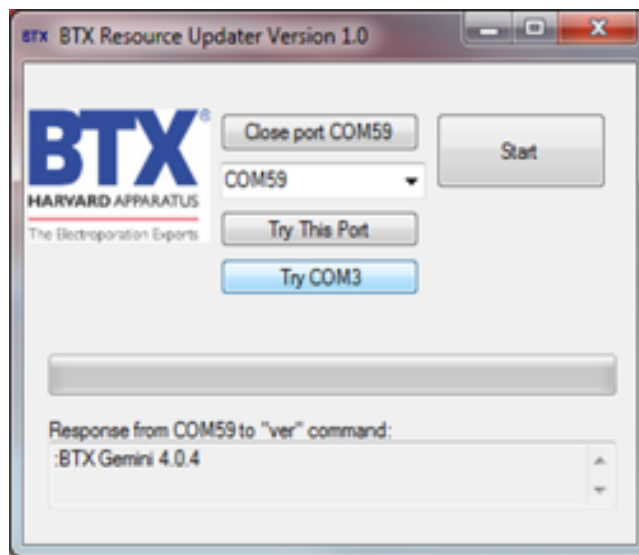
8. After a connection has been established, press the **Start** button to initiate a scan of all the bitmaps used in the system.

As the updater cycles through the bitmaps, it will display a running status on its progress.
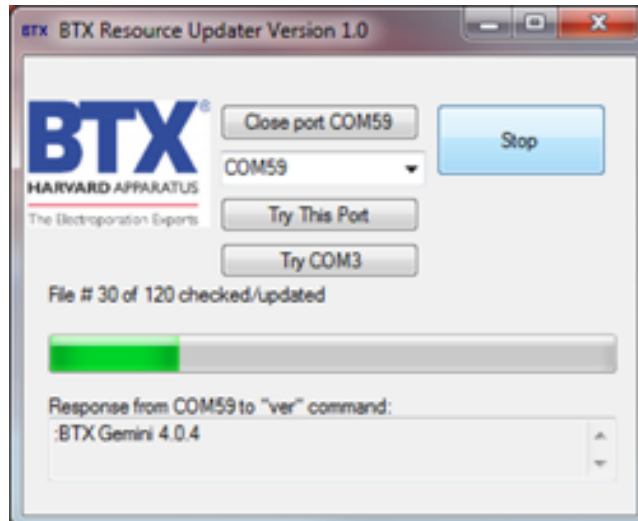
When a bitmap is being updated, detailed progress information is displayed, as shown below.

Upgrading Gemini Series Software
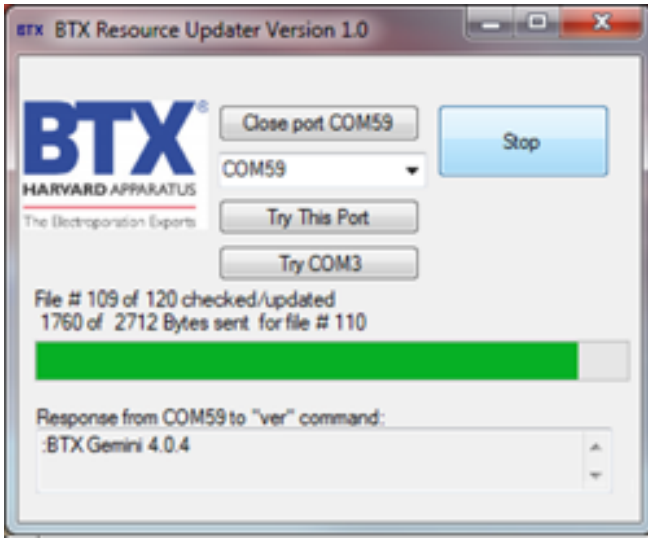
9. The updater will display a message when the update is complete.
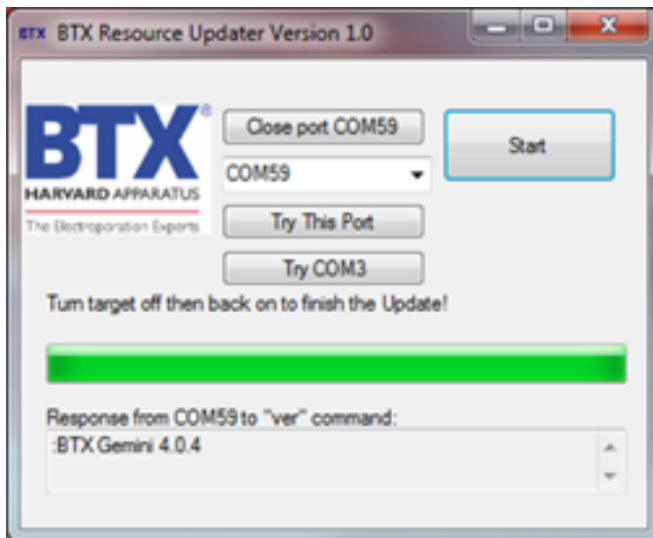
10. Press the [X] button in the top right corner of the box to close the Resource Updater.

11. Power-cycle the BTX Gemini unit to complete the update process.

12. The updater should only need to be used once, so it may be uninstalled using the standard Windows uninstall process, which varies based on the Windows operating system version.

Error Messages & Troubleshooting

The Gemini X2 and ECM 830 touchscreens have a dialog box located on the right side of the touchscreen to display color-coded information or error messages.
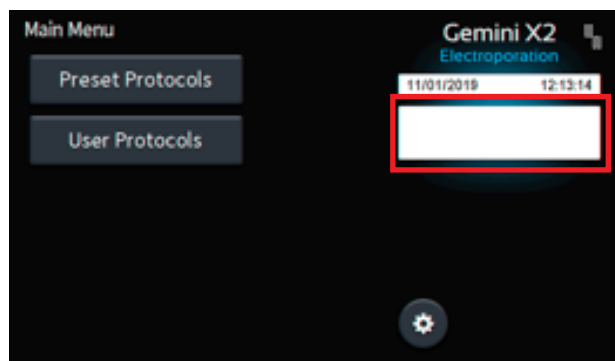
Green or **Blue** color-coded Dialog box messages indicate successful completion of an electroporation protocol or display information to assist the user in data entry. When the dialog box is blue or green, the user may advance to other screens without tapping the messages in the dialog box.

Yellow color-coded dialog box messages display warnings. The user must tap the yellow dialog box on the touchscreen to acknowledge the warning message before advancing with any other operations.

Red color-coded dialog box messages display errors. The user must tap the red dialog box on the touchscreen to acknowledge the error message and resolve the cause of the error before advancing with any other operations.

Following is a table of some dialog box messages specific to the Pulse Switcher. For a full list of other generator error messages, please refer to the Gemini X2 or ECM 830 user manual for more information.

| Dialog Box Color and Text	Displayed When	Recommended Troubleshooting
Pulse Switcher required to run this protocol.	Information is displayed when a Preset or User Defined protocol requiring the pulse switcher is selected.	Ensure the Pulse Switcher is connected to Generator HV outputs and USB connector and powered on to proceed with this protocol.
PULSE SWITCHER CONNECTION HAS BEEN LOST. SCREEN HAS BEEN RESET.	In the Preset Protocol mode, warning is displayed when the USB connection between the Pulse Switcher and the Generator is lost or power to the Pulse Switcher is lost (not during the execution of a protocol).	Tap the dialog box to acknowledge and clear the warning. Check the Pulse Switcher power supply and USB connector to make sure that the Pulse Switcher unit is powered up and connected to the Generator.
Switched protocols require the switcher to remain attached.	In the User Protocols mode protocol setup screen, warning is displayed when the USB connection between the Pulse Switcher and the Generator is lost or power to the Pulse Switcher is lost (not during the execution of a protocol).	Tap the dialog box to acknowledge and clear the warning. Check the Pulse Switcher power supply and USB connector to make sure that the Pulse Switcher unit is powered up and connected to the Generator.
ERROR: SWITCHER DISCONNECTED!	Error is displayed when the USB connection between the pulse switcher and the generator is lost (during the execution of a protocol).	Tap the dialog box to acknowledge and clear the error. Check the Pulse Switcher power supply and USB connector to make sure that the Pulse Switcher unit is powered up and connected to the Generator.
Pulse Switcher connection has been restored. Screen has been reset.	In the User Protocols mode protocol setup screen, warning is displayed when the USB connection between the Pulse Switcher and the Generator is restored or power to the Pulse Switcher is restored.	Tap the dialog box to acknowledge and clear the warning. You may now proceed with other operations.

Ordering Information

Order No.	Description	Qty.
Pulse Switcher Systems		
45-2061	Pulse Switcher. Includes Pulse Switcher, Power Supply and USB connector cable.	1 ea
45-2062	Gemini X2 Pulse Switcher System. Includes Gemini X2 Generator, Pulse Switcher, Power Supply and USB connector cable, Safety Dome, Cuvettes 1 mm, 2 mm,4 mm (pkg. of 30, 10 each), and Cuvette Rack.	1 ea
45-0669	ECM 830 Pulse Switcher System. Includes ECM 830 Generator, Pulse Switcher, Power Supply and USB connector cable, Safety Stand, Cuvettes 1 mm, 2 mm, 4 mm (pkg. of 30, 10 each), and Cuvette Rack.	1 ea
Cuvettes		
45-0134	Cuvette Plus, 1 mm gap, 90 µl, Sterile, pkg. of 10, Gray	1 pkg
45-0124	Cuvette Plus, 1 mm gap, 90 µl, Sterile, pkg. of 50, Gray	1 pkg
45-0140	Cuvette Plus, 1 mm gap, 90 µl, Sterile, (24 x pkg. of 100), Gray	24 pkg
45-0135	Cuvette Plus, 2 mm gap, 400 µl, Sterile, pkg. of 10, Blue	1 pkg
45-0125	Cuvette Plus, 2 mm gap, 400 µl,Sterile, pkg. of 50, Blue	1 pkg
45-0141	Cuvette Plus, 2 mm gap, 400 µl, Sterile, (24 x pkg. of 100), Blue	24 pkg
45-0136	Cuvette Plus, 4 mm gap, 800 µl, Sterile, pkg. of 10, Yellow	1 pkg
45-0126	Cuvette Plus, 4 mm gap, 800 µl, Sterile, pkg. of 50, Yellow	1 pkg
45-0142	Cuvette Plus, 4 mm gap, 800 µl, Sterile, (24 x pkg. of 100), Yellow	24 pkg
Reagents		
47-0002	BTXpress Cytoporation Low Conductivity Medium T, 500 ml volume	1 bottle
47-0003	BTXpress Cytoporation Low Conductivity Medium T4, 500 ml volume	1 bottle
45-0801	BTXpress Solution, 2.0 ml Bottle, for up to 20 Reactions	1 bottle
45-0802	BTXpress Solution, 5.0 ml Bottle, for up to 50 Reactions	1 bottle
45-0805	BTXpress Solution, 10.0 ml Bottle, for up to 100 Reactions	1 bottle

Order No.	Description	Qty.
Accessories		
45-0495	Oocyte Electrode, Platinum Plated, 10 mm, 1 mm gap (Electrode only)	1 ea
45-0496	Oocyte Electrode Kit, Platinum Plated, 10 mm, 1 mm gap, (with cables)	1 kit
45-0110	Flatpack Chambers, 0.56 mm gap, 80 µl volume, pkg. of 50 (requires Safety Stand 45-0207 or 45-0208)	Pkg of 50
45-0109	Flatpack Chambers, 1.83 mm gap, 1.5 ml volume, pkg. of 50 (requires Safety Stand 45-0207 or 45-0208)	Pkg of 50
47-0206	Flatpack Chambers, 4 mm gap, 10 ml volume, pkg. of 10 (requires Safety Stand 45-0208)	Pkg of 10
1 ea		
47-0207	Gemini X2 Safety Dome for Cuvettes Safety Stand for cuvettes (also accepts small volume Flatpacks 45-0110 and 45-0109)	1 ea
47-0208	Safety Stand for Flatpack (accepts cuvettes and all sizes of Flatpack)	1 ea
45-0400	HT-100 Plate Handler, Manual Track Switching	1 ea
45-0465	HT 25 adapter for Plate Handlers	1 ea
45-0468	Replacement pins, pkg. of 25	1 pkg
45-0469	Replacement pins, pkg. of 100	1 pkg
5012-017	Pliers for Changing Pins between 96-well and 25-well formats	1 ea
45-0466	25-Well Disposable Electroporation Plate, 2 mm gap, 125 µl, coated, 1 plate	1 ea
45-0466-M	25-Well Disposable Electroporation Plate, 2 mm gap, 125 µl, 1 plate	1 ea
45-0467	25-Well Disposable Electroporation Plate, 2 mm gap, 125 µl, pkg. of 6	1 pkg
45-0462	25-Well Disposable Electroporation Plate, 4 mm gap, 250 µl, 1 plate	1 ea
45-0463	25-Well Disposable Electroporation Plate, 4 mm gap, 250 µl, pkg. of 6	1 pkg
45-0450	96-Well Disposable Electroporation Plate, 2 mm gap, 125 µl, Coated, 1 plate	1 ea
45-0450-M	96-Well Disposable Electroporation Plate, 2 mm gap, 125 µl, 1 plate	1 ea
45-0452	96-Well Disposable Electroporation Plates, 4 mm gap, 250 µl, 1 plate	1 ea
45-00012	25-Well Plate Seal (1)	1 ea
45-2030	Gemini X2/ECM 830/ECM 630 Foot Pedal	1 ea
45-0122	Genepaddles, 3 x 5 mm (requires 45-0203 holder and 45-0216 cables sold separately)	1 ea
45-0169	Genepaddles Kit, 3 x 5 mm (includes 45-0203 holder and 45-0216 cables)	1 kit
45-0123	Genepaddles, 5 x 7 mm (requires 45-0203 holder and 45-0216 cables sold separately)	1 ea
45-0170	Genepaddles Kit, 5 x 7 mm (includes 45-0203 holder and 45-0216 cables)	1 kit
45-0203	Genetrode/Genepaddle Holder	1 ea
45-0117	Genetrodes, 1 mm L-Shape (GOLD TIP) (requires 45-0203 holder and 45-0216 cables sold separately)	1 ea

Order No.	Description	Qty.
45-0164	Genetrodes, 1 mm L-Shape (GOLD TIP) with 45-0203 holder and 45-0216 cables	1 kit
45-0116	Genetrodes, 3 mm L-Shape (GOLD TIP) (requires 45-0203 holder and 45-0216 cables sold separately)	1 ea
45-0163	Genetrodes, 3 mm L-Shape (GOLD TIP) with 45-0203 holder and 45-0216 cables	1 kit
45-0115	Genetrodes, 5 mm L-Shape (GOLD TIP) (requires 45-0203 holder and 45-0216 cables sold separately)	1 ea
45-0162	Genetrodes Kit, 5 mm L-Shape (GOLD TIP) with 45-203 holder and 45-0216 cables	1 kit
45-0113	Genetrodes, 5 mm Straight (GOLD TIP) (requires 45-0203 holder and 45-0216 cables sold separately)	1 ea
45-0160	Genetrodes Kit, 5 mm Straight (GOLD TIP) with 45-0203 holder and 45-0216 cables	1 kit
45-0114	Genetrodes, 10 mm Straight (GOLD TIP) (requires 45-0203 holder and 45-0216 cables sold separately)	1 ea
45-0161	Genetrodes Kit, 10 mm Straight (GOLD TIP) with 45-0203 holder and 45-0216 cables	1 kit
45-0509	Needle L-Shaped Platinum Electrode, 3mm (requires 45-0508 cables sold separately)	1 ea
45-0510	Needle L-Shaped Platinum Electrode Kit, 3 mm, with 45-0508 cables	1 kit
45-0530	Adherent Cell Electrode, 5mm gap, For 12-well dish adherent electroporation (requires 45-0204 cables sold separately)	1 ea
45-0531	Adherent Cell Electrode, 5mm gap, For 12-well dish adherent electroporation with 45-0204 cables	1 kit
45-0130	Petri Pulser, 2mm gap, For 35 mm dish adherent electroporation	1 ea
45-0100	Petri Dish Electrode, 2mm gap, For 10 cm dish adherent electroporation	1 ea
45-0504	Petri Dish Platinum Electrode Chamber for Tissues, 5 mm gap (requires 45-0216 cables sold separately)	1 ea
45-0505	Petri Dish Platinum Electrode Chamber Kit for Tissues, 5 mm gap, with 45-0216 cables	1 kit
45-0506	Petri Dish Platinum Electrode Chamber for Tissues, 15 mm gap (requires 45-0216 cables sold separately)	1 ea
45-0513	Petri Dish Tissue Chamber Kit for Tissues, 15 mm gap, with 45-0216 cables	1 kit
45-0491	Petri Dish Platinum Electrode Chamber for Tissue Slices, 7 mm, negative	1 ea
45-0492	Platinum Electrode Wand for Tissue Slices, 7 mm, positive	1 ea
45-0490	Petri Dish Platinum Electrode for Tissue Slices Chamber Kit, 7 mm, with 45-0491 chamber, 45-0492 wand 7 mm, 45-0503 cables, 45-0204 cables	1 kit
45-0501	Petri Dish Platinum Electrode Chamber for Tissue Slices, 10 mm, negative	1 ea
45-0502	Platinum Electrode Wand for Tissue Slices, 10 mm, positive	1 ea
45-0500	Petri Dish Platinum Electrode for Tissue Slices Chamber Kit, 10 mm, with 45-0501 chamber, 45-0492 wand 7 mm, 45-0503 cables, 45-0204 cables	1 kit

Order No.	Description	Qty.
45-0490	Petri Dish Platinum Electrode for Tissue Slices Chamber Kit, 10 mm, with 45-0491 chamber, 45-0502 wand 7 mm, 45-0503 cables, 45-0204 cables	1 kit
45-0524	Platinum Tweezertrode, 1 mm Flat (requires 45-0204 cables sold separately)	1 ea
45-0525	Platinum Tweezertrode Kit, 1 mm Flat (includes 45-0204 cables)	1 kit
45-0486	Platinum Tweezertrode Kit, 1 mm Diameter (includes 45-0204 cables)	1 kit
45-0487	Platinum Tweezertrode Kit, 3 mm Diameter (includes 45-0204 cable)	1 kit
45-0489	Platinum Tweezertrode Kit, 5 mm Diameter (includes 45-0204 cables)	1 kit
45-0118	Stainless Tweezertrode Electrode, 7 mm Diameter (requires 45-0204 cables sold separately)	1 ea
45-0165	Stainless Tweezertrode Kit, 7 mm (includes 45-0204 cable)	1 kit
45-0488	Platinum Tweezertrode, 7 mm Diameter (includes 45-0204 cables)	1 kit
45-0119	Stainless Tweezertrode Electrode, 10 mm Diameter	1 ea
45-0166	Stainless Tweezertrode Kit, 10 mm (includes 45-0204 cable)	1 kit
45-0493	Triple Electrode Tweezertrode Kit, 3 mm (includes connection box)	1 kit
45-0494	Triple Electrode Tweezertrode Kit, 5 mm (includes connection box)	1 kit
45-0121	2-Needle Array Electrode Tips, 5 mm gap, Pkg. of 6	1 pkg
45-0206	2-Needle Array Handle, for 5mm gap tips	1 ea
45-0168	2-Needle Array Kit, 5 mm, Pkg. of 6, with Handle	1 kit
45-0120	2-Needle Array Electrode Tips, 10 mm gap, Pkg. of 6	1 pkg
45-0205	2-Needle Array Handle, for 10 mm gap tips	1 ea
45-0167	2-Needle Array Kit, 10 mm, Pkg. of 6, with Handle	1 kit
45-0101	Caliper Electrode , 1.0 cm x 1.0 cm, Brass, Transdermal Delivery Applications	1 ea
45-0102	Caliper Electrode, 2.0 cm x 2.0 cm with extra 1.5 cm x 1.5 cm electrodes included, Stainless Steel, Electrochemotherapy Applications	1 ea

Cables & Adapters

Order No.	Description	Qty.
45-0087	Adaptor Set, Micrograbber to Banana Plug Cables	1 ea
45-0216	Micrograbber to Banana Plug Connection Cables, Red and Black, 10 ft (for use with microslides, Genetrodes and tissue petri dish)	1 ea
45-0503	Micro-Grabber Cable for Tissue Slice Chamber and Oocyte electrode	1 ea
45-0204	Adapter Banana Plug Cables, Red and Black (for use with Tweezertrodes and L-Shaped Genetrodes Electrodes)	1 ea
45-0088	Female/Female Adapter Set for Banana Plug Cables	1 ea
45-0217	Banana to Banana Cables, Red and Black, 10 ft	1 ea

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