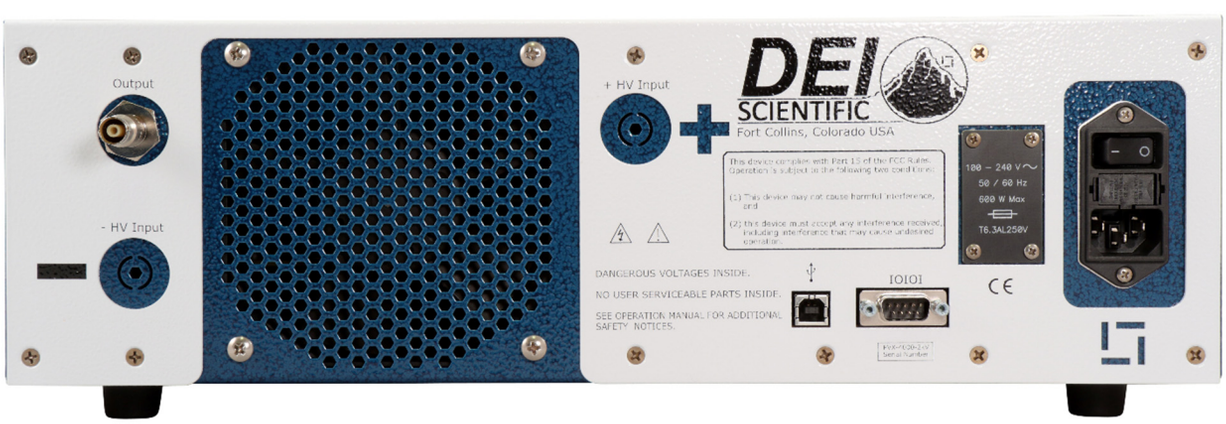
# PVX-4000-2kV

## Pulsed Voltage Source

# Operation Manual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Manual Document 7650-0022 Rev. A05

# Contents

# Safety

- Always refer to the Safe Operating Area (SOA) of the PVX-4000-2kV system, located in the datasheet.

- Do not open the cover of the PVX-4000-2kV. There are no user-serviceable parts inside. Opening the cover exposes you to shock and voids the factory warranty.

- Do not install, handle, or remove the output cables or load while the PVX-4000-2kV is operating. Allow at least 10 minutes after powering down before handling the output cable or load.

- Do not use this device in a manner not specified by the manufacturer.

- Allow sufficient space around this device for air circulation.

- Do not use where liquids are present or in corrosive environments. Clean this instrument by wiping with a dry or damp cloth.

## WARNING

**Risk of lethal electric shock. Do not open the cabinet of this device. Do not touch the output or load while it is operating. This device produces LETHAL levels of electric current, both inside its cabinet and at its output.**

DO NOT OPERATE THIS DEVICE UNLESS ANOTHER PERSON, CAPABLE OF RENDERING FIRST AID OR RESUSCITATION, IS PRESENT.

SAFE AND PROPER OPERATION OF THIS DEVICE IS THE RESPONSIBILITY OF THE USER.

Directed Energy, Inc. (DEI) provides information on its products and associated hazards, but it assumes no responsibility for the after-sale operation and safety practices.



**For more information contact IXYS Colorado: 970.493.1901 or** sales@ixyscolorado.com

# Introduction

## ❖ Description

The PVX-4000-2kV is an air-cooled pulse generator that produces high voltage waveforms. Optimized for high-impedance capacitive loads, the PVX-4000-2kV is well suited for driving extraction grids and deflection plates for electrostatic modulation of particle beams in time-of-flight mass spectrometers and accelerators. The output voltage can be set to ±2000 V using the internal high voltage power supplies.

**The positive and negative high voltage output levels must NOT exceed 2000 V total. Reduce the high voltage on either channel to achieve ≤ 2000 V. Use the below formula:**

$$V_{positive} + |V_{negative}| \leq 2000\ V$$

The system is capable of duty cycles from 2% to 98% and repetition rates from 40 Hz to 30,000 Hz using the internal trigger. With the external trigger the system is capable of single shot to 600 kHz with a pulse width of 500 ns to 100% duty cycle.

Conveniently-located front panel BNC connectors allow the PVX-4000-2kV to be externally gated and synchronized for specialized interconnected equipment applications. The external gate input impedance and the sync output impedance are both 50 Ω. The sync output pulse is synchronized to the leading edge of the output voltage pulse and is active with the external trigger.

The PVX-4000-2kV includes a pulse generator and high voltage DC power supplies, providing you with a standalone test system that can be programmed to perform device testing using the front panel LCD controls or a computer interface (RS-232 and USB).

When changing the frequency, the duty cycle will be maintained. The system will display the new pulse width that changes to maintain the duty cycle. It is recommended to change the frequency before changing the pulse width.

Up to five user configurations may be stored in internal nonvolatile memory and recalled through the front panel or communications interface. The first memory location stores the power-up default parameters.

All error and fault messages are reported on the front panel display and are also available via the computer communications interface. Analog voltage monitors are also provided for monitoring the voltage to the load using an external oscilloscope.



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# ❖ Front Panel Features


**Power LED**
The **Power** LED is lit when there is support power applied to the PVX-4000-2kV.

**Fault LED**
The **Fault** LED is lit when there is a fault/error sensed within the system.

**Enable LED**
The **Enable** LED is lit, and the system output is enabled, when all the following conditions are met:

- There are no faults
- The enable BNC connection is made
- The enable button has been pressed

**Enable Button**
The **Enable** button, press this button to enable and disable the system output.

**Home Button**
The **Home** button, press this button to return to the main menu, once all parameters have been set to the user values.

**Encoder Knob**
The encoder changes the values of the displayed parameters.

**LED Display**
The display shows system information on the home screen. It is used in conjunction with the encoder.


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**Enable Input**

The Enable BNC input accepts either an external dry-contact closure or the factory-supplied shorting BNC plug (PCA-9410).

- Closed contacts or use of the shorting plug allows the output to be enabled. Less than 1000 Ω will allow the system to be enabled.
- Open contacts or removal of the shorting plug disables the output and creates a fault. Greater than 1 MΩ will disable the system.

**Voltage Monitor Output**

The Voltage Monitor ($V_{MON}$) BNC output allows the user to monitor the voltage and signal of the output cable. The $V_{MON}$ voltage is linearly scaled with a ratio of 10:1000. For example, 1000 V at the output corresponds to 10 V on $V_{MON}$. The oscilloscope termination should be set to 1 MΩ.

**Gate Input**

The Gate (external gate) BNC input accepts trigger pulses from an external source. Its input impedance is 50 Ω and should be driven with a 5 V logic level source. The frequency range is single shot to 100 kHz and the pulse width is 500 ns to DC.

**Sync Output**

The Sync BNC output provides synchronization pulses for external devices. The sync pulse corresponds to the leading edge of the output pulse. Its impedance is 50 Ω with voltage levels of 0 V to > +3.3 V. Sync Output Voltage Levels:

- 0 V output = - HV output pulse
- < +3.3 V output = + HV output pulse



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# ❖ Rear Panel Features


**Output**
The voltage output connector, a Winchester Kings 10 kV, 1065-2 plug, is the output connection for system-generated voltage pulses. DO NOT TOUCH any part of this output or cable while the PVX-4000-2kV is powered up and enabled. Please review the Safety section.

**Power Cord Connector**
The power cord connector accepts a type NEMA C14 grounding equipment power cord.

**On/Off Power Switch**
The **On/Off** switch turns the PVX-4000-2kV support power on and off.

**Communication**
The system can communicate with a computer using USB or RS-232 for automated program operation.

- The **RS-232 Interface** operates with settings of 115,200 baud, 8 data bits, 1 stop bit, no parity, and no flow control.
- The **USB Interface** operates as a COM port with settings of 115,200 baud, 8 data bits, 1 stop bit, no parity, and no flow control. The driver can be found on our website.
- When switching communication from RS-232 to USB, no power cycle is needed.
- When switching communication from USB to RS-232, you must power cycle the PVX-4000-2kV.


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# ❖ Accessories Included

**AC Power Cord**
The factory-supplied power cord is a type NEMA C14 grounding equipment power cord.

**Pulsed Output Cable**
The output cable (PCA-9400) is used to connect the PVX-4000-2kV to the load and is two meters in length. The factory supplied output cable has 1.57 pF / 1.0 cm of cable. This needs to be calculated into the total load value.


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# Operating Considerations

## ❖ Output Cabling

The PVX-4000-2kV is designed to drive capacitive loads. Since its output current is limited, a smaller load capacitance results in a faster rise time. If the load characteristics are fixed, only the length and type of interconnecting cable will change the output capacitance.

The unit is supplied with a two-meter length of insulated coaxial cable. DEI recommends that the shortest length of cable possible be used to ensure the fastest possible rise times and best pulse fidelity.

This unit was tested driving a 360 pF load at 2000 V output. The load consisted of a 56 pF capacitor at the end of a two meters of coaxial cable with a characteristic capacitance of 1.57 pF / 1.0 cm of cable. This needs to be calculated into the total load value.

## ❖ Pulse Voltages

The PVX-4000-2kV pulser is rated at a maximum pulse output voltage of ±2000 V DC. Proper precautions should be taken by the user to ensure that the maximum voltage is not exceeded.

## ❖ Trigger Method

Use either the internal trigger source or an external gate to trigger the output pulse.



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# Local Operation

## ❖ Local Mode

Two modes of operation are possible, Local and Remote. Local Mode is automatically selected on power up, allowing the user to change the system configuration through the front panel display and the encoder knob/button. The user can:

- Set the trigger mode (internal or external)
- Set the frequency
- Set the pulse width
- Set the high voltage, positive and negative
- Save a configuration to memory
- Load a configuration from memory
- Enable and disable the output
- Reset a fault
- View the RS-232/USB port settings
- View the system status (temperature, voltage output, etc.)

Press the encoder to change and update the values of the various parameters. On some menus, pressing the encoder allows the user to change the multiplier.

## ❖ Setup

1. Press the **Enable** button to disable the voltage output of the system.
2. The PVX-4000-2kV should be **OFF** for at least ten minutes when connecting or disconnecting the voltage output connector.
3. Connect the output to the load. Verify that the load polarity is correct. If necessary, review the output cable for polarity specifications. Typically, the center pin is the high voltage and the housing is the return.
4. Make the other connections as necessary:

    - External Trigger (if used)
    - Sync (if used)
    - Voltage Monitor ($V_{MON}$) (if used)

5. Connect the BNC Enable shorting connector (factory supplied) on the front of the system, or to a user-supplied connection of less than 1,000 Ω resistance.
6. Connect the AC support power cable.

## ❖ Power Up



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1. Power up the system with the power switch on the rear panel of the PVX-4000-2kV. The **Power** LED lights and the **Fault** LED blinks. The instrument boots up in about 3 seconds.
2. If there are no errors or faults, the Fault LED turns off. If there are errors or faults, the Fault LED lights without blinking after the system has booted.

## ❖ Set the Output Voltage

**The positive and negative high voltage output levels must NOT exceed 2000 V total. Reduce the high voltage on either channel to achieve ≤ 2000 V. Use the below formula:**

$$V_{positive} + |V_{negative}| \leq 2000\ V$$

Set the positive high-voltage output amplitude for the load up to +2000.
Set the negative high-voltage output amplitude for the load up to -2000.

1. Rotate the encoder knob to the **Positive HVPS** or the **Negative HVPS** screen.
2. Press the encoder knob to change the value of the **Positive HVPS** or **Negative HVPS**.
3. Rotate the encoder knob to change the value.
4. Press the encoder knob to change the multiplier (10, 100, or 1000).
5. When the correct value is displayed, press the **Home** button.

## ❖ Set the Trigger Type

When the trigger source is set to **Internal**, the home screen will display the frequency and pulse width values. When the trigger source is set to **External Gate,** the home screen will only display the **External Gate** information. It is recommended to disable the system prior to changing between internal and external triggering.

1. Rotate the encoder knob to the **Trigger Type** screen.
2. Press the encoder knob to select the **Trigger Type**.
3. Rotate the encoder knob between Internal and External Gate.
4. When the correct **Trigger Type** has been selected, press the **Home** button to return to the **Home** screen.

## ❖ Set the Frequency

When changing the frequency, the duty cycle will be maintained. The system will display the new pulse width as it changes to maintain the duty cycle. It is recommended to change the frequency and then the pulse width, unless the duty cycle has priority to the user.

For internal settings:


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1. Rotate the encoder knob to the **Frequency** screen.
2. Press the encoder knob to change the value of the frequency.
3. Rotate the encoder knob to change the value between 40 Hz to 30,000 Hz.
4. Press the encoder knob to change the multiplier value of the frequency.
5. Rotate the encoder knob to change the value. Press the encoder knob to change the minimum multiplier amount:

    a. 40 to 1000 Hz, multiplier @ 10 Hz
    b. 1000 to 30,000 Hz, multiplier @ 100 Hz

6. When the correct value is displayed press the **Home** button to return to the **Home** screen.

For external settings:

1. Set the **Frequency** on the external signal generator.

## ❖ Set the Pulse Width

For internal settings:

1. Rotate the encoder knob to the **pulse width** screen.
2. Press the encoder knob to change the value of the pulse width.
3. Using the encoder knob, set the pulse width between 2% to 98% of duty cycle.
4. Press the encoder knob to change the multiplier value of the pulse width.
5. Rotate the encoder knob to change the value, press the encoder knob to change the minimum multiplier amount:
    a. 6.4 µs from 40 Hz to 1000 Hz
    b. 0.4 µs from 1100 Hz to 5000 Hz
    c. 0.05 µs from 5100 Hz to 30000 Hz

6. When the correct value is displayed, press the **Home** button to return to the **Home** screen.

For external settings:

1. Set the **pulse width** on the external signal generator.

## ❖ Enable System Output

The system can be enabled if the following are met:

- There are no faults
- The enable BNC connection is made with less than 1000 Ω (shorted)

1. If using an external trigger, enable the external signal generator.


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2. Enable the PVX-4000-2kV unit by pressing the enable button. The green enable LED turns ON. Typically, the user must press the enable button for up to 2 seconds.
3. The PVX-4000-2kV is now sending high voltage pulses through the output connection.

## ❖ Power Down

1. Disable the system by pressing the **Enable** button on the front panel. The green Enable LED turns off. Typically, the user has to press the enable button for 2 seconds.
2. If using an external gate, turn OFF or disable the external trigger source.
3. Turn the support power OFF by using the power switch on the rear of the system.

## ❖ Save System Setup

1. Rotate the encoder knob to the **Save Settings** screen.
2. Press the encoder knob to enter the save menu.
3. Rotate the encoder knob to choose the memory location, 1 to 5. During power up the system defaults to memory location 1 parameters.
4. Press the encoder knob to save the values in the chosen memory location. The screen will display "**Saving to location # n**", indicating the data is being saved.
5. After the parameters have been saved to memory, press the **Home** button to return to the **Home** screen.

## ❖ Restore System Setup

1. Rotate the encoder knob to the **Restore Settings** screen.
2. Press the encoder knob to enter the Restore menu.
3. Rotate the encoder knob to choose the memory location, 1 to 5. During power up the system defaults to memory location 1 parameters.
4. Press the encoder knob to restore the values from the chosen memory location. The screen will display "**Loading data from location # n**", indicating the data is being restored.
5. When finished restoring the parameters from memory, press the **Home** button to return to the **Home** screen.



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# Remote Operation

## ❖ Remote Mode

A host PC can remotely control the configuration and operation of the PVX-4000-2kV through its RS-232 and USB interfaces. This feature allows the user to create system-level control software to run standardized test procedures for research, test, and manufacturing validation environments.

Any external communication from the RS-232 or USB port automatically updates the values on the **Home** screen of the front panel.

Any communication on the USB port will disable the RS-232 port. The RS-232 port will be disabled until the PVX-4000-2kV is power cycled, at which time the RS-232 is active by default.

The PVX-4000-2kV serial communication parameters are displayed when the user rotates the encoder knob to the last menu screen, **RS232/USB**. The parameters are 115200 baud, 8 data bits, no parity, 1 stop bit, and no flow control. The end-of-data packet character is the ASCII new line character (‘/n’). Upon seeing the termination character, the unit assumes the entire data packet is received and processes the command.

The command set is based upon the SCPI (Standard Commands for Programmable Instruments) protocol. It has been optimized for use in DEI’s equipment for application ease and device efficiency. Each command includes a string of words, and if necessary, data or a keyword. Commands and queries must be in all capital letters. Commands and queries that require data, denoted as n, must have a space between the command and the data.

For every command sent to the PVX-4000-2kV, a response will be sent back to the user from the PVX-4000-2kV. The user’s software must wait for a response before sending another command to avoid an overflow of the PVX-4000-2kV receive buffer.

NOTE: Any change to a command adjustment typically requires less than 200 ms to complete.

When changing the frequency the duty cycle will be maintained. The system will display the new pulse width that changes to maintain the duty cycle. It is recommended to change the frequency and then the pulse width, unless the duty cycle is priority to the user.



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# ❖ Command List

In the examples, the command or query is in black; the response is in blue italics.

***IDN?**

Abbreviation for identity; returns the manufacturer's name, unit model number, serial number, firmware revision, and manufacture date. Example:

*IDN?
*DEI Scientific, PVX-4000-2kV, 170151, D01P03, 00*

**OUTPUT?**

Returns the state of the output (Enabled or Disabled). Example:

OUTPUT?
*Enabled*

**OUTPUT:ENABLE**

Enables the output. Performs the same function as pressing the front-panel ENABLE button. Example:

OUTPUT:ENABLE
*Enabled*

**OUTPUT:DISABLE**

Disables the output. Performs the same function as pressing the front-panel ENABLE icon. Example:

OUTPUT:DISABLE
*Disabled*

**OUTPUT:TRIGGER?**

Returns the trigger source type (Internal, or External). Example:

OUTPUT:TRIGGER?
*INTERNAL*

**OUTPUT:TRIGGER:INTERNAL, or OUTPUT:TRIGGER:EXTERNAL**

Sets the trigger type. The trigger types are Internal, or External. Example:

OUTPUT:TRIGGER:INTERNAL
*INTERNAL*

OUTPUT:TRIGGER:EXTERNAL
*EXTERNAL*



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**PULSE:WIDTH?**

Returns the pulse width of the output pulse in nano-seconds. Example:

PULSE:WIDTH?
*10,000 ns*

**PULSE:WIDTH nn**

Sets the pulse width of the output pulse in nano-seconds. Example:

PULSE:WIDTH 10000
*10,000 ns*

**PULSE:FREQ?**

Returns the trigger frequency in hertz. Example:

PULSE:FREQ?
*6000 Hz*

**PULSE:FREQ n**

Sets the trigger frequency in hertz. The value of n must be between 40 Hz and 30000 Hz. Example:

PULSE:FREQ 2400
*2400 Hz*

**VOLT:POSITIVE?**

Returns the positive voltage in volts. Example:

VOLT:POSITIVE?
*1000*

**VOLT:POSITIVE nn**

Sets the positive voltage in volts. Example:

VOLT:POSITIVE 1000
*1000*

**VOLT:NEGATIVE?**

Returns the negative voltage in volts. Example:

VOLT:NEGATIVE?
*-1000*

**VOLT:NEGATIVE nn**

Sets the negative voltage in volts. Example:

VOLT:NEGATIVE 1000
*-1000*



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**SAVE:n**

Saves the current configuration to non-volatile memory. The value of n must be between 1 and 5. Example:

SAVE:3
*SAVE:3*

**RECALL:n**

Recalls saved configurations. The value of n must be between 1 and 5. Example:

RECALL:2
*RECALL:2*

**FAULT?**

Returns the fault codes. If no fault the response will be 0. Example:

FAULT?
*0*

**FAULT:CLEAR**

Clears the fault codes. Example:

FAULT:CLEAR
*FAULT:CLEAR*

## ❖ Fault Codes

The following are the fault codes:

- 0 = no fault code, system ready to be enabled.
- 1 = enable fault code, the BNC shorting plug is not present. The enable BNC connection is made with less than 1000 Ω (shorted), or use the factory supplied shorting plug.
- 2 = temperature fault code, the system has exceeded the allowed temperature for operation. The system will need to cool down and will require the customer to press the “Home” button to clear this fault code.


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# Warranty and Service

## ❖ Warranty

Directed Energy, Inc. (DEI) warrants equipment it manufactures to be free from defects in materials and factory workmanship under conditions of normal use, and agrees to repair or replace any standard product that fails to perform as specified within one year after date of shipment to the original owner. OEM, modified, and custom products are warranted, as stated above, for ninety (90) days from date of shipment to original owner. This Warranty shall not apply to any product that has been:

I. Repaired, worked on, or altered by persons unauthorized by DEI in such a manner as to injure, in DEI's sole judgment, the performance, stability, or reliability of the product;
II. Subjected the product to misuse, neglect, or accident; or
III. Connected, installed, adjusted, or used otherwise than in accordance with instructions furnished by DEI.

DEI reserves the right to make any changes in the design or construction of its products at any time, without incurring any obligation to make any change whatever in units previously delivered.

DEI's sole obligation, and buyer's sole remedies, under this agreement shall be limited to a refund of the purchase price, or at DEI's sole discretion, to the repair or replacement of products in kind that prove, to DEI's satisfaction, to be defective, when returned to the DEI factory, transportation prepaid by the buyer, within the warranty period. DEI shall in no way be liable for damages consequential or incidental to defects in its products, for failure of delivery in whole or in part, for injuries resulting from its use, or for any other cause.

Returns must be preauthorized and accompanied by a DEI return authorization number.

The foregoing states the entire warranty extended by DEI, and is given and accepted in lieu of 1) any and all other warranties, expressed or implied, including but not limited to the implied warranties of merchantability and fitness for any particular purpose and 2) any obligation, liability, right, claim or remedy in contract or tort.



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# ❖ Factory Service and Support

For more information about your instrument or for an operation problem, please contact the factory:

Directed Energy, Inc.
1609 Oakridge Dr., Suite 100
Fort Collins, Colorado 80525
(970) 493-1901, ext. 101

sales@ixyscolorado.com
techsupport@ixyscolorado.com
http://ixyscolorado.com/

# Declaration of Conformity

## CE DECLARATION OF CONFORMITY

CE

### DECLARATION OF CONFORMITY

Manufacturer's Name: Directed Energy Inc.

Manufacturer's Address: 1609 Oakridge Drive, Suite 100; Fort Collins, CO 80525; USA

Equipment Description: Pulsed Voltage Source

Equipment Model Designation: PVX-4000-2kV

Application of Council Directive: 73/23/EEC on the harmonization of the laws related to Member States relating to electrical equipment designed for use within certain voltage limits, as amended by: Council Directive 93/68/EEC and Council Directive 2014/108/EC, FCC Part 15 and ICES-003 on the approximation of the laws related to Member States relating to electromagnetic compatibility.

| Referenced Safety Standards: | Referenced EMC Standards: |
|---|---|
| IEC 61010-1 | EN 55011 |
| EN 61010-1 | 47 CFR FCC Part 15 |
| | ICES-003 |
| | EN61326-1 |
| | EN 61000-3-2 |
| | EN 61000-3-3 |
| | EN 61000-4-2 |
| | EN 61000-4-3 |
| | EN 61000-4-4 |
| | EN 61000-4-5 |
| | EN 61000-4-6 |
| | EN 61000-4-8 |
| | EN 61000-4-11 |

I, the undersigned, hereby declare that the equipment specified above conforms to the above Directive(s) and Standard(s).

Signature:

Printed Name: Stephen Krausse

Title: DEI General Manager



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