



DIRECTED ENERGY, INC.

**PCX-7410
10A CW/QCW
Laser Diode Driver/Current Source
OPERATION MANUAL**

SERIAL NUMBER: _____

DATE: _____

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******* WARNING *******

SAFE OPERATING PROCEDURES AND PROPER USE OF THE EQUIPMENT ARE THE RESPONSIBILITY OF THE USER OF THIS SYSTEM.

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.

1.0 Quick-Start Guide

This quick-start guide provides a step-by-step guide to manually operating the PCX-7410. Please refer to the appropriate sections of the manual for additional instructions and guidelines. The SAFETY warnings in the manual should be read and understood prior to operating the PCX-7410.

1.1 Turning On And Operating The PCX-7410

1. Connect the *Output* to an appropriate load using the output stripline supplied by DEI. The output is provided on a DB-37 connector. Pins 1-19 are negative, and should be connected to the laser diode cathode. Pins 20-37 are positive, and should be connected to the laser diode anode. Pins 1-19 are the wider row of the connector, and are on the top side. Pins 20-37 are the narrower row of the connector, and are on the bottom side.
2. Pins 4 and 12 of the rear panel DB-15 connector labeled "Control Port" are switch closure interlocks. These pins are in series with the output cable interlock. These pins can be wired to a door switch, system kill switch, or other safety interlock. If the pins are not connected, or if the output cable interlock is broken, the unit will issue an interlock fault, and will cease operation. **If an external interlock circuit is not used, the INTERLOCK pins 4 and 12 must be jumpered together in order to satisfy the PCX-7410's interlock circuit. If the INTERLOCK pins are not jumpered together, the user will not be able to enable the output and an Interlock Fault will be displayed on the LCD.** The output cable is also interlocked. See Section 6.4.1 for details.
3. Plug the AC power cord into the PCX-7410, and into an appropriate AC socket.
4. Turn on the PCX-7410 by pressing the **POWER** button.
5. The front panel display will read *PCX-7410 Ver X.X* on the top line and *Local Mode* on the bottom line.
6. Press **SELECT** to access the *Config Pulses* menu. Choose *Yes* by turning the **ENCODER** wheel and press **SELECT** to enter the menu. The display will now read *Trig Source: IntPRF*. By turning the **ENCODER** wheel chose between Internal PRF, External PRF and Single Shot. Press the **SELECT** button when the desired mode is displayed.
7. If the *Internal PRF* trigger source (this is the default) was selected, the next option displayed is the Pulse Frequency. The **RANGE** button selects the frequency exponent, and the encoder wheel sets the number. Using the **RANGE** button and **ENCODER** wheel, select the desired frequency. The power-on default is 20.0Hz. To choose 2.00KHz, press the RANGE button 2 times. The first press will change the frequency to 200Hz and the second to 2.00KHz. The encoder wheel will then allow you to set an specific value. Press **SELECT** to implement

the selection. If your selections are OK, press **SELECT** again to move to the next option, otherwise readjust and repeat.

8. The next option displayed is the *Pulse Width Config* menu. Adjusting the Pulse Width is done in the same manor as Frequency. The power-on default is 1.00 μ s. Using the **RANGE** button and **ENCODER** wheel, select the desired Pulse Width. Press **SELECT** to implement the selection. If your selections are OK, press **SELECT** again to move to the next option, otherwise readjust and repeat.
9. The next option displayed is the *Duty Cycle Config* menu. If a Pulse Width was selected in the previous menu, this menu can be skipped by pressing **SELECT**. If no Pulse Width was previously selected, the Duty Cycle can be set using the **ENCODER**. When the desired Duty Cycle is displayed press **SELECT**. The next thing displayed is the updated pulse width. Press **SELECT** again to move back to the main menu.
10. The display will read *Config Pulses* again. To move to the next menu press select. To readjust Pulse parameters turn the **ENCODER** until the display reads yes, press **SELECT** and repeat previous setup.
11. The next option lets you choose the amplitude of the Bias Current and the Pulsed Current. The display will read *Config Output*. To enter this menu turn the **ENCODER** until yes appears on the display, then press **SELECT**.
12. The display will read *Ibias 0.0A*. Using the **RANGE** button and **ENCODER** wheel, select the desired Bias Amplitude. Press **SELECT** to implement the selection. Press **SELECT** again to move to the next option.
13. The display will read *Iforward 0.0A*. Using the **RANGE** button and **ENCODER** wheel, select the desired Bias Amplitude. Press **SELECT** to implement the selection. Press **SELECT** again to move back to the main menu.
14. The display will read *Config Output* again. To move to the next menu press select. To readjust Pulse parameters turn the **ENCODER** until the display reads yes, press **SELECT** and repeat previous setup.
15. The next menu is for setting the Over Current and Over Voltage trip points. The power-on default for Over Current is 10 amps and the default for Over Voltage is 20 volts. To change these values turn the **ENCODER** wheel clockwise to change the display to **YES**. Press the **SELECT** button. The first option is Over Current. Using the **RANGE** button and **ENCODER** wheel, select the desired Over Current trip point. Press **SELECT** to implement the selection. Press **SELECT** again to move to the Over Voltage trip. Again use the **RANGE** button and **ENCODER** wheel, select the desired Over Voltage trip point. Press **SELECT** to implement the selection. Press **SELECT** again to move back to the main menu.
16. The unit is now completely set. To enable both the I-forward and the I-bias current sources in summed operation simply press the **PULSE ON** button from

any menu location. To Disable Output press the **PULSE ON** button again from any menu location. (The default Enable Output setting is to enable I-forward and I-bias. See Section 8.5 for more details about the *Enable Outputs* options)

17. To return back to the start point press the **MODE** button.
18. When the PCX-7410 is operating with the default enable output setting of I-forward + I-bias, the pulsed current setpoint (I_f) and bias current setpoint (Bias) are displayed on the LCD display, and the "Pulse On" LED is illuminated.
19. The front panel analog current monitor BNC connector labeled "I MON" is used to view a scaled representation of the output current waveform. This monitor may be connected to the input of an oscilloscope using a 50Ω terminator. The scaling of this monitor is $20A/V$ into 50Ω . The waveform shape and amplitude is representative of the actual output current waveform.

2.0 PCX-7410 DESCRIPTION

2.1 Conceptual Description

The PCX-7410 is a laser diode driver capable of generating DC and pulse current waveforms. The PCX-7410 incorporates two internal current sources that are summed to form the output current waveform. One current source can generate DC signals from 0 to 5A and the second can generate square wave pulsed signals from 0 to 10A. When summed together the PCX-7410 can generate a signal capable of a maximum 10A peak current with a offset from 0 to 5A DC. This unique current source design makes the PCX-7410 a great solution to address a broad scope of applications.

The PCX-7410 can be locally controlled from its front panel using the buttons and encoder wheel. If remote hosting is desired the PCX-7410 can be controlled using a modified SCPI protocol through its RS-232 or GPIB port. This language based command set makes remote controlling the PCX-7410 easy to learn and easy to operate.

Up to five user configurations may be stored in internal non-volatile memory, and recalled through the front panel or through a remote interface.

The PCX-7410 offers the following features:

Frequency	Pulse repetition frequency from single shot to 100KHz
Pulse Width	Each channel provides independently adjustable width, with 25ns resolution
Width And Duty Cycle	The width of the output pulses can be programmed, or the width calculated based on a duty cycle (ratio of pulsing to not pulsing)
Trigger Sources	Internal, External, Single-Shot (Front Panel Pushbutton)
I-bias Setpoint	Sets the desired DC current amplitude in the output current waveform. This can be from 0 to 5A.
I-Pulse Setpoint	Sets the desired pulsed current amplitude in the output current waveform. This can be from 0 to 10A
Output Polarity	Positive or negative output voltage polarity
Configuration Store And Recall	Stores up to 5 user configurations in non-volatile memory

3.0 SPECIFICATIONS

PARAMETER	Value
PULSE OUTPUT	
Polarity	Positive or Negative, user-selectable via front panel or computer interface
Current Range	10mA to 10A
Maximum Voltage	>18V
Maximum Duty Cycle	95% in pulsed mode at full current, CW (DC) at up to 5A
Pulse Current Resolution	10mA
Pulse Rise Time	<30ns (10%-90%)
Over/undershoot	<5%
Ripple	<1%
Output Connector	DB37 with a stripline connector, rear panel
CW (DC) BIAS CURRENT	
Current Range	10mA to 5A
Maximum Voltage	18V
Bias Current Resolution	10mA
Bias Ripple	<0.5% of maximum
INTERNAL RATE GENERATOR	
Trigger Modes	Internal PRF, Single-Shot, External Trigger
Pulse Recurrence Frequency	Single Shot, 2Hz to 100KHz internal, >1 MHz externally triggered ⁽¹⁾
Frequency Resolution	3 Digits
Frequency Accuracy	25ppm
Rate Jitter, 1 st Sigma	30E-9 x Rate Period
Pulse Width	50 Nanoseconds to 500 Milliseconds and CW
Pulse Width Resolution	25 Nanoseconds below 1 Microsecond 50 Nanoseconds from 1 Microsecond to 10 Microseconds 3 Digits Above 10 Microseconds
Duty Cycle	1% to 95% in 1% resolution
EXTERNAL TRIGGER INPUT	
Type	Positive Edge Trigger
Input Amplitude	TTL into 50Ω
Minimum Trigger Pulse Width	100ns
Input Trigger Connector	BNC, Front Panel
SYNC MONITOR OUTPUT	
Sync Monitor Output	TTL output into 1 MegΩ, 2.5V into 50Ω
Sync Monitor Connector	BNC, Front Panel
CURRENT MONITOR OUTPUT	
Current Monitor Output	20A/1V output into 50Ω
Current Monitor Connector	BNC, Front Panel
COMPUTER INTERFACES	
Serial Interface Type	RS-232 9600 Baud, 8,N,1
Serial Interface Connector	DB-9, Rear Panel
GENERAL	
Internal Non-Volatile Storage	5 Configurations
Operating Temperature Range	0°C to +40°C
Cooling Requirements	Forced air cooled
Input AC Power	90-264VAC, 47-63Hz, 28W Maximum
Dimensions (H X W X D)	3 ½" H x 8 ½" W x 13" D (8.9cm H x 21.6cm W x 33cm D)
Weight	11.8 lbs. (5.4kg) Approximate

(1) At Pulse repetition frequencies > 1MHz, duty cycle should be limited to < 50%.

Table 1: PCX-7410 Specifications

4.0 SAFETY

Normal use of test equipment exposes the user to a certain amount of danger from electrical shock because testing may be performed with exposed voltages present, dictating the use of caution when operating or servicing this equipment. The following is a summary of general safety precautions that must be observed during all phases of operation and repair of the PCX-7410.

4.1 Operating Safety Summary

The safety information contained in this summary is for both operating and servicing personnel. Specific warnings may be found throughout this manual, but may not appear in this summary.

4.1.1 Power Source

The PCX-7410 is designed to operate from a regulated power source. To assure proper system operation the input voltage should not vary by more than 10% from the recommended specification. PCX-7410 accepts input voltages from 90VAC to 264VAC at 47Hz to 63Hz.

A protective grounding connection by way of the grounding conductor in the AC power cord is essential.

4.1.2 Grounding

The PCX-7410 is grounded through the grounding conductor of the AC power cord. **To avoid electrical shock, plug the PCX-7410 into a properly wired receptacle before making connection to any input or output connectors.** Use only a power cord that is in good condition.

4.1.3 Cover Removal

To avoid personal injury, do not remove the covers. **Do not operate the PCX-7410 while the covers are removed.** Operating the unit with the top cover removed voids any and all warranties associated with the PCX-7410.

4.1.4 General Operating Precautions

Do not open the unit while the system is in operation. Use caution when handling or removing the output cables while the unit is operating. Turn off equipment when making connections in high voltage or high current circuits. Discharge high voltage capacitors after removing power.

4.2 Servicing Safety Summary

DEI strongly recommends that all repairs and adjustments be performed by factory qualified personnel. DEI will not be responsible for personal injury or damage to the pulse generator that occurs during repair by any party other than the factory. Any repairs, adjustments or modifications made by anyone other than authorized DEI personnel voids the factory warranty.

5.0 PREPARATION FOR USE

5.1 General

After unpacking, initial inspection and electrical installation procedures should be performed to assure that the unit is in good working order. If it is determined that the unit is damaged, the carrier should be notified immediately. Repair problems should be directed to the service department,

Directed Energy, Inc. (DEI),
Fort Collins, Colorado.
Telephone: (970) 493-1901
FAX: (970) 493-1903
EMAIL: deiinfo@directedenergy.com

5.2 Initial Inspection

1. Inspect unit for exterior mechanical damage.
2. Inspect power input cord and input power module for obvious signs of damage.

5.3 Electrical Installation

Standard units are shipped ready for use with a nominal 90 - 264 VAC input.

6.0 OPERATING CONSIDERATIONS

6.1 Local Mode Operation

This is the default operating mode that the unit assumes upon power up. It is designed for user front panel control. This allows the user to configure, test and operate the PCX-7410 without a host PC.

6.2 Remote Mode Operation

Through the RS-232 interface or the GPIB interface, the PCX-7410 can be remotely operated by a host PC. This feature allows the user to create system level control software to run standardized test procedures for research, test or manufacturing validation environments.

6.3 Front Panel Controls and Indicators

The PCX-7410 front panel consists of five function buttons, an encoder wheel, and a display, facilitating stand-alone operation. Below is a brief description of the function supported by each front panel component. The photo identifies each of the controls and indicators.

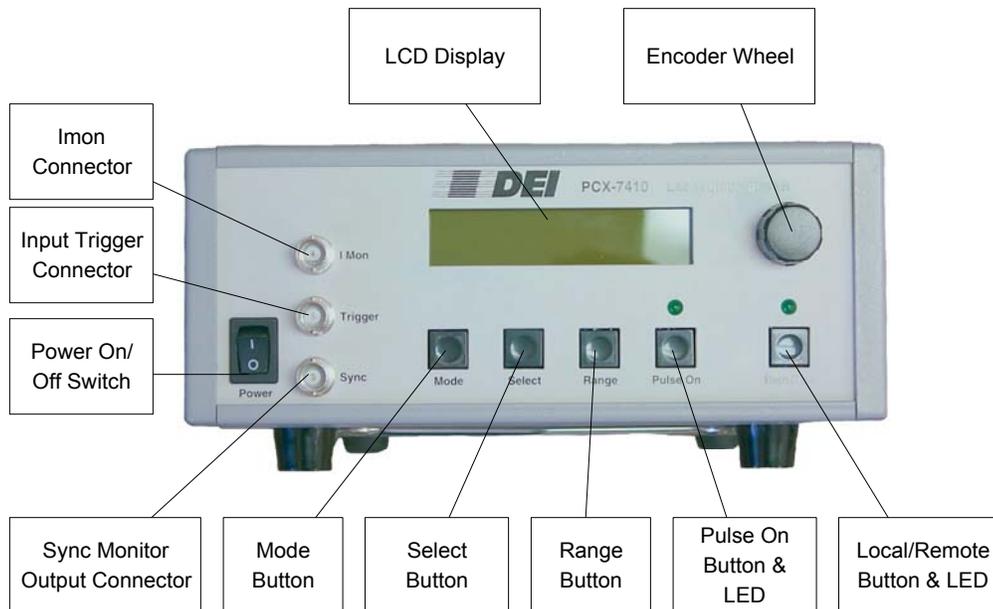


Figure 1
PCX-7410 Front Panel

6.3.1 Power Switch

The switch labeled "POWER" controls all AC power in the chassis. The PCX-7410 has approximately a 3 second power on delay for the internal DC voltage regulators to sequence.

6.3.2 Imon

This is a real time current monitor output suitable for interfacing with an oscilloscope or other data collection system. The output is 20A:1V when operated into a 50 Ohm termination. This signal shows the output current monitored at the PCX-7410, not monitored at the diode load.

6.3.3 Synchronous Pulse Monitor (Sync Monitor)

This is a 5V TTL signal into 1 meg-Ohm or 2.5V signal into 50 Ohms that is synchronous with the frequency generator trigger. This is designed to assist the user in triggering when monitoring the output signals with an oscilloscope, or for use in triggering an external instrument.

6.3.4 External Input Trigger

This is a TTL into 50 Ohm input signal used for external Pulse Repetition Frequency (PRF) triggering. It is designed to allow the user to trigger multiple PCX-7410 units from a single pulse generator. This allows the user to create synchronous waveforms from multiple units.

6.3.5 Mode Button

This button scrolls through the different operating modes.

6.3.6 Select Button

This button is for traversing the PCX-7410 function tree. By pressing the select button the user moves from trunk to branches, from branches to leafs, and from leafs to branches. Additionally the select button calls the leaf functions that implement the commands in the PCX-7410 hardware. This means that after using the selector wheel and/or the range button to vary the configuration the hardware will not implement the new value until the select button has been pressed.

6.3.7 Range Button

The RANGE button is used when varying parameters that have exponents that can change by a power of 10. By pressing the range button the user can increment the exponent within its acceptable range. This allows the user to quickly set the parameters, without having to excessively scroll the encoder wheel. The RANGE button functions with the following commands:

- Set Frequency
- Set Pulse Width
- Set I-Bias
- Set I-Pulse

The RANGE button is effectively a 10X multiplier. For example, when setting frequency, the resolution of the encoder wheel is three digits (i.e. 1.00Hz, 10.0Hz, 100Hz, 1.00KHz). Therefore without adjusting the range, the encoder wheel must be turned many times to increase the frequency from 1Hz to 100Hz. However if the frequency is set to 1.00Hz, if the RANGE button is pressed once, it changes to 10.0Hz. If it is pressed twice, it changes to 100Hz. When pressed three times, it changes to 1.00KHz. Therefore from the power-up default of 1.00Hz, to set the output to 100Hz, press the RANGE button twice. Pressing it once will change it to 10.0Hz, and pressing it again will change it to 100Hz.

Setting the pulse width is similar to setting frequency. For example, to set the width to 300ns, set the width to 25ns, press the RANGE button once to increment it to 250ns, then rotate the encoder wheel to increase it to 300ns. At this point, pressing the RANGE button again would increase the width to 3.00us, pressing it again increments it to 30.0us, etc.

6.3.8 Pulse On Button

This button enables and disables the output current. It has a corresponding LED which illuminates if the output is enabled.

6.3.9 Local/Remote Button

This button is for switching the PCX-7410 into remote or GUI controlled operation or into local front panel control. This button has a corresponding LED. This front panel indicator displays the unit's control mode. In local front panel control mode the LED is OFF. If operating from a serial remote host the LED is ON.

6.3.10 Encoder Wheel

This is for varying the parameters such as Frequency, Pulse Width, I-Bias, I-Pulse, etc. Additionally it is also used to answer all yes and no confirmation questions.

6.4 Rear Panel Connectors



Figure 2
PCX-7410 Rear Panel

6.4.1 Output Connector

The female DB-37 connector labeled "Output" is the current source output. The output is provided on a DB-37 connector. Pins 1-19 are negative, and should be connected to the laser diode cathode. Pins 20-37 are positive, and should be connected to the laser diode anode. Pins 1-19 are the wider row of the connector, and are on the top side. Pins 20-37 are the narrower row of the connector, and are on the bottom side.

The output cable of the PCX-7410 is interlocked through a magnetic interlock switch. This switch is wired in series with the external interlock circuit on the "Control Port" DB-15 connector (see Section 6.4.4). The output cable provided by DEI has a magnet installed on the cable housing. This cable must be plugged into the PCX-7410 in order to satisfy the interlock circuit. **If the output cable is not plugged in, the interlock will not be satisfied and the user will not be able to enable the output and an Interlock Fault will be displayed on the LCD.**

If a user-supplied cable is used in place of the cable provided with the unit, the magnetic interlock switch must be closed using a magnet comparable to that provided with the DEI-supplied output cable. DEI does not recommend using an output cable other than the one provided with the PCX-7410.

6.4.2 RS-232 Connector

The male DB-9 connector labeled "RS-232" is the RS-232 interface for those units with the optional RS-232 interface. Its pin out is standard three wire RS-232. The serial operating parameters are baud rate is 9600, 8 data bits, no parity, and 1 stop bit.

Pin No.	Name	Function
Pin 2	TxD	Receive
Pin 3	RxD	Transmit
Pin 5	GND	Ground

6.4.3 GPIB Connector

This female 24 pin connector is a standard General Purpose Instrument Bus (GPIB) interface. The pin out corresponds to the industry standard and to avoid redundancy it is not broken out here. The PCX-7410 default GPIB address is 1

6.4.4 Control Port Connector

The female DB-15 connector labeled "Control Port". It is used for interfacing an external interlock with the PCX-7410. Only two of the pins are used, the others are reserved for future development.

Pin No.	Description
Pin 4	Interlock-1
Pin 12	Interlock-2
All Others	Reserved

Pins 4 and 12 of this connector are switch closure interlocks. These pins are in series with the output cable interlock. These pins can be wired to a door switch, system kill switch, or other safety interlock. If the pins are not connected, or if the output cable interlock is broken, the unit will issue an interlock fault, and will cease operation. **If an external interlock circuit is not used, the INTERLOCK pins 4 and 12 must be jumpered together in order to satisfy the PCX-7410's interlock circuit. If the INTERLOCK pins are not jumpered together, the user will not be able to enable the output and an Interlock Fault will be displayed on the LCD.**

6.4.5 AC Power Entry Module

The driver is grounded through the grounding conductor of the AC power cord. To avoid electrical shock, plug the driver into a properly wired receptacle before making connection to any input or output connectors. Use only a power cord that is in good condition.

The PCX-7410 accepts input voltages of 90-264VAC, 47-63Hz.

7.0 HARDWARE OPERATING INSTRUCTIONS

This section provides basic operating instructions for the PCX-7410 hardware.

7.1 Power-Up Procedures

The unit should be powered up using the following procedures:

1. Connect the *Output* to an appropriate load using the output stripline supplied by DEI or other low inductance cable. (See Section 6.0).
2. Pins 4 and 12 of the rear panel DB-15 connector labeled "Control Port" are switch closure interlocks. These pins are in series with the output cable interlock. These pins can be wired to a door switch, system kill switch, or other safety interlock. If the pins are not connected, or if the output cable interlock is broken, the unit will issue an interlock fault, and will cease operation. **If an external interlock circuit is not used, the INTERLOCK pins 4 and 12 must be jumpered together in order to satisfy the PCX-7410's interlock circuit. If the INTERLOCK pins are not jumpered together, the user will not be able to enable the output and an Interlock Fault will be displayed on the LCD.**
3. Plug the AC power cord into the PCX-7410, and into an appropriate AC socket.
4. Turn on the PCX-7410 by pressing the **POWER** button.
5. Configure the unit from either the front panel, GPIB or RS-232 port. See the quick-start guide in Section 1.0 of this manual for specific operating instructions, and Sections 8 and 9 for detailed operation instructions.

8.0 LOCAL MODE OPERATING INSTRUCTIONS

8.1 PCX-7410 Home Menu

Local mode operation is implemented with a command function tree. The trunk of the tree would be represented by the home state. This is the *Home Menu*. From the *Home Menu* the other branches of the function tree can be accessed. Other main branches include *Config Pulses*, *Config Output*, *Set Trip Values*, *Enable Outputs* and *Update Configs* are accessible. Metaphorically speaking each of these menus has leaves below them. For example from the *Config Pulses* branch the leaf functions of *Set Trig Source*, *Set Freq*, *Set Width*, and *Set Duty Cycle* are accessible.

Included in Appendix A located at the end of this manual is the local mode menu tree diagram. It is recommended that the user keep this menu tree handy when first learning the structure of the Local mode operation. Once the user is familiar they

will find local mode operation a handy alternative for configuring and operating the PCX-7410.

8.2 Configuring the Pulse Generator Branch

The PCX-7410 allows the user to configure the pulse generator parameters of trigger source frequency, and pulse width. From this menu state the user can select Yes or No to either access the pulse generator parameters or skip them, respectively.

8.2.1 Setting the Trigger Source

This is where the user can choose from Internal Pulse Repetition Frequency (IntPRF), External PRF (ExtPRF), External Tracking PRF (ExtTRK) or Single Shot (SS) mode. In internal frequency generator mode, the repetition rate is internally generated based on a 24MHz crystal oscillator. External PRF and External Tracking PRF allow the PCX-7410 to be triggered by an external pulse generator or control system. An array of PCX-7410's can be remotely controlled by a host PC and gated from one pulse generator. The Single Shot mode is for applications that need single pulses or frequencies less than one hertz.

In Internal PRF (IntPRF) mode, the frequency is set through the *Set Freq* command and the pulse width is set through the *Set Width* command.

In External PRF (ExtPRF) mode, the pulse frequency is controlled by the input trigger, and the pulse width is set through the *Set Width* command. When a TTL trigger is received on the front panel trigger input, output pulses are generated, with width equal to the width set in the *Set Width* command.

In External Tracking (ExtTRK) mode, the pulse frequency and pulse width are controlled by the input trigger. When a TTL trigger is received on the front panel trigger input, output pulses are generated, with the width equal to the width of the input trigger, at the frequency of the input trigger. For example, if the trigger is 1 microsecond in width repeating at 100Hz, the output pulse will also be 1 microsecond in width repeating at 100Hz. If the trigger input is increased to 2 microseconds in width, the output pulse width will increase to 2 microseconds in width.

In Single-Shot (SS) mode, when the **PULSE ON** front panel button is pressed, an output pulse is generated, with width equal to the width set in the *Set Width* command.

8.2.2 Setting Frequency

Available only when the trigger source is in the Internal PRF mode. Frequency can be varied by the encoder wheel and/or the range button for user convenience. The **RANGE** button selects the frequency exponent, and the encoder wheel sets the

number (see Section 6.3.7 above). The unit supports 1% resolution of frequencies and allows for user control to this level of accuracy.

8.2.3 Setting Pulse Width

The pulse width specifies the duration of the output pulse. The **RANGE** button can be used for changing the pulse width exponent, and the encoder wheel sets the number. Using the **RANGE** button and **ENCODER** wheel, select the pulse width (see Section 6.3.7 above). The PCX-7410 supports 1% accuracy, and the width is displayed in engineering units.

8.2.4 Setting Duty Cycle

Only available in the Internal PRF trigger source, this variable is for users who do not want to manually calculate the pulse width to frequency ratio. Based upon the internal frequency generator setpoint, the PCX-7410 will change the pulse width to match the desired “Pulse On Time” duty cycle. If a pulse width is entered, the *Duty Cycle* does not need to be entered. Conversely, if Duty Cycle is selected, the pulse width will be calculated and implemented by the PCX-7410 based upon the frequency and duty cycle that are entered. The duty cycle is varied using the **ENCODER** wheel.

8.3. Configuring the Output Current Source Branch

The PCX-7410 allows the user to configure the pulse and DC current source set points and the pulse polarity. From this menu state the user can select *Yes* or *No* to either access the output current source parameters or skip them, respectively.

8.3.1 Setting the I-Bias Current Source

The I-bias is the DC component of the output current waveform. The I-bias has resolution of 10mA and can be set from 0 to 5A. The **RANGE** button can be used for changing the I-bias exponent, and the encoder wheel sets the number. Using the **RANGE** button and **ENCODER** wheel, select the I-bias.

When set to zero the I-bias current source is not enabled and is not used to create the output current source. When operating without the I-bias current source the PCX-7410 is an excellent pulsed current source.

8.3.2 Setting the I-Forward Current Source

The I-forward is the pulsed component of the output current waveform. The I-forward has resolution of 10mA and can be set from 0 to 10A. This current pulse is has the AC characteristics of frequency and width set in the *Config Pulses* branch. The PCX-7410 is limited to a maximum output current of 10A. When the I-bias and I-forward reach a sum of 10A the PCX-7410 issues a warning message and will not let the operator set the current sources above this limit.

When set to zero the I-forward current source is not enabled and does not contribute to the output current source. When operating without the I-forward current source the PCX-7410 is an excellent DC current source.

The **RANGE** button can be used for changing the I-forward exponent, and the encoder wheel sets the number. Using the **RANGE** button and **ENCODER** wheel, select the I-forward.

8.3.3 Setting Pulse Polarity

The pulse polarity configures the output voltage polarity of the PCX-7410. The **ENCODER** wheel when turned to the right will set *Positive* polarity. When turned to the left it will change to *Negative* polarity.

When in positive polarity the negative output terminal is connected to ground and the voltage pulse is positive with respect to ground. This is also called common anode configurations.

In negative polarity the positive terminal is connected to ground and the voltage pulse is negative with respect to ground. This is also called common cathode configuration.

8.4 Setting Trip Values

For diode load protection the PCX-7410 is equipped with over current and over voltage protection. Properly setting these limits will ensure the output waveform stays in the safe operating region for any load connected to the PCX-7410.

8.4.1 Setting Voltage Trip

This voltage trip is a protection circuit that monitors the voltage output at the PCX-7410. When the voltage exceeds this limit the hardware is disabled and the digital control system reports a fault. This value can be changed from 0 to 20V in 100mV increments. The **RANGE** button can be used for changing the voltage trip exponent, and the encoder wheel sets the number. Using the **RANGE** button and **ENCODER** wheel, select the voltage trip

8.4.2 Setting Current Delta Trip

This current delta trip is a protection circuit that monitors the current output at the PCX-7410. This value is specified as an incremental increase or current delta above the output current. This method allows the PCX-7410 to monitor DC and pulsed waveforms with the same incremental current trip and not need separate trip set points for each the bias current source and the pulsed forward current source.

When the current exceeds the output current **plus** this current delta value the hardware is disabled and the digital control system reports a fault. This value can be changed from 0 to 10A in 50mA increments. The **RANGE** button can be used for

changing the current delta trip exponent, and the encoder wheel sets the number. Using the **RANGE** button and **ENCODER** wheel, select the current delta trip

8.5 Enable Output

This option lets the user specify which current source they wish to have the **PULSE ON** button enable and disable. The PCX-7410 will allow the user to enable/disable only the I-bias DC current source, or the I-forward AC current source, or both summed together. The **ENCODER** wheel when turned to the right will take move from I-forward to I-bias to I-bias + I-forward. When turned to the left it will change from I-bias + I-forward to I-bias to I-forward.

One unique operating mode that the PCX-7410 allows is to operate with the bias current enabled and then manually enable and disable the I-forward AC current source. To do this first configure the pulse generator parameters and set the I-bias and I-forward to the desire current levels. Then in the *Enable Outputs* branch set the **PULSE ON** button to only turn on the I-bias current source. Implement this by pressing the **SELECT** button. Now press the **PULSE ON** button and the I-bias DC current will be enable, but the I-forward AC current will not be. Now to enable and disable the I-forward current only under the *Enable Outputs* branch select the I-forward option and this will set the **PULSE ON** button to enable/disable the I-forward AC current. Now the DC bias will stay enabled and the AC I-forward can be controlled independently. To turn off the bias current change the **PULSE ON** button back to the I-bias option in the *Enable Outputs* branch and use the **PULSE ON** button.

8.6 Reading and Clearing Faults

In normal operation the PCX-7410 will display the *No Faults* message. However, in the event that a fault is active it will display the *Show Faults?* message. By using the **ENCODER** wheel the user can select *Yes* or *No* to access the fault buffer. When answering *Yes* to the *Show Faults?* message only the active fault will be displayed. Individually displayed and viewed with the **SELECT** button are:

- Interlock Fault
- Over Voltage Fault
- I-Bias Over Current Fault
- I-Forward Over Current Fault
- Over Temperature Fault

8.6.1 Clearing Active Faults

When there is an active fault the PCX-7410 will disable the current output. Before the unit can re-enable current output the faults must be cleared. In the function tree the normal *No Faults* message will be replaced with a *Show Faults?* option. The

ENCODER can be used to bypass the *Show Faults?* menu and access the *Clear Faults* menu. To do this simply use the **ENCODER** to answer the *Show Faults?* option with a “No” and the **SELECT** button to implement the command. Now the *Clear Faults* option is displayed answered with a Yes. Pressing the **SELECT** button causes the PCX-7410 to attempt to clear all active faults. In the event that the fault is not cleared the PCX-7410 will still indicate the *PCX-Faulted* status and user intervention is needed to determine the cause of the fault. Usually the faults are caused by an interlock or output cabling problem.

Answering the *Clear Faults* with a *No* will move to the *Update Configs* menu and no hardware resets will be attempted.

8.7 Saving and Loading System Setups in Local Mode

8.7.1 Saving A System Setup in Local Mode

For user convenience the PCX-7410 has the ability to save up to five different configurations. Using these five configurations the user can keep their most used configurations in a fast access state. By selecting one of the five configurations and saving from this menu option the user can later recall their favorite system setups. Located in non-volatile RAM, the setups will be intact even when system power is off.

Parameters saved are: Configuration Name, Trigger source, Frequency, Pulse Width, I-Bias, I-Forward, V-trip, Delta I-Trip, Pulse Polarity.

8.7.2 Loading A System Setup

To access an existing setup the user can select one of the five saved configurations and then let the PCX-7410 load the different parameters associated with the configuration.

9.0 Operating Modes

9.1 Timing Diagram

The timing diagram below defines the frequency, width variables, and their temporal relationship to each other. Additionally it shows the throughput delay associated with the current sources.

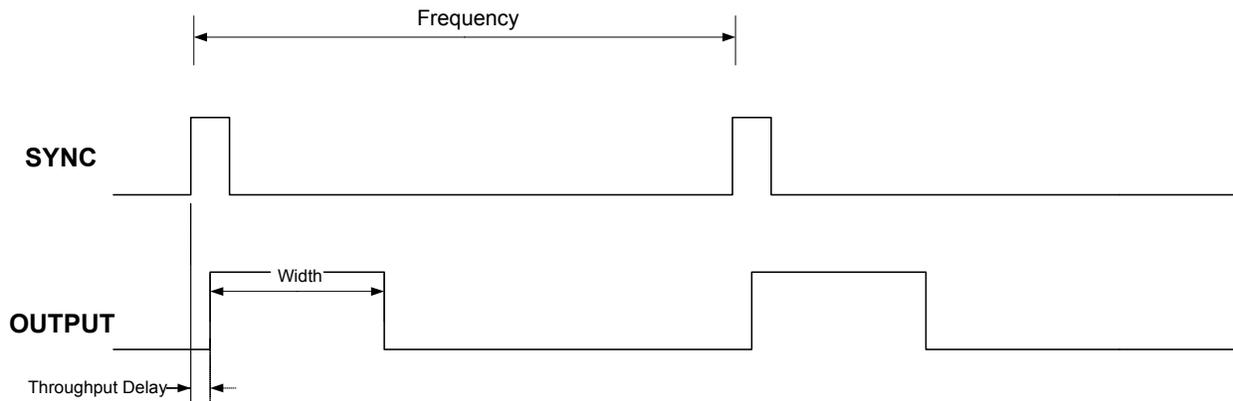


Figure 3
Timing Diagram

Please note that in external trigger mode, all outputs are delayed from the leading edge of the external trigger signal. This external trigger delay is about 50ns.

9.2 CW or DC Current Source Operation

This mode of operation is for creating only a DC current output. The PCX-7410 is capable of creating DC current outputs from 0 to 5A with 10mA resolution. To operate in this mode set the I-bias current source to the desired output current level. Set the I-forward current level to 0A. Next set the Enable Outputs option to I-bias. Now the **PULSE ON** button will enable and disable the DC bias current source, and the pulsed I-forward current source will not be used. (See section 8.3 for details on setting I-bias and I-forward. See section 8.5 for a detailed discussion of the Enable Outputs branch)

9.3 Quasi CW or Pulsed Current Operation

This mode of operation is for creating only a pulsed current output. The PCX-7410 is capable of creating pulsed current outputs from 0 to 10A with 10mA resolution. To operate in this mode set the I-forward current source to the desired output current level. Set the I-bias current level to 0A. Next set the Enable Outputs option to I-forward. Now the **PULSE ON** button will enable and disable the DC bias current source, and the pulsed I-forward current source will not be used. (See section 8.3 for details on setting I-bias and I-forward. See section 8.5 for a detailed discussion of the Enable Outputs branch)

9.4 Summed DC and Pulse Current Operation

This mode of operation allows a DC bias current to be operating and the pulsed I-forward current to be added to this DC bias. To operate in this mode set the I-bias current level to the desired DC bias. Set the I-forward current source to the desired pulsed output current. Next set the Enable Outputs option to I-bias +I-forward. Now the **PULSE ON** button will enable and disable both the bias and the pulsed forward current sources.

An example of how this works is: To have a 3A bias with a pulsed forward current that has a total amplitude of 7.5A here is how to configure the PCX-7410. Configure the pulse generator to the desired trigger source, frequency and pulse width. Set the I-bias to 3A. Next set the I-forward to 4.5A. (The difference between the bias and the amplitude of the pulsed current.) Now set the Enable Outputs to I-bias + I-forward. From here the **PULSE ON** will enable and disable the 3A bias with 7.5A pulse amplitude waveform.

(See section 8.3 for details on setting I-bias and I-forward. See section 8.5 for a detailed discussion of the Enable Outputs branch)

10.0 Remote Hosting

10.1 RS-232 Serial Operation

This remote control port allows a user to connect a personal computer as the remote host to the DEI PCX-7410. Utilizing a standard three wire interface and DEI's defined communication protocol the user can write a custom control program for their particular testing needs.

10.1.1 Serial Instructions:

The serial instructions are sent using an ASCII string of characters to manipulate the PCX-7410 settings. The commands must be sent in their entirety, character by character from a terminal will cause a timeout. The command includes a string of words and if necessary, data or a keyword. Each word in the string has a long form and a short form, the PCX-7410 will recognize both forms. In the table below the short form is represented by capital letters and the long form by the capital letters followed by the lowercase (the entire word). The actual interface is NOT case sensitive so upper/lower case and long/short form can all be interlaced.

The words incased in brackets in the following table are optional and the unit will perform the same instruction whether this word is included in the command or not. In between each word in the string there must be a semicolon in between each of the words with no empty spaces and there should be nothing after the string (the interface will ignore any new line or return characters after it has received a command in its entirety). Before a Data/Keyword there must be at least one space. To query the PCX-7410 on a setting or status, the same string is used except there is no data or keyword and the string is terminated with a question mark. There should be no empty spaces between the string and the question mark. Individual instructions are clarified in the next section along with examples for each command.

Setting	String	Data/Keyword
Pulse Width	[SOURce]:PULSe:WIDTh	In Seconds
Duty Cycle	[SOURce]:PULSe:DCYCLe	0-95
Polarity	[SOURce]:PULSe:POLArity	(POSitive, NEGative)
Frequency	[SOURce]:FREQuency	In Hertz
Trigger Source	[SOURce]:ROSCillator:SOURce	(INTernal,EXTernal, TRK,SingleShot)
Outputs ON/OFF	OUTPut:CHANnel	(ON,OFF)
lforward	IFORward	In mA

Itrip	ITRip	In mA
Ibias	IBIAs	In mA
Vtrip	VTRip	In Volts*10 le: 25 = 2.5V
Faults	FAULt:LIST	N/A
Load Config	MMEMory:LOAD	1-5
Save Config	MMEMory:STORE	1-5
Active Config?	MMEMory:ACTIVE?	N/A
Identify Device	*IDN?	N/A
Enable Outputs	OUTPut:ENABLE:(IBIAs, IFORward,ALL)	N/A
Remote/Local	SYSTem:LOCK	(ON,OFF)
Set GPIB Address	GPIB:ADDRess	0-30
Read GPIB Address	GPIB:ADDRess?	N/A

10.1.2 Individual Instruction Set Clarification

Frequency: Setting the frequency to 15kHz is as follows.

Setting Examples: `FREQ 150E2`, `FREQUENCY 15E3`, etc.

Reading Examples: `FREQUENCY?`, `SOURCE:FREQ?`, etc.

Pulse Width: Setting the pulse width to 150us is as follows. To read the pulse width

Setting Examples -> `SOURCE:PULSE:WIDTH 150E-6`, `PULS:WIDT 15E-5`, etc.

Reading Examples -> `SOURCE:PULSE:WIDTH?`, `PULS:WIDT?`, etc.

Duty Cycle: Acceptable values for this parameter are from 1 to 95, representing the duty cycle values from 1% to 95%. Please note that the PCX-7410 does not compute non whole number values of duty cycle. This means if the duty cycle is 20.3% the PCX-7410 will not respond. Setting the duty cycle to 25% is as follows.

Setting Examples -> `SOURCE:PULSE:DCYCLE 25`, `PULS:DCYCY 25`, etc.

Reading Examples -> `SOURCE:PULSE:DCYCLE?`, `PULSE:DCYCY?`, etc.

Trigger Source: There are three acceptable keywords for this instruction. Setting and reading the trigger source in short form is as follows.

Setting Examples -> `ROSC:SOUR INT`, `ROSC:SOUR EXT`, `ROSC:SOUR SS`, etc.

Reading Examples -> `ROSC:SOUR?`

Pulse Enable (IBIAS only, IFORWARD only, Both):

Setting Examples -> OUTP:ENAB:IBIAS, OUTP:ENAB:IFORWARD, OUTP:ENAB:ALL, etc.

Reading Examples -> OUTP:ENAB?

Save Configurations: Save configuration 3 is as follows

Examples -> MMEM:STOR 3, mmemory:store 3, etc.

Load Configuration: Loading configuration 3 is as follows

Examples -> MMEM:LOAD 3, mmemory:load 3, etc.

Read Active Configuration: This will read the most current active configuration.

Example: MMEM:ACTIVE?

IBIAS: To set Ibias to 3.4 amps is as follows:

Setting Examples -> IBIAS 3400, IBIA 34E2, etc.

Reading Examples -> IBIAS?, IBIA?

IFORWARD: To set Iforward to 3.4 amps is as follows:

Setting Examples -> IFOR 3400, IFORWARD 34E2, etc.

Reading Examples -> IFORWARD?, IFOR?

ITRIP: To set Itrip to 3.4 amps is as follows:

Setting Examples -> ITRIP 3400, ITR 34E2, etc.

Reading Examples -> ITRIP?, ITR?

VTRIP: To set Vtrip to 12.5 Volts is as follows:

Setting Examples -> VTR 125, VTRIP 125, etc.

Reading Examples -> VTR?, VTRIP?

FAULTS: To reset/read the faults is as follows.

Resetting Examples -> FAULT:LIST RES, FAUL:LIST RESET, etc.

Reading Examples -> FAULT:LIST?

TURNING ON/OFF OUTPUT: To turn on the output is as follows.

Setting Examples -> OUTP:CHAN ON, OUTPUT:CHANNEL ON, etc.

Reading Examples -> OUTP:CHAN?

Local/Remote Mode: Turning the unit to remote mode is as follows.

Setting Examples -> SYSTEM:LOCK ON, SYST:LOCK ON, etc.

Reading Examples -> SYST:LOCK?

DPE Set Address: To set the GPIB primary address of the PCX-7410. Here is an example of setting the address to 2.

Setting Example -> GPIB:ADDR 2

DPE Read Address: To read the GPIB primary address of the PCX-7410.

Reading Example -> GPIB:ADDR?

10.1.3 Serial Programming Features and Limitations

- When the PCX-7410 is in remote mode it disables the encoder wheel and all of the user front panel buttons except for Local/Remote. This button allows the user to change the mode from the unit's front panel interface.
- The PCX-7410 will accept remote commands in Local mode. Please note that if the remote host elects to operate in this mode it becomes the remote host's responsibility to poll for any parameter status change. The PCX-7410 does not notify the remote host when parameters change.
- The PCX-7410 will not accept one character at a time, the string must be sent in its full command form.

10.2 GPIB Operation

The default gpib address in the PCX-7410 is address 1. The protocol for sending commands over the gpib is the same as the RS-232 interface. The PCX-7410 expects the commands to be terminated only with an EOI signal. There should be no terminating characters other than the EOI. Additionally, due to code overhead, the instructions should be sent with at least 100ms between commands to allow for processing. For specific commands see the previous section 10.1.

11.0 FACTORY SERVICE AND SUPPORT

For more information regarding your PCX-7410 system or for information pertaining to an operational problem, please contact the factory for further assistance:

DIRECTED ENERGY, INC.
2401 RESEARCH BLVD SUITE 108
FORT COLLINS, CO 80526
TEL (970) 493-1901
FAX (970) 493-1903
EMAIL deiinfo@directedenergy.com

12.0 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 the 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 judgement, the performance, stability, or reliability of the product;
- II. Subjected to misuse, negligence 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.

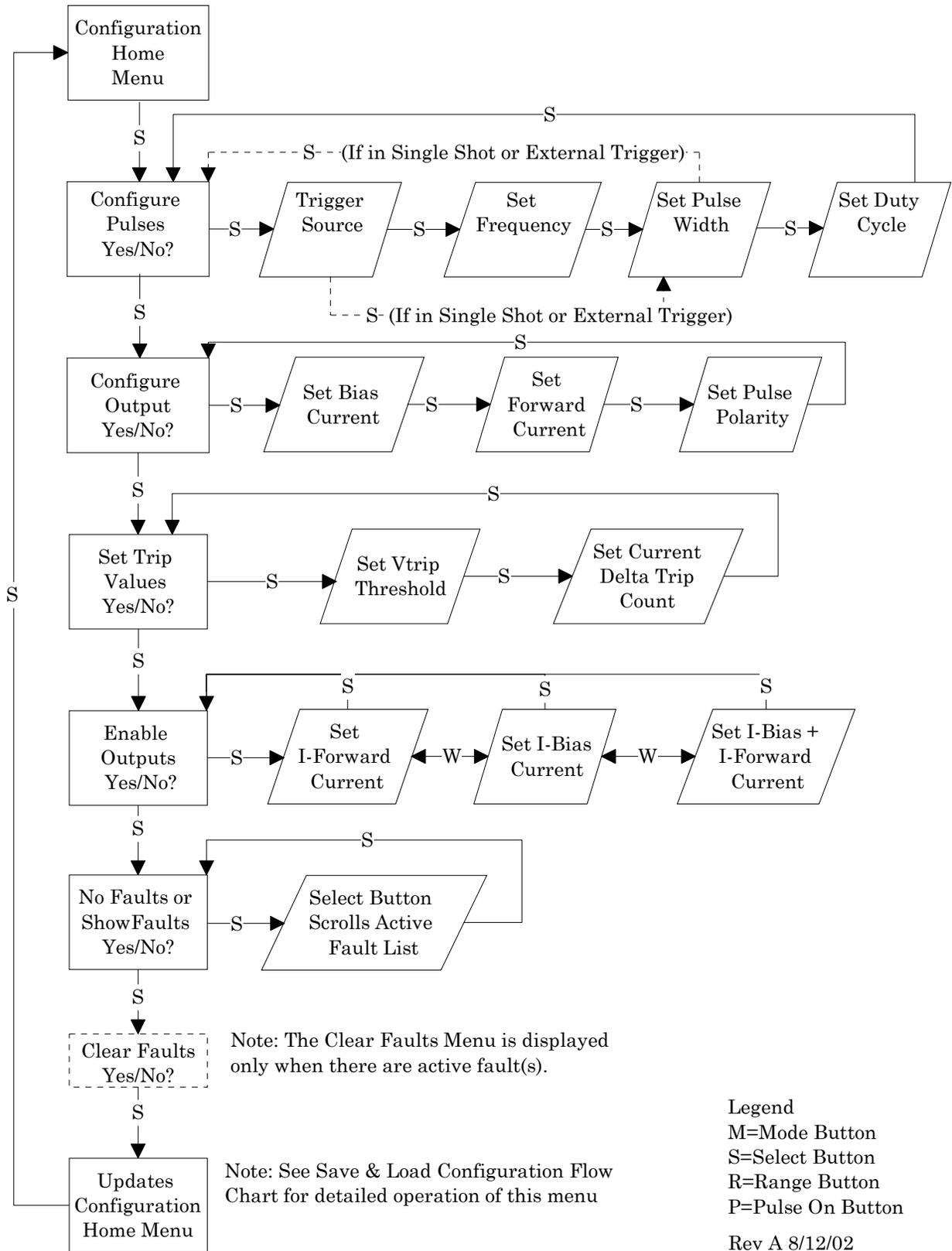
DEI's sole obligation, and buyer's sole remedies, under this agreement shall be limited to a refund of the purchase price, or at DEI's sole discretion, to the repair or replacement of products in kind that prove, to DEI's satisfaction, to be defective, when returned to the DEI factory, transportation 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 by 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.

Appendix A

PCX-7410 Function Tree



Legend
 M=Mode Button
 S=Select Button
 R=Range Button
 P=Pulse On Button

Rev A 8/12/02
 PCX-7410 Operation.flo

PCX-7410 Function Tree: Update Configuration Menu

