DATREND Systems Inc.

vPad-XSC™

Automation Interface for Impulse 7000 Defibrillator Analyzer

User Manual

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DATREND Systems Inc.

To order this manual, use Part Number 6100-097

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Unpacking and Inspection

Follow standard receiving practices upon receipt of the instrument. Check the shipping carton for damage. If damage is found, stop unpacking the instrument. Notify the freight carrier and ask for an agent to be present while the instrument is unpacked. There are no special unpacking instructions, but be careful not to damage the instrument when unpacking it. Inspect the instrument for physical damage such as bent or broken parts, dents, or scratches.

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Our routine method of shipment is via common carrier. Upon delivery, if physical damage is found, retain all packing materials in their original condition and contact the carrier immediately to file a claim.

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This instrument was thoroughly tested and inspected and found to meet DSI’s manufacturing specifications when it was shipped from the factory. Calibration measurements are traceable to the National Research Council of Canada (NRC) and/or the National Institute of Standards and Technology (NIST). Devices for which there are no NRC/NIST calibration standards are measured against in-house performance standards using accepted test procedures.

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Datrend Systems Inc. ("DSI") warrants this instrument to be free from defects in materials and workmanship under normal use and service for 90 days from the date of original purchase. During the warranty period DSI will, at our option, either repair or replace defects in materials and workmanship at no charge; provided the product is returned (shipping, duty, brokerage and taxes prepaid) to DSI. Any and all transportation charges incurred are the responsibility of the purchaser and are not included within this warranty. This warranty extends only to the original purchaser and does not cover damage from abuse, neglect, accident or misuse or as the result of service or modification by other than DSI. IN NO EVENT SHALL DATREND SYSTEMS INC. BE LIABLE FOR CONSEQUENTIAL DAMAGES.

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- Power failure, surges, or spikes,
- Damage in transit or when moving the instrument,
- Improper power supply such as low voltage, incorrect voltage, defective wiring or inadequate fuses,
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This warranty gives you specific legal rights and you may have other rights, which vary from province to province, state to state, or country to country. This warranty is limited to repairing the instrument to DSI's specifications.

When you return an instrument to DSI for service, repair or calibration, we recommend shipment using the original shipping foam and container. If the original packing materials are not available, we recommend the following guide for repackaging:
- Use a double-walled carton of sufficient strength for the weight being shipped.
- Use heavy paper or cardboard to protect all instrument surfaces. Use non-abrasive material around all projecting parts.
- Use at least four inches of tightly packed, industrial-approved, shock-absorbent material all around the instrument.

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Warranty Disclaimer

Should you elect to have your instrument serviced and/or calibrated by someone other than Datrend Systems, please be advised that the original warranty covering your product becomes void when the tamper-resistant Quality Seal is removed or broken without proper factory authorization. We strongly recommend, therefore, that you send your instrument to Datrend Systems for service and calibration, especially during the original warranty period.
In all cases, breaking the tamper-resistant Quality Seal should be avoided at all cost, as this seal is the key to your original instrument warranty. In the event that the seal must be broken to gain internal access to the instrument (e.g., in the case of a customer-installed firmware upgrade), you must first contact Datrend Systems at 1-800-667-6557. You will be required to provide us with the serial number for your instrument as well as a valid reason for breaking the Quality Seal. You should break this seal only after you have received factory authorization. Do not break the Quality Seal before you have contacted us! Following these steps will help ensure that you will retain the original warranty on your instrument without interruption.

WARNING

Unauthorized user modifications or application beyond the published specifications may result in electrical shock hazards or improper operation. Datrend Systems will not be responsible for any injuries sustained due to unauthorized equipment modifications.

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THIS PRODUCT CONTAINS NO USER-SERVICEABLE COMPONENTS. UNAUTHORIZED REMOVAL OF THE INSTRUMENT COVER SHALL VOID THIS AND ALL OTHER EXPRESSED OR IMPLIED WARRANTIES.

Table of Contents

1 Overview

vPad-XSC™ for Impulse 7000 (referred to as "*the Interface*" in this manual) is an intelligent hardware interface which supports vPad electrical safety analyzers having the vPad-Check™ software application (App) installed. The Interface allows vPad-Check to conduct automated maintenance and inspection sequences on defibrillators and transcutaneous pacemakers using the Impulse 7000 analyzer from Fluke Biomedical Inc.

In addition to automated control of Impulse 7000 operation, the vPad-XSC provides:

- automatic assessment of measurement results based on user-defined limits
- test reports in summary or detailed format

This manual provides guidance for users integrating vPad-Check™ and the Interface into new and existing maintenance processes.

1.1 Standard Accessories

- XSC Interface unit (P/N 7400-113)
- RJ-12 cable (P/N 3140-069) for connection to XBUS port on vPad safety analyzer
- USB Device cable (P/N 3140-440) for connection to Impulse 7000
- User Manual (P/N 6100-097)

For a complete list of available accessories, visit www.datrend.com or contact Datrend Customer Service (see Chapter 4 for contact details)

1.2 Checklists and vPL

In vPad-Check, equipment maintenance and inspection procedures are called ***Checklists***. A Checklist can contain a sequence of prompts for the operator as well as machine instructions to configure the vPad safety analyzer and to conduct other tests through a remote instrument. In this case, the remote instrument is an Impulse 7000 defibrillator and transcutaneous pacemaker analyzer.

In a Checklist, prompts and machine instructions are written as statements in ***vPad Programming Language*** (vPL). A statement generally consists of a specific keyword followed by one or more parameters. For example, the statement

```
xopen   "Impulse 7000" | U | 5
```

initializes a data connection between the Interface and Impulse using the keyword "`xopen`". Other statements are responsible for configuring and initiating tests through Impulse.

Checklists can be written on the Android tablet, or on a personal computer (PC), using a text editor. Once a new Checklist has been written, it can be imported to vPad-Check through a USB flash drive or directly from the PC. Further information on Checklists and vPL, including a full list of vPL keywords, is provided in the **vPad-Check Operating Manual** which can be opened with the Datrend Docs app: 

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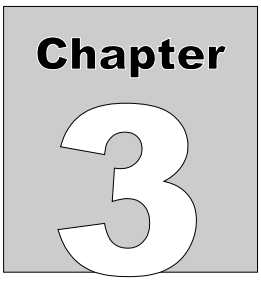
Chapter 2

2 Connection and Setup

Connect the USB-A port of the Interface to the USB-B port of Impulse 7000 using the USB device cable (P/N 3140-440) provided. Power up Impulse and allow it to start up completely before proceeding.

Connect the XBUS port on the Interface to the XBUS port on the vPad safety analyzer using the RJ12 cable (P/N 3140-069) provided with the Interface. Note that the two XBUS ports on the Interface are interchangeable. This enables several vPad-XSC interfaces of different types to be chained in series if necessary.

Once connected to the vPad safety analyzer, the "Power" and "Online" LED indicator on the Interface should light up to show that it is now ready for operation.



3 Checklist Programming

A Checklist contains operator prompts and machine instructions for conducting an automated maintenance and inspection sequence. To create or edit a Checklist (with a *.vpl* extension), you may use any text editor that works with plain text (*.txt*) files. Sample Checklists to control Impulse 7000 through the Interface are provided with your vPad-Check installation.

Any Checklist that controls Impulse may consist of at least three types of instructions: initialization, configuration, and test.

3.1 Initialization

Before attempting to send commands to Impulse, a Checklist must first initialize the connection. For example, the vPL statement

```
xopen    "Impulse 7000" | U | 5
```

causes the Interface to attempt handshaking with Impulse. The character "U" in uppercase is an identifier which represents the vPad-XSC™ for Impulse 7000; the "U" is mandatory and enables vPad-Check to address commands to the Impulse Interface specifically. The value "`5`" sets a delay time in seconds, after which the data connection is checked before proceeding with subsequent Checklist steps; this value can be reduced to "`2`" when a wired connection is in use. "`Impulse 7000`" is simply a description of the device under control by the Interface and this may be modified to a different description, if desired. For a complete explanation of the "`xopen`" statement, refer to the **vPad-Check Operating Manual**.

When vPad-Check encounters this statement, it will interrogate the Interface and notify the operator whether initialization was successful. If handshaking succeeds, the "Online" indicator will light up on the Interface unit. If not, the operator should verify connections and power, then retry the initialization.

3.2 Configuration

As an optional function, the Interface has the ability to automatically assign a pass/fail result for measurement data obtained from Impulse 7000. Configuration statements can set limits for automatic pass/fail assessment, as well as to change Impulse settings for defibrillator and pacemaker tests. In a Checklist, pass/fail limits and Impulse settings are configured with "`xctrl`" statements. For more information on the "`xctrl`" statement, refer to the **vPad-Check Operating Manual**.

3.2.1 Setting Limits and Tolerances

The Interface supports the following Impulse 7000 test functions:

- defibrillator energy
- defibrillator charge time
- defibrillator sync delay (cardioversion)

- pacer pulse
- pacer refractory period
- pacer noise immunity *****
- pacer sensitivity

When automatically assigning a pass or fail result, each test utilizes one or more pass/fail limits which are stored in the Interface's memory.

***** *Note*: Impulse 7000 is not able to measure pacer noise immunity directly. The user must manually assign a pass/fail result for a simulated noise signal of fixed frequency and amplitude.

Limits are initially configured to default values when power is applied to the Interface, but may be modified through the "`lim`" command. Modified limit settings do not persist once the Interface is disconnected from the vPad safety analyzer, or the safety analyzer is powered off. They are set as required during Checklist runtime. Limit configuration statements in vPL are of the form

```
xctrl    "< info >" | lim< id >,< type >,< p1 >,< p2 >
```

where:

< *info* >	is a description of the limit setting, which is briefly displayed to the user
< *id* >	is an ID number (1, 2, 3...) representing the limit to be set,
< *type* >	is the type of limit, such as a target with % tolerance or a min/max range,
< *p1* >	is the first pass/fail threshold, the effect of which depends on limit type, and
< *p2* >	is a second pass/fail threshold which, again, depends on limit type.

Table 1 lists the permitted values for the "`lim`" command. Additionally, any limit type can be set to "**`none`**", which disables automatic assessment for the affected test types. If the Interface receives a limit configuration command with a disallowed limit type, that particular limit will be disabled. Note that the units of measurement are assumed when specifying a limit value.

Table 1: Allowed Values for Limit Configuration

lim	<*limit_ID*>,	<*limit_type*>,	<*param_1*>,	<*param_2*>
TEST LIMIT	ALLOWABLE VALUES in **bold**			
defib energy	**1**	**target**	**0** to **999** %/J	**percent** or **units**
		range	**0** to **999** J	**0** to **999** J
defib charge time	**2**	**max**	**0** to **16000** s	-
defib sync delay	**3**	**range**	**-300** to **1000** ms	**0** to **16000** ms
pacer pulse current	**4**	**target**	**0** to **999** %/mA	**percent** or **units**
		range	**0** to **999** mA	**0** to **999** mA
pacer pulse rate	**5**	**target**	**0** to **999** %/PPM	**percent** or **units**
pacer pulse width	**6**	**target**	**0** to **999** %/ms	**percent** or **units**
pacer pulse energy	**7**	**target**	**0** to **999** %	**percent** only
pacer paced refractory period	**8**	**min**	**0** to **16000** ms	-
		max	**0** to **16000** ms	-
		range	**0** to **16000** ms	**0** to **16000** ms
pacer sensed refractory period	**9**	**min**	**0** to **16000** ms	-
		max	**0** to **16000** ms	-
		range	**0** to **16000** ms	**0** to **16000** ms
pacer noise immunity	**10**	**min**	**0** to **16000** µV	-
		max	**0** to **16000** µV	-
		range	**0** to **16000** µV	**0** to **16000** µV
pacer sensitivity	**11**	**min**	**0** to **16000** µV	-
		max	**0** to **16000** µV	-
		range	**0** to **16000** µV	**0** to **16000** µV

3.2.1.1 Example 1: Setting a Defibrillator Energy Limit

To illustrate how the "`lim`" command is used, the consider following statement:

```
xctrl  "Setting defib energy tol. to 10%" | lim1,target,10,percent
```

For this statement,

`1`	immediately following the "`lim`" command specifies the limit is for defib energy;
`target`	specifies the limit type as a target with tolerance, as opposed to a min/max range;
`10`	is the tolerance value (±10); and
`percent`	sets the tolerance type as a percentage, as opposed to a number of joules (`units`).

Note that this defib energy limit will be shared for all three defibrillator tests (defibrillator energy, charge time, and sync delay). The "target" value referred to above is not included with the limit, but is specified in the vPL statement that executes the energy measurement itself.

3.2.1.2 Example 2: Setting Defibrillator Charge Time Limit

In this next example, the vPL statement sets the defib charge time limit to a maximum of 12 seconds:

```
xctrl  "Setting charge time limit to max. 12 sec" | lim2,max,12
```

For this statement,

`2`	immediately following the "`lim`" command specifies the limit is for charge time;
`max`	specifies limit type as maximum, the only allowable type for charge time,
`12`	is the maximum value (12 seconds)

In this case, the "`lim`" command does not include a <*param_2*> since it is not required.

Limits persist until modified by a "`xctrl`" statement. There is no need to set a defib energy limit for a charge time test if it has previously been set for a debrillator energy test.

3.2.1.3 Example 3: Setting Pacemaker Pulse Current Limit

The following vPL statement sets pacer pulse current limit to a target with tolerance in mA:

```
xctrl  "Setting pulse current tol. to +/-3mA" | lim4,target,3,units
```

For this statement,

`4`	immediately following the "`lim`" command specifies the limit is for pacer current;
`target`	specifies the limit type as a target with tolerance, as opposed to a min/max range;
`3`	is the tolerance value (±3); and
`units`	sets the tolerance type as a number of milliamps as opposed % (`percent`).

The "target" value referred to above is not included with the limit, but is specified in the vPL statement that executes the pacer pulse test itself.

3.2.1.4 Example 4: Setting Pacemaker Sensitivity Limit

Before executing a pacer sensitivity test, a Checklist can set pass/fail limits through following vPL statement:

```
xctrl  "Setting sensitivity limit: 25 to 45uV" | lim11,range,25,45
```

For this statement,

`11`	immediately following the "`lim`" command specifies the limit is for pacer sensitivity;
`range`	sets limit type as a min/max range as opposed to a minimum or maximum only;
`25`	is the minimum value (25 microvolts), and
`45`	is the maximum value (45 microvolts).

No target is needed for range limits. Measurement results are automatically assessed as long as limit is not set to "none".

3.2.1.5 Example 5: Disabling a Limit

Sometimes automatic assessment may not be desirable, in which case a vPL statement similar to the following can be used to disable a particular limit. For example:

```
xctrl     "Disabling pulse width limit" | lim6,none
```

For this statement,

6	immediately following the "lim" command specifies the limit is for pacer pulse width;
none	sets the limit to "none", disabling automatic pass/fail. Other parameters of the command are omitted because they are not necessary.

Once a limit has been disabled, a target specified in a "xtest" statement will appear in the Test Record, but the corresponding measurement value will not be passed or failed automatically.

3.2.2 Resetting Limits to Defaults

The following vPL statement resets all limit settings to defaults:

```
xctrl  "< info >" | rslm
```

where:

< *info* > is a descriptive message which is briefly displayed to the user.

Table 2 lists the limit default values, which are assigned at power-on of the Interface, or in response to the "`rslm`" command as above.

Table 2: Default Limit Settings

TEST LIMIT	ID	DEFAULT VALUES		
		LIMIT TYPE	PARAMETER 1	PARAMETER 2
defib energy	1	target	± 15 %	percent
defib charge time	2	max	15 s	-
defib sync delay	3	range	20 ms min	65 ms max
pacer pulse current	4	target	± 10 %	percent
pacer pulse rate	5	target	± 2 PPM	units
pacer pulse width	6	none	-	-
pacer pulse energy	7	none	-	-
pacer paced refractory period	8	none	-	-
pacer sensed refractory	9	none	-	-
pacer noise immunity	10	min	6000 µV	-
pacer sensitivity	11	max	2000 µV	-

3.2.3 ECG Simulation

Impulse 7000 simulates ECG signals while conducting defibrillator tests. A Checklist may select an ECG waveform through the Interface. This is typically done prior to performing a defib or pacer test. ECG configuration statements are of the form

```
xctrl  "< info >" | ECG< code >< scale >< mode >
```

where:

- < *info* > is a description of the waveform, which is briefly displayed to the user
- < *code* > is an ECG waveform identifier shown in Table 3,
- < *scale* > is the simulation amplitude scale ('0' = off, '1' = 1mV, '2' = 2mV, '3' = 0.5mv), and
- < *mode* > is the mode of reaction to a defibrillator discharge ('0' = none, '1' = convert to NSR).

Table 3 contains a list of ECG waveforms supported by Impulse 7000 and their corresponding wave codes.

Table 3: ECG Waveforms

CODE	ECG WAVEFORM
AX	**Off**
BE	**Normal Sinus Rhythm 150 PPM**
BF	**Normal Sinus Rhythm 180 PPM**
BG	**Normal Sinus Rhythm 240 PPM**
BH	**Normal Sinus Rhythm 300 PPM**
DA	**Coarse Atrial Fibrillation**
DB	**Fine Atrial Fibrillation**
DC	**Asystole**
DH	**Ventricular Tachycardia 190 PPM**
DI	**Torsades de Pointes 200 PPM**
DJ	**Coarse Ventricular Fibrillation**
DK	**Fine Ventricular Fibrillation**

3.2.3.1 Example 6: Configuring ECG Simulation

The following vPL statement configures Impulse's ECG simulator:

```
xctrl  "Setting ECG to Fine VFIB" | ECGDK21
```

For this statement,

ECG	is the command for ECG simulation,
DK	is the wave code for Fine Ventricular Fibrillation,
2	sets simulation amplitude to 2.0 mV, and
1	indicates that the simulator should return to normal sinus rhythm after a defibrillator discharge.

This type of statement would typically precede a statement that tests defibrillator energy or other aspect of defibrillator performance.

3.2.4 Pacemaker Test Load

Most pacemaker manufacturers specify the load resistance at which their device should be tested. vPL statements that configure pacer loads are of the form

```
xctrl  "< info >" | PLD< code >
```

where:

< *info* >	is a description of the selected load, which is briefly displayed to the user; and
< *code* >	is the unique identifier for a particular pacer load.

For a full list of pacer load codes, refer to **Table 4**.

Table 4: Pacer Loads

CODE	PACER LOAD	CODE	PACER LOAD	CODE	PACER LOAD	CODE	PACER LOAD
A	50 Ω	I	450 Ω	Q	850 Ω	Y	1250 Ω
B	100 Ω	J	500 Ω	R	900 Ω	Z	1300 Ω
C	150 Ω	K	550 Ω	S	950 Ω	a	1350 Ω
D	200 Ω	L	600 Ω	T	1000 Ω	b	1400 Ω
E	250 Ω	M	650 Ω	U	1050 Ω	c	1450 Ω
F	300 Ω	N	700 Ω	V	1100 Ω	d	1500 Ω
G	350 Ω	O	750 Ω	W	1150 Ω	e	1550 Ω
H	400 Ω	P	800 Ω	X	1200 Ω	f	1600 Ω

3.2.4.1 Example 7: Configuring Pacemaker Test Load

The following vPL statement configures Impulse 7000's pacer test load:

```
xctrl  "Setting pacer load to 600 ohms" | PLDL
```

For this statement,

PLD is the command for pacer load selection, and
L is the pacer load code for 600 ohms.

This type of statement would typically precede statements that test pacemaker performance.

3.3 Defibrillator Tests

Once a Checklist has initialized communication with the Interface, configured Impulse 7000 test settings and, optionally, prepared limits for automatic pass/fail assessment, vPad is ready to execute a range of defibrillator tests. A typical Checklist will include prompts instructing the operator how to set up the defibrillator and Impulse, followed by remote test statements.

While executing a test, the Interface acts as an intermediary that relays commands to Impulse and reformats the numerical results into a form suitable for vPad-Check and the Test Record.

vPL statements which trigger a remote test begin with the "`xtest`" keyword, in the form

```
xtest  "< instr >" | < cmd >,< targ1 >,< targ2 >,...
```

where:

- < *instr* > is an instruction that is displayed to the user while the test is in progress,
- < *cmd* > is a command representing the test to be executed by Impulse, and
- < *targ1* >
- < *targ2* > ... are optional targets associated with automatic pass/fail assessment of the measurement results, separated by commas (", ").

The number of targets specified in the "`xtest`" statement depends on the test to be executed. Automatic pass/fail assessment is disabled if a required target has not been specified in the statement. In this case, a "---" will appear in the Test Record report instead of a user-defined target.

For a detailed description of the vPL "`xtest`" statement, refer to **vPad-Check Operating Manual**.

3.3.1 Defibrillator Energy Test

To perform a defibrillator energy test, use a vPL statement of the form

```
xtest    "< instr >" | DEH< fmt >,< targ >
```

where:

< *instr* >	is an instruction to be displayed to the user while the energy test is in progress,
DEH	is the command to measure defib energy,
< *fmt* >	can be "**S**" for short report format or "**L**" for long format, and
< *targ* >	is an optional energy target (in joules) for automatic pass/fail assessment.

Note the comma ("**,**") separating the required parameters from the optional target energy.

3.3.1.1 Example 8: Measuring Defibrillator Energy

A Checklist may start a defibrillator energy test with a target of 2 joules through a vPL statement similar to the following:

```
xtest  "Set energy to 2J and discharge defib now!" | DEHS,2
```

For this statement,

DEH	commands Impulse to prepare for a defibrillator discharge,
S	instructs the Interface to prepare a short report, and
2	is the optional target energy (J).

Assuming the defib energy limit is set to its default value, the Interface automatically assigns a "PASS" result if the energy measured is 2 J ±15 %. For the case of a "PASS", the Test Report will contain an entry similar to the following:

```
Task:   Set energy to 2J and discharge defib now!
Data:   Defibrillator Energy Test   Limit: 2 J +/- 15 %
           Energy:   1.9 J
Result: PASS
```

Short reports contain only the essential measurements from the analyzed discharge. If more details are needed, a statement specifying the long format report can be used, for example:

```
xtest  "Set energy to 2J and discharge defib now!" | DEHL,2
```

For the same measurement data as shown above for the short format, the long format would appear in the Test Record as:

```
Task:   Set energy to 2J and discharge defib now!
Data:   Defibrillator Energy Test   Limit: 2 J +/- 15 %
           Total Energy:    2.0 J   Wave:  BIPHASIC
           Phase Delay:    0.44 ms  Tilt: 75.3 %
                           PHASE-1  PHASE-2
           Peak Voltage (V):   190       93
           Peak Current (A):  3.80     1.86
           Avg. Voltage (V):   136       66
           Avg. Current (A):  2.72     1.32
           Pulse Width (ms):  4.13     4.13
Result: PASS
```

The above example result is for a biphasic defibrillator waveform. Pulsed biphasic waveform reports are similar, though they include phase frequency (Hz) and duty cycle (%) measurements instead of phase delay and tilt.

3.3.2 Defibrillator Charge Time Test

To perform a defibrillator charge time test, use a vPL statement of the form

xtest "< *instr* >" | DCHS,< *targ* >

where:

< *instr* > is an instruction to be displayed to the user while the charge time test is in progress,
DCHS is the command to measure defib charge time, and
< *targ* > is an optional energy target (in joules) for automatic pass/fail assessment.

Note the comma ("**,**") separating the required parameters from the optional target energy.

3.3.2.1 Example 9: Measuring Defibrillator Charge Time

A Checklist may start a defibrillator charge time test with a target of 100 joules through a vPL statement similar to the following:

```
xtest "Charge NOW, then discharge when ready." | DCHS,100
```

For this statement,

DCHS commands Impulse to initiate a charge time test; and
100 is the optional target energy (J).

Assuming that defib energy and charge time limits are set to defaults, the Interface automatically assigns a "PASS" result if the energy measured is 100 J ±15 % and charge time is less than 15 s. For the case of a "PASS", the Test Report will contain an entry similar to the following:

```
Task:   Charge NOW, then discharge when ready.
Data:   Defibrillator Charge Time Test:
           Energy Limits:   100 J +/- 15 %
           Energy:  99.0 J
           Maximum Charge Time:    15 s
                Result:   8.7 s
Result: PASS
```

3.3.3 Defibrillator Sync Delay (Cardioversion) Test

To perform a defibrillator sync delay test, use a vPL statement of the form

```
xtest  "< instr >" | DSHRS,< targ >
```

where:

< *instr* > is an instruction to be displayed to the user while the sync test is in progress,
DSHRS is the command to measure defib sync delay, and
< *targ* > is an optional energy target (in joules) for automatic pass/fail assessment.

Note the comma ("**,**") separating the required parameters from the optional target energy.

3.3.3.1 Example 10: Measuring Defibrillator Sync Delay

A Checklist may start a defibrillator sync delay test with a target of 70 joules through a vPL statement similar to the following:

```
xtest  "Set defib to sync mode and discharge now!" | DSHRS,70
```

For this statement,

DSHRS commands Impulse to prepare for a sync'ed discharge; and
70 is the optional target energy (J).

Assuming that defib energy and sync delay limits are set to defaults, the Interface automatically assigns a "PASS" result if the energy measured is 70 J ±15 % and sync delay is between 20 ms and 65 ms. For the case of a "PASS", the Test Report will contain an entry similar to the following:

```
Task:   Set defib to sync mode and discharge now!
Data:   Defibrillator Sync Delay Test:
           Energy Limits: 70 J +/- 15 %
           Energy: 70.2 J
           Delay Limit: Min 20  ms  Max 65  ms
                Result:  +46 ms
Result: PASS
```

3.4 Pacemaker Tests

Once a Checklist has initialized communication with the Interface, configured Impulse 7000 test settings and, optionally, prepared limits for automatic pass/fail assessment, vPad is ready to execute a range of pacemaker tests. A typical Checklist will include prompts instructing the operator how to set up the pacer and Impulse, followed by remote test statements.

3.4.1 Pacemaker Pulse Test

To perform a pacer pulse test, use a vPL statement of the form

`xtest "< instr >" | PPL< delay >,< targ >,...`

where:

< *instr* > is an instruction to be displayed to the user while the pacer pulse test is in progress,
PPL is the command for measuring pacer pulses,
< *delay* > is the number of measurements to discard before capturing a final result, which can be a number from **`0 to 99`**, and
< *targ* >, ... is a series of optional targets for automatic pass/fail assessment, listed in the following order:

pulse current	(in milliamps)
pulse rate	(in pulse per minute)
pulse width	(in milliseconds)
pulse energy	(in microjoules)

The < *delay* > parameter allows users to specify a number of pulse measurements to skip before a final measurement is recorded, thereby giving the pacer time to stabilize its output before a pass/fail test is applied.

Note the comma (“**,**”) separating the required parameters from the optional target values. In order to enable automatic assessment, the statement must specify both the pulse current and the pulse rate target. Pulse width and pulse energy measurements are assessed if targets are included, and ignored if they are not.

3.4.1.1 Example 11: Measuring Pacemaker Pulse

A Checklist may start a pacemaker pulse test through a vPL statement similar to the following:

```
xtest    "Wait! Then verify pacer pulse test result" | PPL0,30,70
```

For this statement,

PPL	commands Impulse to begin analyzing pacer pulses,
0	means the Interface will report on the first pacer pulse detected,
30	is the optional target pulse current (mA), and
70	is the optional target pulse rate (PPM).

Assuming that pacer pulse current and rate limits are set to defaults, the Interface automatically assigns a "PASS" result if the measured current is 30 mA ±10 % and pulse rate is 70 PPM ±2 PPM. For the case of a "PASS", the Test Report will contain an entry similar to the following:

```
Task:   Wait! Then verify pacer pulse test result
Data:   Pacemaker Pulse Test:
                  Acceptable Limits       Results
           Current:      30 mA +/- 10 %     +29.5 mA
              Rate:     70 PPM +/- 2 PPM     70.1 PPM
             Width:     --- ms              18.27 ms
            Energy:     --- uJ               3906 uJ
Result: PASS
```

A placeholder "- - -" appears in the test data whenever a target is not specified or a limit is not enabled. If pulse width limit and pulse energy limit had been enabled with these vPL statements:

```
xctrl   "Setting pulse width tol to +/-2ms" | lim6,target,2,units
xctrl   "Setting pulse energy tol to +/-10%" | lim7,target,10,percent
```

and the test execution statement was extended to include width and energy targets:

```
xtest  "Wait! Then verify pacer pulse test result" | PPL0,30,70,18,4000
```

then the same measurement data would appear in the Test Report as:

```
Task:   Wait! Then verify pacer pulse test result
Data:   Pacemaker Pulse Test:
                  Acceptable Limits       Results
           Current:      30 mA +/- 10 %     +29.8 mA
              Rate:     70 PPM +/- 2 PPM     70.1 PPM
             Width:      18 ms +/- 2 ms      18.27 ms
            Energy:    4000 uJ +/- 10 %       3906 uJ
Result: PASS
```

In the above example where all targets are specified and all limits are enabled, then each one of the four measured values must be within limits for a "PASS" result.

3.4.2 Pacemaker Refractory Period Test

To perform a pacemaker refractory test, use a vPL statement of the form

xtest "< *instr* >" | PRFS

where:

< *instr* > is an instruction to be displayed to the user while the refractory test is in progress, and
PRFS is the command to measure pacer refractory period.

Impulse 7000 measures two pulse characteristics for this test: the paced refractory period (PRP) and the sensed refractory period (SRP). Since the only limit types allowed for both measurements are "`min`", "`max`", and "`range`", no target is needed in the "`xtest`" statement. Results are automatically passed or failed after pacer PRP and SRP limits have been enabled.

3.4.2.1 Example 12: Measuring Pacemaker Refractory Period

A Checklist may start a pacemaker refractory test with automatic pass/fail through vPL statements similar to the following:

```
xctrl   "Setting PRP limit: 200 to 500ms" | lim8,range,200,500
xctrl   "Setting SRP limit: max 300ms" | lim9,max,300

xtest   "Wait! Then verify refractory test result" | PRFS
```

For the above "`xtest`" statement,

PRFS commands Impulse to immediately begin testing the pacer refractory period.

Since the PRP limit and SRP limit are enabled prior to running the test, the Interface automatically assigns a "PASS" result if the PRP is between 200 ms and 500 ms, and SRP is less than 300 ms. For the case of a "PASS", the Test Report will contain an entry similar to the following:

```
Task:   Wait! Then verify pacer refractory test result
Data:   Pacer Refractory Test:
           Pacer Rate:    70.1  PPM
                                  Min     Max   Result
           Paced Refr.  (ms):     200     500    340
           Sensed Refr. (ms):     ---     300    126
Result: PASS
```

A placeholder "- - -" appears in the test data whenever a limit is not applicable, for example, a minimum SRP when the limit is set to "`max`", or when the limit has not been enabled.

3.4.3 Pacemaker Noise Immunity Test

To perform a pacemaker noise immunity test, use a vPL statement of the form

```
xtest    "< instr >" | PN< freq >< ampl >
```

where:

< *instr* >	is an instruction to be displayed to the user while the immunity test is in progress,
PN	is the command to generate a simulated noise signal,
< *freq* >	is the noise frequency, which can be "**A**" for 60 Hz or "**B**" for 50 Hz, and
< *ampl* >	is the amplitude of noise signal generated, which can be a number from **1 to 9** (mV) or **0** for 10 mV.

A noise immunity limit is not implemented because Impulse 7000 is not capable of measuring a value of noise immunity. Instead, a message will be displayed prompting the user to manually verify whether the simulated noise signal is filtered out by the device under test.

3.4.3.1 Example 13: Measuring Pacemaker Noise Immunity

A Checklist may start a pacer noise immunity test through a vPL statement similar to the following:

```
xtest   "Generating ECG noise!" | PNA0
```

For this statement,

PN	commands Impulse to immediately begin simulating ECG noise,
A	sets the test noise to 60 Hz, and
0	sets noise amplitude to 10 mV.

All noise immunity tests with Impulse 7000 must be manually evaluated by the user. If the user assigns a FAIL result, the Test Report would contain the manual result following an automated prompt similar to the following:

```
Task:   Generating ECG noise!
Data:   Pacer Noise Immunity Test:
           This test generates an NSR60 ECG signal with
           60 Hz / 10 mV noise. Check if DUT can filter
           out line-frequency interference.
Result: FAIL
```

No measurement or limit is displayed.

3.4.4 Pacemaker Sensitivity Test

To perform a pacemaker sensitivity test, use a vPL statement of the form

```
xtest     "< instr >" | PSNS
```

where:

< *instr* > is an instruction to be displayed to the user while the sensitivity test is in progress, and
PSNS is the command to measure pacer sensitivity.

Since the only limit types allowed for pacer sensitivity limit are "`min`", "`max`", and "`range`", no target is needed in the "`xtest`" statement. Results are automatically assessed as long as the limit is enabled.

3.4.4.1 Example 14: Measuring Pacemaker Sensitivity

A Checklist may start a pacer sensitivity test through a vPL statement similar to the following:

```
xtest     "Wait! Then verify sensitivity result" | PSNS
```

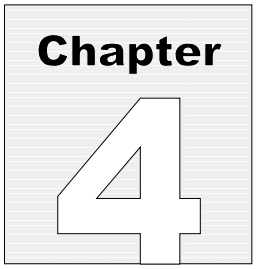
For the this statement,

PSNS commands Impulse to immediately begin generating pacer triggers.

Assuming that the pacer sensitivity limit is set to default, the Interface automatically assigns a "PASS" result if measured sensitivity is less than 2000 µV. In the case of a "PASS", the Test Report would contain an entry similar to the following:

```
Task:   Wait! Then verify sensitivity test result
Data:   Pacer Sensitivity Test:
           Pacer Pulse Rate:  70.1 PPM
           Sensitivity:  Min   --- uV  Max  2000 uV
                Result:   1100 uV
Result: PASS
```

A placeholder "- - -" appears in the test data whenever a limit is not applicable, such as the minimum sensitivity when limit is set to "`max`", or the limit is not enabled.



4 Calibration and Maintenance

The vPad-XSC interface has no calibration requirements.

Firmware for the Interface is field-upgradable. For technical support and the latest firmware updates, contact Datrend Customer Service.

For general service assistance with Datrend products, contact Datrend for a Return Materials Authorization (RMA) number and the location of the nearest Service Facility.

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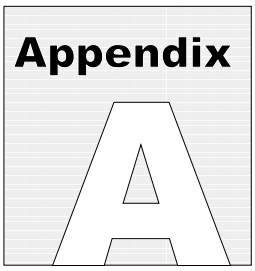

Appendix A: Phase3 Command Reference

A vPad-Check user writes a test script using the VPL programming language. In order to control Impulse 7000, specific test commands are coded into the CMD: message of VPL. A vPad-Check user doesn't have to know the actual Impulse 7000 commands. Instead, we use a command code set very similar to that for the existing Datrend product, Phase 3. The following is a summary of the Phase 3 remote control command set.

Command	Description
ECG<*code***><***scale***><***mode***>**	Set up the ECG simulator
PLD<*load_code***>**	Select pacer load resistance
DE<*range***>C**	Test defib energy; return CSV data
DCHC	Test defib charge time; return CSV data
DS<*range***><***sync***>C**	Test defib sync; return CSV data
PP<*method***>C**	Test pacer pulse; return CSV data
PRFC	Test pacer refractory time; return CSV data
PN<*freq***>C**	Test pacer noise immunity; return CSV data
PSNC	Test pacer sensitivity; return CSV data

As we can see, the Phase 3 commands use **code** in many places instead of hard numbers, for example, for the pacer load resistance. Basically the interface box uses the same style as above, except some of the specific phase 3 commands are not implemented, for example, some of the ECG wave form simulations.

During interface box initialization, the interface box sends the following commands to Impulse 7000:

IDENT
REMOTE
EXIT

For IDENT command, the interface box checks response from the Impulse 7000 and tries to match the word IMPULSE. The response for REMOTE command is ignored because Impulse may already be in remote mode. For EXIT command the interface box checks for the * response. If correct responses from the Impulse 7000 are received the interface box acknowledges the vPad-Check by the DACOM slave-ACK message. By default, the interface box sets the Impulse 7000 to main mode. The mode will be changed automatically to DEFIB, PAPULSE, PASENSE, PAREFRACT or ECGNOISE as corresponding commands are received.

For the vPad-Check script received from the tablet, the interface box translates recognized CMD: message into one or more Impulse 7000 commands, according to the following table.

Table 1 Interface Box Translation Reference Table

NOTE: ECG amplitude is set according to <scale> parameter. If a scale of 0 is specified, ECG simulation is turned off after all other parameters are set. Only <mode> 0 and 1 are recognized, resulting in nonconvert or convert option.

vPad-Check Command	Translated Impulse 7000 command set	Description / Notes
ECGAA - ECGAL	N/A	Performance group not recognized
ECGAX<scale><mode>	MODE=DEFIB ECGAMPL=<1.00|2.00|0.50> DCONVERT=<Noconvert | Convert> EXIT	Waveform AX turns off ECG simulation after setting scale and mode See *NOTE*
ECGBA - ECGBD	N/A	NSR with BPM lower than 150 not recognized
ECGBE<scale><mode>	MODE=DEFIB DNSR=150 ECGAMPL=<1.00|2.00|0.50> DCONVERT=<Noconvert | Convert>	See *NOTE*
ECGBF<scale><mode>	MODE=DEFIB DNSR=180 ECGAMPL=<1.00|2.00|0.50> DCONVERT=<Nonconvert | Convert>	See *NOTE*
ECGBG<scale><mode>	MODE=DEFIB DNSR=240 ECGAMPL=<1.00|2.00|0.50> DCONVERT=<Nonconvert | Convert>	See *NOTE*

ECGBH <scale><mode>	MODE=DEFIB DNSR=300 ECGAMPL=<1.00|2.00|0.50> DCONVERT=<Nonconvert | Convert>	See *NOTE*
ECGCA- ECGCI	N/A	Arrhythmia group not recognized
ECGDA <scale><mode>	MODE=DEFIB DAFIB=Coarse ECGAMPL=<1.00|2.00|0.50> DCONVERT=<Nonconvert | Convert>	See *NOTE*
ECGDB <scale><mode>	MODE=DEFIB DAFIB=Fine ECGAMPL=<1.00|2.00|0.50> DCONVERT=<Nonconvert | Convert>	See *NOTE*
ECGDC <scale><mode>	MODE=DEFIB DASYSTOLE ECGAMPL=<1.00|2.00|0.50> DCONVERT=<Nonconvert | Convert>	See *NOTE*
ECGDD - ECGDG	N/A	Not recognized
ECGDH <scale><mode>	MODE=DEFIB DMONOVTACH=190 ECGAMPL=<1.00|2.00|0.50> DCONVERT=<Nonconvert | Convert>	See *NOTE*
ECGDI <scale><mode>	MODE=DEFIB DPOLYVTACH=1 ECGAMPL=<1.00|2.00|0.50> DCONVERT=<Nonconvert | Convert>	See *NOTE*
ECGDJ <scale><mode>	MODE=DEFIB DVFIB=Coarse ECGAMPL=<1.00|2.00|0.50> DCONVERT=<Nonconvert | Convert>	See *NOTE*

ECGDK <scale><mode>	MODE=DEFIB DVFIB=Fine ECGAMPL=<1.00|2.00|0.50> DCONVERT=<Nonconvert | Convert>	See *NOTE*
ECGDL	N/A	Not recognized
ECGEA - ECGEE ECGFA - ECGFE ECGGA - ECGGE ECGAX	N/A	Not recognized
PLDA ... PLDd	PAINPUT=PACER PALOAD=0050 ... PALOAD=1500	Pacer signal should be connected to the PACER input instead of DEFIB input.
PLDe ... PLDf	N/A	Not recognized
DEHS DEHL DELS DELL	MODE=DEFIB DREADY	DREADY will cause the Impulse 7000 to measure Defib pulse properties, sync time and charge time. However, here only pulse properties will be reported to vPad-Check. The last letter in the command indicates whether the report format will be Short or Long.
DSH DSL	MODE=DEFIB DREADY	DREADY will cause the Impulse 7000 to measure Defib pulse properties, sync time and charge time. However, here only the Defib energy and the sync time will be reported to vPad-Check.

DCH	MODE=DEFIB DREADY	DREADY will cause the Impulse 7000 to measure Defib pulse properties, sync time and charge time. However, here only the Defib energy and the charge time will be reported to vPad-Check.
PPA PPL PPT PPP	MODE=PAPULSE PAREADY	Measures pacer pulse amplitude, width and PPM. Method (A,L,T,P) is ignored because Impulse only has one method.
PRF	MODE=PAREFRACT PARAUTO	Determines PRP and SRP.
PSN	MODE=PASENSE PASRWAVE=TRI,040,0 PASAUTO	Runs the pacer sensitivity test with a triangular wave of 40 ms pulse width and positive polarity.
PNA<amp>	MODE=ECGNOISE NOISEAMPL=<amp*1.0mV> NOISE=60,T	Runs the pacer noise immunity test with NSR60 and 60Hz noise. If <amp> is not 1 - 9, amplitude defaults to 10.0 mV. Test result (pass or fail) has to be entered manually.

PNB<amp>	MODE=ECGNOISE NOISEAMPL=<amp*1.0mV> NOISE=50,T	Runs the pacer noise immunity test with NSR60 and 50Hz noise. If <amp> is not 1 - 9, amplitude defaults to 10.0 mV. Test result (pass or fail) has to be entered manually.
#<direct command>	<direct command>	# is the special token to allow VPL programmers to control Impulse 7000 directly using xctrl command. The interface box will check the confirmation '*' from Impulse 7000 and return ACK or NACK to vPad-check.

NOTE: ECG amplitude is set according to <scale> parameter. If a scale of 0 is specified, ECG simulation is turned off after all other parameters are set. Only <mode> 0 and 1 are recognized, resulting in nonconvert or convert option.


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