FILES ASSOCIATED WITH THIS SPECIFICATION

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P314-IXS-FIRMWARE-P314 R2.docx	this document

CHANGE HISTORY

ECO#	DATE	DESCRIPTION OF CHANGE
0479	1/14/2016	Rev 1 Release: Firmware for 24VDC battery operation
	2/17/2016	Correction: Interlock fault description (#13.14i)
	6/14/2017	Rev 2 Release: - Document RS232, wired Ethernet, and Wi-Fi connection type - Add pre-warning feature - List and update all commands and fault definitions
	4/3/2018	Rev 3 Release: - Variable Watchdog command added up to 30 sec. - Buzzer Enable/Disable command added

TITLE: IXS-FIRMWARE-P314 Specification	Released by: ECO 0479
GENERATED BY: Hemanth Atluri	APPROVED BY: Minh Tran
USED ON:	DOC OWNER: X-ray Eng	DATE: 04/03/2018

DIGITAL COMMUNICATION PROTOCOL

13.   **DIGITAL INTERFACE**

Overview

RS-232, Ethernet, or Wi-Fi-based digital interface provides the ability to program the output voltage, output current, exposure time, etc.; monitor the output voltage and current, and monitor fault conditions and other indications of the X-ray controller.

13.1   **a. RS-232 Interface**

Connect a DB-9 male-to-female straight-through cable from the computer's RS-232 port to J3 on the x-ray controller.

Settings: 9600 baud, 8 data bits, no parity, 1 stop bit, no handshaking.

Only pins 2, 3, and 5 (RxD, TxD, and G) are needed.

Pins 1, 4, 6, 7, 8, and 9 (DCD, DTR, DSR, RTS, CTS, and RI) are not connected, so hardware handshaking is not supported. Software handshaking (XON/XOFF) is not supported.

b. Wired Ethernet Interface (when module and connector are present)

Connector: RJ45   10/100Mbps Ethernet

IP Address: 192.168.10.1   Port: 10001   TCP connection type: Raw

c. Wi-Fi Interface (when module and antenna are present)

IEEE 802.11a/b/g/n.   SSID: [derived from model number and serial number] IP Address: 192.168.1.1   Port: 10001   TCP connection type: Raw

13.2   **Command Structure**

There are two categories of commands from the host computer to the X-ray controller.

1) Commands that have an argument.

2) Commands that do not have an argument.

The syntax of commands that have an argument is:

<STX>CMDARG<CR>

The syntax of commands that do not have an argument is:

<STX>CMD<CR>

The symbols above are substituted as follows:

<STX>   The ASCII start-of-text character, 0x02.

CMD   One of the commands defined below.

ARG   The argument string that is defined below for each command. <CR>

The ASCII carriage return character, 0x0D.

13.3   **Query Structure**

Queries sent from the host computer to X-ray controller are ASCII strings structured as shown below:

<STX>RPT<CR>

The symbols above are substituted as follows: <STX>
The ASCII start-of-text character, 0x02 RPT
One of the commands defined below.
 <CR>   The ASCII carriage-return character, 0x0D.

13.4   Command Arguments

Command arguments (when used) are 1 to 5 characters (ASCII digits 0-9), representing a number.

13.5   Command and Query Definitions:

Name	Command*	Reply**	Comments
Set voltage	VPxxxx	VPxxxx	xxx.x = 000.0 – [max] KV
Set current	CPxxxxx	CPxxxxx	x.xxxx = 0.0000 – [max] mA
Set exposure time	OTxxxxx	OTxxxxx	xxxxx = 000.00 – 999.99 seconds (000.00 = continuous exposure.)
Set prewarning time	PTMxx	PTMxx	xx = 00 – 60 seconds
Report prewarning time	PTST	xx	xx = 00 – 60 seconds
Start X-ray	ENBL1	ENBLx	x = '1': X-ray has started x = '0': X-ray has not started (not allowed, or entered prewarning)
Stop X-ray	ENBL0	ENBL0	
Report faults	FLT	x<SP>x<SP>x<SP>x<SP>x<SP>x<SP>x<SP>x<SP>x<SP>x<SP>x	x x x x x x x x x x x = (see below)
Report prewarning state	PSTAT	x	x = '1': In prewarning x = '0': Not in prewarning
Report X-ray state	STAT	x	x = '1': X-ray is on x = '0': X-ray is off
Report voltage, current, temperature, filament, and battery	MON	vvvv<SP>ccccc<SP>tttt<SP>ffff<SP>bbbb	vvv.v = 000.0 – [max] kV c.cccc = 0.0000 – [max] mA ttt.t = 000.0 – [070.0] °C f.fff = 0.000 – 9.999 A bb.bb = 00.00 – [29.99] VDC
Clear faults	CLR	CLR	
Enable or disable Watchdog Plus new Watchdog Time	WDOGxx or WDOGx	WDOGxx or WDOGx	x = '1': Enable Watchdog x = '0': Disable Watchdog x or xx: New Watchdog Time in seconds from 2 to 30

Report Watchdog state	WSTAT	x	x = '1': Watchdog is on x = '0': Watchdog is off
Watchdog keep-alive	WDTE	OK	(no-op.)
Report model number	MNUM	mmmmmmmmmmmmmmm	mmmmmmmmmmmmmmm = model number of unit
Report serial number	SNUM	ssssssssssss	ssssssssssss = serial number of unit
Com port echo	FREV	xnnn	xnnn = 2000
Report cumulative X-ray on time	XTM	hhhhh<SP>mm	hhhhh = 00000 – 65534 hours mm = 00 – 59 minutes
Buzzer On/Off Switch	BUZZENBLx	BUZZENBLx	x = '1': Turn Buzzer On x = '0': Turn Buzzer Off
Report Buzzer State On or Off	BUZZENBLSTAT	x	x = '1': Buzzer is in On State x = '0': Buzzer is in Off State

* Each command is preceded by <STX> and terminated by <CR>. (Not shown in table.) **
Each reply is preceded by <STX> and terminated by <CR>. (Not shown in table.) <SP>
indicates the ASCII space character, 0x20.

13.6   OT command, Set exposure time

This command sets X-ray exposure time. Each time X-ray is started, a timer is also started. When Xray has been on for the set exposure time, the X-ray controller turns off X-ray. Exception: When exposure time is set to 0.00, X-rays will run continuously. To specify continuous exposure (no time limit), for fluoroscopy or other use, set 0.00 seconds.
On power-up, the default setting is 0.00 seconds.

13.7   WDOGx command, Enable or disable Watchdog

This command enables or disables the Watchdog feature. Upon power-up, the X-ray controller starts with the Watchdog feature enabled. WDOG0 turns off the Watchdog feature. Watchdog remains off until re-enabled by WDOG1 command or the next power cycle.

13.8   WDTE command, Watchdog keep-alive

If the X-ray controller doesn't receive any command for 5 seconds, the Watchdog function turns off Xrays. Normally, the computer monitors the state of the X-ray controller by sending query commands every second (more or less). The computer can optionally send the WDTE command to keep the Watchdog function from triggering. The WDTE command resets the Watchdog timer (like all other commands), but it doesn't do anything; it only replies "OK".
This command can be used to detect a connected X-ray controller. The computer software can send this command to each available com port. If the computer receives the expected reply, then an X-ray controller is probably present, and the software can send additional commands.

13.9   FREV command, Com port echo
(This command can also be used to detect a connected X-ray controller.)

13.10 Command Handling Command Response
Time:
The X-ray controller processes and replies to all commands anywhere from less than 100ms plus output ramp time.

13.11 Command Buffering
The X-ray controller does not buffer commands. The X-ray controller processes one command at a time. Before sending another command, wait for the reply from the previous command.

13.12 FLT Reply Bit Definitions

Bit (x0 x1 x2 x3 x4 x5 x6 x7 x8 x9 x10)	Meaning
x0	x0 = '1': Duty cycle mode active (not used) x0 = '0': (duty cycle not active)
x1	x1 = '1': FAULT: Overvoltage x1 = '0': (no fault)
x2	x2 = '1': FAULT: Power limit exceeded x2 = '0': (no fault)
x3	x3 = '1': FAULT: Overcurrent x3 = '0': (no fault)
x4	x4 = '1': WARNING or FAULT: Arc x4 = '0': (no fault)
x5	x5 = '1': FAULT: Over temperature x5 = '0': (no fault)
x6	x6 = '1': FAULT: Anode overvoltage x6 = '0': (no fault)
x7	x7 = '1': FAULT: Cathode overvoltage x7 = '0': (no fault)
x8	x8 = '1': INTERLOCK open x8 = '0': (interlock not open)
x9	x9 = '1': FAULT: Regulation x9 = '0': (no fault)
x10	x10 = '1': FAULT: Battery low x10 = '0': (no fault)

13.13 Fault Cause and Effect:
If a shutdown occurred from a fault, the fault must be cleared before X-ray can be turned on.

When a fault occurs, the clear-faults command "CLR" must be used to clear the fault.

Fault conditions do not cause the X-ray controller to forget any settings, such as voltage, current, and on-time. For example, if the voltage is set to 150 kV and a fault occurs, the voltage will still be set to 150 kV after the fault is cleared.

13.14 Fault Bit Definitions:

a. **Duty cycle mode active:** (not applicable to this model)

b. **FAULT: Overvoltage:** When anode or cathode overvoltage fault occurred. This will disable the high voltage output.

c. **FAULT: Power limit exceeded:** When the output power exceeds the maximum power rating by 5% to 10%. This will disable the high voltage output.

d. **FAULT: Overcurrent:** When output current exceeds the maximum current rating by 5% to 10%. This will disable the high voltage output. (Max duration of overcurrent before shutdown is 100ms.)

e. **WARNING or FAULT: Arc:** When an arc is detected, this bit goes active for 10 seconds. If more arcs occur during the 10 seconds, it remains active until 10 seconds after the last arc. Xrays are not stopped.
   If four arcs occur within 10 seconds, x-rays are stopped. This bit remains active, and x-rays cannot be started, until a clear-faults command is issued.

f. **FAULT: Over temperature:** When oil temperature reaches 60°C ± 3°C. This will disable the high voltage output.

g. **FAULT: Anode overvoltage:** When anode output voltage exceeds the maximum rated output by 5% to 10%. This will disable the high voltage output. (Max duration of overvoltage before shutdown is 100ms.)

h. **FAULT: Cathode overvoltage:** When cathode output exceeds the maximum rated output by 5% to 10%. This will disable the high voltage output. (Max duration of overvoltage before shutdown is 100ms.)

i. **INTERLOCK open:** When J3-7 and J3-8 are not connected. This will disable the high voltage output.

j. **FAULT: Regulation:** When kV or mA is no longer in regulation. This will disable the high voltage output.

k. **FAULT: Battery low:** Battery needs to be recharged. This will disable the high voltage output.

(End of document.)