

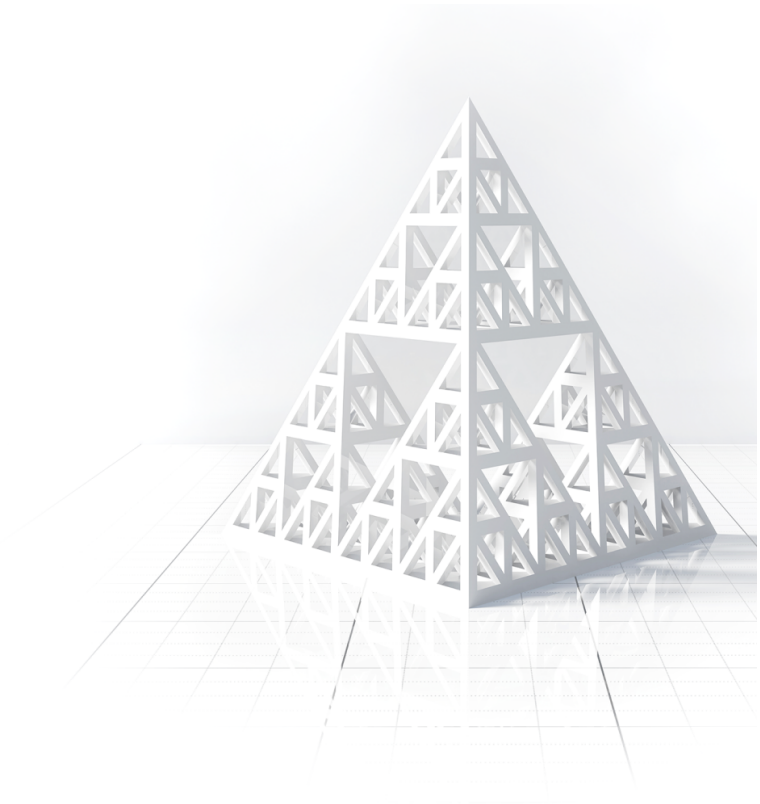
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FX4

# FX4 - Programmer Manual

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Version: v2



## Table of Contents

<b>1</b>	<b>Introduction.....</b>	<b>3</b>
1.1	Version Control.....	3
1.2	References.....	3
<b>2</b>	<b>FX4 Programming.....</b>	<b>4</b>
2.1	Analog Input IO.....	4
2.2	Analog Output IO.....	4
2.3	Digital Input and Outputs.....	5
2.3.1	Digital IO Configuration.....	6
2.4	Relay Control.....	6
2.5	High Voltage Module.....	6
2.6	Dose Controller.....	6

# 1 Introduction

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<b>Owner</b>	Project Lead
<b>Purpose</b>	Explain the programming concepts necessary to use the API and extend the product through external applications.
<b>Scope</b>	FX4 related programming concepts.
<b>Intended Audience</b>	Software developers interested in using the product.
<b>Process</b>	Standard Manual Creation Process
<b>Training</b>	<b>NOT APPLICABLE</b>

## 1.1 Version Control

Version	Description	Saved by	Saved on	Status
v2	Added digital IO interfaces and references back to IGX.	Matthew Nichols	May 3, 2024 7:39 PM	<b>APPROVED</b>
v1	Initial release, still a work in progress.	Matthew Nichols	Feb 21, 2024 11:25 PM	<b>APPROVED</b>



### Document Control

Current document version: v.1

No reviewers assigned.

## 1.2 References

Document	Document ID	Author	Version
IGX - Programmer Manual	2439249921	@Matthew Nichols	1

## 2 FX4 Programming

The concepts and methods described in this manual build on the concepts established in the IGX - Programmer Manual. Please see that document for explanation and examples of how basic IGX programming and interfaces work. This manual will only cover the device-specific IO and functionality that is unique to the FX4.

### 2.1 Analog Input IO

These IO relate to configuring and collecting data on the analog current inputs of the FX4. The units of the channel inputs are based on the user configurable setting called "Sample Units", valid options include pA, nA, uA, mA, and A.

All 4 channels use the same interface IO and are independently controlled. Replace `channel_x` with `channel_1`, `channel_2`, `channel_3`, or `channel_4` respectively.

IO Path	Description
<code>/fx4/adc/channel_x</code>	<b>READONLY</b> <b>NUMBER</b> Measured current input.
<code>/fx4/adc/channel_x/scalar</code>	<b>NUMBER</b> Simple unitless scalar applied to the channel, 1 by default.
<code>/fx4/adc/channel_x/zero_offset</code>	<b>NUMBER</b> Current offset in nA for the channel.

The following IO are not channel independent and are applied to all channels simultaneously.

IO Path	Description
<code>/fx4/channel_sum</code>	<b>READONLY</b> <b>NUMBER</b> Sum of the current input channels.
<code>/fx4/adc_unit</code>	<b>STRING</b> Sets the current user units for each channel and sum. Options: "pa", "na", "ua", "ma", "a"
<code>/fx4/range</code>	<b>STRING</b> Sets the current input range. See GUI for how each range code corresponds to the maximum current input limits and BW. Options: "0", "1", "2", "3", "4", "5", "6", "7"
<code>/fx4/adc/sample_frequency</code>	<b>NUMBER</b> The frequency in Hz that sample data will be averaged to. This controls the signal-to-noise and data rate for all channels.
<code>/fx4/adc/conversion_frequency</code>	<b>NUMBER</b> The frequency in Hz that the ADC will convert analog to digital values at. By default, this is 100kHz, and you will only rarely need to change this value.
<code>/fx4/adc/offset_correction</code>	<b>READONLY</b> <b>NUMBER</b> Sum of all channel's current offsets.

### 2.2 Analog Output IO

These IO relate to the configuration of the general-purpose analog outputs of the FX4 found under the analog inputs on the front panel. All 4 channels use the same interface IO and are independently controlled. Replace `channel_x` with `channel_1`, `channel_2`, `channel_3`, or `channel_4` respectively.

IO Path	Description
/fx4/dac/channel_x	<b>NUMBER</b> Command voltage output. This value can only be written to when output mode is set to manual.
/fx4/dac/channel_x/readback	<b>READONLY NUMBER</b> Measured voltage output. This is most helpful when using expression output mode.
/fx4/dac/channel_x/output_mode	<b>STRING</b> Sets the output mode for the channel. Options: "manual", "expression", "process_control"
/fx4/dac/channel_x/slew_control_enable	<b>BOOL</b> Enables or disables slew rate limiting.
/fx4/dac/channel_x/slew_rate	<b>NUMBER</b> Slew rate in V/s for the channel.
/fx4/dac/channel_x/upper_limit	<b>NUMBER</b> The maximum allowed command voltage for the channel. Applies to all operation modes.
/fx4/dac/channel_x/lower_limit	<b>NUMBER</b> The minimum allowed command voltage for the channel. Applies to all operation modes.
/fx4/dac/channel_x/output_expression	<b>STRING</b> Sets the expression string used by the channel when it is in the expression output mode.
/fx4/dac/channel_x/reset_button	<b>BUTTON</b> Resets the command voltage to 0.

## 2.3 Digital Input and Outputs

These IO relate to controlling the various general purpose digital inputs and outputs found on the FX4.

IO Path	Description
/fx4/fr1	<b>READONLY BOOL</b> Fiber receiver 1.
/fx4/ft1	<b>BOOL</b> Fiber transmitter 1.
/fx4/fr2	<b>READONLY BOOL</b> Fiber receiver 2.
/fx4/ft2	<b>BOOL</b> Fiber transmitter 2.
/fx4/fr3	<b>READONLY BOOL</b> Fiber receiver 3.
/fx4/ft3	<b>BOOL</b> Fiber transmitter 3.
/fx4/digital_expansion/d1	<b>BOOL</b> D1 bidirectional digital expansion IO.
/fx4/digital_expansion/d2	<b>BOOL</b> D2 bidirectional digital expansion IO.
/fx4/digital_expansion/d3	<b>BOOL</b> D3 bidirectional digital expansion IO.
/fx4/digital_expansion/d4	<b>BOOL</b> D4 bidirectional digital expansion IO.

### 2.3.1 Digital IO Configuration

All digitals have child IO for configuring their behavior including an operating mode which controls how that digital will operate. Each digital will have a different set of available options. See the GUI for details on what options are available for what IO.

Child IO Path	Description
<code>.../mode</code>	<b>STRING</b> Operation mode for the digital. Options: "input", "output", "pwm", "timer", "encoder", "capture", "uart_rx", "uart_tx", "can_rx", "can_tx", "pru_input", or "pru_output"
<code>.../process_signal</code>	<b>STRING</b> The process control signal name, if there is one.
<code>.../pull_mode</code>	<b>STRING</b> Pull up/down mode for a digital input. Options: "up", "down", or "disable"

## 2.4 Relay Control

Both relays are independently controlled and share the same type of interface. Replace `relay_x` with `relay_a` or `relay_b` respectively.

IO Path	Description
<code>/fx4/relay_x/permit/user_command</code>	<b>BOOL</b> Commands the relay open or closed. A true command will try to close the relay if the interlocks are granted, and false command will always open the relay.
<code>/fx4/relay_x/state</code>	<b>READONLY STRING</b> The current state of the relay. Locked relays are open but cannot be closed due to an interlock. States: "opened", "closed", or "locked"
<code>/fx4/relay_x/automatically_close</code>	<b>BOOL</b> When set to true, the relay will automatically close when the interlocks are granted. False by default.
<code>/fx4/relay_x/cycle_count</code>	<b>READONLY NUMBER</b> The number of relay cycles since the last reset. Useful for tracking relay lifetime.

## 2.5 High Voltage Module

See the IGX - Programmer Manual for details on the FX4 high voltage interface. The component parent path is `/fx4/high_votlage`.

## 2.6 Dose Controller

See the IGX - Programmer Manual for details on the FX4 dose controller interface. The component parent path is `/fx4/dose_controller`.