

## COMPREHENSIVE SERVICES

We offer competitive repair and calibration services, as well as easily accessible documentation and free downloadable resources.

## SELL YOUR SURPLUS

We buy new, used, decommissioned, and surplus parts from every NI series. We work out the best solution to suit your individual needs.

 Sell For Cash    Get Credit    Receive a Trade-In Deal

## OBSOLETE NI HARDWARE IN STOCK & READY TO SHIP

We stock **New**, **New Surplus**, **Refurbished**, and **Reconditioned** NI Hardware.



*Bridging the gap between the manufacturer and your legacy test system.*

 1-800-915-6216

 [www.apexwaves.com](http://www.apexwaves.com)

 [sales@apexwaves.com](mailto:sales@apexwaves.com)

All trademarks, brands, and brand names are the property of their respective owners.

***Request a Quote***

 **CLICK HERE**

***NI-9514***

# NI 951x C Series Modules Object Dictionary

This document contains the NI 951x C Series drive interface modules vendor extensions to the object dictionary.

## Contents

---

|                                                          |    |
|----------------------------------------------------------|----|
| Input/Output & Feedback Objects .....                    | 3  |
| Position Actual Value (PDO, Index 0x6063) .....          | 3  |
| Actual Velocity (PDO, Index 0x606C) .....                | 3  |
| Sensor Selector Code (SDO, Index 0x606A) .....           | 3  |
| Auxiliary Position (PDO, Index 0x2200) .....             | 3  |
| Auxiliary Velocity (PDO, Index 0x2201) .....             | 4  |
| Velocity & Acceleration Format (SDO, Index 0x2202) ..... | 4  |
| Capture Position (PDO, Index 0x2204) .....               | 4  |
| Compare Position (PDO, Index 0x2205) .....               | 4  |
| Zero-Velocity Threshold (SDO, Index 0x2206) .....        | 5  |
| Module Control (PDO, Index 0x2210) .....                 | 5  |
| Module Status (PDO, Index 0x2211) .....                  | 8  |
| Module I/O Configuration (SDO, Index 0x2220) .....       | 11 |
| Module I/O Active State (SDO, Index 0x2221) .....        | 11 |
| Module I/O Type (SDO, Index 0x2223) .....                | 14 |
| Encoder 0 Phase A and B Filter (SDO, Index 0x2230) ..... | 15 |
| Encoder 0 Index Filter (SDO, Index 0x2231) .....         | 16 |
| Encoder 1 Phase A and B Filter (SDO, Index 0x2232) ..... | 16 |
| Position Capture Filter (SDO, Index 0x2233) .....        | 16 |
| Limit Filters (SDO, Index 0x2234) .....                  | 17 |
| Digital Input Filters (SDO, Index 0x2235) .....          | 18 |
| Position Compare Window (SDO, Index 0x2240) .....        | 19 |
| Compare Pulse Width (SDO, Index 0x2241) .....            | 19 |
| Compare Period (SDO, Index 0x2242) .....                 | 19 |
| Fault and System Configuration Objects .....             | 20 |
| Control Word (PDO, Index 0x6040) .....                   | 20 |
| Status Word (PDO, Index 0x6041) .....                    | 20 |
| Manufacturer Status Register (PDO, Index 0x1002) .....   | 21 |
| Error Register (SDO, Index 0x1001) .....                 | 22 |
| Heartbeat Period (SDO, Index 0x2402) .....               | 23 |
| Control Loop Adjust Threshold (SDO, Index 0x2410) .....  | 23 |
| Safe States (SDO, Index 0x2420) .....                    | 24 |
| Module FPGA Firmware Version (SDO, Index 0x2430) .....   | 25 |
| Drive Operation And Status Objects .....                 | 26 |
| Steps Generated (PDO, Index 0x2550) .....                | 26 |
| Stepper Configuration (SDO, Index 0x2551) .....          | 26 |

|                                                                                                    |    |
|----------------------------------------------------------------------------------------------------|----|
| Control Loop Objects.....                                                                          | 27 |
| Modes of Operation (SDO, Index 0x6060) .....                                                       | 27 |
| Modes of Operation Display (SDO, Index 0x6061) .....                                               | 27 |
| Position Command Value (PDO, Index 0x6062) .....                                                   | 27 |
| Position Error Limit Value (SDO, Index 0x6065) .....                                               | 27 |
| Position Error Value (SDO, Index 0x60F4) .....                                                     | 28 |
| PID Gains (SDO, Index 0x60FB, Sub-Index 0x00) .....                                                | 28 |
| Position Loop Proportional Gain (SDO, Index 0x60FB, Sub-Index 0x01) .....                          | 28 |
| Position Loop Differential Gain (SDO, Index 0x60FB, Sub-Index 0x02) .....                          | 28 |
| Position Loop Integral Gain (SDO, Index 0x60FB, Sub-Index 0x03) .....                              | 29 |
| Velocity Feedback Gain (SDO, Index 0x60FB, Sub-Index 0x04) .....                                   | 29 |
| Position Loop Velocity Feedforward Gain (SDO, Index 0x60FB, Sub-Index 0x05) .....                  | 29 |
| Position Loop Acceleration Feedforward Gain (SDO, Index 0x60FB, Sub-Index 0x06) .....              | 29 |
| Position Loop Derivative Time (SDO, Index 0x60FB, Sub-Index 0x07) .....                            | 30 |
| Position Loop Integral Limit (SDO, Index 0x60FB, Sub-Index 0x08) .....                             | 30 |
| Output Update Period (SDO, Index 0x60FB, Sub-Index 0x09) .....                                     | 30 |
| Secondary Position Loop Proportional Gain (SDO, Index 0x60FB, Sub-Index 0x11) .....                | 30 |
| Secondary Position Loop Differential Gain (SDO, Index 0x60FB, Sub-Index 0x12) .....                | 31 |
| Secondary Position Loop Integral Gain (SDO, Index 0x60FB, Sub-Index 0x13) .....                    | 31 |
| Secondary Velocity Feedback Gain (SDO, Index 0x60FB, Sub-Index 0x14) .....                         | 31 |
| Secondary Position Loop Velocity Feedforward Gain (SDO, Index 0x60FB,<br>Sub-Index 0x15) .....     | 31 |
| Secondary Position Loop Acceleration Feedforward Gain (SDO, Index 0x60FB,<br>Sub-Index 0x16) ..... | 32 |
| Secondary Position Loop Derivative Time (SDO, Index 0x60FB, Sub-Index 0x17) .....                  | 32 |
| Secondary Position Loop Integral Limit (SDO, Index 0x60FB, Sub-Index 0x18) .....                   | 32 |
| Secondary Control Loop Period Multiple (SDO, Index 0x60FB, Sub-Index 0x19) .....                   | 32 |
| Setpoint Control (PDO, Index 0x2600) .....                                                         | 33 |
| Trajectory Velocity (PDO, Index 0x2601) .....                                                      | 33 |
| Trajectory Acceleration (PDO, Index 0x2602) .....                                                  | 33 |
| Setpoint Status (PDO, Index 0x2604) .....                                                          | 33 |
| Control Loop Period (SDO, Index 0x2610) .....                                                      | 34 |
| System Scan Period (SDO, Index 0x2611) .....                                                       | 34 |
| Torque Positive Limit (SDO, Index 0x2620) .....                                                    | 34 |
| Torque Negative Limit (SDO, Index 0x2621) .....                                                    | 35 |
| Torque Offset (SDO, Index 0x2622) .....                                                            | 35 |
| Target Position (PDO, Index 0x607A) .....                                                          | 35 |
| Interpolated Data Record (SDO, Index 0x60C1, Sub-Index 0x00) .....                                 | 35 |
| Spline Data Coefficient 0 Whole (PDO, Index 0x60C1, Sub-Index 1) .....                             | 36 |
| Spline Data Coefficient 0 Fraction (PDO, Index 0x60C1, Sub-Index 2) .....                          | 36 |
| Spline Data Coefficient 1 (PDO, Index 0x60C1, Sub-Index 3) .....                                   | 36 |
| Spline Data Coefficient 2 (PDO, Index 0x60C1, Sub-Index 4) .....                                   | 36 |
| Spline Data Coefficient 3 (PDO, Index 0x60C1, Sub-Index 5) .....                                   | 36 |
| Control Loop Gain Set (SDO, Index 0x2650, Sub-Index 0x00) .....                                    | 37 |
| Control Loop Gain Set 1 (SDO, Index 0x2650, Sub-Index 1) .....                                     | 37 |
| PID Gain Format (SDO, Index 0x2651) .....                                                          | 37 |
| Where to Go for Support .....                                                                      | 38 |

## Input/Output & Feedback Objects

### Position Actual Value (PDO, Index 0x6063)

| Format | Access | Units          | Range              | PDO Mapping | Default | Supported On |
|--------|--------|----------------|--------------------|-------------|---------|--------------|
| i32    | R      | Encoder counts | $\pm (2^{31} - 1)$ | Yes         | 0x0     | NI 951x      |

#### Description

Provides the position feedback from the primary encoder or Encoder 0.

### Actual Velocity (PDO, Index 0x606C)

| Format                          | Access | Units               | Range              | PDO Mapping | Default | Supported On |
|---------------------------------|--------|---------------------|--------------------|-------------|---------|--------------|
| i32                             | R      | Module clock ticks* | $\pm (2^{31} - 1)$ | Yes         | 0x0     | NI 951x      |
| * 1 module clock tick is 25 ns. |        |                     |                    |             |         |              |

#### Description

Provides the actual motor velocity calculated as the number of module clock ticks between encoder counts of Encoder 0. This value is set to zero if the module clock ticks between the encoder counts are larger than the specified **Zero-Velocity Threshold** (SDO, Index 0x2206). This value is positive when the motor is moving in the forward direction.

### Sensor Selector Code (SDO, Index 0x606A)

| Type     | Access | Units | Range | PDO Mapping | Default | Supported On |
|----------|--------|-------|-------|-------------|---------|--------------|
| Signed16 | RW     | N/A   | 0–1   | No          | 0       | NI 9516      |

#### Description

0 = Provides the actual velocity value from the position encoder / primary feedback device

1 = Provides the actual velocity value from the velocity encoder / secondary feedback device

This object is used in conjunction with the **Feedback Mode** in the **Module Control Object** (PDO, Index 0x2210). The feedback selects the source of the primary feedback.

### Auxiliary Position (PDO, Index 0x2200)

| Format | Access | Units          | Range              | PDO Mapping | Default | Supported On |
|--------|--------|----------------|--------------------|-------------|---------|--------------|
| i32    | R      | Encoder counts | $\pm (2^{31} - 1)$ | Yes         | 0x0     | NI 9516      |

#### Description

Provides the motor position in encoder counts derived from the auxiliary feedback device, which is Encoder 1 for the NI 9516.

## Auxiliary Velocity (PDO, Index 0x2201)

| Format                          | Access | Units               | Range              | PDO Mapping | Default | Supported On |
|---------------------------------|--------|---------------------|--------------------|-------------|---------|--------------|
| i32                             | R      | Module clock ticks* | $\pm (2^{31} - 1)$ | Yes         | 0x0     | NI 9516      |
| * 1 module clock tick is 25 ns. |        |                     |                    |             |         |              |

### Description

Provides the actual motor velocity calculated as the number of module clock ticks between encoder counts of Encoder 1. This value is set to zero if the module clock ticks between the encoder counts are larger than the **Zero-Velocity Threshold** (SDO, Index 0x2206). This value is positive when the motor is moving in the forward direction.

## Velocity & Acceleration Format (SDO, Index 0x2202)

| Type | Access | Units | Range | PDO Mapping | Default | Supported On |
|------|--------|-------|-------|-------------|---------|--------------|
| u8   | RW     | N/A   | N/A   | No          | 0x0     | NI 951x      |

### Description

Configures the data format for **Trajectory Velocity** (PDO, Index 0x2601) and **Trajectory Acceleration** (PDO, Index 0x2602) as floating point or fixed-point.

| Bit | Description                                                                                     |
|-----|-------------------------------------------------------------------------------------------------|
| 0   | Velocity & Acceleration Format<br>0 = 32-bit floating point<br>1 = fixed-point 16.16 (LV 32.16) |
| 1–7 | Reserved                                                                                        |

## Capture Position (PDO, Index 0x2204)

| Type | Access | Units          | Range              | PDO Mapping | Default | Supported On |
|------|--------|----------------|--------------------|-------------|---------|--------------|
| i32  | R      | Encoder counts | $\pm (2^{31} - 1)$ | Yes         | 0x0     | NI 951x      |

### Description

Provides the encoder position where the reference position or the high-speed capture input occurred.

## Compare Position (PDO, Index 0x2205)

| Type | Access | Units          | Range              | PDO Mapping | Default | Supported On |
|------|--------|----------------|--------------------|-------------|---------|--------------|
| i32  | W      | Encoder counts | $\pm (2^{31} - 1)$ | Yes         | 0x0     | NI 951x      |

## Description

Specifies the encoder position at which to output a position compare output. For periodic position compare outputs, this specifies the starting position. Specify the position compare output type using the **Module I/O Configuration** object (SDO, Index 0x2220)

## Zero-Velocity Threshold (SDO, Index 0x2206)

| Type                            | Access | Units               | Range          | PDO Mapping | Default    | Supported On |
|---------------------------------|--------|---------------------|----------------|-------------|------------|--------------|
| u32                             | RW     | Module clock ticks* | 1 – 0x7FFFFFFF | No          | 0x17D78400 | NI 951x      |
| * 1 module clock tick is 25 ns. |        |                     |                |             |            |              |

## Description

Defines the **Zero-Velocity Threshold** in module clock ticks. If the time between encoder ticks/updates is equal to or greater than this value, the velocity is reported as zero.

## Module Control (PDO, Index 0x2210)

| Type | Access | Units | Range | PDO Mapping | Default | Supported On |
|------|--------|-------|-------|-------------|---------|--------------|
| u32  | W      | N/A   | N/A   | Yes         | 0x0     | NI 951x      |

## Description

Enables and disables special functionality on the dedicated I/O pins and controls the status of the general-purpose module I/O. This object also contains the Master Heartbeat. This object is bitmapped as follows:

| Bit | Description                                                                                                                                                                                                                                                                                           |
|-----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0   | Compare Enable:<br>0 = Disable (Default)<br>1 = Enable*<br><br>* Edge sensitive enable. A '0' to '1' transition is required to enable compare. For single-point compare, Compare is automatically disabled after a compare event. To re-enable, the enable must first transition to '0' and then '1.' |
| 1   | Capture Enable:<br>0 = Disable (Default)<br>1 = Enable*<br><br>* Edge sensitive enable. A '0' to '1' transition is required to enable capture. Capture is automatically disabled after a Capture event. To re-enable, the enable must first transition to '0' and then '1.'                           |
| 2   | Capture Condition:<br>0 = Active Transition (Default)<br>1 = Inactive Transition                                                                                                                                                                                                                      |

| Bit | Description                                                                                                                                                                                                                                                                                             |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3–6 | <p>Capture Source:</p> <p>0000 = High Speed Position Capture Input (Default)</p> <p>0001 = Index</p> <p>0010 = Forward Limit</p> <p>0011 = Reverse Limit</p> <p>0100 = Home</p> <p>0101 = Digital Input 0</p> <p>0110 = Digital Input 1</p> <p>0111 = Digital Input 2</p> <p>1000 = Digital Input 3</p> |
| 7–8 | <p>Motion Feedback Mode:</p> <p>00 = Encoder 0 is primary feedback (Default)</p> <p>01 = Reserved</p> <p>10 = Encoder 1 is primary (Option available only on NI 9516)</p> <p>11 = Reserved</p>                                                                                                          |
| 9   | <p>Position Error clear:</p> <p>0 = Do not Clear (Default)</p> <p>1 = Clear</p> <p>* Edge sensitive clear. A '0' to '1' transition clears the latch.</p>                                                                                                                                                |
| 10  | <p>Forward Limit Latch Clear</p> <p>0 = Do not Clear (Default)</p> <p>1 = Clear</p> <p>* Level sensitive clear. A '0' keeps the latch cleared.</p>                                                                                                                                                      |
| 11  | <p>Reverse Limit Latch Clear</p> <p>0 = Do not Clear (Default)</p> <p>1 = Clear</p> <p>* Level sensitive clear. A '0' keeps the latch cleared.</p>                                                                                                                                                      |
| 12  | <p>Home Limit Latch Clear</p> <p>0 = Do not Clear (Default)</p> <p>1 = Clear</p> <p>* Level sensitive clear. A '0' keeps the latch cleared.</p>                                                                                                                                                         |

| Bit | Description                                                                                                                                                                                                                                                                                              |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 13  | <p>Digital Input 0 Latch Clear</p> <p>0 = Do not Clear (Default)</p> <p>1 = Clear</p> <p>* Level sensitive clear. A '0' keeps the latch cleared.</p>                                                                                                                                                     |
| 14  | <p>Digital Input 1 Latch Clear</p> <p>0 = Do not Clear (Default)</p> <p>1 = Clear</p> <p>* Level sensitive clear. A '0' keeps the latch cleared.</p>                                                                                                                                                     |
| 15  | <p>Digital Input 2 Latch Clear</p> <p>0 = Do not Clear (Default)</p> <p>1 = Clear</p> <p>* Level sensitive clear. A '0' keeps the latch cleared.</p>                                                                                                                                                     |
| 16  | <p>Digital Input 3 Latch Clear</p> <p>0 = Do not Clear (Default)</p> <p>1 = Clear</p> <p>* Level sensitive clear. A '0' keeps the latch cleared.</p>                                                                                                                                                     |
| 17  | <p>Compare Output Control</p> <p>Used for the raw state of the Position Compare output when the <b>Compare Mode</b> in the <b>Module I/O Configuration</b> object (SDO, Index 0x2220) is set for raw digital output.</p> <p>0 = Low (Default)</p> <p>1 = High</p>                                        |
| 18  | <p>Drive Enable Output Control</p> <p>Used for the raw state of the Drive Enable output when Drive Enable is configured as a digital output. Configure Drive Enable as a digital output using the <b>Module I/O Configuration</b> object (SDO, Index 0x2220).</p> <p>0 = Off (Default)</p> <p>1 = On</p> |
| 19  | <p>Digital Output 0 Control</p> <p>0 = Off (Default)</p> <p>1 = On</p>                                                                                                                                                                                                                                   |
| 20  | <p>Digital Output 1 Control</p> <p>0 = Off (Default)</p> <p>1 = On</p>                                                                                                                                                                                                                                   |

| Bit   | Description                                                                                                                                                                                                                                                                                                               |
|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 21    | Limit LED Control<br>0 = LED Off (Default)<br>1 = LED On                                                                                                                                                                                                                                                                  |
| 22–23 | Reserved                                                                                                                                                                                                                                                                                                                  |
| 31–24 | Master Heartbeat<br>8-bit Master Heartbeat: The Heartbeat Consumer in the module is enabled immediately on transition to Operational state. When enabled the Consumer latches the Heartbeat value in this register and then expects the value to be incremented by one every <b>Heartbeat Period</b> (SDO, Index 0x2402). |

## Module Status (PDO, Index 0x2211)

| Type | Access | Units | Range | PDO Mapping | Default | Supported On |
|------|--------|-------|-------|-------------|---------|--------------|
| u32  | R      | N/A   | N/A   | Yes         | 0x0     | NI 951x      |

### Description

This object is bitmapped as follows:

| Bit | Description                                                                                                                                                                                                                                                                                                                                                  |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0   | Position Compare Flag:<br>0 = No Compare Event<br>1 = Compare Event<br><br>Set when the current position is the compare position. When performing a periodic position compare operation it is set on the first compare event. The Position Compare Flag clears when Compare is disabled.                                                                     |
| 1   | Capture Flag:<br>0 = No Capture Event<br>1 = Capture Event<br><br>Set on a capture event. The Capture Flag clears when Capture is disabled.                                                                                                                                                                                                                  |
| 2   | Position Capture overlap status<br>0 = No Overlap Error<br>1 = Overlap Error<br><br>If a capture event occurred when capture is enabled and one or more capture triggers are received then this flag is set. Note that in case of multiple triggers, the Capture position PDO still contains the position that was captured on the very first capture event. |

| Bit | Description                                                                                                                                                                                                                                                                                                                                                                                            |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3   | <p>Position Compare overlap status</p> <p>0 = No Overlap Error</p> <p>1 = Overlap Error</p> <p>In case of a periodic position compare, if the compare output pulse is still active but the next compare position is reached then the overlap status bit is set. This occurs when the <b>Compare Pulse Width</b> (SDO, Index 0x2241) is greater than the <b>Compare Period</b> (SDO, Index 0x2242).</p> |
| 4   | <p>Position Error Status</p> <p>0 = No Position Error</p> <p>1 = Position Error</p> <p>Set when position error occurs. The <b>Position Error Limit Value</b> must be set using the SDO: 0x6065. Read the <b>Position Error Value</b> using the SDO: 0x60F4.</p>                                                                                                                                        |
| 5   | <p>Forward Limit Raw Input State</p> <p>0 = Off</p> <p>1 = On</p>                                                                                                                                                                                                                                                                                                                                      |
| 6   | <p>Reverse Limit Raw Input State</p> <p>0 = Off</p> <p>1 = On</p>                                                                                                                                                                                                                                                                                                                                      |
| 7   | <p>Home Raw Input State</p> <p>0 = Off</p> <p>1 = On</p>                                                                                                                                                                                                                                                                                                                                               |
| 8   | <p>Digital Input 0 Raw Input State</p> <p>0 = Off</p> <p>1 = On</p>                                                                                                                                                                                                                                                                                                                                    |
| 9   | <p>Digital Input 1 Raw Input State</p> <p>0 = Off</p> <p>1 = On</p>                                                                                                                                                                                                                                                                                                                                    |
| 10  | <p>Digital Input 2 Raw Input State</p> <p>0 = Off</p> <p>1 = On</p>                                                                                                                                                                                                                                                                                                                                    |
| 11  | <p>Digital Input 3 Raw Input State</p> <p>0 = Off</p> <p>1 = On</p>                                                                                                                                                                                                                                                                                                                                    |

| Bit   | Description                                                                                                                                                                                                                                                                       |
|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 12    | Forward Limit State Change Latch<br>0 = No Change<br>1 = Change of State                                                                                                                                                                                                          |
| 13    | Reverse Limit State Change Latch<br>0 = No Change<br>1 = Change of State                                                                                                                                                                                                          |
| 14    | Home State Change Latch<br>0 = No Change<br>1 = Change of State                                                                                                                                                                                                                   |
| 15    | Digital Input 0 State Change Latch<br>0 = No Change<br>1 = Change of State                                                                                                                                                                                                        |
| 16    | Digital Input 1 State Change Latch<br>0 = No Change<br>1 = Change of State                                                                                                                                                                                                        |
| 17    | Digital Input 2 State Change Latch<br>0 = No Change<br>1 = Change of State                                                                                                                                                                                                        |
| 18    | Digital Input 3 State Change Latch<br>0 = No Change<br>1 = Change of State                                                                                                                                                                                                        |
| 19    | Position Capture Raw Input State<br>0 = Low<br>1 = High                                                                                                                                                                                                                           |
| 20–23 | Reserved                                                                                                                                                                                                                                                                          |
| 31–24 | Module Heartbeat<br><br>8-bit Module Heartbeat: The Heartbeat Producer in the module is enabled immediately on transition to Safe Operational state. The Heartbeat value starts from zero on enable and then increments by one every <b>Heartbeat Period</b> (SDO, Index 0x2402). |

## Module I/O Configuration (SDO, Index 0x2220)

| Type | Access | Units | Range | PDO Mapping | Default    | Supported On |
|------|--------|-------|-------|-------------|------------|--------------|
| u32  | RW     | N/A   | N/A   | No          | 0x00000040 | NI 951x      |

### Description

This object is bitmapped as follows:

| Bit  | Description                                                                                         |
|------|-----------------------------------------------------------------------------------------------------|
| 0–1  | Compare Mode:<br>00 = Single (Default)<br>01 = Periodic<br>10 = Reserved<br>11 = Raw Digital Output |
| 2–3  | Compare Action:<br>00 = Pulse (Default)<br>01 = Set<br>10 = Toggle                                  |
| 4    | Encoder Index Reference Criteria Phase A:<br>0 = Phase A Inactive (Default)<br>1 = Phase A Active   |
| 5    | Encoder Index Reference Criteria Phase B:<br>0 = Phase A Inactive (Default)<br>1 = Phase A Active   |
| 6    | Drive Enable Output Pin Functionality<br>0 = General Purpose Output<br>1 = Drive Enable (Default)   |
| 7–31 | Reserved                                                                                            |

## Module I/O Active State (SDO, Index 0x2221)

| Type | Access | Units | Range | PDO Mapping | Default    | Supported On |
|------|--------|-------|-------|-------------|------------|--------------|
| u32  | RW     | N/A   | N/A   | No          | 0x000003C0 | NI 951x      |

### Description

This object is bitmapped as follows:

| Bit | Description                                                     |
|-----|-----------------------------------------------------------------|
| 0   | Encoder 0 Phase A Active State<br>0 = High (Default)<br>1 = Low |
| 1   | Encoder 0 Phase B Active State<br>0 = High (Default)<br>1 = Low |
| 2   | Encoder 0 Index Active State<br>0 = High (Default)<br>1 = Low   |
| 3   | Encoder 1 Phase A Active State<br>0 = High (Default)<br>1 = Low |
| 4   | Encoder 1 Phase B Active State<br>0 = High (Default)<br>1 = Low |
| 5   | Drive Enable Active State<br>0 = On (Default)<br>1 = Off        |
| 6   | Position Capture Active State<br>0 = High<br>1 = Low (Default)  |
| 7   | Position Compare Active State<br>0 = High<br>1 = Low (Default)  |
| 8   | Step Active State<br>0 = High<br>1 = Low (Default)              |
| 9   | Direction Active State<br>0 = High<br>1 = Low (Default)         |

| Bit   | Description                                                                                                                                      |
|-------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| 10    | Analog Output Inversion<br>0 = Do not Invert (Default)<br>1 = Invert                                                                             |
| 11    | Reserved                                                                                                                                         |
| 12    | Forward Limit Active State<br>0 = On (Default)<br>1 = Off<br>* This only applies when the input is used with the high-speed capture circuitry.   |
| 13    | Reverse Limit Active State<br>0 = On (Default)<br>1 = Off<br>* This only applies when the input is used with the high-speed capture circuitry.   |
| 14    | Home Active State<br>0 = On (Default)<br>1 = Off<br>* This only applies when the input is used with the high-speed capture circuitry.            |
| 15    | Digital Input 0 Active State<br>0 = On (Default)<br>1 = Off<br>* This only applies when the input is used with the high-speed capture circuitry. |
| 16    | Digital Input 1 Active State<br>0 = On (Default)<br>1 = Off<br>* This only applies when the input is used with the high-speed capture circuitry. |
| 17    | Digital Input 2 Active State<br>0 = On (Default)<br>1 = Off<br>* This only applies when the input is used with the high-speed capture circuitry. |
| 18    | Digital Input 3 Active State<br>0 = On (Default)<br>1 = Off<br>* This only applies when the input is used with the high-speed capture circuitry. |
| 19–31 | Reserved                                                                                                                                         |

## Module I/O Type (SDO, Index 0x2223)

| Type | Access | Units | Range | PDO Mapping | Default | Supported On |
|------|--------|-------|-------|-------------|---------|--------------|
| u16  | RW     | N/A   | N/A   | No          | 0x0     | NI 951x      |

### Description

This object is bitmapped as follows:

| Bit | Description                                                              |
|-----|--------------------------------------------------------------------------|
| 0   | Step Output Type:<br>0 = Single-Ended (Default)<br>1 = Differential      |
| 1   | Direction Output Type:<br>0 = Single-Ended (Default)<br>1 = Differential |
| 2   | Drive Enable Output Type:<br>0 = Sinking (Default)<br>1 = Sourcing       |
| 3   | Forward Limit Input Type:<br>0 = Sinking (Default)<br>1 = Sourcing       |
| 4   | Reverse Limit Input Type:<br>0 = Sinking (Default)<br>1 = Sourcing       |
| 5   | Home Input Type:<br>0 = Sinking (Default)<br>1 = Sourcing                |
| 6   | Digital Input 0 Type<br>0 = Sinking (Default)<br>1 = Sourcing            |
| 7   | Digital Input 1 Type<br>0 = Sinking (Default)<br>1 = Sourcing            |
| 8   | Digital Input 2 Type<br>0 = Sinking (Default)<br>1 = Sourcing            |

| Bit   | Description                                                    |
|-------|----------------------------------------------------------------|
| 9     | Digital Input 3 Type<br>0 = Sinking (Default)<br>1 = Sourcing  |
| 10    | Digital Output 0 Type<br>0 = Sinking (Default)<br>1 = Sourcing |
| 11    | Digital Output 1 Type<br>0 = Sinking (Default)<br>1 = Sourcing |
| 12–15 | Reserved                                                       |

### Encoder 0 Phase A and B Filter (SDO, Index 0x2230)

| Type                            | Access | Units               | Range          | PDO Mapping | Default      | Supported On |
|---------------------------------|--------|---------------------|----------------|-------------|--------------|--------------|
| u8                              | RW     | Module clock ticks* | 0 to 255 ticks | No          | 0x14 (500ns) | NI 951x      |
| * 1 module clock tick is 25 ns. |        |                     |                |             |              |              |

#### Description

Specifies the digital filter for Encoder 0 Phase A and Encoder 0 Phase B in module clock ticks. Pulses shorter than the filter time period are guaranteed to be filtered. A value of 0 disables filtering.

Recommended Encoder and Index Filter settings for common velocity settings:

| Velocity (counts/sec) | Encoder Filter | Index Filter |
|-----------------------|----------------|--------------|
| 500 k                 | 0x28           | 0x14         |
| 1000 k                | 0x14 (Default) | 0x0A         |
| 2000 k                | 0x10           | 0x08         |
| 4000 k                | 0x08           | 0x04         |
| 8000 k                | 0x04           | 0x02         |
| 16000 k               | 0x02           | 0x01         |
| 20000 k               | 0x01           | 0x01         |

## Encoder 0 Index Filter (SDO, Index 0x2231)

| Type                            | Access | Units               | Range          | PDO Mapping | Default     | Supported On |
|---------------------------------|--------|---------------------|----------------|-------------|-------------|--------------|
| u8                              | RW     | Module clock ticks* | 0 to 255 ticks | No          | 0xA (250ns) | NI 951x      |
| * 1 module clock tick is 25 ns. |        |                     |                |             |             |              |

### Description

Specifies the digital filter for Encoder 0 Index. Pulses shorter than the filter time period are guaranteed to be filtered. A value of 0 disables filtering.

## Encoder 1 Phase A and B Filter (SDO, Index 0x2232)

| Type                            | Access | Units               | Range          | PDO Mapping | Default      | Supported On |
|---------------------------------|--------|---------------------|----------------|-------------|--------------|--------------|
| u8                              | RW     | Module clock ticks* | 0 to 255 ticks | No          | 0x14 (500ns) | NI 9516      |
| * 1 module clock tick is 25 ns. |        |                     |                |             |              |              |

### Description

Specifies the digital filter for Encoder 1 Phase A and Encoder 1 Phase B. Pulses shorter than the filter time period are guaranteed to be filtered. A value of 0 disables filtering.

## Position Capture Filter (SDO, Index 0x2233)

| Type | Access | Units | Range | PDO Mapping | Default | Supported On |
|------|--------|-------|-------|-------------|---------|--------------|
| u8   | RW     | N/A   | 0 – 5 | No          | 0x01    | NI 951x      |

### Description

Specifies the digital filter for the high-speed Position Capture input. Pulses shorter than the filter time period are guaranteed to be filtered.

| Register Value | Filter Setting |
|----------------|----------------|
| 0x00           | 50 ns          |
| 0x01 (Default) | 100 ns         |
| 0x02           | 500 ns         |
| 0x03           | 1 µs           |
| 0x04           | 10 µs          |
| 0x05           | 100 µs         |

## Limit Filters (SDO, Index 0x2234)

| Type | Access | Units | Range | PDO Mapping | Default | Supported On |
|------|--------|-------|-------|-------------|---------|--------------|
| u8   | RW     | N/A   | N/A   | No          | 0x00    | NI 951x      |

### Description

Specifies the digital filters for the Forward Limit, Reverse Limit, and Home inputs. Pulses shorter than the filter time period are guaranteed to be filtered.

This object is bitmapped as follows:

| Bit | Description                                                                                      |
|-----|--------------------------------------------------------------------------------------------------|
| 0–1 | Forward Limit Filter<br>00 = 50 $\mu$ s (Default)<br>01 = 500 $\mu$ s<br>10 = 1 ms<br>11 = 10 ms |
| 2–3 | Reverse Limit Filter<br>00 = 50 $\mu$ s (Default)<br>01 = 500 $\mu$ s<br>10 = 1 ms<br>11 = 10 ms |
| 4–5 | Home Filter<br>00 = 50 $\mu$ s (Default)<br>01 = 500 $\mu$ s<br>10 = 1 ms<br>11 = 10 ms          |
| 6–7 | Reserved                                                                                         |

## Digital Input Filters (SDO, Index 0x2235)

| Type | Access | Units | Range | PDO Mapping | Default | Supported On |
|------|--------|-------|-------|-------------|---------|--------------|
| u8   | RW     | N/A   | N/A   | No          | 0x00    | NI 951x      |

### Description

This object is bitmapped as follows:

| Bit | Description                                                                                                                    |
|-----|--------------------------------------------------------------------------------------------------------------------------------|
| 0–1 | Digital Input 0 Filter<br>00 = 50 $\mu$ s (Default)<br>01 = 500 $\mu$ s<br>10 = 1 ms<br>11 = 10 ms                             |
| 2–3 | Digital Input 1 Filter<br>00 = 50 $\mu$ s (Default)<br>01 = 500 $\mu$ s<br>10 = 1 ms<br>11 = 10 ms                             |
| 4–5 | Digital Input 2 Filter (Only supported in NI 9512)<br>00 = 50 $\mu$ s (Default)<br>01 = 500 $\mu$ s<br>10 = 1 ms<br>11 = 10 ms |
| 6–7 | Digital Input 3 Filter (Only supported in NI 9512)<br>00 = 50 $\mu$ s (Default)<br>01 = 500 $\mu$ s<br>10 = 1 ms<br>11 = 10 ms |

## Position Compare Window (SDO, Index 0x2240)

| Type | Access | Units          | Range | PDO Mapping | Default | Supported On |
|------|--------|----------------|-------|-------------|---------|--------------|
| u8   | RW     | Encoder counts | 1–255 | No          | 0x05    | NI 951x      |

### Description

Specifies the window for periodic position compare operations. The module will not produce another position compare output until the position is outside the **Position Compare Window** from the previous position compare output. This prevents multiple position compare outputs at the same position in case of jitter in the system. Specify the position compare type using the **Module I/O Configuration** object (SDO, Index 0x2220).

## Compare Pulse Width (SDO, Index 0x2241)

| Type | Access | Units               | Range                       | PDO Mapping | Default    | Supported On |
|------|--------|---------------------|-----------------------------|-------------|------------|--------------|
| u16  | RW     | Module clock ticks* | 4 to $2^{16}-1$<br>(65,535) | No          | 0x00000028 | NI 951x      |

\* 1 module clock tick is 25 ns.

### Description

Sets the pulse width of the position compare output, when the **Compare Action** in the **Module I/O Configuration** object (SDO, Index 0x2220) is **Pulse**.

## Compare Period (SDO, Index 0x2242)

| Type | Access | Units          | Range                          | PDO Mapping | Default    | Supported On |
|------|--------|----------------|--------------------------------|-------------|------------|--------------|
| u32  | RW     | Encoder counts | 1 to $2^{20}-1$<br>(1,048,575) | No          | 0x00000010 | NI 951x      |

### Description

Specifies the period between compare events in encoder counts when **Compare Mode** in the **Module I/O Configuration** object (SDO, Index 0x2220) is **Periodic**.



**Note** The SDO is 32 bits, but the module only supports a maximum width of 20 bits.

## Fault and System Configuration Objects

### Control Word (PDO, Index 0x6040)

| Type | Access | Units | Range | PDO Mapping | Default | Supported On |
|------|--------|-------|-------|-------------|---------|--------------|
| u16  | W      | N/A   | N/A   | Yes         | 0x0     | NI 951x      |

#### Description

Controls the state of the device. It can be used to enable or disable the controller, start and abort moves in all operating modes, and clear fault conditions.

This object is bitmapped as follows:

| Bit  | Description                                                                                                                                                                                                                                                      |
|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0–2  | Reserved                                                                                                                                                                                                                                                         |
| 3    | Axis Enable:<br>When this bit is cleared the outputs are in the user-specified safe states.                                                                                                                                                                      |
| 4–6  | Move Modes: <ul style="list-style-type: none"><li>• 000 = Deactivated: Indicates that the drive is disabled.</li><li>• 001 = Moving: Indicates that the axis is moving.</li><li>• 010 = Profile Complete: Indicates that the axis is profile complete.</li></ul> |
| 7    | Reset Fault. This bit must be used to clear any existing Faults in the module, if the fault conditions are no longer active.<br><br>* Edge sensitive: A ‘0’ to ‘1’ transition is required to clear faults.                                                       |
| 8–15 | Reserved                                                                                                                                                                                                                                                         |

### Status Word (PDO, Index 0x6041)

| Type | Access | Units | Range | PDO Mapping | Default | Supported On |
|------|--------|-------|-------|-------------|---------|--------------|
| u16  | R      | N/A   | N/A   | Yes         | 0x0     | NI 951x      |

#### Description

Displays the current state of the device and is bitmapped as follows:

| Bit | Description                                                                                                                      |
|-----|----------------------------------------------------------------------------------------------------------------------------------|
| 0–2 | Reserved                                                                                                                         |
| 3   | Fault: Set when there is a Fault. Read the <b>Manufacturer Status Register</b> object (PDO, Index 0x1002) to identify the fault. |
| 4–9 | Reserved                                                                                                                         |
| 10  | Target reached: Spline done bit                                                                                                  |

| Bit   | Description                                                             |
|-------|-------------------------------------------------------------------------|
| 11–13 | Reserved                                                                |
| 14    | Axis Active:<br>0 = Axis is killed or disabled.<br>1 = Axis is enabled. |
| 15    | Reserved                                                                |

## Manufacturer Status Register (PDO, Index 0x1002)

| Type | Access | Units | Range | PDO Mapping | Default | Supported On |
|------|--------|-------|-------|-------------|---------|--------------|
| u32  | R      | N/A   | N/A   | Yes         | 0x0     | NI 951x      |

### Description

This object contains all the module faults:

| Bit | Fault Name                                    | Description                                                                                                                                                                                                                                                                                                            |
|-----|-----------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0   | Module Undervoltage Fault                     | The external power supply ( $V_{sup}$ ) exceeds the module voltage power supply specifications. Verify that the power supply is within the module specifications and that the supply is properly connected to the module.                                                                                              |
| 1   | Module Overvoltage Fault                      | The external power supply ( $V_{sup}$ ) is not connected or does not meet the minimum power supply specifications. Verify that the power supply is within the module specifications and that the supply is properly connected to the module.                                                                           |
| 2   | Drive Enable Short Circuit                    | The drive enable output has a short circuit. Verify that the output current is within specifications and check your Drive Enable Output connections.                                                                                                                                                                   |
| 3   | Digital Output 0 Short Circuit (NI 9512 Only) | Digital Output 0 has a short circuit. Verify that the output current is within specifications and check your Digital Output connections.                                                                                                                                                                               |
| 4   | Digital Output 1 Short Circuit (NI 9512 Only) | Digital Output 1 has a short circuit. Verify that the output current is within specifications and check your Digital Output connections.                                                                                                                                                                               |
| 5   | Timing Synchronization Fault                  | The maximum amount of jitter and/or drift in the system has been exceeded. Verify that you do not have any processes on the RT system running at a higher priority than the NI Scan Engine, and that your real-time target is not overloaded. If the problem persists, contact National Instruments technical support. |

| Bit   | Fault Name                                                                                                                                                  | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 6     | Heartbeat Communication Fault                                                                                                                               | The communication between the module and the chassis has been interrupted. Verify that your system connections are correct, adjust your cabling to reduce noise on the system, and try increasing the <b>Heartbeat Period</b> (SDO, Index 0x2402).                                                                                                                                                                                                                                      |
| 7     | Processor Watchdog Fault                                                                                                                                    | A fault occurred in the module internal processor. Please contact National Instruments technical support.                                                                                                                                                                                                                                                                                                                                                                               |
| 8     | Internal Power Supply Fault                                                                                                                                 | The module has detected a failure in its internal power supply. Please contact National Instruments technical support.                                                                                                                                                                                                                                                                                                                                                                  |
| 9–29  | Reserved                                                                                                                                                    | —                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 30–31 | Current Cartridge EtherCAT State<br>00 = Initialization (Init)<br>01 = Pre-Operational (Pre-Op)<br>10 = Safe-Operational (Safe-Op)<br>11 = Operational (Op) | Current Cartridge EtherCAT State <ul style="list-style-type: none"> <li>• 00 = Init: Module power-on state. Outputs are set to high impedance.</li> <li>• 01 = Pre-Op: Module configuration state. Outputs are set to safe states. Input states are not sampled.</li> <li>• 10 = Safe-Op: Module safe or fault state. Outputs are set to safe states. Input states are sampled.</li> <li>• 11 = Op: Module is fully operational. Outputs are enabled and inputs are sampled.</li> </ul> |

## Error Register (SDO, Index 0x1001)

| Type | Access | Units | Range | PDO Mapping | Default | Supported On |
|------|--------|-------|-------|-------------|---------|--------------|
| u8   | R      | N/A   | N/A   | No          | 0x0     | NI 951x      |

### Description

This object is bitmapped as follows:

| Bit | Description                                                        |
|-----|--------------------------------------------------------------------|
| 0   | Generic error. Set any time there is a module fault.               |
| 1–3 | Reserved                                                           |
| 4   | Communication error: Set when there is a Heartbeat Fault.          |
| 5–6 | Reserved                                                           |
| 7   | Manufacturer Specific Error: Set any time there is a module fault. |

## Heartbeat Period (SDO, Index 0x2402)

| Type | Access | Units                 | Range | PDO Mapping | Default | Supported On |
|------|--------|-----------------------|-------|-------------|---------|--------------|
| u8   | RW     | Number of scan cycles | 0–255 | No          | 0x1     | NI 951x      |

### Description

Specifies the number of scans between two consecutive heartbeat checks, in scan cycles. If on a heartbeat check the system detects a communication error, Heartbeat Communication Fault is returned. The default setting of 1 scan cycle causes the system to be intolerant to communication errors by causing a timeout on any loss of data due to communication errors. If your system is known to have communication errors but your application can tolerate intermittent data loss due to communication errors you can try increasing the number of scans between heartbeat checks. National Instruments recommends leaving the Heartbeat Period at 1 scan for system safety. Data loss during a move could cause your motor to stall and/or jump.

A value of 0 disables the Heartbeat Period. The Module Heartbeat count rolls over once it reaches terminal count (255). The Heartbeat Consumer checking for Master Heartbeat expects the Master Heartbeat to roll over after reaching terminal count (255).

## Control Loop Adjust Threshold (SDO, Index 0x2410)

| Type                            | Access | Units               | Range | PDO Mapping | Default | Supported On |
|---------------------------------|--------|---------------------|-------|-------------|---------|--------------|
| u16                             | RW     | Module clock ticks* | 4–255 | No          | 0x0028  | NI 951x      |
| * 1 module clock tick is 25 ns. |        |                     |       |             |         |              |

### Description

Specifies the maximum correction that can be applied to the PID or Spline Loop time to correct for scan to scan jitter or drift. Total correction in a scan = Control Loop Adjust × Number of PIDs in the Scan.



**Note** This object affects the PID loop when used with an NI 9514 or NI 9516 module, or the Spline Loop when used with an NI 9512 module.

## Safe States (SDO, Index 0x2420)

| Type | Access | Units | Range | PDO Mapping | Default | Supported On |
|------|--------|-------|-------|-------------|---------|--------------|
| u16  | RW     | N/A   | N/A   | No          | 0x0A80  | NI 951x      |

### Description

This object is bitmapped as follows:

| Bit | Description                                                                                  |
|-----|----------------------------------------------------------------------------------------------|
| 0–1 | Drive Enable safe state:<br>00 = Off (Default)<br>01 = On<br>10 = No Change                  |
| 2–3 | Digital Output 0<br>00 = Off (Default)<br>01 = On<br>10 = No Change                          |
| 4–5 | Digital Output 1<br>00 = Off (Default)<br>01 = On<br>10 = No Change                          |
| 6–7 | Position Compare<br>00 = Low<br>01 = High<br>10 = No Change (Default)<br>11 = High Impedance |
| 8–9 | Step<br>00 = Low<br>01 = High<br>10 = No Change (Default)<br>11 = High Impedance             |

| Bit   | Description                                                                           |
|-------|---------------------------------------------------------------------------------------|
| 10–11 | Direction<br>00 = Low<br>01 = High<br>10 = No Change (Default)<br>11 = High Impedance |
| 12–31 | Reserved                                                                              |

## Module FPGA Firmware Version (SDO, Index 0x2430)

| Type | Access | Units | Range | PDO Mapping | Default | Supported On |
|------|--------|-------|-------|-------------|---------|--------------|
| u32  | R      | N/A   | N/A   | No          | N/A     | NI 951x      |

### Description

32-bit FPGA binary/firmware version number.

## Drive Operation And Status Objects

---

### Steps Generated (PDO, Index 0x2550)

| Type | Access | Units           | Range               | PDO Mapping | Default | Supported On |
|------|--------|-----------------|---------------------|-------------|---------|--------------|
| u32  | R      | Number of Steps | 0 to ( $2^{32}-1$ ) | Yes         | 0x0     | NI 9512      |

#### Description

Contains the actual number of steps generated.

### Stepper Configuration (SDO, Index 0x2551)

| Type | Access | Units | Range | PDO Mapping | Default | Supported On |
|------|--------|-------|-------|-------------|---------|--------------|
| u8   | RW     | N/A   | N/A   | No          | 0x0     | NI 9512      |

#### Description

Specifies the output mode and duty cycle for the stepper outputs. The value programmed into this object is bitmapped as follows:

| Bit | Description                                                                   |
|-----|-------------------------------------------------------------------------------|
| 0   | Stepper output mode.<br>0 = Step-Direction Mode (Default)<br>1 = CW-CCW Mode. |
| 1   | Stepper Duty Cycle.<br>0 = 50% (Default)<br>1 = 25%                           |
| 2–7 | Reserved                                                                      |

## Control Loop Objects

### Modes of Operation (SDO, Index 0x6060)

| Type                                                                                                                                                                                          | Access | Units | Range | PDO Mapping | Default | Supported On                              |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-------|-------|-------------|---------|-------------------------------------------|
| i8                                                                                                                                                                                            | RW     | N/A   | N/A   | No          | 7       | NI 951x<br>Write States*:<br>Init, Pre-Op |
| * Writes to this register are only supported in Init and Pre-Operational states. An SDO write request in any other state returns an SDO Error in response. Reads are supported in all states. |        |       |       |             |         |                                           |

#### Description

Selects the drive mode of operation. The available modes of operation are:

| Value | Description                |
|-------|----------------------------|
| –8    | Torque Mode                |
| 7     | Interpolated position mode |

### Modes of Operation Display (SDO, Index 0x6061)

| Type | Access | Units | Range | PDO Mapping | Default | Supported On |
|------|--------|-------|-------|-------------|---------|--------------|
| i8   | R      | N/A   | N/A   | No          | 7       | NI 951x      |

#### Description

Contains the current mode of operation.

### Position Command Value (PDO, Index 0x6062)

| Type | Access | Units          | Range             | PDO Mapping | Default | Supported On |
|------|--------|----------------|-------------------|-------------|---------|--------------|
| i32  | W      | Encoder Counts | 0 to $(2^{31}-1)$ | Yes         | 0       | NI 951x      |

#### Description

Specifies the commanded position.

### Position Error Limit Value (SDO, Index 0x6065)

| Type | Access | Units          | Range             | PDO Mapping | Default | Supported On |
|------|--------|----------------|-------------------|-------------|---------|--------------|
| i32  | RW     | Encoder Counts | 0 to $(2^{31}-1)$ | No          | 1000    | NI 951x      |

#### Description

Specifies the maximum allowable position error before setting the **Position Error Status** bit in the **Module Status** object (PDO, Index 0x2211).

## Position Error Value (SDO, Index 0x60F4)

| Type | Access | Units          | Range             | PDO Mapping | Default | Supported On |
|------|--------|----------------|-------------------|-------------|---------|--------------|
| i32  | R      | Encoder Counts | 0 to $(2^{31}-1)$ | No          | 0       | NI 951x      |

### Description

Contains the amount of position error.

## PID Gains (SDO, Index 0x60FB, Sub-Index 0x00)

| Type | Access | Units | Range | PDO Mapping | Default | Supported On        |
|------|--------|-------|-------|-------------|---------|---------------------|
| u32  | R      | N/A   | 25    | No          | 25      | NI 9514 and NI 9516 |

### Description

Specifies the total number of elements under this object. This currently returns 25.

## Position Loop Proportional Gain (SDO, Index 0x60FB, Sub-Index 0x01)

| Type | Access | Units | Range           | PDO Mapping | Default | Supported On        |
|------|--------|-------|-----------------|-------------|---------|---------------------|
| f32  | RW     | N/A   | 0 to 16,777,216 | No          | 100     | NI 9514 and NI 9516 |

### Description

Specifies the contribution of restoring force directly proportional to the position error. Also referred to as Kp.

## Position Loop Differential Gain (SDO, Index 0x60FB, Sub-Index 0x02)

| Type | Access | Units | Range           | PDO Mapping | Default | Supported On        |
|------|--------|-------|-----------------|-------------|---------|---------------------|
| f32  | RW     | N/A   | 0 to 16,777,216 | No          | 1000    | NI 9514 and NI 9516 |

### Description

Specifies the contribution of restoring force proportional to the rate of change (derivative) of position error. Also referred to as Kd.

### Position Loop Integral Gain (SDO, Index 0x60FB, Sub-Index 0x03)

| Type | Access | Units | Range           | PDO Mapping | Default | Supported On           |
|------|--------|-------|-----------------|-------------|---------|------------------------|
| f32  | RW     | N/A   | 0 to 16,777,216 | No          | 0       | NI 9514 and<br>NI 9516 |

#### Description

Specifies the contribution of restoring force that increases with time, ensuring that the static position error in the servo loop is forced to zero. Also referred to as Ki.

### Velocity Feedback Gain (SDO, Index 0x60FB, Sub-Index 0x04)

| Type | Access | Units | Range           | PDO Mapping | Default | Supported On           |
|------|--------|-------|-----------------|-------------|---------|------------------------|
| f32  | RW     | N/A   | 0 to 16,777,216 | No          | 0       | NI 9514 and<br>NI 9516 |

#### Description

Specifies the contribution of restoring force (damping) proportional to the velocity of the motor/actuator. Also referred to as Kv.

### Position Loop Velocity Feedforward Gain (SDO, Index 0x60FB, Sub-Index 0x05)

| Type | Access | Units | Range           | PDO Mapping | Default | Supported On           |
|------|--------|-------|-----------------|-------------|---------|------------------------|
| f32  | RW     | N/A   | 0 to 16,777,216 | No          | 0       | NI 9514 and<br>NI 9516 |

#### Description

Specifies the contribution in the DAC command output that is directly proportional to the instantaneous trajectory velocity. Also referred to as Vff.

### Position Loop Acceleration Feedforward Gain (SDO, Index 0x60FB, Sub-Index 0x06)

| Type | Access | Units | Range           | PDO Mapping | Default | Supported On           |
|------|--------|-------|-----------------|-------------|---------|------------------------|
| f32  | RW     | N/A   | 0 to 16,777,216 | No          | 0       | NI 9514 and<br>NI 9516 |

#### Description

Specifies the contribution in the drive command output that is directly proportional to the instantaneous trajectory acceleration. Also referred to as Aff.

### Position Loop Derivative Time (SDO, Index 0x60FB, Sub-Index 0x07)

| Type | Access | Units | Range           | PDO Mapping | Default | Supported On           |
|------|--------|-------|-----------------|-------------|---------|------------------------|
| f32  | RW     | N/A   | 1 to 16,777,216 | No          | 2       | NI 9514 and<br>NI 9516 |

#### Description

Specifies how often (in update samples) the derivative of position error is calculated. Also referred to as Td.

### Position Loop Integral Limit (SDO, Index 0x60FB, Sub-Index 0x08)

| Type | Access | Units | Range           | PDO Mapping | Default | Supported On           |
|------|--------|-------|-----------------|-------------|---------|------------------------|
| f32  | RW     | N/A   | 0 to 16,777,216 | No          | 1000    | NI 9514 and<br>NI 9516 |

#### Description

Specifies an upper bound for the contribution of the integral term in the PID loop. Also referred to as Ilim.

### Output Update Period (SDO, Index 0x60FB, Sub-Index 0x09)

| Type | Access | Units | Range           | PDO Mapping | Default | Supported On           |
|------|--------|-------|-----------------|-------------|---------|------------------------|
| f32  | RW     | N/A   | 1 to 16,777,216 | No          | 1       | NI 9514 and<br>NI 9516 |

#### Description

Specifies the output update period, generally from 1 to 10, to determine the how often the control loop output updates. For a Control Loop Period longer than 1 ms, set this register as a multiple of the Control Loop Period. Also referred to as Tout.

### Secondary Position Loop Proportional Gain (SDO, Index 0x60FB, Sub-Index 0x11)

| Type | Access | Units | Range           | PDO Mapping | Default | Supported On           |
|------|--------|-------|-----------------|-------------|---------|------------------------|
| f32  | RW     | N/A   | 0 to 16,777,216 | No          | 100     | NI 9514 and<br>NI 9516 |

#### Description

Specifies the contribution of restoring force directly proportional to the position error. Also referred to as Kp.

## Secondary Position Loop Differential Gain (SDO, Index 0x60FB, Sub-Index 0x12)

| Type | Access | Units | Range           | PDO Mapping | Default | Supported On           |
|------|--------|-------|-----------------|-------------|---------|------------------------|
| f32  | RW     | N/A   | 0 to 16,777,216 | No          | 1000    | NI 9514 and<br>NI 9516 |

### Description

Specifies the contribution of restoring force proportional to the rate of change (derivative) of position error. Also referred to as Kd.

## Secondary Position Loop Integral Gain (SDO, Index 0x60FB, Sub-Index 0x13)

| Type | Access | Units | Range           | PDO Mapping | Default | Supported On           |
|------|--------|-------|-----------------|-------------|---------|------------------------|
| f32  | RW     | N/A   | 0 to 16,777,216 | No          | 0       | NI 9514 and<br>NI 9516 |

### Description

Specifies the contribution of restoring force that increases with time, ensuring that the static position error in the servo loop is forced to zero. Also referred to as Ki.

## Secondary Velocity Feedback Gain (SDO, Index 0x60FB, Sub-Index 0x14)

| Type | Access | Units | Range           | PDO Mapping | Default | Supported On           |
|------|--------|-------|-----------------|-------------|---------|------------------------|
| f32  | RW     | N/A   | 0 to 16,777,216 | No          | 0       | NI 9514 and<br>NI 9516 |

### Description

Specifies the contribution of restoring force (damping) proportional to the velocity of the motor/actuator. Also referred to as Kv.

## Secondary Position Loop Velocity Feedforward Gain (SDO, Index 0x60FB, Sub-Index 0x15)

| Type | Access | Units | Range           | PDO Mapping | Default | Supported On           |
|------|--------|-------|-----------------|-------------|---------|------------------------|
| f32  | RW     | N/A   | 0 to 16,777,216 | No          | 0       | NI 9514 and<br>NI 9516 |

### Description

Specifies the contribution in the DAC command output that is directly proportional to the instantaneous trajectory velocity. Also referred to as Vff.

## Secondary Position Loop Acceleration Feedforward Gain (SDO, Index 0x60FB, Sub-Index 0x16)

| Type | Access | Units | Range           | PDO Mapping | Default | Supported On           |
|------|--------|-------|-----------------|-------------|---------|------------------------|
| f32  | RW     | N/A   | 0 to 16,777,216 | No          | 0       | NI 9514 and<br>NI 9516 |

### Description

Specifies the contribution in the drive command output that is directly proportional to the instantaneous trajectory acceleration. Also referred to as Aff.

## Secondary Position Loop Derivative Time (SDO, Index 0x60FB, Sub-Index 0x17)

| Type | Access | Units | Range           | PDO Mapping | Default | Supported On           |
|------|--------|-------|-----------------|-------------|---------|------------------------|
| f32  | RW     | N/A   | 1 to 16,777,216 | No          | 2       | NI 9514 and<br>NI 9516 |

### Description

Specifies how often (in update samples) the derivative of position error is calculated. Also referred to as Td.

## Secondary Position Loop Integral Limit (SDO, Index 0x60FB, Sub-Index 0x18)

| Type | Access | Units | Range           | PDO Mapping | Default | Supported On           |
|------|--------|-------|-----------------|-------------|---------|------------------------|
| f32  | RW     | N/A   | 0 to 16,777,216 | No          | 1000    | NI 9514 and<br>NI 9516 |

### Description

Specifies an upper bound for the contribution of the integral term in the PID loop. Also referred to as Ilim.

## Secondary Control Loop Period Multiple (SDO, Index 0x60FB, Sub-Index 0x19)

| Type | Access | Units | Range           | PDO Mapping | Default | Supported On           |
|------|--------|-------|-----------------|-------------|---------|------------------------|
| f32  | RW     | N/A   | 1 to 16,777,216 | No          | 1       | NI 9514 and<br>NI 9516 |

### Description

Specifies the output update period, generally from 1 to 10, to determine the how often the control loop output updates. For a Control Loop Period longer than 1 ms, set this register as a multiple of the Control Loop Period. Also referred to as Tout.

## Setpoint Control (PDO, Index 0x2600)

| Type | Access | Units | Range | PDO Mapping | Default | Supported On |
|------|--------|-------|-------|-------------|---------|--------------|
| u32  | W      | N/A   | N/A   | Yes         | 0x0     | NI 951x      |

### Description

The control object for setpoint data. This object is bitmapped as follows:

| Bit   | Description                                                                                                                                                                                                                                                                  |
|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0–15  | Torque setpoint. Only applicable when <b>Modes of Operation</b> (SDO, Index 0x6060) is set to <b>Torque Mode</b> , ignored otherwise.                                                                                                                                        |
| 16–23 | Setpoint update counter. This counter is incremented when there is new setpoint data for the module. In Torque mode, this needs to be incremented every scan period. In Position mode, this needs to be incremented when there is a new Position Setpoint (and spline data). |

## Trajectory Velocity (PDO, Index 0x2601)

| Type | Access | Units                    | Range        | PDO Mapping | Default | Supported On |
|------|--------|--------------------------|--------------|-------------|---------|--------------|
| f32  | W      | Counts/<br>sample period | $\pm 2^{24}$ | Yes         | 0       | NI 951x      |

### Description

Provides the output from the trajectory generator used for Vff calculation.

## Trajectory Acceleration (PDO, Index 0x2602)

| Type | Access | Units                                 | Range        | PDO Mapping | Default | Supported On |
|------|--------|---------------------------------------|--------------|-------------|---------|--------------|
| f32  | W      | Counts/<br>sample period <sup>2</sup> | $\pm 2^{24}$ | Yes         | 0       | NI 951x      |

### Description

Provides the output from the trajectory generator used for Aff calculation.

## Setpoint Status (PDO, Index 0x2604)

| Type | Access | Units | Range             | PDO Mapping | Default | Supported On |
|------|--------|-------|-------------------|-------------|---------|--------------|
| u32  | R      | N/A   | 0 to $(2^{16}-1)$ | Yes         | 0       | NI 951x      |

### Description

Contains the status object for setpoint data. This object is bitmapped as follows:

| Bit   | Description           |
|-------|-----------------------|
| 0–15  | Actual torque output. |
| 16–31 | Reserved              |

## Control Loop Period (SDO, Index 0x2610)

| Type | Access | Units               | Range           | PDO Mapping | Default | Supported On                                        |
|------|--------|---------------------|-----------------|-------------|---------|-----------------------------------------------------|
| u32  | RW     | Module clock ticks* | See Description | No          | 0x7D0   | NI 951x<br>Write States <sup>†</sup> : Init, Pre-Op |

\* 1 module clock tick is 25 ns.

<sup>†</sup> Writes to this register are only supported in Init and Pre-Operational states. An SDO write request in any other state returns an SDO Error in response. Reads are supported in all states.

### Description

PID/Spline Loop Period: Number of module clock ticks per cycle. 1 FPGA Tick = 25 ns

Range: Control Loop Period is a non-zero value with the following range:

$$50 \mu\text{s} \leq \text{Control Loop Period} \leq 1 \text{ ms}$$



**Note** This object affects the PID loop when used with an NI 9514 or NI 9516 module, or the Spline Loop when used with an NI 9512 module.

## System Scan Period (SDO, Index 0x2611)

| Type | Access | Units         | Range           | PDO Mapping | Default         | Supported On                           |
|------|--------|---------------|-----------------|-------------|-----------------|----------------------------------------|
| u32  | RW     | Control loops | See Description | No          | 0xC8<br>(10 ms) | NI 951x<br>Write States*: Init, Pre-Op |

\* Writes to this register are only supported in Init and Pre-Operational states. An SDO write request in any other state returns an SDO Error in response. Reads are supported in all states.

### Description

Specifies the total time period of the system scan cycle, expressed in number of control loop cycles. Refer to the **Control Loop Period** object (SDO, Index 0x2610).

For a given combination of Control Loop Period and System Scan Period objects, the following must hold true:

$$\text{Control Loop Period (0x2610)} \times 25 \times \text{System Scan Period (0x2611)} = \text{System Scan Time in nanoseconds}$$

## Torque Positive Limit (SDO, Index 0x2620)

| Type | Access | Units | Range              | PDO Mapping | Default | Supported On |
|------|--------|-------|--------------------|-------------|---------|--------------|
| i16  | RW     | N/A   | $\pm (2^{15} - 1)$ | No          | 0       | NI 951x      |

### Description

Specifies the positive (maximum) voltage limit for the Drive Command output. The torque limit defines a clamp for the Drive Command output, which is useful for systems where the maximum torque output must be smaller than the +10 to -10 voltage range. The positive and negative limits can be both positive

or both negative to limit the drive command output to a unipolar range. The only restriction is that the **Torque Positive Limit** cannot be less than the **Torque Negative Limit**.

### Torque Negative Limit (SDO, Index 0x2621)

| Type | Access | Units | Range              | PDO Mapping | Default | Supported On |
|------|--------|-------|--------------------|-------------|---------|--------------|
| i16  | RW     | N/A   | $\pm (2^{15} - 1)$ | No          | 0       | NI 951x      |

#### Description

Specifies the negative (minimum) voltage limit for the Drive Command output. The torque limit defines a clamp for the Drive Command output, which is useful for systems where the maximum torque output must be smaller than the +10 to –10 voltage range. The positive and negative limits can be both positive or both negative to limit the drive command output to a unipolar range. The only restriction is that the **Torque Negative Limit** cannot be more than the **Torque Positive Limit**.

### Torque Offset (SDO, Index 0x2622)

| Type | Access | Units | Range              | PDO Mapping | Default | Supported On |
|------|--------|-------|--------------------|-------------|---------|--------------|
| i16  | RW     | N/A   | $\pm (2^{15} - 1)$ | No          | 0       | NI 951x      |

#### Description

Specifies the voltage by which to shift the drive command output without requiring any action from the PID loop.

### Target Position (PDO, Index 0x607A)

| Type | Access | Units | Range              | PDO Mapping | Default | Supported On |
|------|--------|-------|--------------------|-------------|---------|--------------|
| i32  | RW     | N/A   | $\pm (2^{31} - 1)$ | No          | 0       | NI 951x      |

#### Description

Contains the destination position of the trajectory generator; this is used to dead zone stiction.

### Interpolated Data Record (SDO, Index 0x60C1, Sub-Index 0x00)

| Type | Access | Units | Range | PDO Mapping | Default | Supported On |
|------|--------|-------|-------|-------------|---------|--------------|
| u8   | R      | N/A   | 5     | No          | 5       | NI 951x      |

#### Description

Contains the number of entries for interpolated data.

### Spline Data Coefficient 0 Whole (PDO, Index 0x60C1, Sub-Index 1)

| Type | Access | Units | Range              | PDO Mapping | Default | Supported On |
|------|--------|-------|--------------------|-------------|---------|--------------|
| i32  | W      | N/A   | $\pm (2^{31} - 1)$ | Yes         | 0       | NI 951x      |

#### Description

Specifies the whole portion of coefficient 0 for the spline polynomial used to calculate interpolated points.

### Spline Data Coefficient 0 Fraction (PDO, Index 0x60C1, Sub-Index 2)

| Type | Access | Units | Range        | PDO Mapping | Default | Supported On |
|------|--------|-------|--------------|-------------|---------|--------------|
| f32  | W      | N/A   | $\pm 2^{24}$ | Yes         | 0       | NI 951x      |

#### Description

Specifies the fractional portion of coefficient 0 for the spline polynomial used to calculate interpolated points.

### Spline Data Coefficient 1 (PDO, Index 0x60C1, Sub-Index 3)

| Type | Access | Units | Range        | PDO Mapping | Default | Supported On |
|------|--------|-------|--------------|-------------|---------|--------------|
| f32  | W      | N/A   | $\pm 2^{24}$ | Yes         | 0       | NI 951x      |

#### Description

Specifies a coefficient for the spline polynomial used to calculate interpolated points.

### Spline Data Coefficient 2 (PDO, Index 0x60C1, Sub-Index 4)

| Type | Access | Units | Range        | PDO Mapping | Default | Supported On |
|------|--------|-------|--------------|-------------|---------|--------------|
| f32  | W      | N/A   | $\pm 2^{24}$ | Yes         | 0       | NI 951x      |

#### Description

Specifies a coefficient for the spline polynomial used to calculate interpolated points.

### Spline Data Coefficient 3 (PDO, Index 0x60C1, Sub-Index 5)

| Type | Access | Units | Range        | PDO Mapping | Default | Supported On |
|------|--------|-------|--------------|-------------|---------|--------------|
| f32  | W      | N/A   | $\pm 2^{24}$ | Yes         | 0       | NI 951x      |

#### Description

Specifies a coefficient for the spline polynomial used to calculate interpolated points.

## Control Loop Gain Set (SDO, Index 0x2650, Sub-Index 0x00)

| Type | Access | Units | Range | PDO Mapping | Default | Supported On           |
|------|--------|-------|-------|-------------|---------|------------------------|
| u8   | R      | N/A   | 1     | No          | 1       | NI 9514 and<br>NI 9516 |

### Description

Specifies the total number of elements under this object.

## Control Loop Gain Set 1 (SDO, Index 0x2650, Sub-Index 1)

| Type | Access | Units | Range | PDO Mapping | Default | Supported On           |
|------|--------|-------|-------|-------------|---------|------------------------|
| u8   | R/W    | N/A   | 0–5   | No          | 0       | NI 9514 and<br>NI 9516 |

### Description

Gain Selector Condition for the first alternative gain set.

| Bit | Description                                                                                                                 |
|-----|-----------------------------------------------------------------------------------------------------------------------------|
| 0–2 | 000 : None<br>001 : Auxiliary Feedback (NI 9516 only: Encoder 1)<br>010 : Acceleration<br>011 : Velocity<br>100 : Direction |
| 3–7 | Reserved                                                                                                                    |

## PID Gain Format (SDO, Index 0x2651)

| Type | Access | Units | Range | PDO Mapping | Default | Supported On           |
|------|--------|-------|-------|-------------|---------|------------------------|
| u8   | RW     | N/A   | N/A   | No          | 0x0     | NI 9514 and<br>NI 9516 |

### Description

Configures the data format for the PID gains to be floating point or fixed-point.

| Bit | Description                                                                      |
|-----|----------------------------------------------------------------------------------|
| 0   | PID Gain Format<br>0 = 32-bit floating point<br>1 = fixed-point 16.16 (LV 32.16) |
| 1–7 | Reserved                                                                         |

## Where to Go for Support

---

The National Instruments Web site is your complete resource for technical support. At [ni.com/support](http://ni.com/support) you have access to everything from troubleshooting and application development self-help resources to email and phone assistance from NI Application Engineers.

A Declaration of Conformity (DoC) is our claim of compliance with the Council of the European Communities using the manufacturer's declaration of conformity. This system affords the user protection for electromagnetic compatibility (EMC) and product safety. You can obtain the DoC for your product by visiting [ni.com/certification](http://ni.com/certification). If your product supports calibration, you can obtain the calibration certificate for your product at [ni.com/calibration](http://ni.com/calibration).

National Instruments corporate headquarters is located at 11500 North Mopac Expressway, Austin, Texas, 78759-3504. National Instruments also has offices located around the world to help address your support needs. For telephone support in the United States, create your service request at [ni.com/support](http://ni.com/support) and follow the calling instructions or dial 512 795 8248. For telephone support outside the United States, contact your local branch office:

Australia 1800 300 800, Austria 43 662 457990-0, Belgium 32 (0) 2 757 0020,  
Brazil 55 11 3262 3599, Canada 800 433 3488, China 86 21 5050 9800,  
Czech Republic 420 224 235 774, Denmark 45 45 76 26 00, Finland 358 (0) 9 725 72511,  
France 01 57 66 24 24, Germany 49 89 7413130, India 91 80 41190000, Israel 972 3 6393737,  
Italy 39 02 41309277, Japan 0120-527196, Korea 82 02 3451 3400, Lebanon 961 (0) 1 33 28 28,  
Malaysia 1800 887710, Mexico 01 800 010 0793, Netherlands 31 (0) 348 433 466,  
New Zealand 0800 553 322, Norway 47 (0) 66 90 76 60, Poland 48 22 328 90 10,  
Portugal 351 210 311 210, Russia 7 495 783 6851, Singapore 1800 226 5886,  
Slovenia 386 3 425 42 00, South Africa 27 0 11 805 8197, Spain 34 91 640 0085,  
Sweden 46 (0) 8 587 895 00, Switzerland 41 56 2005151, Taiwan 886 02 2377 2222,  
Thailand 662 278 6777, Turkey 90 212 279 3031, United Kingdom 44 (0) 1635 523545

National Instruments, NI, [ni.com](http://ni.com), and LabVIEW are trademarks of National Instruments Corporation. Refer to the *Terms of Use* section on [ni.com/legal](http://ni.com/legal) for more information about National Instruments trademarks. Other product and company names mentioned herein are trademarks or trade names of their respective companies. For patents covering National Instruments products/technology, refer to the appropriate location: **Help»Patents** in your software, the `patents.txt` file on your media, or the *National Instruments Patent Notice* at [ni.com/patents](http://ni.com/patents).