

Table of contents

| | | |
|----------|---|----------|
| 1 | Product identification..... | 1 |
| 2 | Winder/Unwinder operation | 3 |
| 2.1 | Introductions | 3 |
| 2.2 | Entire structure..... | 4 |
| 2.3 | Main speed command..... | 5 |
| 2.3.1 | Main speed reference..... | 6 |
| 2.3.2 | Quick stop | 7 |
| 2.4 | Tension reference section..... | 8 |
| 2.4.1 | Tension reference | 9 |
| 2.4.2 | Taper feature | 9 |
| 2.4.3 | Tension boost/down features | 11 |
| 2.4.4 | Tension reference ramp..... | 11 |
| 2.5 | Web PID controller part..... | 12 |
| 2.5.1 | PID controller | 13 |
| 2.5.2 | Inertia compensation feature | 16 |
| 2.5.3 | P/I gain switching feature (multifunction input and gain change during the operation) | 17 |
| 2.6 | Diameter calculation section | 19 |
| 2.6.1 | Bobbin selection and diameter initialization feature | 20 |
| 2.6.2 | Diameter calculation feature..... | 22 |
| 2.6.3 | Diameter calculation stop mode | 23 |
| 2.6.4 | Web feature without diameter calculation | 24 |
| 2.7 | Final speed calculation section | 25 |
| 2.7.1 | PID output method (fixed/unfixed PID controller)..... | 25 |
| 2.7.2 | Final speed [Hz] calculation..... | 27 |
| 2.7.3 | Web feature without diameter calculation | 27 |
| 2.7.4 | Reverse slow speed feature | 28 |
| 2.7.5 | Splice feature | 28 |
| 2.7.6 | Calculation function for the frequency to the main speed 100%..... | 30 |

| | | |
|----------|--|-----------|
| 2.8 | Analog output part..... | 31 |
| 2.9 | Web break detection section | 32 |
| 2.10 | Web feature without diameter calculation part..... | 34 |
| 2.10.1 | Compensation gain calculation | 34 |
| 2.10.2 | Stop gain calculation during acceleration/deceleration feature | 36 |
| 3 | Capstan operation | 37 |
| 3.1 | Introductions | 37 |
| 3.2 | Entire structure..... | 39 |
| 3.3 | Main speed reference section..... | 40 |
| 3.4 | Tension reference section..... | 40 |
| 3.5 | Web PID controller section | 40 |
| 3.6 | Analog output section..... | 40 |
| 3.7 | Web break detection section | 40 |
| 3.8 | Material thickness calculation section..... | 41 |
| 3.8.1 | Material thickness initialization feature | 42 |
| 3.8.2 | Material thickness calculation feature | 44 |
| 3.8.3 | Material thickness calculation stop feature | 45 |
| 3.9 | Final speed calculation section | 46 |
| 3.9.1 | PID output method (fixed/unfixed PID controller)..... | 47 |
| 3.9.2 | Reverse slow speed feature | 47 |
| 3.9.3 | Splice feature | 47 |
| 4 | Advanced feature group (PAR → APP) | 49 |
| 5 | Other features | 59 |
| 5.1 | Advanced auto torque boost (for selecting automatic adjustment when a high starting torque is needed)..... | 59 |
| 5.2 | Output Volt Bias function | 61 |

1 Product identification

The S100 Inverter comes from a product range suitable for various drive capacities and power supplies. Each model in the product range has its specifications detailed on the rating plate. Check the rating plate before installing the product to ensure that the product meets your requirements.

Note

Check the product name, open the packaging, and confirm that the product is free from defects. Contact your supplier if you have any questions about your product.

LSLV0055S100-4EOFNSW

INPUT 380-480V 3 Phase 50/60Hz
 HD: 11.0A, ND: 14.7A

OUTPUT 0-Input V 3 Phase 0.01-400Hz
 HD: 12A, ND: 16A
 9.1kVA

Ser. No 55025310146
 Inspected by D. K. YU
 KCC-REM-LSR-XXXXXXX

CE

UL US LISTED
 HD. CONT. EQ.
 7/2A

Made in KOREA

Model name

Power source specifications

Output specifications

LSLV 0055 S100 - 4EOFNSW

Motor capacity

| | |
|----------------|----------------|
| 0004 - 0.4 kW | 0150 - 15 kW |
| 0008 - 0.75 kW | 0185 - 18.5 kW |
| 0015 - 1.5 kW | 0220 - 22 kW |
| 0022 - 2.2 kW | 0300 - 30 kW |
| 0037 - 3.7 kW | 0370 - 37 kW |
| 0040 - 4.0 kW | 0450 - 45 kW |
| 0055 - 5.5 kW | 0550 - 55 kW |
| 0075 - 7.5 kW | 0750 - 75 kW |
| 0110 - 11 kW | |

Series name

Input voltage

- 2 - 3-phase 200 V
- 4 - 3-phase 400 V

Keypad

- E - LED keypad
- C - LCD keypad

UL Type

- O - UL Open Type

EMC filter

- F - Built-in EMC
- N - Non-EMC

Reactor

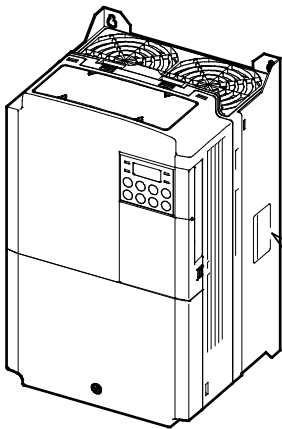
- N - Non-Reactor
- D - Built-in DCL

I/O

- M - 3.5 mm
- S - 5 mm

Exclusive product

- W - Web version



2 Winder/Unwinder operation

2.1 Introductions

A winder, also known as a “spooler,” is a device used to wind web material, such as metal wire or steel plates, into a roll while maintaining the defined tension. An unwinder does the opposite—it unwinds the material while maintaining the required tension.

The S100 inverter’s winder and unwinder operations consist of PID operations based on the analog feedback it receives from the tension-sensors and control components, such as dancers or load cells. The resulting closed loop tension control system winds or unwinds the material at a constant tension.

The S100 inverter’s closed loop tension control system for web (winding) applications (Web-PID controller) is slightly different from a generic PID controller.

$$\text{Motor speed [rpm]} = \frac{\text{Line speed [mpm]}}{\text{Diameter} \times \pi [m]} \quad \text{– Formula (1.1.1)}$$

As the winder operation progresses, the actual diameter [m] of spool increases. As you can see in the formula 1.1.1, the motor speed [rpm] must be lowered as the diameter increases to maintain a constant line speed [mpm]. The Web PID controller lowers the motor speed (the inverter's output frequency). Also, it internally calculates and estimates the increasing diameter, and lowers the inverter's output frequency according to the calculated diameter.

Unlike the winder operation, the actual diameter [m] of the spool decreases as the unwinder operation progresses. As you can see in formula 1.1.1, motor speed [rpm] must be raised as the diameter decreases to maintain a constant line speed [mpm]. The Web PID controller raises the motor speed (the inverter's output frequency). Also, it internally calculates and estimates the decreasing diameter, and raises the inverter's output frequency according to the calculated diameter.

This method is capable of producing a more stable performance than the method that controls the winder tension using only a generic PID controller. This is because the internally calculated diameter guarantees the inverter's output frequency. This makes the Web PID controller cover a very small proportion of the inverter's output frequency. Therefore, the risk that the output of Web PID controller will become saturated disappears and the forced oscillation of I controller output decreases sharply.

Other main features include:

Removing dancer or load cell transients during the operation (related code: APP50)

Inertia compensation (related code: APP56–57)

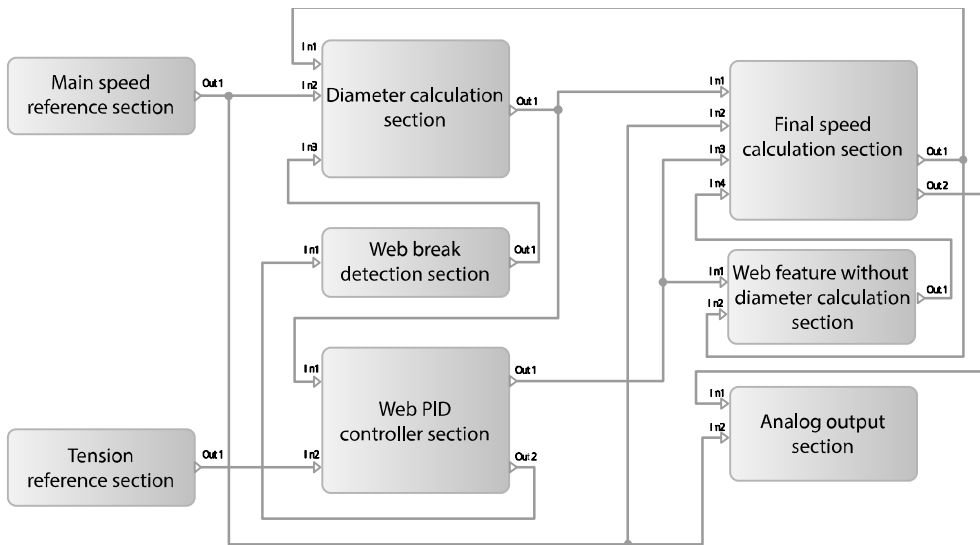
Quick stop while maintaining the tension (related code: APP89)

Senses imminent rupture of the web material (related code: APP77–81)

To use winder (spooler) and unwinder feature of the S100, configure as shown below:

| Group | Code | Keypad display | Name | Setting value |
|-------|------|----------------|--|----------------|
| APP | 01 | App Mode | Application selection | 5: Web Control |
| APP | 02 | Web Mode Sel | Tension control operation mode selection | 0 Winder |
| | | | | 1 Unwinder |

2.2 Entire structure



The input and output of each section are as the following:

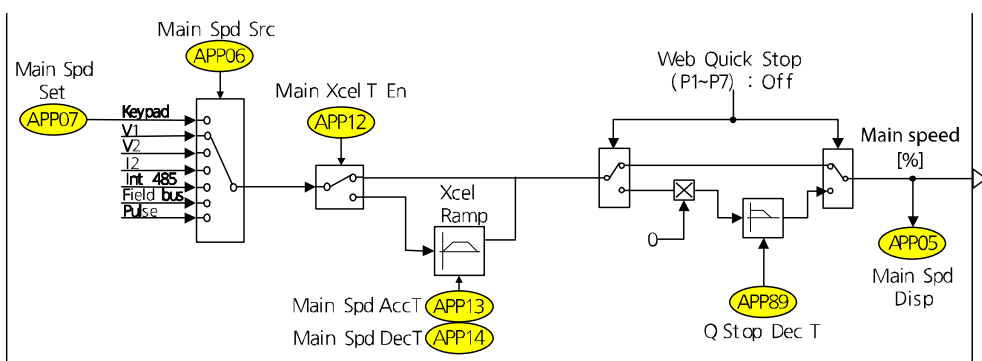
| Section | Input | Output |
|------------------------------|-------|----------------------------|
| Main speed reference section | - | Out1 Main speed [%] |
| Tension reference section | - | Out1 Tension reference [%] |

| Section | Input | Output |
|--|-----------------------------------|---------------------------------|
| Web PID controller section | In1 Diameter [%] | Out1 PID Out [%] |
| | In2 Tension reference [%] | Out2 PID Feedback [%] |
| Diameter calculation section | In1 Current output frequency [Hz] | Out1 Diameter [%] |
| | In2 Main speed [%] | |
| | In3 Web Break occurrence (0/1) | |
| Final speed calculation section | In1 Diameter [%] | Out1 Final speed reference [Hz] |
| | In2 Main speed [%] | |
| | In3 PID output [%] | Out2 Main speed + PID [%] |
| | In4 Compensation Gain [%] | |
| Analog output section | In1 Main speed + PID [%] | - |
| | In2 Main speed [%] | |
| Web break detection section | In1 PID Feedback [%] | Out1 Web Break occurrence (0/1) |
| Web feature without diameter calculation section | In1 PID output [%] | Out1 Compensation Gain [%] |
| | In2 Current output frequency [Hz] | |

2.3 Main speed command

The unit of the main speed is a percentage of the maximum line speed. For example, to operate system at a speed of 400 [mpm] when the system’s maximum line speed is 800 [mpm], set the main speed reference to 50 [%] (=400/800x100 [%]).

You can set main speed reference using the keypad, analog input, and communication.



2.3.1 Main speed reference

| Group | Code | Keypad display | Name | Default setting | Range | | | | | | | | | | | | | | |
|-------|----------|----------------|--|-----------------|---|---|--------|---|-----|---|----|---|----|---|---------|---|----------|----|-------|
| APP | 05 | Main Spd Disp | Main speed reference display | Read Only [%] | | | | | | | | | | | | | | | |
| APP | 06 | Main Spd Src | Main speed command method | V1 | <table border="1"> <tr><td>0</td><td>Keypad</td></tr> <tr><td>1</td><td>V1</td></tr> <tr><td>3</td><td>V2</td></tr> <tr><td>4</td><td>I2</td></tr> <tr><td>5</td><td>Int.485</td></tr> <tr><td>7</td><td>Fieldbus</td></tr> <tr><td>11</td><td>Pulse</td></tr> </table> | 0 | Keypad | 1 | V1 | 3 | V2 | 4 | I2 | 5 | Int.485 | 7 | Fieldbus | 11 | Pulse |
| 0 | Keypad | | | | | | | | | | | | | | | | | | |
| 1 | V1 | | | | | | | | | | | | | | | | | | |
| 3 | V2 | | | | | | | | | | | | | | | | | | |
| 4 | I2 | | | | | | | | | | | | | | | | | | |
| 5 | Int.485 | | | | | | | | | | | | | | | | | | |
| 7 | Fieldbus | | | | | | | | | | | | | | | | | | |
| 11 | Pulse | | | | | | | | | | | | | | | | | | |
| APP | 07* | Main Spd Set | Main speed keypad settings | 0.00 [%] | 0.00–100.00 [%] | | | | | | | | | | | | | | |
| APP | 12 | Main XcelT En | Main speed acceleration/deceleration selection | No | <table border="1"> <tr><td>0</td><td>No</td></tr> <tr><td>1</td><td>Yes</td></tr> </table> | 0 | No | 1 | Yes | | | | | | | | | | |
| 0 | No | | | | | | | | | | | | | | | | | | |
| 1 | Yes | | | | | | | | | | | | | | | | | | |
| APP | 13** | Main Spd AccT | Main speed acceleration time | 10.0 [sec] | 0.0–300.0 [sec] | | | | | | | | | | | | | | |
| APP | 14** | Main Spd DecT | Main speed deceleration time | 20.0 [sec] | 0.0–300.0 [sec] | | | | | | | | | | | | | | |

* The code is displayed when APP06 (Main Spd Src) is set to "Keypad."

* The code is displayed when APP12 (Main XcelT En) is set to "Yes."

| Code and feature | Description |
|-------------------------|--|
| APP-05 Main Spd Disp | This displays the main speed [%]. Displays the target main speed [%] when the inverter is stopped, and displays the ramp main speed [%] when the inverter is in operation. |
| APP-06 Main Spd Src | <p>You can select a main speed command method. When "Keypad" is selected, the inverter operates according to the main speed [%] entered at APP07 (Main Spd Set).</p> <p>When "V1" is selected, you can set the main speed reference using the analog input on the basic I/O board. At this time, the filter, gain, and offset of the analog input can be adjusted at IN07–11 (V1 Filter/Gain/Offset). When "V2" or "I2" is selected, the filter, gain, and offset of the analog input can be adjusted at IN37–47 (V2 Filter/Gain/Offset) or IN52–56 (I2 Filter/Gain/Offset).</p> <p>"Int.485" can receive the main speed reference via the RS485 communication (Modbus-RTU, LS INV 485) that is built into the basic I/O board. "Fieldbus" can receive the main speed reference via the communication option card. At this time, to the first decimal place is valid when commanding the main speed [%] using "Int.485" (the RS 485 communication built into the basic I/O board) and "Fieldbus" (communication option card). For example, to set main speed reference to 60.0 [%], from the internal 485 communication,</p> |

| Code and feature | Description |
|--|--|
| | communication option card, or PLC option card, enter "600" to the common address "0x0396." |
| APP-07 Main Spd Set | When APP06 (Main Spd Src) is set to "Keypad," the inverter operates at the main speed reference entered in this code. |
| APP-12 Main XcelT En | You can set the acceleration and deceleration time of the main speed. When "Yes" is selected, the main speed ramp increases/decreases in the acceleration/deceleration time entered at APP13 (Main Spd AccT) and APP14 (Main Spd DecT). When "Yes" is selected, DRV03 (Acc Time) and DRV04 (Dec Time) change to 0.5 [sec]. The default setting of this code is "No," and at this time, the main speed has to be set to ramp increase/decrease via the external host controller. Otherwise, the main speed reference can be come into step and the system may become unstable. |
| APP-13 Main Spd AccT, APP-14 Main Spd DecT | These codes are displayed when APP12 (Main XcelT En) is set to "Yes." You can set the acceleration and deceleration time of the main speed. The standard acceleration/deceleration time is 100 [%] of the main speed. For example, when APP13 (Main Spd AccT) is set to 10 [sec], which is the default setting, the time required to accelerate the main speed from 0 [%] to 50 [%] is 5 [sec] (=10 [sec]x50 [%]/100 [%]). |

2.3.2 Quick stop

When an emergency occurs in the closed loop tension control system that uses dancer or load cell, you can quickly stop the system while maintaining the tension.

This feature stops the inverter in a time that is set in APP89 (Q Stop Dec T) when the multifunction input set at "Web Quick Stop" becomes On. The deceleration time is always constant, regardless of the inverter's current output frequency.

For example, if inverters 1, 2, and 3 are linked in the system and are operating and the current output frequencies are 25 Hz, 50 Hz, and 60 Hz respectively, all inverters decelerate in 3 [sec], which is the default setting for APP89 (Q Stop Dec T), when the multifunction input "Web Quick Stop" becomes On.

At this time, the inverter output is not blocked and the tension is maintained because the output of the PID controller is valid.

| Group | Code | Keypad display | Name | Default setting | Range |
|-------|-------|----------------|------------------------------|-----------------|-------|
| In | 65-71 | Px Define | Multifunction input settings | Web Quick Stop | - |

| Group | Code | Keypad display | Name | Default setting | Range |
|-------|------|----------------|------------------------------|-----------------|-----------------|
| APP | 89 | Q Stop Dec T | Quick stop deceleration time | 3.0 [sec] | 0.1–300.0 [sec] |

| Code and feature | Description |
|---------------------------|--|
| APP-89 Quick Stop DecT | Sets the deceleration time for Quick stop while maintaining tension during the operation for the closed loop tension control system that uses a dancer or load cell. |

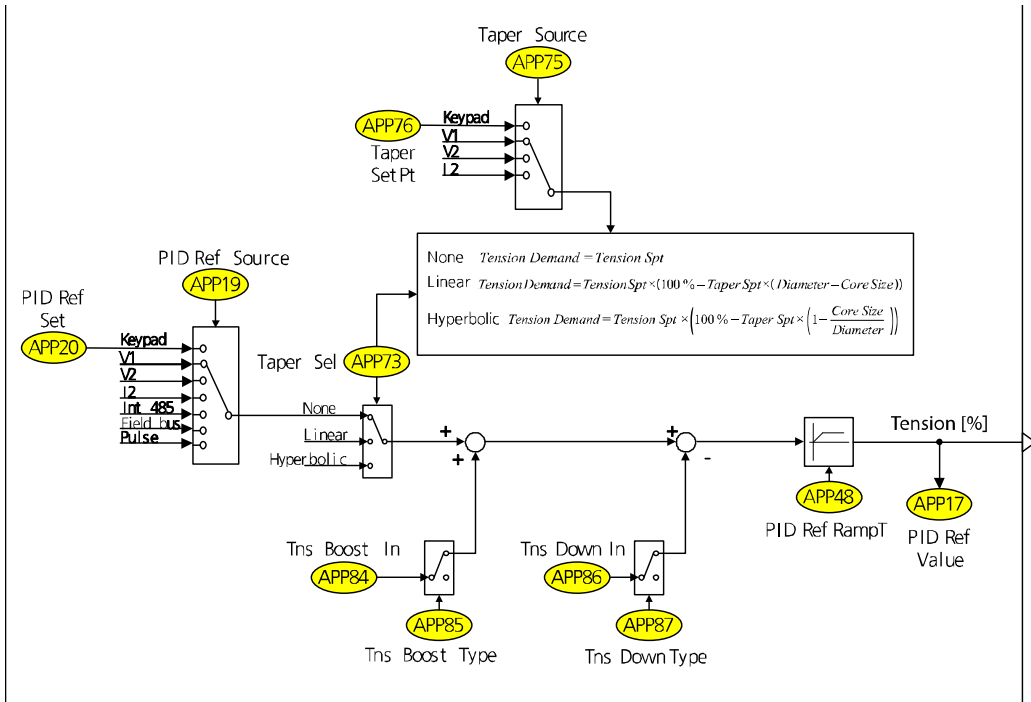
⚠ Caution

Even when the "Web Quick Stop" terminal input becomes On and Quick stop has been performed, the output of the inverter is not blocked. You must turn the inverter's operation command to Off and block the output of the inverter after Quick stop.

2.4 Tension reference section

The unit of tension reference is a percentage of the maximum load. For example, to maintain 10 [kgf] power when the maximum power (load) measurement of system is 20 [kgf], set the tension reference to 50 [%] (=10/20x100 [%]).

You can set the tension reference using the keypad, analog input, and communication.



2.4.1 Tension reference

| Group | Code | Keypad display | Name | Default setting | Range | | | | | | | | | | | | | | |
|-------|----------|----------------|--|-----------------|---|---|--------|---|----|---|----|---|----|---|---------|---|----------|----|-------|
| APP | 17 | PID Ref Value | PID reference monitor | Read Only [%] | | | | | | | | | | | | | | | |
| APP | 19 | PID Ref Source | PID reference source selection | 0: Keypad | <table border="1"> <tr><td>0</td><td>Keypad</td></tr> <tr><td>1</td><td>V1</td></tr> <tr><td>3</td><td>V2</td></tr> <tr><td>4</td><td>I2</td></tr> <tr><td>5</td><td>Int.485</td></tr> <tr><td>7</td><td>Fieldbus</td></tr> <tr><td>11</td><td>Pulse</td></tr> </table> | 0 | Keypad | 1 | V1 | 3 | V2 | 4 | I2 | 5 | Int.485 | 7 | Fieldbus | 11 | Pulse |
| 0 | Keypad | | | | | | | | | | | | | | | | | | |
| 1 | V1 | | | | | | | | | | | | | | | | | | |
| 3 | V2 | | | | | | | | | | | | | | | | | | |
| 4 | I2 | | | | | | | | | | | | | | | | | | |
| 5 | Int.485 | | | | | | | | | | | | | | | | | | |
| 7 | Fieldbus | | | | | | | | | | | | | | | | | | |
| 11 | Pulse | | | | | | | | | | | | | | | | | | |
| APP | 20* | PID Ref Set | PID reference source settings (Keypad) | 50.00 [%] | -100–100.00 [%] | | | | | | | | | | | | | | |

* The code is displayed when APP19 (PID Ref Source) is set to "Keypad."

| Code and feature | Description |
|--------------------------|---|
| APP-17 PID Ref Value | Displays the current PID reference [%]. |
| APP-19 PID Ref Source | You can choose between the input method for the PID controller reference from keypad, analog, internal communication, or external communication option. |
| APP-20 PID Ref Set | You can set the reference of the PID controller via the keypad. The code is displayed when APP19 (PID Ref Source) is set to "Keypad." |

2.4.2 Taper feature

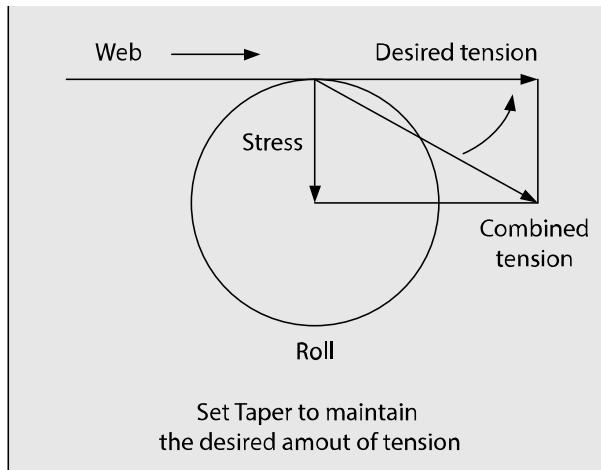
| Group | Code | Keypad display | Name | Default setting | Range | | | | | | |
|-------|------------|----------------|------------------------------|-----------------|--|---|--------|---|--------|---|------------|
| In | 65–71 | Px Define | Multifunction input settings | Web Taper Dis | - | | | | | | |
| APP | 73 | Taper Sel | Taper feature selection | 0: None | <table border="1"> <tr><td>0</td><td>None</td></tr> <tr><td>1</td><td>Linear</td></tr> <tr><td>2</td><td>Hyperbolic</td></tr> </table> | 0 | None | 1 | Linear | 2 | Hyperbolic |
| 0 | None | | | | | | | | | | |
| 1 | Linear | | | | | | | | | | |
| 2 | Hyperbolic | | | | | | | | | | |
| APP | 74 | Taper Spt Val | Taper setting value monitor | Read Only [%] | | | | | | | |
| APP | 75 | Taper Source | Taper value setting method | 0: Keypad | <table border="1"> <tr><td>0</td><td>Keypad</td></tr> <tr><td>1</td><td>V1</td></tr> <tr><td>3</td><td>V2</td></tr> </table> | 0 | Keypad | 1 | V1 | 3 | V2 |
| 0 | Keypad | | | | | | | | | | |
| 1 | V1 | | | | | | | | | | |
| 3 | V2 | | | | | | | | | | |

Winder/Unwinder operation

| Group | Code | Keypad display | Name | Default setting | Range |
|-------|------|----------------|----------------------------|-----------------|--------------------|
| | | | | | 4 12 |
| APP | 76 | Taper SetPt | Taper keypad setting value | 0.00 [%] | -100.00–100.00 [%] |

The stress towards the center increases as the Diameter expands from the Center Wind Application. When the desired tension is in the tangent direction, tension from stress is also generated. So the sum of the two vectors represents the total tension. To maintain the desired amount of tension, use the Taper feature. The feature decreases the PID reference according to the calculated diameter and offsets the size of vector that is generated by stress. Refer to the following for the conceptual diagram and formulas.

You can apply the Taper feature to the load that the load cell (weight sensor) is applied to and then to the load that the dancer (position sensor) is applied to.

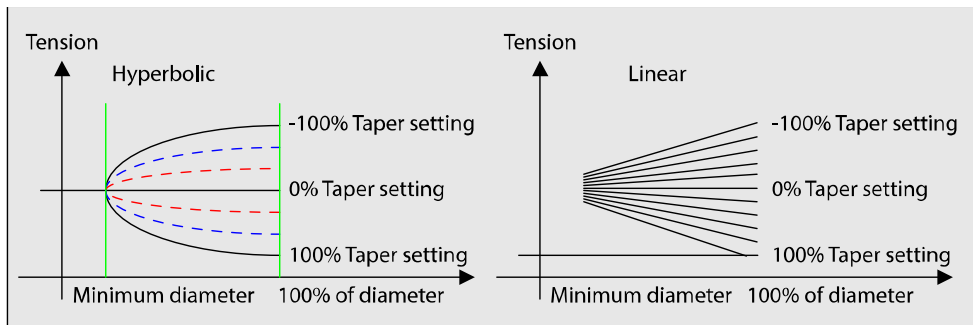


Hyperbolic Taper:

$$Tension\ Demand = Tension\ Spt \times \left(100\% - Taper\ Spt \times \left(1 - \frac{Core\ Size}{Diameter} \right) \right)$$

Linear Taper:

$$Tension\ Demand = Tension\ Spt \times \left(100\% - Taper\ Spt \times (Diameter - Core\ Size) \right)$$



[Taper concepts and tension trends according to the settings]

2.4.3 Tension boost/down features

You can boost/down the tension (PID Reference) by as much as the setting value.

| Group | Code | Keypad display | Name | Default setting | Range |
|-------|-------|----------------|------------------------------|-----------------|-------------------------------|
| In | 65-71 | Px Define | Multifunction input settings | Web Boost En | - |
| In | 65-71 | Px Define | Multifunction input settings | Web Down En | - |
| APP | 84 | Tns Boost In | Tension boost settings | 0.00 [%] | 0.00-50.00 [%] |
| APP | 85 | Tns Boost Type | Tension boost types | 0: Fixed | 0 Fixed 1 Proportional |
| APP | 86 | Tns Down In | Tension down settings | 0.00 [%] | 0.00-50.00 [%] |
| APP | 87 | Tns Down Type | Tension down types | 0: Fixed | 0 Fixed 1 Proportional |

2.4.4 Tension reference ramp

Using the ramp, you can increase the final tension reference that the Taper feature is applied to or that the boost/down is applied to for a specified time.

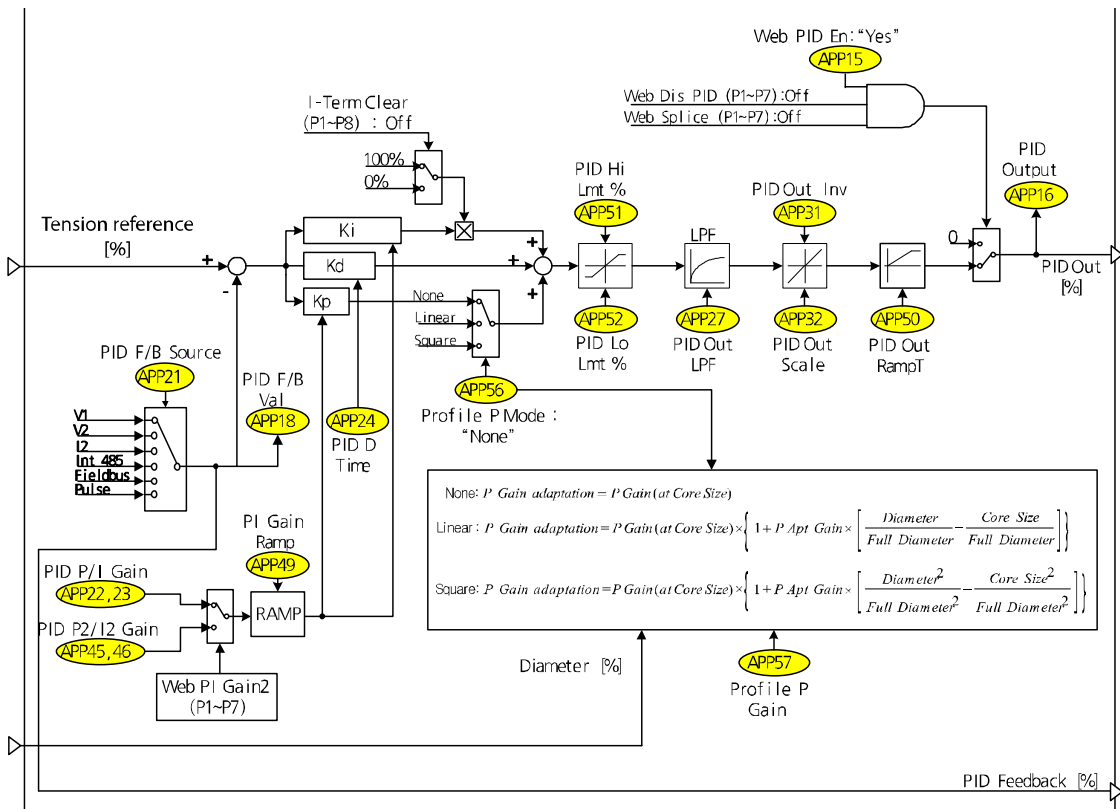
The final tension reference that the tension reference ramp is applied to can be exported to the analog output. In this case, set the AO1 Gain value to 300.0%, because the maximum value of the final tension reference is 300.00%.

Winder/Unwinder operation

| Group | Code | Keypad display | Name | Default setting | Range |
|-------|------|----------------|-----------------------------|-----------------|-----------------|
| APP | 48 | PID Ref RampT | Tension reference ramp time | 0.0 [sec] | 0.0–300.0 [sec] |
| OUT | 01 | AO1 | Analog output 1 | Tension Ref | - |

| Code and feature | Description |
|-------------------------|--|
| APP-48 PID Ref RampT | You can ramp increase the final tension reference for a specified time. This is used to prevent the PID output saturation that occurs by difference between the initial start-up reference value and the feedback value. |

2.5 Web PID controller part



In a closed loop control system, the output of the PID controller is determined using the analog feedback value received by a tension detection device, such as a dancer or load cell. This PID controller is defined as a Web PID controller because this PID controller is

optimized to the tension control systems.

The added features include:

The feature that improves initial transients of a dancer or load cell by increasing the PID output via the ramp during the inverter's initial start-up (APP50: PID Out RampT)

The inertia compensation feature that changes the PID controller's P gain via the diameter [%] estimated by the diameter calculation section (APP56: Profile P Mode, APP57: Profile P Gain)

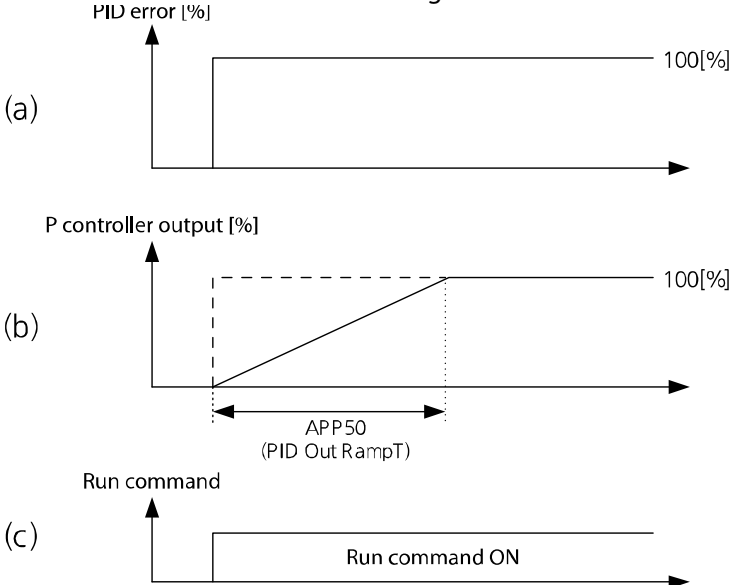
2.5.1 PID controller

| Group | Code | Keypad display | Name | Default setting | Range |
|-------|-------|----------------|-----------------------------------|-----------------|---|
| In | 65-71 | Px Define | Multifunction input settings | Web Dis PID | - |
| APP | 15 | Web PID En | Tension PID control selection | 1: Yes | 0 No 1 Yes |
| APP | 16 | PID Output | PID output monitor | Read Only [%] | |
| APP | 18 | PID Fdb Value | PID feedback monitor | Read Only [%] | |
| APP | 21 | PID Fdb Source | PID feedback source selection | 1: V1 | 0 V1 2 V2 3 I2 4 Int.485 6 Fieldbus 10 Pulse |
| APP | 22 | PID P-Gain | PID controller proportional gain | 50.0 [%] | 0.0-1000.0 [%] |
| APP | 23 | PID I-Time | PID controller integral time | 10.0 [s] | 0.0-200.00 [s] |
| APP | 24 | PID D-Time | PID controller derivative time | 0 [ms] | 0-1000 [ms] |
| APP | 27 | PID Out LPF | PID output filter | 0 [ms] | 0-10000 [ms] |
| APP | 31 | PID Out Inv | PID output reverse | 0: No | 0 No 1 Yes |
| APP | 32 | PID Out Scale | PID output scale | 30.0 [%] | 0.0-1000.0 [%] |
| APP | 50 | PID Out RampT | PID output when booting Ramp time | 5.0 [s] | 0.0-300.00 [s] |
| APP | 51 | PID Hi Lmt | Maximum PID output [%] | 100.0 [%] | APP53-100.0 [%] |
| APP | 52 | PID Lo Lmt | Minimum PID | -100.0 [%] | -100-APP52 [%] |

Winder/Unwinder operation

| Group | Code | Keypad display | Name | Default setting | Range |
|-------|------|----------------|--------------------------------|-----------------|----------------|
| | | | output [%] | | |
| APP | 53 | PID I Limit | PID I controller limit | 100.0 [%] | 0.0–100.00 [%] |
| APP | 98 | PID Sample T | PID controller execution cycle | 1 [ms] | 1–10 [ms] |

| Code and feature | Description | | | | | | | | | | | | | | | |
|-----------------------------|---|-----------------------------|--|------------------------|-----|-----|---|-----|----|---|----|-----|---|----|----|---|
| APP-15 Web PID En | <p>This determines whether or not to use the Web PID controller. Used as follows in combination with the multifunction input "Web Dis PID."</p> <table border="1"> <thead> <tr> <th>APP15 (Web PID En) settings</th> <th>Multifunction input "Web Dis PID" status</th> <th>Web PID controller use</th> </tr> </thead> <tbody> <tr> <td>Yes</td> <td>Off</td> <td>O</td> </tr> <tr> <td>Yes</td> <td>On</td> <td>X</td> </tr> <tr> <td>No</td> <td>Off</td> <td>X</td> </tr> <tr> <td>No</td> <td>On</td> <td>X</td> </tr> </tbody> </table> | APP15 (Web PID En) settings | Multifunction input "Web Dis PID" status | Web PID controller use | Yes | Off | O | Yes | On | X | No | Off | X | No | On | X |
| APP15 (Web PID En) settings | Multifunction input "Web Dis PID" status | Web PID controller use | | | | | | | | | | | | | | |
| Yes | Off | O | | | | | | | | | | | | | | |
| Yes | On | X | | | | | | | | | | | | | | |
| No | Off | X | | | | | | | | | | | | | | |
| No | On | X | | | | | | | | | | | | | | |
| APP-16 PID Output | This displays the current PID output [%]. | | | | | | | | | | | | | | | |
| APP-18 PID Fdb Value | This displays the current PID feedback [%]. | | | | | | | | | | | | | | | |
| APP-21 PID Fdb Source | You can select between the input method of the PID controller feedback from analog, internal communication, and external communication option. | | | | | | | | | | | | | | | |
| APP-22 PID P-Gain | This is the P1 gain of the PID controller. When the P gain value is 100 [%] and the error value is 100 [%], the P gain output of the P controller is 100 [%]. | | | | | | | | | | | | | | | |
| APP-23 PID I-Time | This is the I1 gain of the PID controller. When the I gain value is 10 [sec] and the error value is 100 [%], the required time for the output of the I controller to become saturated to 100 [%] is 10 [sec]. | | | | | | | | | | | | | | | |
| APP-24 PID D-Time | This is the D gain of the PID controller. When the D gain value is 10 [ms] and the change of error value is 100 [%], the output of the D controller is 100 [%] and the time it takes the output to decrease to approximately 34 [%] is 10 [ms]. | | | | | | | | | | | | | | | |
| APP-27 PID Out LPF | This sets the delayed time constant of the PID controller output. Generally, set this to 0 [ms] for a quick response from the PID controller. However, increasing this setting value increases the PID controller's stability but decreases the PID controller's response time. | | | | | | | | | | | | | | | |
| APP-31 PID Out Inv | This determines whether or not to reverse the output of the PID controller. When "Yes" is selected, the PID output mark is output in reverse. This is useful when the direction of a tension detector, such as a dancer or load cell, is reversed. | | | | | | | | | | | | | | | |

| Code and feature | Description |
|-----------------------------|---|
| APP-32 PID Out Scale | <p>This adjusts the output scale of the PID controller. You must first assume that the PID controller is saturated. At this time, setting this code to 100 [%] makes the output of the PID controller 100 [%] and setting this code to 30 [%] makes the output of the PID controller 30 [%].</p> |
| APP-50 PID Out RampT | <p>You can ramp increase the PID output during the inverter's initial start-up for a specified time. This feature gradually increases the PID controller's output during the initial start-up, and improves the transient characteristics during the initial start-up of a dancer or load cell, such as slope.</p> <p>The following figure (b) shows the output of the P controller when the P gain is 100 [%] and the PID error value is 100 [%] at start-up. The dotted line in the figure (b) shows the output of the P controller when APP50 (PID Out RampT) is set to "0 [sec]". The solid line in the figure (b) shows that the output of the P controller ramp increases in the time specified at APP50 (PID Out RampT) during the initial start-up. In other words, the solid line in the figure (b) is more advantageous than the dotted line when it comes to the transient during the inverter's initial start-up.</p>  <p>(a) PID error [%] vs. time. The error signal is a step function that jumps from 0 to 100% at the start of the run command.</p> <p>(b) P controller output [%] vs. time. The dotted line shows a step response where the output jumps to 100% immediately. The solid line shows a ramp response where the output increases linearly over a period of time labeled 'APP50 (PID Out RampT)' before reaching 100%.</p> <p>(c) Run command vs. time. The run command is a step function that switches from OFF to ON at the start of the process.</p> <p>[Operation by APP50 (PID Out RampT)]</p> <p>Also, APP50 (PID Out Ramp T) is based on when the output of the PID controller is 100 [%]. For example, when APP50 (PID Out RampT) is set to 5 [sec], the time required for the output of PID controller to become saturated to 100 [%] during the initial start-up is 5 [sec], and the time required for the output of the PID controller to become saturated to 50 [%] during the initial start-up is 2.5 [sec].</p> |
| APP-51, 52 PID Hi/Lo Lmt | <p>This sets the maximum/minimum output of the PID controller. Also, the cumulative value of the I controller is limited to the</p> |

| Code and feature | Description |
|------------------------|---|
| | maximum/minimum value specified in this code. |
| APP-53 PID I Limit | This is the output limit value of the I controller for the anti-windup. |
| APP-98 PID Sample T | This changes the execution cycle of the Web PID controller. |

2.5.2 Inertia compensation feature

| Group | Code | Keypad display | Name | Default setting | Range |
|-------|------|----------------|--------------------------|-----------------|----------------|
| APP | 56 | Profile P Mode | P Gain profile selection | 0: None | 0 None |
| | | | | | 1 Linear |
| | | | | | 2 Square |
| APP | 57* | Profile P Gain | Profile gain | 1.00 [%] | 0.01–10.00 [%] |

* The code is displayed when APP56 (Profile P Mode) is set to "Linear" or "Square."

As the actual diameter of the spool increases as the winder operation progresses, the inertia also increases. The inertia must be compensated to the same degree as the increasing (+) value. In contrast, as the actual diameter of the spool decreases as the unwinder operation progresses and the inertia also decreases. The inertia must be compensated to the same degree as the decreasing (-) value.

For inertia compensation, increase the P gain as the diameter increases. The formula is as follows. The following figure shows the P gain trend according to the diameter change.

"None":

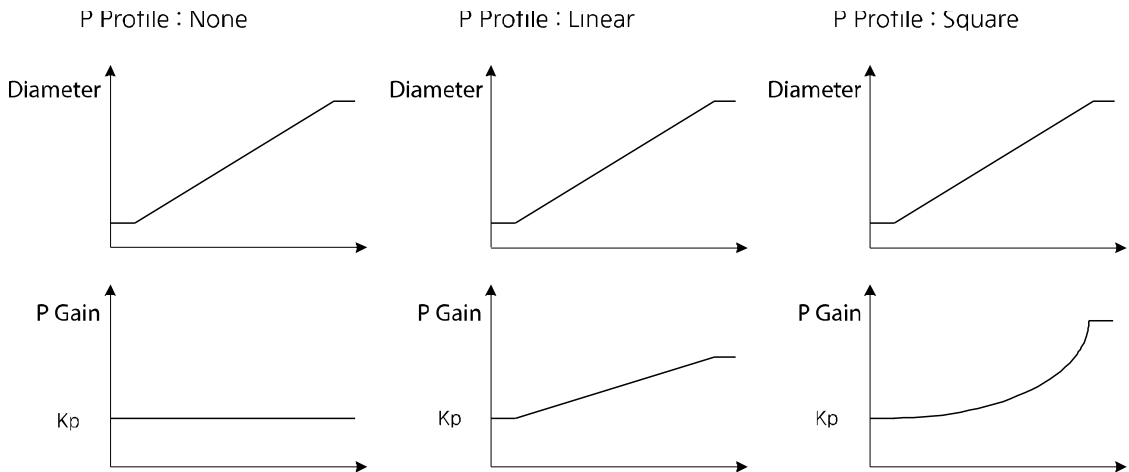
$$\text{Inertia compensation P Gain} = \text{P Gain}$$

"Linear":

$$\text{Inertia compensation P Gain} = \text{P Gain} \times \left\{ 1 + \text{Profile P Gain (APP57)} \times \left[\frac{\text{Diameter}}{\text{Full Diameter}} - \frac{\text{Bobbin Diameter}}{\text{Full Diameter}} \right] \right\}$$

"Square":

$$\text{Inertia compensation P Gain} = \text{P Gain} \times \left\{ 1 + \text{Profile P Gain} \times \left[\frac{\text{Diameter}^2}{\text{Full Diameter}^2} - \frac{\text{Bobbin Diameter}^2}{\text{Full Diameter}^2} \right] \right\}$$



[The P gain trend according to the APP56 (Profile P Mode) setting]

2.5.3 P/I gain switching feature (multifunction input and gain change during the operation)

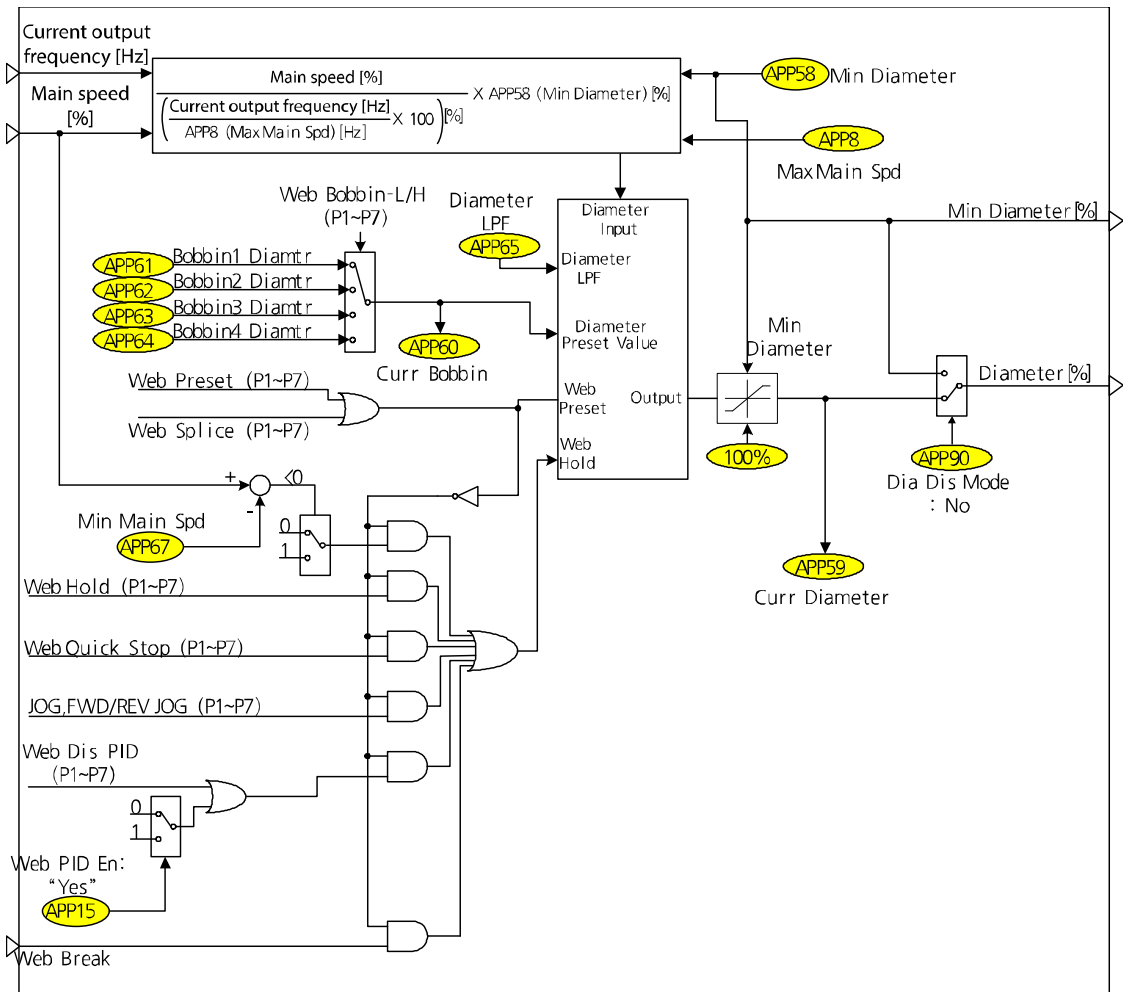
The system response may be unstable if the input set at "Web PI Gain2" is changed during inverter operation or if the P/I gain switch occurs momentarily without a switching ramp time when a user changes the APP22 (PID P-Gain) and APP23 (PID I-Time) settings directly. To prevent these problems, APP49 (PI Gain Ramp) helps the P/I gain switch to change slowly according to the proper setting value.

Winder/Unwinder operation

| Group | Code | Keypad display | Name | Default setting | Range |
|-------|-------|----------------|------------------------------------|-----------------|-----------------|
| In | 65–71 | Px Define | Multifunction input settings | Web PI Gain2 | - |
| APP | 22 | PID P-Gain | PID controller proportional gain | 50.0 [%] | 0.0–1000.0 [%] |
| APP | 23 | PID I-Time | PID controller integral time | 10.0 [s] | 0.0–200.00 [s] |
| APP | 45 | PID P2-Gain | PID controller proportional gain 2 | 100.0 [%] | 0.0–1000.0 [%] |
| APP | 46 | PID I2-Time | PID controller integral time 2 | 20.0 [s] | 0.0–200.00 [s] |
| APP | 49 | PI Gain Ramp | PI gain switching ramp time | 30.0 [sec] | 0.0–300.0 [sec] |

| Code and feature | Description | | | | | | |
|---|---|---|-------------------|-----|--|----|--|
| APP-49 PI Gain Ramp | <p>This is the ramp time change applied when P/I gain switching occurs at the multifunction input "Web PI Gain2" during the inverter operation. This is also applied when a user changes the P/I gain directly using the keypad during the inverter operation. The ramp time is switched based on 1000 [%] of P gain and 200 [sec] of I gain. For example, when APP49 (PI Gain Ramp) is set to 30 [sec], the time required to change P gain from 100 [%] to 200 [%] is 3 [sec] ($=30 \times 100 / 1000$).</p> <p>The P/I gain selection method is based on the multifunction input at "Web PI Gain2."</p> <table border="1"> <thead> <tr> <th>Multifunction input "Web PI Gain2" status</th> <th>Selected P/I gain</th> </tr> </thead> <tbody> <tr> <td>Off</td> <td>APP22 (PID P-Gain), APP23 (PID I-Time)</td> </tr> <tr> <td>On</td> <td>APP45 (PID P2-Gain), APP46 (PID I2-Time)</td> </tr> </tbody> </table> | Multifunction input "Web PI Gain2" status | Selected P/I gain | Off | APP22 (PID P-Gain), APP23 (PID I-Time) | On | APP45 (PID P2-Gain), APP46 (PID I2-Time) |
| Multifunction input "Web PI Gain2" status | Selected P/I gain | | | | | | |
| Off | APP22 (PID P-Gain), APP23 (PID I-Time) | | | | | | |
| On | APP45 (PID P2-Gain), APP46 (PID I2-Time) | | | | | | |

2.6 Diameter calculation section



In the tension control system, the correlation of the line speed of the winder/unwinder, motor speed, and diameter is explained in formula 1.6.1.

$$\text{Line speed [mpm]} = \text{Motor speed [rpm]} \times (\text{Diameter} \times \pi) [\text{m}] = \text{Constant} - \text{Formula (1.6.1)}$$

Consider the following example of the winder in a closed loop tension control system. The line speed [mpm] is always consistent unless a user changes the line speed and the actual diameter [m] increases as time passes. Therefore, as you can see in formula 1.6.1, the output of the Web PID controller becomes a negative (-) value because the tension applied to the dancer or load cell increases as the line speed that is supposed to be consistent increases. The line speed in formula 1.6.1 decreases because the actual motor speed [rpm] decreases and is maintained.

Using the consistent line speed of the winder [mpm] and the actual motor speed [rpm] that

decreases, the diameter calculation can be estimated as shown in formula 1.6.2. The diameter can be estimated to increase as time passes.

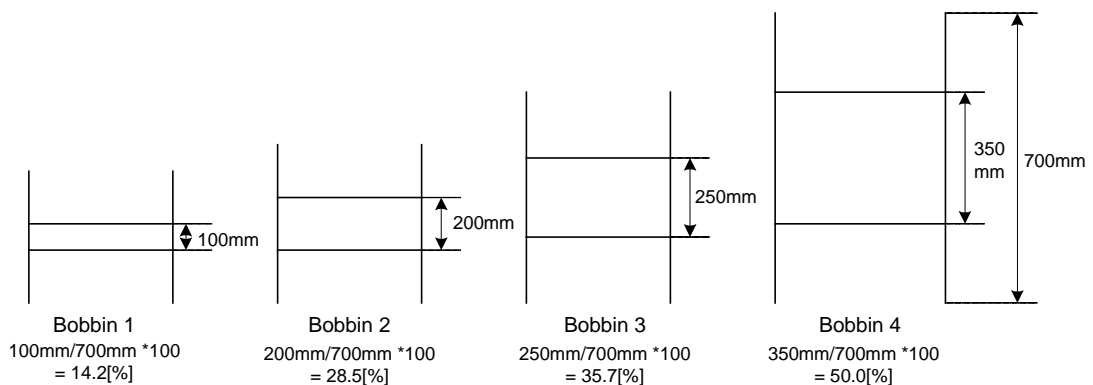
$$\text{Estimated diameter} \times \pi [m] = \frac{\text{Line speed [mpm]}}{\text{Motor speed [rpm]}} \quad - \text{Formula (1.6.2)}$$

The following example is for the unwinder. Along with the winder, the line speed [mpm] is always consistent unless a user changes the line speed and the actual diameter [m] decreases as time passes, unlike the winder. Therefore, as you can see in formula 1.6.1, the tension that is applied to a dancer or load cell increases as the line speed decreases like a winder. However, unlike a winder, the unwinder internally reverses the output mark of the Web PID controller. Therefore, the output of the Web PID controller becomes a positive (+) value, and the line speed in formula 1.6.1 decreases because the actual motor speed [rpm] increases, unlike a winder, and is maintained. Using the consistent line speed of the unwinder [mpm] and the actual motor speed [rpm] that increases, the diameter calculation can be estimated as shown in formula 1.6.2. The diameter can be estimated to decrease as time passes.

2.6.1 Bobbin selection and diameter initialization feature

| Group | Code | Keypad display | Name | Default setting | Range |
|-------|-------|----------------|------------------------------|-----------------|-----------------|
| In | 65-71 | Px Define | Multifunction input settings | Web Preset | - |
| In | 65-71 | Px Define | Multifunction input settings | Web Bobbin-L | - |
| In | 65-71 | Px Define | Multifunction input settings | Web Bobbin-H | - |
| APP | 60 | Curr Bobbin | Current bobbin display | Read Only | |
| APP | 61 | Bobbin1 Diamtr | Bobbin 1 diameter [%] | 10.0 [%] | APP58-100.0 [%] |
| APP | 62 | Bobbin2 Diamtr | Bobbin 2 diameter [%] | 15.0 [%] | APP58-100.0 [%] |
| APP | 63 | Bobbin3 Diamtr | Bobbin 3 diameter [%] | 20.0 [%] | APP58-100.0 [%] |
| APP | 64 | Bobbin4 Diamtr | Bobbin 4 diameter [%] | 25.0 [%] | APP58-100.0 [%] |

| Code and feature | Description | | | | | | | | | | | | | | | |
|------------------------------------|---|------------------------------------|------------------------------------|-----------------|-----|-----|-----------------|-----|----|-----------------|----|-----|-----------------|----|----|-----------------|
| APP-60 Curr Bobbin | This displays the number of currently selected bobbins (1–4). | | | | | | | | | | | | | | | |
| APP-61–64 Bobbin # Diamtr | <p>The diameter of the bobbin is selected by the combination of the multifunction inputs "Web Bobbin-L" and "Web Bobbin-H." When bobbin is selected, turn On Off the multifunction input "Web Preset" to initialize the diameter of selected bobbin.</p> <table border="1"> <thead> <tr> <th>Multifunction input "Web Bobbin-H"</th> <th>Multifunction input "Web Bobbin-L"</th> <th>Selected bobbin</th> </tr> </thead> <tbody> <tr> <td>Off</td> <td>Off</td> <td>Bobbin1 (APP61)</td> </tr> <tr> <td>Off</td> <td>On</td> <td>Bobbin2 (APP62)</td> </tr> <tr> <td>On</td> <td>Off</td> <td>Bobbin3 (APP63)</td> </tr> <tr> <td>On</td> <td>On</td> <td>Bobbin4 (APP64)</td> </tr> </tbody> </table> <p>For example, if there are 4 types of bobbins as in the figure below, enter the calculated values 14.2 [%], 28.5 [%], 35.7 [%], and 50.0 [%] at APP61~64 (Bobbin # Diamtr). Then, enter 14.2 [%], the diameter of Bobbin 1, which is the smallest bobbin, to APP58 (Min Diameter). Select the currently installed bobbin in combination with the multifunction input "Web Bobbin-L" and "Web Bobbin-H," and then turn On/Off the multifunction input "Web Preset" to initialize.</p> | Multifunction input "Web Bobbin-H" | Multifunction input "Web Bobbin-L" | Selected bobbin | Off | Off | Bobbin1 (APP61) | Off | On | Bobbin2 (APP62) | On | Off | Bobbin3 (APP63) | On | On | Bobbin4 (APP64) |
| Multifunction input "Web Bobbin-H" | Multifunction input "Web Bobbin-L" | Selected bobbin | | | | | | | | | | | | | | |
| Off | Off | Bobbin1 (APP61) | | | | | | | | | | | | | | |
| Off | On | Bobbin2 (APP62) | | | | | | | | | | | | | | |
| On | Off | Bobbin3 (APP63) | | | | | | | | | | | | | | |
| On | On | Bobbin4 (APP64) | | | | | | | | | | | | | | |



[When there are various sizes of bobbins]

⚠ Caution

You must switch the multifunction input "Web Preset" On/Off when replacing the bobbin. Then, the diameter cannot be calculated if the multifunction input "Web Preset" is On.

2.6.2 Diameter calculation feature

| Group | Code | Keypad display | Name | Default setting | Range |
|-------|------|----------------|--------------------------------------|-----------------|-----------------|
| APP | 58 | Min Diameter | Minimum bobbin diameter keypad value | 10.0 [%] | 5.0–100.00 [%] |
| APP | 59 | Curr Diameter | Current diameter display | 10.0 [%] | APP58–100.0 [%] |
| APP | 65 | Diameter LPF | Diameter calculation filter | 50.0 [sec] | 0.0–300.0 [sec] |
| APP | 08 | Max Main Spd | Frequency to the main speed 100% | 60.0 [Hz] | 0.0–DRV20 [Hz] |

Formula 1.6.2 can be reconfigured when converting to the [%] scale.

$$\text{Estimated diameter } [\%] = \frac{\text{Main speed } [\%]}{\frac{\text{Current output frequency } [\text{Hz}]}{\text{APP8 (Max Main Spd)}} \times 100 [\%]} \times \text{APP58 (Min Diameter)} - \text{Formula (1.6.3)}$$

The explanation of the winder operation principles is as follows.

The main speed reference [%] is always consistent unless a user changes the main speed reference. The actual diameter [m] of winder bobbin increases as time passes. At the same time, the tension applied to the dancer or load cell also increases. Therefore, the output of the Web PID controller becomes a negative (-) value, and the current output frequency [Hz] of the inverter decreases. Therefore, the estimated diameter [%] increases according to formula 1.6.3. The estimated diameter [%] is limited internally to a maximum of 100 [%] and a minimum APP58 (Min Diameter). You can adjust the calculation speed of diameter [%] by setting a time constant of the estimated diameter [%] to APP65 (Diameter LPF).

The estimated diameter [%] is a very important element in deciding the inverter's final speed reference [Hz]. For details, refer to **2.7 Final speed calculation section on page 25**.

| Code and feature | Description |
|-------------------------|--|
| APP-58 Min Diameter | Enter the proportion [%] of a bobbin's unfilled diameter to the bobbin's full diameter when the material is fully wound. If the types of bobbins are various as the earlier figure, enter proportion [%] of the smallest diameter of the smallest bobbin per the biggest diameter of the biggest bobbin. In a situation such as shown in the earlier figure, enter 14.2 [%] to APP58 (Min Diameter). |
| APP-59 Curr Diameter | This displays the diameter [%] of the current bobbin. The diameter [%] of the selected bobbin is displayed after the multifunction input "Web Preset" On/Off and the diameter calculated by the formula 1.6.3 is updated during the operation. |

| Code and feature | Description |
|------------------------|---|
| APP-65 Diameter LPF | Set the delay time constant of the diameter [%] calculation. Generally, specify a value around the traverse turnaround time. |
| APP-08 Max Main Spd | <p>Enter the maximum speed [Hz] of the smallest bobbin's minimum diameter when the main speed reference is 100 [%]. The following is an example. In the earlier figure, the minimum diameter of the smallest bobbin is 0.1 m (=100 mm). Suppose the maximum line speed of this system is 350 [mm] and the four pole motor and the belt rate (motor is faster) are 2.3/1. At this time, the value that is to be entered to APP08 (Max Main Spd) can be calculated as follows.</p> $APP8 (Max Main Spd) = \frac{350[mpm]}{0.10[m] \times \pi} \times 2.3(\text{Belt ratio}) \times \frac{4 (\text{Number of poles})}{120} = 85.46[\text{Hz}]$ |

2.6.3 Diameter calculation stop mode

| Group | Code | Keypad display | Name | Default setting | Range |
|-------|-------|----------------|-------------------------------------|-----------------|-----------------|
| In | 65-71 | Px Define | Multifunction input settings | Web Hod | - |
| APP | 66 | Web Hold Freq | Diameter calculation stop frequency | 5.00 [Hz] | 0.00-30.00 [Hz] |
| APP | 67 | Min Main Spd | Minimum main speed | 0.0 [%] | 0.0-100.00 [%] |

The diameter calculation must be stopped when one of the following occurs — multifunction input "Web Hold" is On, jog operation is occurring, Web PID prohibition status, slow speed under APP66 (Web Hold Freq) and APP67 (Min Main Spd), and quick stop section by the multifunction input "Web Quick Stop". Diameter calculation is meaningful only during normal operation.

The diameter calculation is stopped under the following conditions:

- Multifunction input "Web Hold": On
- Main speed reference [%] < APP67 (Min Main Sped)
- Output frequency [Hz] < APP66 (Web Hold Freq)
- Quick stop by the multifunction input "Web Quick Stop": On
- Break sensing status (Web Break) is entered
- Multifunction input "Web Dis PID": On
- APP15 (Web PID En): Yes
- Jog operation

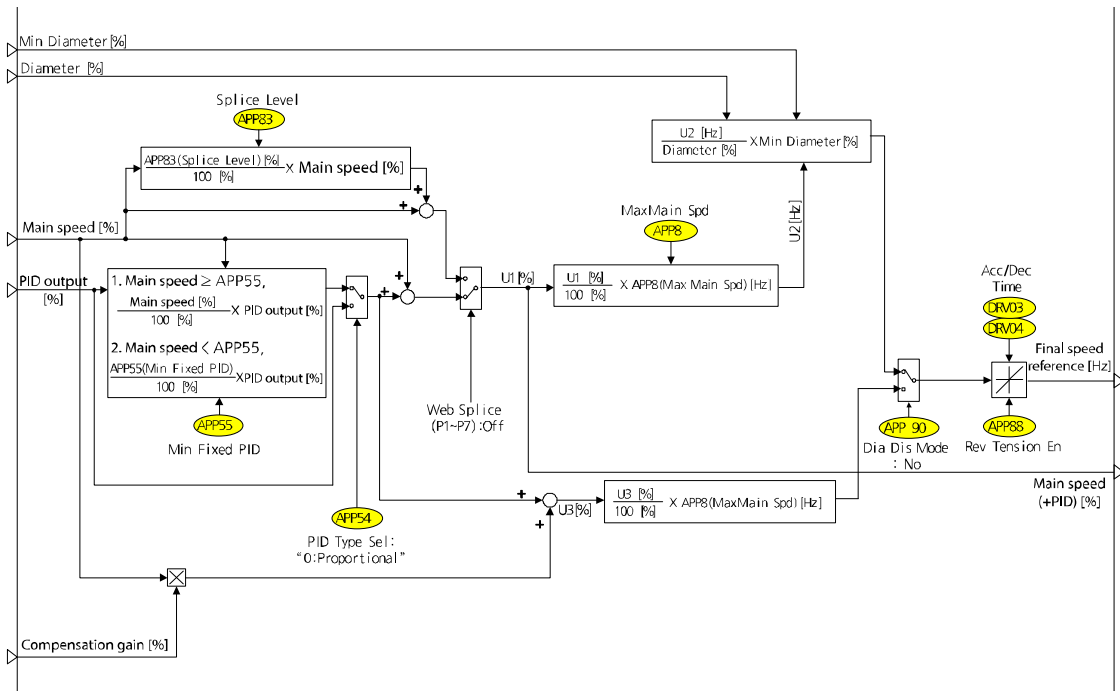
2.6.4 Web feature without diameter calculation

| Group | Code | Keypad display | Name | Default setting | Range | |
|-------|------|----------------|--|-----------------|-------|-----|
| APP | 90 | Dia Dis Mode | Web feature without diameter selection | 0: No | 0 | No |
| | | | | | 1 | Yes |

Select this to perform a tension control operation without using the diameter value. When APP90 is set to "Yes," the current diameter becomes the minimum diameter (Min Diameter), regardless of the diameter calculation, and the diameter value does not affect the tension control.

For details about the Web feature without diameter calculation, refer to [2.10 Web feature without diameter calculation part on page 34](#).

2.7 Final speed calculation section



[Final speed calculation section]

The final speed calculation section determines the inverter's final speed reference [Hz] using the main speed [%] calculated in the main speed reference section, the PID output [%] calculated in the Web PID controller section, and the diameter [%] calculated in the diameter calculation section.

2.7.1 PID output method (fixed/unfixed PID controller)

| Group | Code | Keypad display | Name | Default setting | Range |
|-------|------|----------------|---|-----------------|-------------------------------|
| APP | 54 | PID Type Sel | PID controller type selection | 0: Proportional | 0 Proportional 1 Fixed |
| APP | 55* | Min Fixed PID | Minimum value of the fixed PID controller | 20.0 [%] | 0.0–50.00 [%] |

* The code is displayed when APP54 (PID Type Sel) is set to "Proportional."

When APP54 (PID Type Sel) is set to "Fixed," the PID output [%], the output of the Web PID controller, is always consistent regardless of the main speed [%] as shown in formula 1.7.1.

$$\text{Final PID output [\%]} = \text{PID output [\%]} \quad \text{-- Formula (1.7.1)}$$

When APP54 (PID Type Sel) is set to "Proportional" (the default setting), the PID output [%], the output of the Web PID controller, is proportional to the main speed [%] as shown in formula 1.7.2. That is to say, the proportion that the PID output [%] takes in the main speed is constantly maintained. The PID output [%] decreases as the main speed [%] decreases. The PID output [%] increases proportionally as the main speed [%] increases.

$$\text{Final PID output [\%]} = \text{PID output [\%]} \times \frac{\text{Main speed reference [\%]}}{100.0 [\%]} \quad \text{-- Formula (1.7.2)}$$

However, if the low main speed reference under the value set at APP55 (Min Fixed PID) is commanded when APP54 (PID Type Sel) is set to "Proportional," the inverter operates as shown in formula 1.7.3. The controller's small output in the low main speed reference at APP55 (Min Fixed PID) can be prevented by operating as shown in formula 1.7.3.

$$\text{Final PID output [\%]} = \text{PID output [\%]} \times \frac{\text{APP55 (Min Fixed PID) [\%]}}{100.0 [\%]} \quad \text{-- Formula (1.7.3)}$$

The following table shows how the final PID output [%] is determined by APP54 (PID Type Sel) if APP32 (PID Out Scale) is set to "20 [%]" and APP55 (Min Fixed PID) is set to "10 [%]," and if the PID output is currently saturated to 20 [%].

(Note 1), in the following table, is determined by formula 1.7.3 because the main speed is 2% or 8%, which is less than 10 [%] value set at APP55 (Min Fixed PID). (Note 2) is determined by formula 1.7.2 because the main speed is 20% or 80%, which is more than 10 [%] value set at APP55 (Min Fixed PID).

PID output comparison depends on the PID controller type (APP54: PID Type Sel)

| Main speed reference [%] | PID output [%] when APP54 (PID Type Sel) is Fixed | PID output [%] when APP54 (PID Type Sel) is Proportional |
|--------------------------|---|--|
| 2.0 | 20.0 | 2.0 (Note 1) |
| 8.0 | 20.0 | 2.0 (Note 1) |
| 20.0 | 20.0 | 4.0 (Note 2) |
| 80.0 | 20.0 | 16.0 (Note 2) |

2.7.2 Final speed [Hz] calculation

In the earlier diagram, U1 [%] is "main speed [%] + PID output [%]" and can be reconfigured to 1.7.4 when converting to the [Hz] scale.

$$\text{Main speed + PID output [Hz]} = \frac{\text{Main speed + PID output [\%]}}{100.0 [\%]} \times \text{APP8 (Max Main Spd) [Hz]} - \text{Formula (1.7.4)}$$

Formula 1.7.5 is a modification of formula 1.6.1 in section 6.6. The final speed [Hz] is calculated and output using formula 1.7.5.

$$\text{Line speed [mpm]} = \text{Motor speed [rpm]} \times (\text{Diameter} \times \pi)[m] = \text{Consistant} - \text{Formula (1.6.1)}$$

$$\text{Main speed [Hz]} = \frac{\text{Line speed [mpm]}}{(\text{Diameter} \times \pi)[m]} = \frac{\text{Main speed + PID output [Hz]}}{\text{Estimated diameter [\%]}} \times \text{APP58 (Min Diameter) [\%]} - \text{Formula (1.7.5)}$$

2.7.3 Web feature without diameter calculation

| Group | Code | Keypad display | Name | Default setting | Range | |
|-------|------|----------------|--|-----------------|-------|-----|
| APP | 90 | Dia Dis Mode | Web feature without diameter selection | 0: No | 0 | No |
| | | | | | 1 | Yes |

Select this to calculate the final speed reference without using the diameter value. When APP90 is set to "Yes," the speed reference is calculated using the main speed, compensation gain, and PID output value. See formula 1.7.6 for details.

$$\text{Final speed [\%]} = (\text{Main speed} \times \text{Compensation gain}) + \text{PID Output [\%]} - \text{Formula (1.7.6)}$$

For details about the Web feature without diameter calculation, refer to **2.10 Web feature without diameter calculation part on page 34.**

ⓘ Caution

The final speed [Hz], which is the final value of formula 1.7.5 that is periodically calculated in the final speed calculation part, accelerates/decelerates frequently. At this time, the acceleration/deceleration time is DRV03 (Acc Time) and DRV04 (Dec Time).

Also, DRV03 (Acc Time) and DRV04 (Dec Time) must be set to a short time shorter than 2.0 [sec] for quick reflection of the final speed when using the Web Control.

2.7.4 Reverse slow speed feature

| Group | Code | Keypad display | Name | Default setting | Range | |
|-------|------|----------------|--------------------------------------|-----------------|-------|-----|
| APP | 88 | Rev Tension En | Reverse slow speed feature selection | 0: No | 0 | No |
| | | | | | 1 | Yes |

| Code and feature | Description |
|--------------------------|--|
| APP-88 Rev Tension En | <p>In the final speed calculation section's figure, consider that $U1 [\%]$, main speed reference $[\%]$ + PID output $[\%]$ is minus (-). In this situation, the inverter operates in forward direction when this function code is selected to "Yes" and the forward operation command is issued. But if this function code is set to "No," the initial setting, and the forward operation command is issued, the inverter does not operate in the reverse direction and the output frequency is limited to 0 [Hz].</p> <p>When this function is set to "1: Yes," and if the PID output $[\%]$ is negative (-) while the main speed reference is 0 $[\%]$, the inverter operates in the reverse direction as much as the absolute value of the PID output $[\%]$ and the tension of material applied to the closed loop tension control system can be maintained.</p> |

2.7.5 Splice feature

| Group | Code | Keypad display | Name | Default setting | Range |
|-------|-------|----------------|------------------------------|-----------------|-------------------|
| In | 65–71 | Px Define | Multifunction input settings | Web Splice | - |
| APP | 83 | Splice Level | Splice level | 0.0 $[\%]$ | 0.0–100.00 $[\%]$ |

The splice system allows you to replace a bobbin during the operation by controlling the two motors using two separated inverters. The replacement of a bobbin must be performed without a line speed change. When the multifunction input set by inverter's "62: Web Splice" is ON, the output of the Web PID controller is blocked and the inverter's final speed reference is determined only by the results of the formulas at 1.7.6 - 1.7.8 that main speed $[\%]$ and APP83 (Splice Level) are combined.

The reason that the right hand side of the formula 1.7.6 is as follows. When material is starting to be rolled onto a new bobbin, the load changes sharply and the material may sag. To avoid this, the inverter increases speed to as much as the value set in APP83 (Splice Level) when the material is rolled to a new bobbin. For example, when APP83 (Splice Level) set to

20 [%] and the main speed reference is 50 [%], the main speed reference [%] becomes 60 [%] (= 50 [%] + 50 [%] x 20 [%] / 100 [%]) if the multifunction input that is set by "62: Web Splice" is ON.

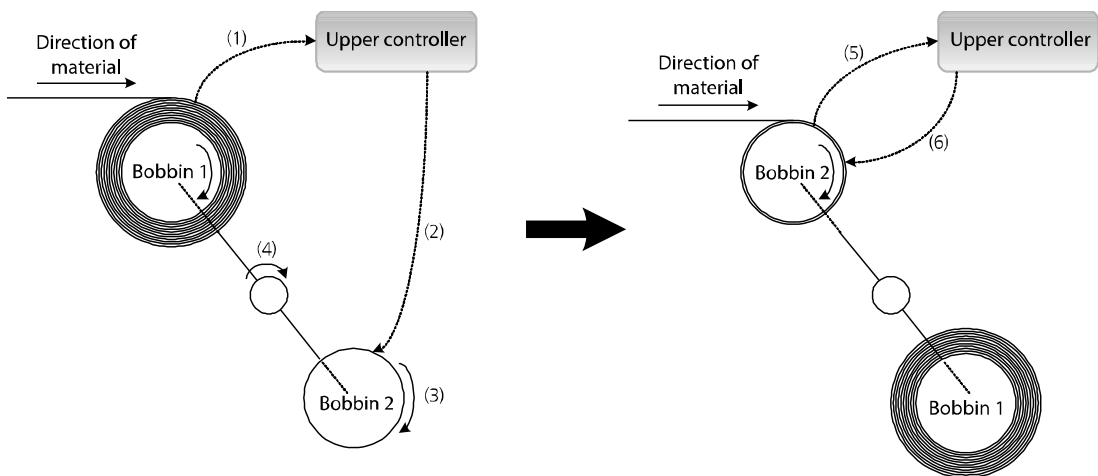
$$\text{Main speed reference [\%]} = \text{Main speed [\%]} + \text{Main speed [\%]} \times \frac{\text{APP83(Splice Level) [\%]}}{100 [\%]} - \text{Formula (1.7.6)}$$

The formula can be reconfigured to 1.7.7 when converting to the [Hz] scale.

$$\text{Main speed reference [Hz]} = \frac{\text{Final main speed reference [\%]}}{100.0 [\%]} \times \text{APP8 (Max Main Spd) [Hz]} - \text{Formula (1.7.7)}$$

Formula 1.7.7 goes through the formula 1.7.8 and outputs the inverter's final speed reference. The reason that "initial diameter [%]" is in the denominator of the right-hand side, such as in formula 1.7.8, is because diameter of the bobbin is initialized to diameter set among APP 61 to 64 when the multifunction input set at "62: Web Splice" becomes ON.

$$\text{Main speed reference [Hz]} = \frac{\text{Main speed reference [Hz]}}{\text{Initial diameter [\%]}} \times \text{APP58 (Min Diameter) [\%]} - \text{Formula (1.7.8)}$$



[Main concept of splice]

The general structure of the winder's splice system can be explained in the above figure. The operating sequence is as follows.

Bobbin (1), currently rolling material, sends a signal to the upper controller when the bobbin is almost full. ((1) in the figure)

The upper controller sends an ON signal to the multifunction input that is set by "62: Web Splice" of the inverter that controls Bobbin (2), which is currently empty. ((2) in the figure)

The inverter starts to operate Bobbin 2 in a reference value where only the main speed reference [%] and APP83 (Splice Level) are combined, such as in formula 1.7.6 to 1.7.8, while blocking the output of the Web PID controller. ((3) in the figure)

The spindle that switches bobbins rotates and switches the position of Bobbin 1 and Bobbin 2. ((4) in the figure)

The signal is sent to the upper controller when the bobbin is switched to Bobbin 2. ((5) in the figure)

The upper controller sends an OFF signal to the multifunction input that is set by "62: Web Splice" of the inverter that controls Bobbin 2 to stop the splice operation. The Web PID controller starts operating again and the diameter calculation is restarted. The output frequency of the inverter is determined by the formula 1.7.5. ((6) in the figure)

2.7.6 Calculation function for the frequency to the main speed 100%

| Group | Code | Keypad display | Name | Default setting | Range |
|-------|------|----------------|----------------------------------|-----------------|-----------------|
| APP | 08 | Max Main Spd | Frequency to the main speed 100% | 60.0 [Hz] | 0.0–DRV20 [Hz] |
| APP | 09 | Max Line Spd | Maximum line speed [mpm] | 565.2 [mpm] | 1–5000.0 [mpm] |
| APP | 10 | Gear Ratio | Gear ratio | 1.00 | 0.10–100.00 |
| APP | 11 | Min Dia [m] | Minimum diameter [m] | 0.100 [m] | 0.010–5.000 [m] |

For tension control, the frequency to the main speed 100%, when the diameter is at the minimum, must be set. To enter the value, the maximum line speed of the tension control system, the minimum diameter of the bobbin in use, and the gear ratio between the motor and winder are needed.

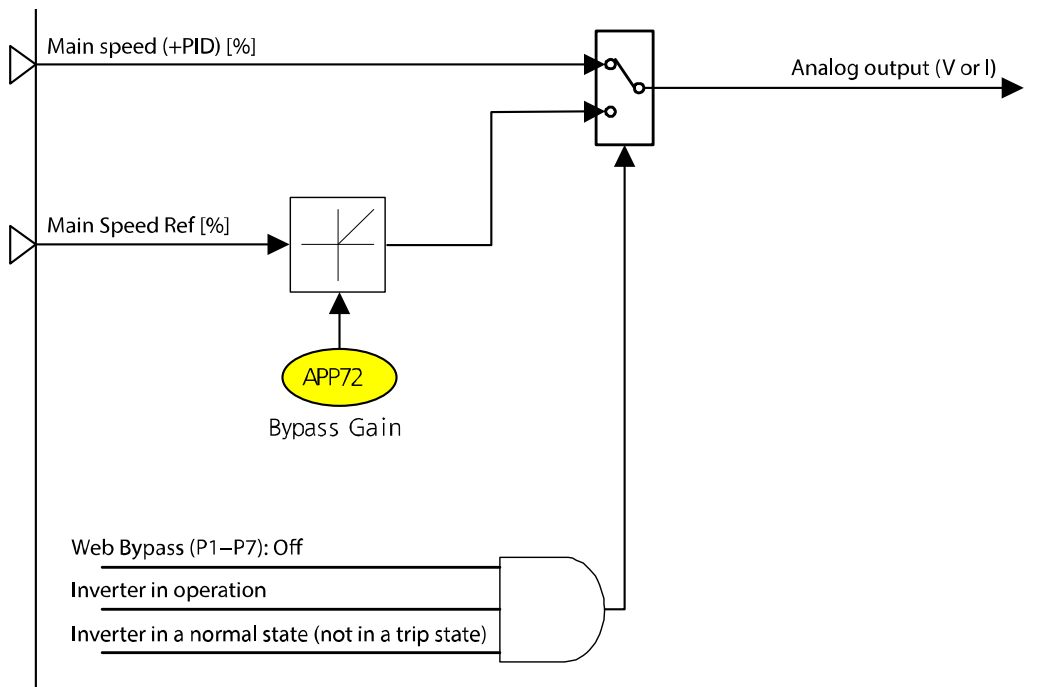
Users may calculate the frequency to the main speed 100% and set the value at APP08 (Max Main Spd), but if you do not know the formula, set APP09 to "11" to automatically calculate and set the value at APP08(Max Main Spd).

The calculation formula is as shown in formula 1.7.9. The number of poles in the motor in BAS11 (Pole Number) is used to convert the formula that converted the [rpm] scale to [Hz] scale formula.

Maximum motor speed (APP08)[Hz] =

$$\text{Gear ratio (APP10)} \times \frac{\text{Maximum line speed (APP09)[mpm]}}{\text{Minimum diameter (APP11)[m]} \times \pi} \times \frac{\text{Number of poles (BAS11)}}{120} - \text{Formula (1.7.9)}$$

2.8 Analog output part

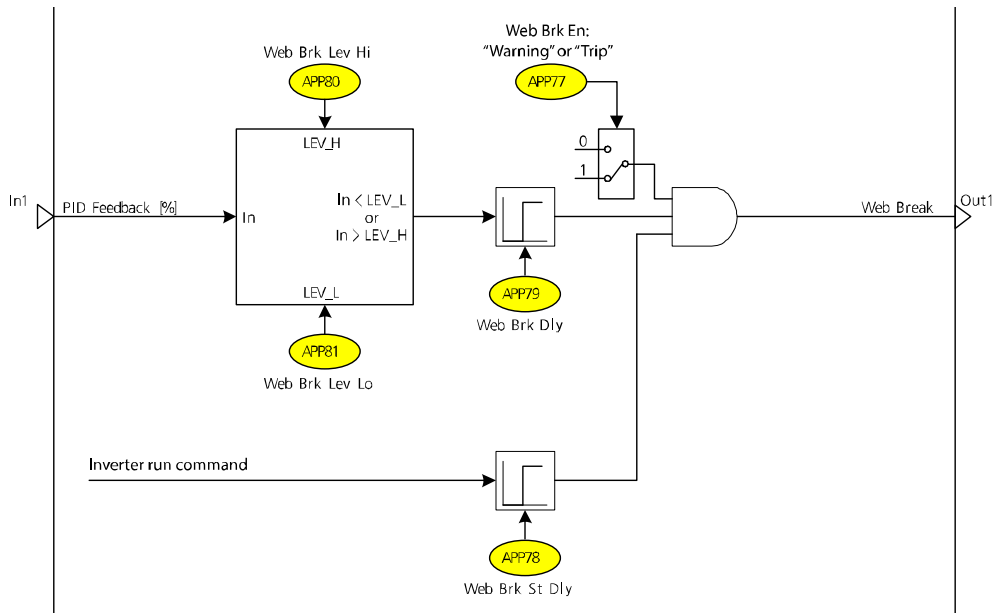


| Group | Code | Keypad display | Name | Default setting | Range |
|-------|-------|----------------|------------------------------|-----------------|----------------|
| In | 65-71 | Px Define | Multifunction input settings | Web Bypass | - |
| OUT | 01 | AO1 Mode | Analog output 1 | Web Spd Out | - |
| APP | 72 | Bypass Gain | Bypass gain | 100.0 [%] | 0.0-300.00 [%] |

The main speed + PID output [%] can be output via the analog output during normal inverter operation (multifunction input "Web Bypass" is Off, inverter is in operation, and inverter is not in a trip state but in a normal state).

When the inverter is not in a normal operation state (multifunction input is On, inverter is stopped, or inverter is in a trip state), the main speed [%] is multiplied by APP72 (Bypass Gain) and output via the analog output.

2.9 Web break detection section



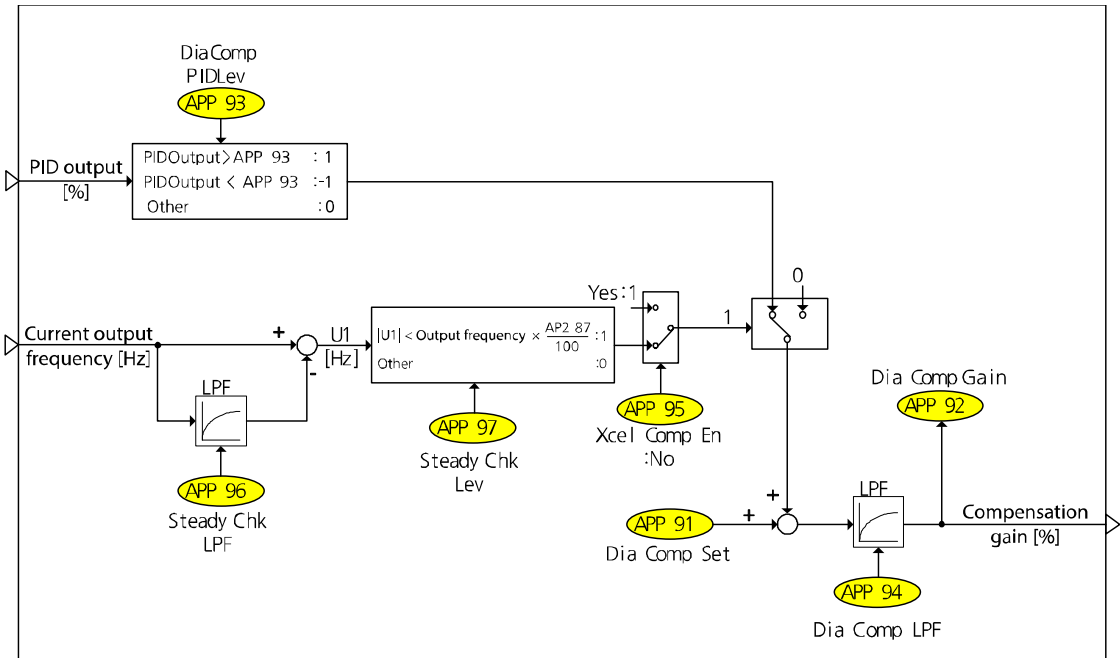
The closed loop tension control system uses a tension detection device such as a dancer or load cell. If the feedback value received by the tension detection device maintains a small or large value for more than the set time, the inverter considers that the web material can rupture and notifies to the upper controller through the multifunction output terminal. Also, the inverter starts a proper protective operation according to the settings.

| Group | Code | Keypad display | Name | Default setting | Range | | | | | | |
|-------|----------|----------------|---|-----------------|--|---|------|---|---------|---|----------|
| OUT | 31-33 | Relay 1, 2, Q1 | Multifunction output terminal | Web Break | - | | | | | | |
| APP | 77 | Web Brk En | Web break detection feature selection | 0: None | <table border="1"> <tr> <td>0</td> <td>None</td> </tr> <tr> <td>1</td> <td>Warning</td> </tr> <tr> <td>2</td> <td>Free-run</td> </tr> </table> | 0 | None | 1 | Warning | 2 | Free-run |
| 0 | None | | | | | | | | | | |
| 1 | Warning | | | | | | | | | | |
| 2 | Free-run | | | | | | | | | | |
| APP | 78* | Web Brk St Dly | Web break detection delay time during initial booting | 10.0 [sec] | 0.0-300.0 [sec] | | | | | | |
| APP | 79* | Web Brk Dly | Web break detection delay time | 5.0 [sec] | 0.0-300.0 [sec] | | | | | | |
| APP | 80* | Web Brk Lev Hi | Maximum web break detection | 80.0 [%] | APP80, 100.0 [%] | | | | | | |
| APP | 81* | Web Brk Lev Lo | Minimum web break detection | 20.0 [%] | 0.0-APP79 [%] | | | | | | |

* The code is displayed when APP77 (Web Brk En) is set to "Warning" or "Free-run."

| Code and feature | Description |
|--------------------------|--|
| APP-77 Web Brk En | <p>When "None" is selected, the web break detection feature does not operate.</p> <p>When "Free-run" is selected, the inverter free-run stops when a web break is detected. If the multifunction output terminal is set to "29: Trip," the multifunction output terminal becomes On.</p> <p>When "Warning," the default setting, is selected and a web break is detected, the inverter does not free-run stop and operates normally. The Warning is displayed on the digital screen. If the multifunction output terminal is set to "40: Web Break," only the selected multifunction output terminal becomes On. When the user issues a stop command to the inverter and the inverter decelerates and is completely stopped, the Warning on the digital screen disappears and the multifunction output set to "40: Web Break" becomes Off.</p> |
| APP-78 Web Brk St Dly | <p>The web break detection feature does not operate from the inverter's initial startup to the time set in this code. Because the position of the dancer or load cell is unstable during the initial startup and web break detection during this period is meaningless.</p> |
| APP-79 Web Brk Dly | <p>If the amount of analog feedback from the dancer or load cell remains in more than the web break detection level (APP80: Web Brk Lev Hi) or in less than the web break detection level (APP81: Web Brk Lev Lo) for the time specified in this code, the inverter makes a decision about the Web Break status.</p> |
| APP-80 Web Brk Lev Hi | <p>Web break detection starts when the amount of analog feedback is more than the value specified in this code.</p> |
| APP-81 Web Brk Lev Lo | <p>Web break detection starts when the amount of analog feedback is less than the value specified in this code.</p> |

2.10 Web feature without diameter calculation part



2.10.1 Compensation gain calculation

If information about diameter of the bobbin used in the closed loop tension control system does not exist or if the number of bobbins is more than the configurable value, the inverter can be controlled without compensation using a gain calculation. When APP90 is set to "Yes," the speed reference is calculated using the main speed, compensation gain, and PID output value.

When a user configures the compensation gain APP91 (Dia Comp Set) before the operation and operation starts, the compensation gain [%] is calculated by comparing the PID output value and the reference value at APP93 (DiamComp PIDLev). The calculated gain value appears at APP92 (Dia Comp Gain).

When the inverter is stopped, the APP92 (Dia Comp Gain) value is changed to the default compensation gain at APP91 (Dia Comp Set).

| Group | Code | Keypad display | Name | Default setting | Range |
|-------|------|----------------|--|-----------------|-------------------|
| APP | 90 | Dia Dis Mode | Web without diameter calculation selection | 0: No | 0 No 1 Yes |
| APP | 91* | Dia Comp Set | Diameter compensation gain initial value | 100.0 [%] | 0.0–300.0 [%] |
| APP | 92* | Dia Comp Gain | Diameter compensation gain monitor | Read Only [%] | |
| APP | 93* | DiaComp PIDLev | Calculation standard PID output value | 10.00 [%] | 0.00–100.00 [%] |
| APP | 94* | Dia Comp LPF | Diameter compensation gain filter | 50.0 [sec] | 0.0–300.0 [sec] |

* The code is displayed when APP90 (Dia Dis Mode) is selected to "1: Yes."

| Code and feature | Description |
|--------------------------|--|
| APP-90 Dia Dis Mode | Set this to control the closed loop tension system without the diameter calculation. |
| APP-91 Dia Comp Set | Set the initial diameter compensation gain value. When using various bobbins, setting the diameter value for the medium size bobbin helps to carry out proper control of every bobbin. |
| APP-92 Dia Comp Gain | When stopped, the value configured at APP91 is displayed. When operation starts, the compensation gain value calculated by the compensation gain calculation condition is displayed. |
| APP-93 DiaComp PIDLev | Sets the PID output standard to the calculated diameter compensation gain. If the PID output value is larger than the set value, the compensation gain value increases. On the other hand, if the PID output value is smaller than the negative (-) value of the set value, the compensation gain value decreases. |
| APP-94 Dia Comp LPF | Sets the time to the calculated diameter compensation gain. Set a small APP94 value for quick control. |

2.10.2 Stop gain calculation during acceleration/deceleration feature

If compensation gain is calculated during acceleration/deceleration, the PID output value becomes an unstable transient and proper gain calculation become unavailable. But if compensation gain is not calculated when the acceleration/deceleration time is very long, the PID output value may become saturated. Therefore, an appropriate choice necessary, according to the system.

| Group | Code | Keypad display | Name | Default setting | Range | |
|-------|------|----------------|---|-----------------|-----------------|-----|
| APP | 95* | Xcel Comp En | Diameter compensation gain during acceleration/deceleration selection | 0: No | 0 | No |
| | | | | | 1 | Yes |
| APP | 96** | Steady Chk LPF | Constant speed judgment speed filter | 1.0 [sec] | 0.0–100.0 [sec] | |
| APP | 97** | Steady Chk Lev | Constant speed judgment speed difference | 1.00 [%] | 0.00–50.00 [%] | |

* The code is displayed when APP90 (Dia Dis Mode) is selected to "1: Yes."

** The code is displayed when APP95 (Xcel Comp En) is set to "0: No."

| Code and feature | Description |
|--------------------------|---|
| APP-95 Xcel Comp En | This selects the diameter compensation gain calculation during acceleration/deceleration. When "No" is selected, the compensation gain calculation is executed only in the constant speed section. When "Yes" is selected, the compensation gain calculation is executed in all acceleration/deceleration sections. |
| APP-96 Steady Chk LPF | If the diameter compensation gain calculation is executed only in the constant speed section, this code applies a Low Pass Filter to the current output frequency to be compared with the current output frequency to decide the constant speed section. |
| APP-97 Steady Chk Lev | If the diameter compensation gain calculation is executed only in the constant speed section, this code sets the difference between the current output frequency and the current output frequency after passing through the filter to decide the constant speed section. If the difference is more than the value set at APP97, the inverter judges the section as an acceleration/deceleration section and does not calculate the compensation gain. |

3 Capstan operation

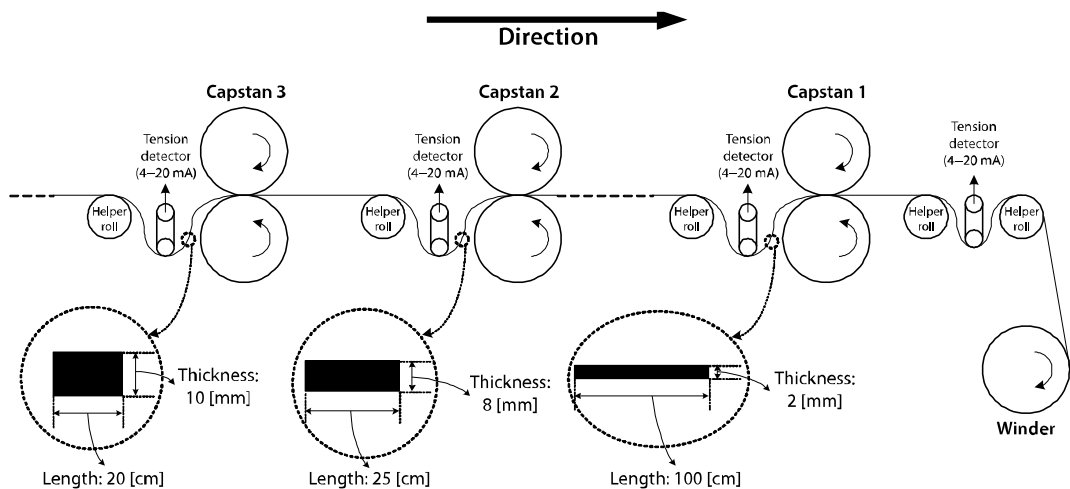
3.1 Introductions

A capstan is a device that rolls and pulls heavy objects at a constant speed.

The capstan is located between the unwinder and winder in steel, steel making, and iron making processes, and allows for a continuous process by maintaining tension.

Same as the winder/unwinder feature, the capstan feature of the S100 inverter receives feedback of the analog amount from the tension control detection device, such as a dancer and load cell, and maintains tension by operating the PID controller.

The S100 inverter's closed loop tension control system for web (winding) applications (Web-PID controller) is slightly different from a generic PID controller.



[Principle of capstan operation]

As shown in the above figure, the speed of capstan rotation must become faster as the thickness of web material gets thinner during the continuous process. Materials that have different thicknesses and lengths must be processed at the same time because the material must not lean to one side so that the continuous process is properly processed. The materials for each process are different, there is no material loss in each process and the volume of materials is always the same. Therefore, the length of material that is processed in capstan 1 (100 [cm]) is four times of the length of material processed in capstan 2 (25 [cm]) because the thickness of the material processed in capstan 1 (2 [mm]) is 1/4 of the thickness of material that is processed in capstan 2 (8 [mm]). Therefore, the rotation speed of capstan 1 must be four times faster than the speed of capstan 2 to process materials of different

lengths in the same period of time.

In this principle, formula 2.1.1 is used for capstan operation. The formula is similar to formula 1.1.1 of winder/unwinder.

$$\text{Motor speed [rpm]} = \frac{\text{Line speed [mpm]}}{\text{Diameter} \times \pi [m]} \quad - \text{Formula (1.1.1)}$$

$$\text{Motor speed [rpm]} = \frac{\text{Line speed [mpm]}}{\text{Diameter of capstan} \times \pi [m]} \times \frac{\text{Standard material thickness [m]}}{\text{Current material thickness [m]}} \quad - \text{Formula (2.1.1)}$$

The motor speed, inverter's output frequency, is controlled and the current material thickness is internally calculated by the Web PID controller. The inverter's output frequency is finally decided using the current material thickness calculated using formula 2.1.1.

This method provides a more stable performance than the method that controls the capstan tension using only a generic PID controller. Since the internally calculated material thickness guarantees the inverter's output frequency once more and this makes the Web PID controller to cover a very small proportion of inverter's output frequency. Therefore, the risk that the output of Web PID controller will become saturated disappears and the forced oscillation of I controller output decreases sharply.

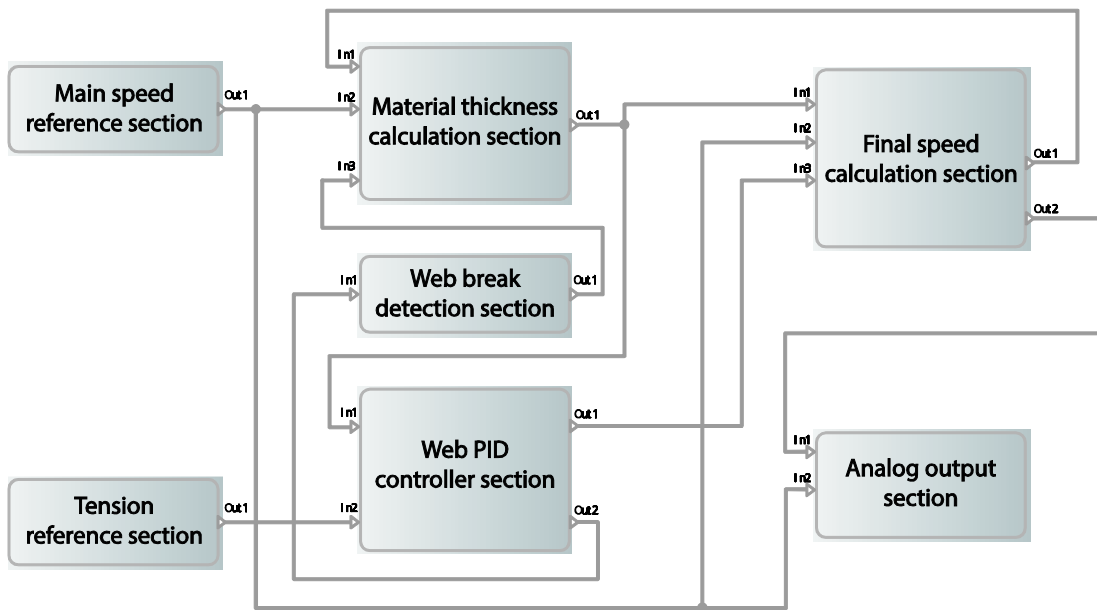
Other main features include:

- Removing dancer or load cell transients during the operation (related code: APP50)
- Quick stop while maintaining the tension (related code: APP89)
- Senses imminent rupture of the web material (related code: APP77–81)

To use capstan feature of S100, configure as shown below:

| Group | Code | Keypad display | Name | Setting value |
|-------|------|----------------|--|----------------|
| APP | 01 | App Mode | Application selection | 5: Web Control |
| APP | 02 | Web Mode Sel | Tension control operation mode selection | 2: Capstan |

3.2 Entire structure



Input and output of each part are as follows:

| Part | Input | | Output | |
|--|-------|-------------------------------|--------|----------------------------|
| Main speed reference section | - | | Out1 | Main speed [%] |
| Tension reference section | - | | Out1 | Tension reference [%] |
| Web PID controller part | In1 | Thickness [%] | Out1 | PID output [%] |
| | In2 | Tension reference [%] | Out2 | PID Feedback [%] |
| Material thickness calculation section | In1 | Current output frequency [Hz] | Out1 | Thickness [%] |
| | In2 | Main speed [%] | | |
| | In3 | Web Break occurrence (0/1) | | |
| Final speed calculation section | In1 | Thickness [%] | Out1 | Final speed reference [Hz] |
| | In2 | Main speed [%] | | |
| | In3 | PID output [%] | Out2 | Main speed + PID [%] |
| Analog output section | In1 | Main speed + PID [%] | - | |
| | In2 | Main speed [%] | | |
| Web break detection section | In1 | PID Feedback [%] | Out1 | Web Break occurrence (0/1) |

3.3 Main speed reference section

This section is the same as the main speed reference section of the winder/unwinder. Refer to **2.3 Main speed command on page 5.**

3.4 Tension reference section

This section is the same as the tension reference section of the winder/unwinder. Refer to **2.4 Tension reference section on page 8.**

3.5 Web PID controller section

This section is the same as the Web PID controller section of the winder/unwinder. Refer to **2.5 Web PID controller part on page 12.**

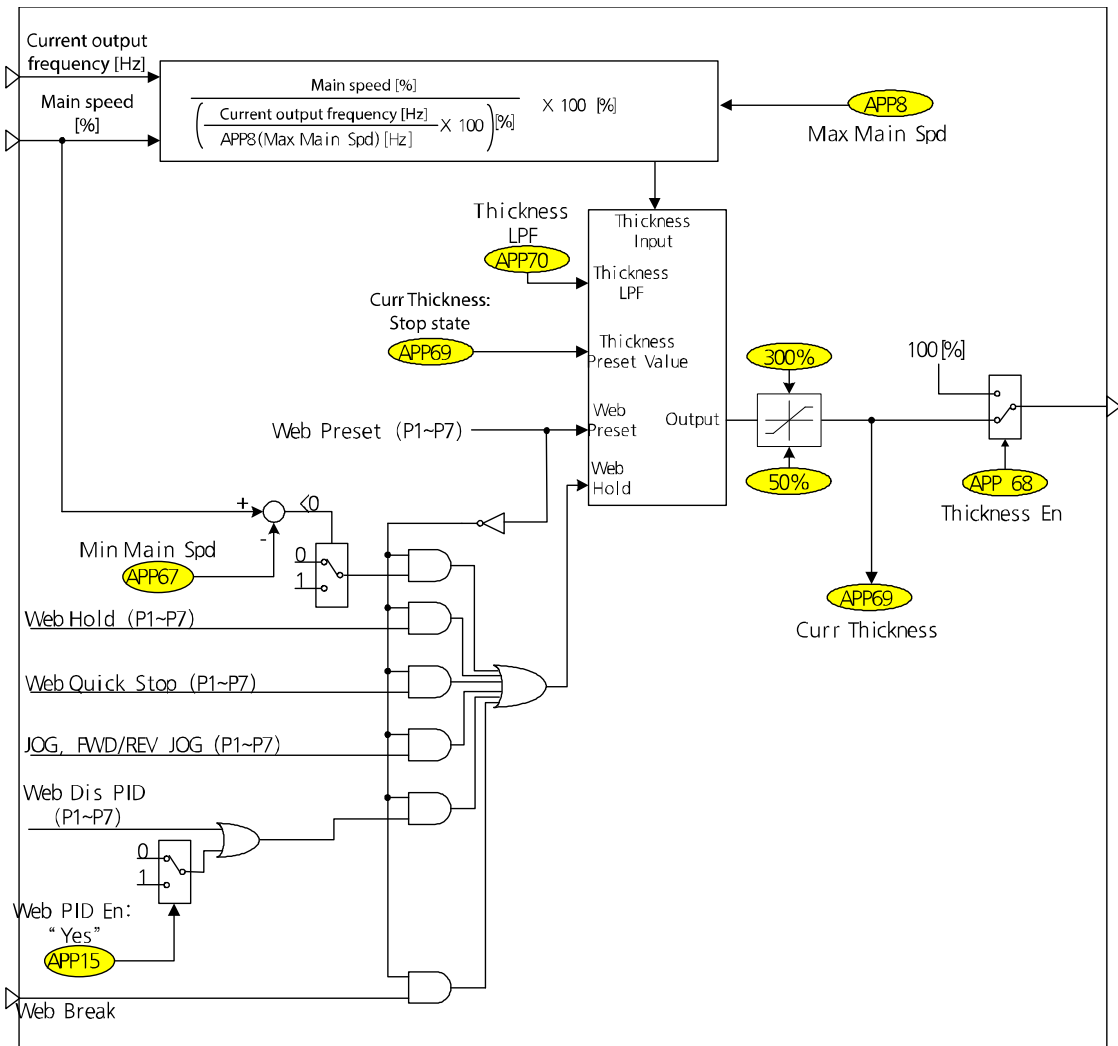
3.6 Analog output section

This section is the same as the analog output section of the winder/unwinder. Refer to **2.8 Analog output part on page 31.**

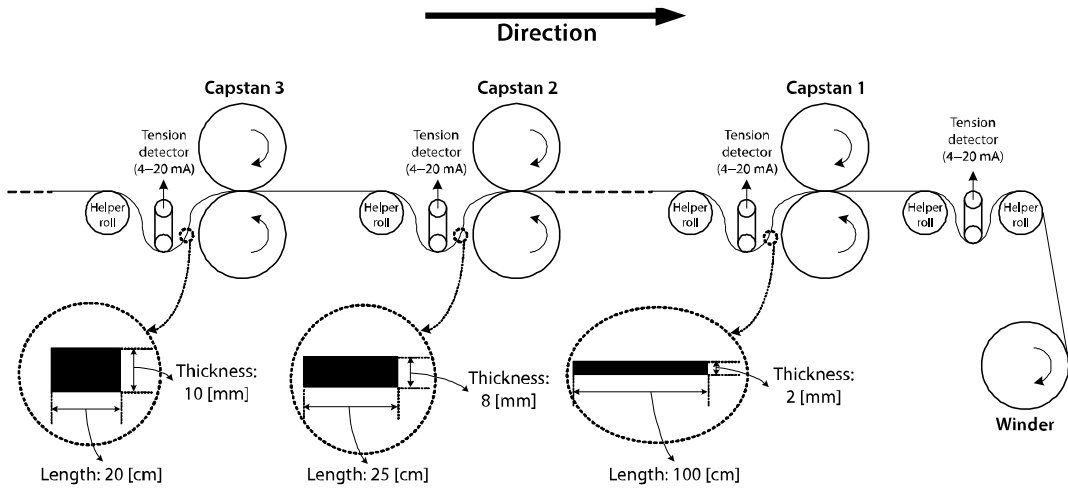
3.7 Web break detection section

This section is the same as the web break detection section of the winder/unwinder. Refer to **2.9 Web break detection section on page 32.**

3.8 Material thickness calculation section



The following figure shows the closed loop tension control system's continuous process. The thickness of the web material decreases as the process progresses. However, the material input volume in each capstan is constant. Therefore, as shown in the figure, the material length of capstan 3, 2, and 1 can be expected to 20 [cm], 25 [cm], and 100 [cm] respectively when considering the material thickness input to capstan 3, 2, and 1 is 10 [mm], 8 [mm], and 2 [mm] respectively. To prevent material from leaning to one side and to ensure normal operation during the continuous process, each capstan's rotation speed must determine the order of capstan 1 > capstan 2 > capstan 3.



[Principle of capstan operation]

In the tension control system, the line speed of a capstan in a continuous process, motor speed, and thickness of material correlate as explained in formula 2.8.1.

$$\text{Motor speed [rpm]} = \frac{\text{Line speed [mpm]} \times \text{Standard material thickness [m]}}{\text{Diameter of caps tan} \times \pi [m]} \times \frac{\text{Standard material thickness [m]}}{\text{Current material thickness [m]}} - \text{Formula (2.8.1)}$$

As shown in formula 2.8.1, the motor speed [rpm] is determined by the line speed [mpm] and current material thickness [m]. Therefore, the current material thickness must be calculated and estimated during the operation. Formula 2.8.2 is a modification of formula 2.8.1. The material thickness can be estimated using formula 2.8.2.


$$\begin{aligned} & \text{Estimated current material thickness [m]} \\ & = \frac{\text{Line speed [mpm]}}{\text{Motor speed [rpm]} \times (\text{Diameter of caps tan} \times \pi) [m]} \times \text{Standard material thickness [m]} - \text{Formula (2.8.2)} \end{aligned}$$

3.8.1 Material thickness initialization feature

| Group | Code | Keypad display | Name | Default setting | Range |
|-------|-------|----------------|--|-----------------|-------------------|
| In | 65-71 | Px Define | Multifunction input settings | Web Preset | - |
| APP | 68 | Thickness En | Material thickness calculation selection | 1: Yes | 0 No 1 Yes |
| APP | 69 | Curr Thickness | Initial material thickness | 100.0 [%] | 50.0- |

| Group | Code | Keypad display | Name | Default setting | Range |
|-------|------|----------------|--|-----------------|------------|
| | | | setting and currently calculating material thickness display | | 300.00 [%] |

| Code and feature | Description |
|--------------------------|--|
| APP-69 Curr Thickness | <p>Enter the initial material thickness [%] in a stopped state. This cannot be set during operation. The material thickness being calculated is displayed during the operation.</p> <p>The example of setting this code is shown below: In the "Principle of capstan operation" figure, when installing the inverter to capstan 1, capstan 2, and capstan 3, 100.0 [%] is entered at APP69 (Curr Thickness) for each inverter during the stop status. When operation starts, the estimated material thickness values that are calculated in the iS7 are displayed at APP69 (Curr Thickness) of each inverter. If the main speed and gear ratio are accurately considered in each capstan and accurate values are calculated and entered at APP08 (Max Main Spd), the APP69 (Curr Thickness) value of each inverter will change slowly within a range of 100 [%] ± 5 [%].</p> <p>If the displayed APP69 (Curr Thickness) value is less than 80 [%] (Approx.), that means the value entered at APP08 (Max Main Spd) is too small. Also, if the displayed APP69 (Curr Thickness) value is more than 120 [%] (Approx.), that means the value entered at APP08 (Max Main Spd) is too large.</p> <p>If the entered APP08 (Max Main Spd) value is not accurate, confirm the inverter's output frequency when a main speed value of 100 [%] is entered, and enter the value at APP08 (Max Main Spd). Or, substitute the line speed with a measurement provided by a portable tachometer, gear ratio (or belt ratio), and diameter of capstan to the formula 2.8.4, and enter the calculated value at APP08 (Max Main Spd).</p> |

 Caution

Make sure the multifunction input "Web Preset" is Off. Then material thickness cannot be calculated if the multifunction input "Web Preset" is On.

3.8.2 Material thickness calculation feature

| Group | Code | Keypad display | Name | Default setting | Range | |
|-------|------|----------------|--|-----------------|------------------|-----|
| APP | 68 | Thickness En | Material thickness calculation selection | 1: Yes | 0 | No |
| | | | | | 1 | Yes |
| APP | 69 | Curr Thickness | Initial thickness settings (stop status) or current thickness display (in operation) | 100.0 [%] | 50.0–300.00 [%] | |
| APP | 70 | Thickness LPF | Material thickness calculation filter | 30.0 [sec] | 0.0–300.0 [sec] | |
| APP | 08 | Max Main Spd | Frequency to the main speed 100% | 60.0 [Hz] | DRV19–DRV20 [Hz] | |

Formula 2.8.2 can be reconfigured like formula 2.8.3 when converting to the [%] scale.

$$\text{Estimated current material thickness [\%]} = \frac{\text{Mainspeedinput [\%]}}{\frac{\text{Current output frequency [Hz]} \times 100 [\%]}{\text{APP08 (MaxMainFreq)}}} \times 100 [\%] \quad \text{– Formula (2.8.3)}$$

100 [%], that is multiplied to the right hand side of formula 2.8.3, is the standard thickness of material. This estimated material thickness [%] is limited to a maximum of 300 [%] and a minimum of 50 [%]. You can adjust the calculation time constant of the material thickness [%] by adjusting the time constant of the estimated material thickness [%] at APP70 (Diameter LPF).

The following explains how the material thickness [%] is estimated during the inverter operation using formula 2.8.3.

In the "Principle of capstan operation" figure, consider if APP69 (Curr Thickness) of capstan 2 is changed from 100 [%], the default setting, to 150 [%]. The inverter of capstan 2 now recognizes the material thickness as 150 [%]. This means the inverter of capstan 2 internally recognizes the material thickness as $8 \times 1.5 = 12$ [mm] while the actual material thickness in capstan 2 is 8 [mm]. The amount of tension applied to the dancer or load cell decreases because the capstan is operated 1-1.5 times slower than when the material thickness is 100 [%]. Therefore, the output of the Web PID controller becomes a negative (-) value and the current output frequency [Hz] of formula 2.8.3 increases. The estimated material thickness [%] in formula 2.8.3 decreases and converges to 100 [%] (approx.) of the actual material thickness processed in capstan 2, because the estimated material thickness [%] is inversely proportional to the current output frequency [Hz].

The estimated material thickness [%] is a very important element in deciding the inverter's final speed reference [Hz]. The details are covered in section 2.9 "Final speed calculation section."

| Code and feature | Description |
|--------------------------|---|
| APP-68 Thickness En | Select whether or not to use the material thickness calculation feature. When "No" is selected, the thickness of material is not calculated. |
| APP-69 Curr Thickness | Enter the initial material thickness [%] in a stopped state. This cannot be set during operation. The material thickness being calculated is displayed during the operation. |
| APP-70 Thickness LPF | Set the delay time constant of the material thickness [%] calculation. |
| APP-08 Max Main Spd | <p>Enter the inverter output frequency when the main speed reference is 100 [%]. If you know the machine information, such as line speed, diameter of capstan, and belt ratio, you can calculate APP08 (Max Main Spd) using formula 2.8.4.</p> <p>The following is an example. In the "Principle of capstan operation" figure, if the diameter of capstan 1 is 0.4 [m], the maximum line speed of this system is 900 [mm] and the four pole motor and the belt rate (motor is faster) are 3.2/1. At this time, the value that is to be entered to APP08 (Max Main Spd) can be calculated as follows.</p> $APP08 (Max Main Spd) = \frac{900 [mpm]}{0.40 [m] \times \pi} \times 3.2 (Belt\ ratio) \times \frac{4 (Number\ of\ pole)}{120} = 76.43 [Hz]$ |

3.8.3 Material thickness calculation stop feature

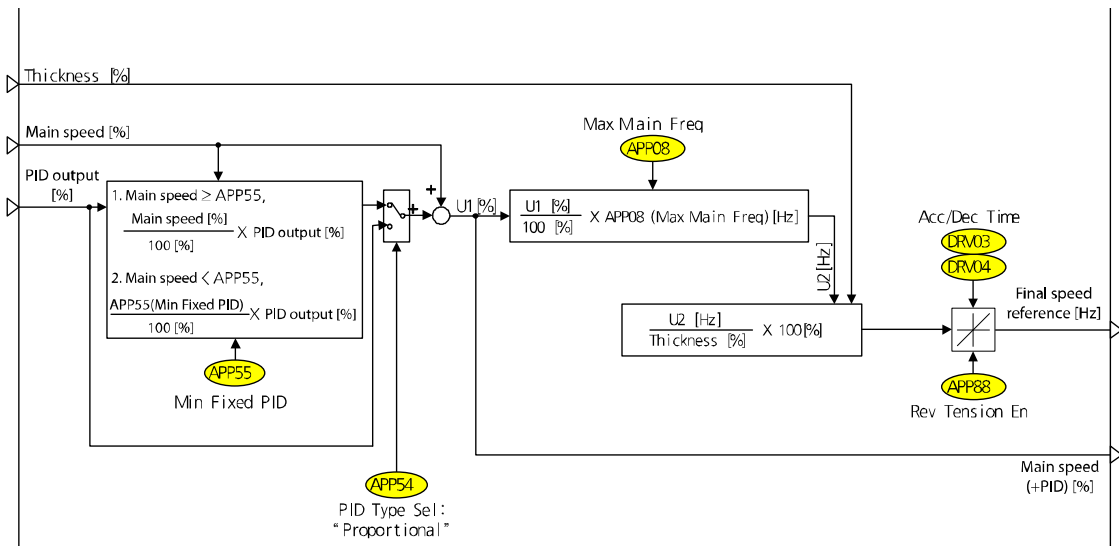
| Group | Code | Keypad display | Name | Default setting | Range |
|-------|-------|----------------|------------------------------|-----------------|----------------|
| In | 65-71 | Px Define | Multifunction input settings | Web Hod | - |
| APP | 67 | Min Main Spd | Minimum main speed | 0.0 [%] | 0.0-100.00 [%] |

The material thickness calculation must be stopped when one of the followings occurs — multifunction input "Web Hold" is On, jog operation, Web PID prohibition status, slow speed under APP67 (Min Main Spd), and quick stop section by the multifunction input "Web Quick Stop". The material thickness calculation is meaningful only during normal operation.

The thickness calculation is stopped under the following conditions:

- Multifunction input "Web Hold": On
- Main speed reference [%] < APP67 (Min Main Sped)
- Quick stop by the multifunction input "Web Quick Stop": On
- Break sensing status (Web Break)
- Multifunction input "Web Dis PID": On
- APP15 (Web PID En): Yes
- Jog operation is entered

3.9 Final speed calculation section



[Final speed calculation section (capstan)]

The final speed calculation section determines the inverter's final output frequency [Hz] using the main speed (In3: main speed [%]) calculated in the main speed reference section, PID output (In4: PID output [%]) and error change compensation frequency (In1) calculated in the Web PID controller section, and the diameter (In2: Thickness [%]) calculated in the material thickness calculation section.

3.9.1 PID output method (fixed/unfixed PID controller)

The details of this feature are the same as [2 Winder/Unwinder operation](#). Refer to [2.7.1 PID output method \(fixed/unfixed PID controller\) on page 25](#).

Final speed [Hz] calculation

In the earlier diagram, U1 [%] is "main speed [%] + PID output [%]" and can be reconfigured like 2.9.1 when converting to the [Hz] scale.

$$\text{Main speed + PID output [Hz]} = \frac{\text{Main speed + PID output [\%]}}{100.0 [\%]} \times \text{APP08 (Max Main Spd) [Hz]} - \text{Formula (2.9.1)}$$

Formula 2.9.2 is a modification of formula 2.8.1 in [3.8 Material thickness calculation section](#). 100 [%], that is multiplied on the right-hand side of formula 2.9.2, is the standard thickness of material. This value is the fixed value.

The final speed [Hz] is calculated and output using formula 2.9.2.

$$\text{Motor speed [rpm]} = \frac{\text{Line speed [mpm]}}{\text{Diameter of caps tan} \times \pi [m]} \times \frac{\text{Standard material thickness [m]}}{\text{Current material thickness [m]}} - \text{Formula (2.8.1)}$$

$$\text{Main speed [Hz]} = \frac{\text{Main speed + PID output [\%]}}{\text{Estimated material thickness [\%]}} \times 100 [\%] - \text{Formula (2.9.2)}$$

⚠ Caution

The final speed [Hz] of formula 2.9.2, which is periodically calculated in the final speed calculation section, accelerates/decelerates frequently. At this time, the acceleration/deceleration time is DRV03 (Acc Time) and DRV04 (Dec Time). DRV03 (Acc Time) and DRV04 (Dec Time) can be set separately, but must be set to a time shorter than 2.0 [sec] for quick reflection of the final speed.

3.9.2 Reverse slow speed feature

The details of this feature are the same as [2 Winder/Unwinder operation](#). Refer to [2.7.4 Reverse slow speed feature on page 28](#).

3.9.3 Splice feature

The splice feature is not supported in capstan operation mode.

4 Advanced feature group (PAR → APP)

The codes highlighted in gray are displayed only when the related codes are selected.

SL: Sensorless vector control feature (dr.09)

***O/X:** Writable/unwritable during operation, **7/L/A:** Keypad/LCD loader/common

| Code | Comm. Address | Name | Keypad Display | Setting Range | Initial Value | Property* | V/F | SL | Ref. |
|-----------------|---------------|---|----------------|---------------|---------------|-----------|-----|----|------|
| 00 | - | Jump code | Jump Code | 1-99 | 9 | O/A | O | O | |
| 01 | 0h1801 | Advanced feature selection | App Mode | 0 | None | 0: None | X/A | O | O |
| | | | | 2 | Proc PID | | | | |
| | | | | 5 | Web Control | | | | |
| 02 ¹ | 0h1802 | Web control mode selection | Web Mode Sel | 0 | Winder | 0: Winder | X/A | O | O |
| | | | | 1 | Unwinder | | | | |
| | | | | 2 | Capstan | | | | |
| 03 ¹ | 0h1803 | Web hide function display selection | WebFunc Shown | 0 | No | 0: No | O/A | O | O |
| | | | | 1 | Yes | | | | |
| 04 ¹ | 0h1804 | Web PID hide function display selection | WebPID Shown | 0 | No | 0: No | O/A | O | O |
| | | | | 1 | Yes | | | | |
| 05 ¹ | 0h1805 | Main speed display | Main Spd Disp | 0-100.00 [%] | - | -/A | O | O | |
| 06 ¹ | 0h1806 | Main speed command method | Main Spd Src | 0 | Keypad | 0: Keypad | X/A | O | O |
| | | | | 1 | V1 | | | | |
| | | | | 3 | V2 | | | | |
| | | | | 4 | I2 | | | | |
| | | | | 5 | Int 485 | | | | |
| | | | | 7 | FieldBus | | | | |
| | | | | 11 | Pulse | | | | |
| | | | | 12 | V3 | | | | |
| | | | | 14 | V4 | | | | |
| 15 | I4 | | | | | | | | |
| 07 ² | 0h1807 | Main speed command (keypad) | Main Spd Set | 0-100.00 [%] | 0.00 | O/A | O | O | |

¹ The code is displayed only when AP.01 is set to 5 (Web Control).

² The code is displayed only when AP.06 is set to 0 (Keypad).

Advanced feature group (PAR→APP)

| Code | Comm. Address | Name | Keypad Display | Setting Range | Initial Value | Property* | V/F | SL | Ref. |
|-----------------|---------------|---|----------------|---|---------------|-----------|-----|----|------|
| 08 ¹ | 0h1808 | Frequency to the main speed reference 100% | Max Main Spd | Starting frequency - maximum frequency [Hz] | 60.00 | O/A | O | O | |
| 09 ³ | 0h1809 | Maximum line speed [mpm] | Max Line Spd | 1-5000.0 [mpm] | 565.2 | X/A | O | O | |
| 10 ³ | 0h180A | Gear ratio | Gear Ratio | 0.1-100.00 | 1.00 | X/A | O | O | |
| 11 ³ | 0h180B | Minimum diameter [m] | Min Dia [m] | 0.01-5.000 [m] | 0.100 | X/A | O | O | |
| 12 ¹ | 0h180C | Main speed acceleration/ deceleration selection | Main XcelT En | 0 | No | 0: No | O/A | O | O |
| | | | | 1 | Yes | | | | |
| 13 ⁴ | 0h180D | Main speed acceleration time | Main Spd AccT | 0.0-300.0 [sec] | 10.0 | O/A | O | O | |
| 14 ⁴ | 0h180E | Main speed deceleration time | Main Spd DecT | 0.0-300.0 [sec] | 20.0 | O/A | O | O | |
| 15 ¹ | 0h180F | Web PID control selection | Web PID En | 0 | No | 1: Yes | O/A | O | O |
| | | | | 1 | Yes | | | | |
| 16 ⁵ | 0h1810 | PID output monitor | PID Output | [%] | - | -/A | O | O | |
| 17 ⁵ | 0h1811 | PID reference monitor | PID Ref Value | [%] | - | -/A | O | O | |
| 18 ⁵ | 0h1812 | PID feedback monitor | PID Fdb Value | [%] | - | -/A | O | O | |
| 19 ⁵ | 0h1813 | PID reference source selection | PID Ref Source | 0 | Keypad | 0: Keypad | X/A | O | O |
| | | | | 1 | V1 | | | | |
| | | | | 3 | V2 | | | | |
| | | | | 4 | I2 | | | | |
| | | | | 5 | Int 485 | | | | |

³ The code is displayed only when AP.03 is set to 1 (Yes).

⁴ The code is displayed only when AP.12 is set to 1 (Yes).

⁵ The code is displayed only when AP.01 is set to 2 (Proc PID) or 5 (Web Control).

| Code | Comm. Address | Name | Keypad Display | Setting Range | Initial Value | Property* | V/F | SL | Ref. |
|-----------------|---------------|---|----------------|--|---------------|-----------|-----|----|------|
| | | | | 7 FieldBus 11 Pulse 12 V3 14 V4 15 I4 | | | | | |
| 20 ⁶ | 0h1814 | PID reference source settings | PID Ref Set | -100.00–100.00 [%] | 50.00 | O/A | O | O | |
| 21 ⁵ | 0h1815 | PID feedback source selection | PID Fdb Source | 0 V1 2 V2 3 I2 4 Int 485 6 FieldBus 10 Pulse 11 V3 13 V4 14 I4 | 0:V1 | X/A | O | O | |
| 22 ⁵ | 0h1816 | PID controller proportional gain | PID P-Gain | 0-1000.0 [%] | 50.0 | O/A | O | O | |
| 23 ⁵ | 0h1817 | PID controller integral time | PID I-Time | 0-200.0 [sec] | 10.0 | O/A | O | O | |
| 24 ⁷ | 0h1818 | PID controller derivative time | PID D-Time | 0 - 1000 [msec] | 0 | O/A | O | O | |
| 25 ⁸ | 0h1819 | PID controller conversion compensation gain | PID F-Gain | 0-1000.0 [%] | 0.0 | O/A | O | O | |
| 26 ⁸ | 0h181A | Proportional gain scale | P Gain Scale | 0-100.0 [%] | 100.0 | X/A | O | O | |

⁶ The code is displayed only when AP.19 is set to 0 (Keypad).

⁷ The code is displayed only when AP.01 is set to 2 (Proc PID) or AP.04 is set to 1 (Yes).

⁸ The code is displayed only when AP.01 is set to 2 (Proc PID).

Advanced feature group (PAR→APP)

| Code | Comm. Address | Name | Keypad Display | Setting Range | Initial Value | Property* | V/F | SL | Ref. |
|-----------------|---------------|-------------------------------------|----------------|------------------------------------|---------------|----------------|-----|----|------|
| 27 ⁷ | 0h181B | PID output filter | PID Out LPF | 0-10000 [msec] | 0 | O/A | O | O | |
| 28 ⁸ | 0h181C | PID mode | PID Mode | 0 | Process PID | 0: Process PID | X/A | O | O |
| | | | | 1 | Normal PID | | | | |
| 29 ⁸ | 0h181D | Maximum PID frequency | PID Limit Hi | Minimum PID frequency-300.00 [Hz] | 60.00 | O/A | O | O | |
| 30 ⁸ | 0h181E | Minimum PID frequency | PID Limit Hi | -300.00-Maximum PID frequency [Hz] | -60.00 | O/A | O | O | |
| 31 ⁵ | 0h181F | PID output reverse | PID Out Inv | 0 | No | 0: No | O/A | O | O |
| | | | | 1 | Yes | | | | |
| 32 ⁵ | 0h1820 | PID output scale | PID Out Scale | 0.1 - 1000.0 [%] | 30.0 | O/A | O | O | |
| 34 ⁸ | 0h1822 | PID controller operation frequency | Pre-PID Freq | 0-Maximum frequency [Hz] | 0 | X/A | O | O | |
| 35 ⁸ | 0h1823 | PID controller operation level | Pre-PID Exit | 0-100.0 [%] | 0.0 | X/A | O | O | |
| 36 ⁸ | 0h1824 | PID controller operation delay time | Pre-PID Delay | 0-9999 [sec] | 600 | O/A | O | O | |
| 37 ⁸ | 0h1825 | PID sleep mode delay time | PID Sleep DT | 0-999.9 [sec] | 60.0 | O/A | O | O | |
| 38 ⁸ | 0h1826 | PID sleep mode frequency | PID Sleep Freq | 0-Maximum frequency [Hz] | 0 | O/A | O | O | |
| 39 ⁸ | 0h1827 | PID wake up level | PID WakeUp Lev | 0-100 [%] | 35 | O/A | O | O | |
| 40 ⁸ | 0h1828 | PID wake up mode | PID WakeUp | 0 | Below Level | 0: Below Level | O/A | O | O |

| Code | Comm. Address | Name | Keypad Display | Setting Range | Initial Value | Property* | V/F | SL | Ref. |
|-----------------|---------------|---|----------------|--|---------------|-----------|-----|----|------|
| | | settings | Mod | 1: Above Level 2: Beyond Level | | | | | |
| 42 ⁷ | 0h182A | PID controller unit selection | PID Unit Sel | 0: % 1: Bar 2: mBar 3: Pa 4: kPa 5: Hz 6: rpm 7: V 8: l 9: kW 10: HP 11: °C 12: °F | 0: % | O/A | O | O | |
| 43 ⁷ | 0h182B | PID unit gain | PID Unit Gain | 0-300.00 [%] | 100.00 | O/A | O | O | |
| 44 ⁷ | 0h182C | PID unit scale | PID Unit Scale | 0: x 100 1: x 10 2: x 1 3: x 0.1 4: x 0.01 | 2: x1 | O/A | O | O | |
| 45 ⁷ | 0h182D | PID second proportional gain | PID P-Gain 2 | 0-1000.0 [%] | 100.0 | X/A | O | O | |
| 46 ⁹ | 0h182E | PID second integral gain | PID I-Time 2 | 0-1000.0 [sec] | 100.0 | X/A | O | O | |
| 48 ⁹ | 0h1830 | Tension reference ramp time | PID Ref RampT | 0-300.0 [sec] | 0.0 | O/A | O | O | |
| 49 ⁹ | 0h1831 | Proportional /integral gain switch time | PI Gain Ramp | 0-300.0 [sec] | 30.0 | O/A | O | O | |
| 50 ¹ | 0h1832 | PID output ramp time at initial booting | PID Out RampT | 0-300.0 [sec] | 5.0 | O/A | O | O | |

⁹ The code is displayed only when AP.04 is set to 1 (Yes).

Advanced feature group (PAR→APP)

| Code | Comm. Address | Name | Keypad Display | Setting Range | Initial Value | Property* | V/F | SL | Ref. |
|------------------|---------------|---|----------------|-----------------------------------|---------------|-----------------|-----|----|------|
| 51 ⁹ | 0h1833 | Maximum PID output [%] | PID Hi Lmt | Minimum PID output-100.0 [%] | 100.0 | O/A | O | O | |
| 52 ⁹ | 0h1834 | Minimum PID output [%] | PID Lo Lmt | -100.0- Maximum PID output [%] | -100.0 | O/A | O | O | |
| 53 ⁹ | 0h1835 | PID I controller limit | PID I Limit | 0-100.0 [%] | 100.0 | O/A | O | O | |
| 54 ¹ | 0h1836 | PID controller type selection | PID Type Sel | 0 | Proportional | 0: Proportional | O/A | O | O |
| | | | | 1 | Fixed | | | | |
| 55 ¹⁰ | 0h1837 | Minimum value of the fixed PID controller | Min Fixed PID | 0-50.0 [%] | 20.0 | O/A | O | O | |
| 56 ⁹ | 0h1838 | Proportional gain profiler selection | Profile P Mode | 0 | None | 0: None | O/A | O | O |
| | | | | 1 | Linear | | | | |
| | | | | 2 | Square | | | | |
| 57 ⁹ | 0h1839 | Profile gain | Profile P Gain | 0.01 - 10.00 [%] | 1.00 | O/A | O | O | |
| 58 ¹ | 0h183A | Minimum bobbin diameter [%] | Min Diameter | 5.0-100.0 [%] | 10.0 | X/A | O | O | |
| 59 ¹ | 0h183B | Current diameter display [%] | Curr Diameter | Minimum bobbin diameter-100.0 [%] | 10.0 | X/A | O | O | |
| 60 ¹ | 0h183C | Current bobbin display | Curr Bobbin | 1-4 | 1 | -/A | O | O | |
| 61 ¹ | 0h183D | Bobbin 1 diameter [%] | Bobbin1 Diamtr | Minimum bobbin diameter-100.0 [%] | 10.0 | O/A | O | O | |
| 62 ³ | 0h183E | Bobbin 2 diameter [%] | Bobbin2 Diamtr | Minimum bobbin | 15.0 | O/A | O | O | |

¹⁰ The code is displayed only when AP.54 is set to 0 (Proportional).

| Code | Comm. Address | Name | Keypad Display | Setting Range | Initial Value | Property* | V/F | SL | Ref. |
|------------------|---------------|--|----------------|-----------------------------------|---------------|-----------|-----|----|------|
| | | | | diameter-100.0 [%] | | | | | |
| 63 ³ | 0h183F | Bobbin 3 diameter [%] | Bobbin3 Diamtr | Minimum bobbin diameter-100.0 [%] | 20.0 | O/A | O | O | |
| 64 ³ | 0h1840 | Bobbin 4 diameter [%] | Bobbin4 Diamtr | Minimum bobbin diameter-100.0 [%] | 25.0 | O/A | O | O | |
| 65 ¹ | 0h1841 | Diameter calculation filter | Diameter LPF | 0-300.0 [sec] | 50.0 | O/A | O | O | |
| 66 ³ | 0h1842 | Diameter calculation stop frequency | Web Hod Freq | 0-30.00 [Hz] | 5.00 | O/A | O | O | |
| 67 ³ | 0h1843 | Minimum main speed | Min Main Spd | 0-50.0 [%] | 0.0 | O/A | O | O | |
| 68 ¹¹ | 0h1844 | Material thickness calculation selection | Thickness En | 0 | No | 1: Yes | X/A | O | O |
| | | | | 1 | Yes | | | | |
| 69 ¹² | 0h1845 | Current thickness display [%] | Curr Thickness | 50.0 - 300.0 [%] | 100.0 | X/A | O | O | |
| 70 ¹² | 0h1846 | Material thickness calculation filter | Thickness LPF | 0-300.0 [sec] | 30.0 | O/A | O | O | |
| 72 ³ | 0h1848 | Bypass gain | Bypass Gain | 0-300.0 [%] | 100.0 | O/A | O | O | |
| 73 ³ | 0h1849 | Inertia compensati | Taper Sel | 0 | None | 0: None | X/A | O | O |
| | | | | 1 | Linear | | | | |

¹¹ The code is displayed only when AP.02 is set to 2 (Capstan).

¹² The code is displayed only when AP.68 is set to 1 (Yes).

Advanced feature group (PAR→APP)

| Code | Comm. Address | Name | Keypad Display | Setting Range | | Initial Value | Property* | V/F | SL | Ref. |
|------------------|---------------|---|----------------|--------------------|------------|---------------|-----------|-----|----|------|
| | | on feature selection | | 2 | Hyperbolic | | | | | |
| 74 ³ | 0h184A | Inertia compensation setting value monitor | Taper Spt Val | -100.00-100.00 [%] | | - | -/A | O | O | |
| 75 ³ | 0h184B | Inertia compensation setting selection | Taper Source | 0 | Keypad | 0: Keypad | X/A | O | O | |
| | | | | 1 | V1 | | | | | |
| | | | | 3 | V2 | | | | | |
| | | | | 4 | I2 | | | | | |
| 76 ¹³ | 0h184C | Inertia compensation setting value (keypad) | Taper SetPt | -100.00-100.00 [%] | | 0.00 | O/A | O | O | |
| 77 ¹ | 0h184D | Web break detection feature selection | Web Brk En | 0 | None | 0: None | O/A | O | O | |
| | | | | 1 | Warning | | | | | |
| | | | | 2 | Free-Run | | | | | |
| 78 ¹⁴ | 0h184E | Web break detection delay time at initial booting | Web Brk St Dly | 0-300.0 [sec] | | 10.0 | O/A | O | O | |
| 79 ¹⁴ | 0h184F | Web break detection delay time | Web Brk Dly | 0-300.0 [sec] | | 5.0 | O/A | O | O | |
| 80 ¹⁴ | 0h1850 | Maximum web break detection | Web Brk Lev Hi | 0-100.0 [%] | | 80.0 | O/A | O | O | |
| 81 ¹⁴ | 0h1851 | Minimum web break detection | Web Brk Lev Lo | 0-100.0 [%] | | 20.0 | O/A | O | O | |

¹³ The code is displayed only when AP.75 is set to 0 (Keypad).

¹⁴ The code is displayed only when AP.77 is set to 1 (Warning) or 2 (Free-Run).

| Code | Comm. Address | Name | Keypad Display | Setting Range | Initial Value | Property* | V/F | SL | Ref. |
|------------------|---------------|--|----------------|-----------------|---------------|-----------|-----|----|------|
| 83 ³ | 0h1853 | Splice level | Splice Level | 0-100.0 [%] | 0.0 | O/A | O | O | |
| 84 ³ | 0h1854 | Tension boost settings | Tns Boost In | 0-50.00 | 0.00 | O/A | O | O | |
| 85 ³ | 0h1855 | Tension boost type selection | Tns Boost Type | 0 | Fixed | 0: Fixed | X/A | O | O |
| | | | | 1 | Proportional | | | | |
| 86 ³ | 0h1856 | Tension down settings | Tns Down In | 0-50.00 | 0.00 | O/A | O | O | |
| 87 ³ | 0h1857 | Tension down type selection | Tns Down Type | 0 | Fixed | 0: Fixed | X/A | O | O |
| | | | | 1 | Proportional | | | | |
| 88 ¹ | 0h1858 | Reverse slow speed feature selection | Rev Tension En | 0 | No | 0: No | X/A | O | O |
| | | | | 1 | Yes | | | | |
| 89 ¹ | 0h1859 | Quick stop deceleration time | Q Stop Dec T | 0.1-300.0 [sec] | 3.0 | O/A | O | O | |
| 90 ³ | 0h185A | Web feature without diameter calculation selection | Dia Dis Mode | 0 | No | 0: No | X/A | O | O |
| | | | | 1 | Yes | | | | |
| 91 ¹⁵ | 0h185B | Diameter compensation gain initial value | Dia Comp Set | 0.1-300.0 [%] | 100.0 | O/A | O | O | |
| 92 ¹⁵ | 0h185C | Diameter compensation gain monitor | Dia Comp Gain | 0-300.0 [%] | - | -/A | O | O | |

¹⁵ The code is displayed only when AP.90 is set to 1 (Yes).

Advanced feature group (PAR→APP)

| Code | Comm. Address | Name | Keypad Display | Setting Range | Initial Value | Property* | V/F | SL | Ref. |
|------------------|---------------|--|----------------|---------------|---------------|-----------|-----|----|------|
| 93 ¹⁵ | 0h185D | PID output value of the compensation gain calculation standard | DiaComp PIDLev | 0-100.00 [%] | 10.00 | O/A | O | O | |
| 94 ¹⁵ | 0h185E | Diameter compensation gain calculation filter | Dia Comp LPF | 0-300.0 [sec] | 50.0 | O/A | O | O | |
| 95 ¹⁵ | 0h185F | Diameter compensation gain calculation selection during acceleration /deceleration | Xcel Comp En | 0 | No | 0: No | O/A | O | O |
| | | | | 1 | Yes | | | | |
| 96 ¹⁶ | 0h1860 | Constant speed judgment speed filter | Steady Chk LPF | 0-100.0 [sec] | 1.0 | O/A | O | O | |
| 97 ¹⁶ | 0h1861 | Constant speed judgment speed difference settings | Steady Chk Lev | 0-50.00 [%] | 1.00 | O/A | O | O | |
| 98 ⁹ | 0h1862 | Web PID calculation cycle | PID Sample T | 2-10 [msec] | 2 | X/A | O | O | |
| 99 ¹ | 0h1863 | Dedicated software version | Web SW Ver | - | - | -/A | O | O | |

¹⁶ The code is displayed only when AP.96 is set to 0 (No).

5 Other features

5.1 Advanced auto torque boost (for selecting automatic adjustment when a high starting torque is needed)

| Group | Code | Keypad display | Name | Setting value |
|-------|------|----------------|-------------------------------------|------------------|
| DRV | 15 | Torque Boost | Torque boost | 2: Advanced Auto |
| | 16 | Fwd Boost | Forward torque boost | 2.0 |
| | 17 | Rev Boost | Reverse torque boost | 2.0 |
| | 26 | Adv ATB Filter | Auto torque boost filter | 100 |
| | 27 | Adv ATB M Gain | Auto torque boost reverse gain | 50.0 |
| | 28 | Adv ATB G Gain | Auto torque boost regeneration gain | 50.0 |

Manual torque boost enables the inverter to output voltage with the torque boost amount preset by the user regardless of the load. Auto torque boost enables the inverter to automatically calculate the torque boost amount, but motor auto-tuning is required. However, advanced auto torque boost enables the inverter to adjust the torque boost amount based on the load without motor auto-tuning.

The amount compensated for the load is adjusted based on the auto torque boost reverse gain (DRV-27) and auto torque boost regeneration gain (DRV-28). It will be used if there isn't enough torque or there is an overcurrent while operating.

| Code and feature | Description |
|--------------------------|--|
| DRV-16 Fwd Boost | Set torque boost for forward operation. |
| DRV-17 Rev Boost | Set torque boost for reverse operation. |
| DRV-26 Adv ATB Filter | Filter gain for calculating auto torque boost amount. |
| DRV-27 Adv ATB M Gain | Gain for calculating auto torque boost amount during reverse. |
| DRV-28 Adv ATB G Gain | Gain for calculating auto torque boost amount during regeneration. |

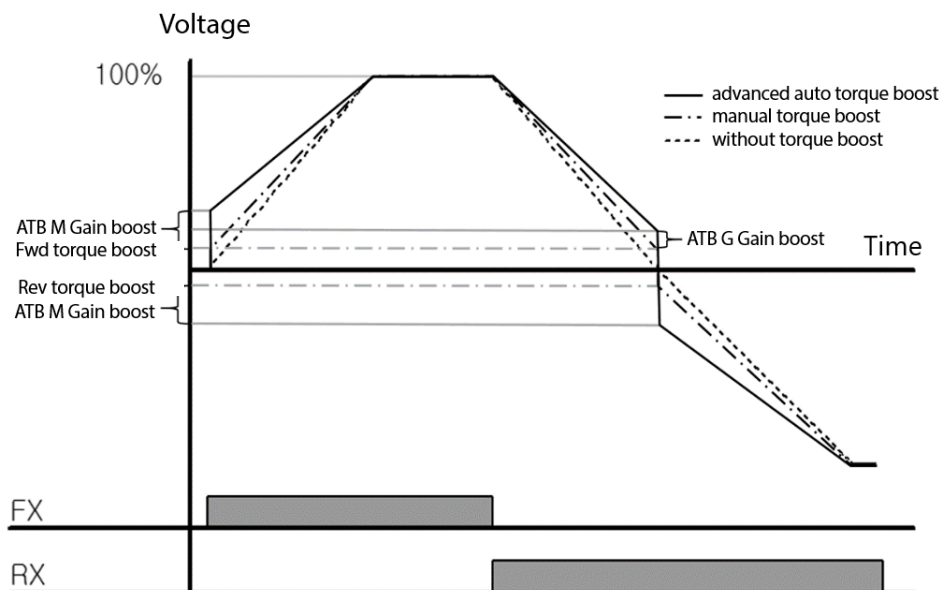
Under no-load conditions, the additional voltage for auto torque boost is zero and the result is the same as manual torque boost. When there is a load, the compensation amount varies depending on the run direction and whether you are operating in reverse. When using advanced auto torque boost in no-load conditions, setting the DRV-16 value and the DRV-17 value differently may cause a current spike.

⚠ Caution

Excessive torque boost will result in over-excitation and motor overheating.

Output voltage = First output voltage + Second boost voltage

- First output voltage
 - = The output voltage value by the parameters of DRV-16 and DRV-17 manual torque boost
 - = (Maximum output voltage - Boost voltage) × (Present frequency/Base frequency) + Boost voltage
- Second boost voltage
 - = The output voltage value by the DRV-27 (ATB M Gain) and DRV-28 (ATB G Gain) parameters and the load
 - = (Rated motor sleep current × Motor phase-to-phase voltage) / (Base frequency) × ATB M or G Gain × (Present output current) / (rated motor current)



5.2 Output Volt Bias function

The output volt bias function is used to change the output voltage by analog input. Originally, the frequency and voltage increase at a fixed rate, but the output volt bias function enables you to control the frequency command and the output voltage command respectively. The frequency can be controlled through the keypad and terminal blocks and the output voltage can be controlled through analog input. The output voltage may be limited when the input voltage (AC Input Volt) is insufficient.

| Group | Code | Keypad display | Name | Default setting | Range | |
|-------|----------------|---|---|-----------------|--------------------------------|----------|
| DRV | 30 | OutVolt Con | Output voltage control | 0: None | 0 | No |
| | | | | | 1 | V1 |
| | | | | | 2 | I2 |
| | | | | | 3 | Int 485 |
| | | | | | 4 | FieldBus |
| | 5 | Keypad | | | | |
| | 31 | Volt at 100% | Output voltage corresponding to 100% of input voltage | 220 | VacMin(170V) - VacMax(480V) | |
| | 32 | 2 nd OutVoltSrc | 2nd output voltage source upon terminal block input | 1: V1 | 0 | No |
| | | | | | 1 | V1 |
| | | | | | 2 | I2 |
| 3 | | | | | Int 485 | |
| 4 | | | | | FieldBus | |
| 5 | Keypad | | | | | |
| 33 | Cmd OutVolt | The setting value for controlling the output voltage through the keypad | 0 | 0-100.0% | | |
| 34 | OutVoltMonitor | Output voltage command monitor | - | Read Only | | |

⚠ Caution

It is recommended to increase the output voltage gradually when controlling the output voltage through analog input while operating at the maximum frequency. If the output voltage increases rapidly from 0 to the maximum value, the overcurrent protective function may be activated.

| Code and feature | Description |
|-----------------------|---|
| DRV-30 OutVolt Con | 0: None (Default) / 1: V1 / 2: I2 / 3: Int 485 / 4: FieldBus / 5: Keypad Sets the source for controlling the frequency and the output voltage respectively. |
| DRV-31 Volt at 100% | The output voltage corresponding to 100% of analog input Default: 200 V (200 V inverters) / 400 V (400 V inverters) |
| DRV-32 2ndVoltSrc | 0: None (Default) / 1: V1 / 2: I2 / 3: Int 485 / 4: FieldBus / 5: Keypad Multifunction input (DI) 19: Sets the activation source when the 2 nd OutVoltSrc is selected and turned on. Sets the source for controlling the frequency and output voltage of the 2ndVolt Src respectively. |
| DRV-33 Cmd OutVolt | The setting value for controlling the output voltage through the keypad |
| DRV-34 OutVoltMonitor | The monitoring value of the output voltage command. Displays the output voltage command while operating if the output voltage control is selected as analog input, communication input, or keypad. |

The output voltage/frequency respective control and PID control in APP group cannot be used at the same time.

The new communication addresses are as follows:

Address for writing voltage command by communication: 0x0398

The scale of communication voltage command is displayed in 0.1% units.

Address for reading the Id current value: 0x031E

Address for reading the Iq current value: 0x031F

The peak value of the Id and Iq current is displayed in 0.01 A units.