Application Note

Document Number	YEGA1003A1000-01
Application	**High performance spindle tool machines, running in Closed Loop**
Industry	Machine manufacturers, making spindle tool machines
Yaskawa Product	GA700 in Closed Loop Vector with DWEZ

Abbreviations

CLV = “Closed Loop Vector”: High performance field oriented vector control with pulse encoder feedback

ASR = “Automatic Speed Controller”: In CLV operation, the ASR regulates the motor speed by using the three pulse encoder tracks as speed feedback

PLC = “Programmable Logic Controller”: An upper control (external device), which provides the speed reference and other signals for the drive.

ppr = “Pulses per revolution”

1 Application Overview

To allow changing of tools in spindle tool machines, it is often required to place the rotor of the motor in a defined angular position.

This could be done manually by hand, but as for manufacturing processes the “non-working time” is very often the most expensive factor, a faster solution is needed.

The fastest and most convenient solution for the user is, to get the rotor stopped to a predefined position, directly from the working process.

This document describes, how to create a solution for this. When closing a digital input, the drive decelerates, orients the rotor to a set position and maintains this position as long as the input is closed and a RUN signal is issued. After releasing this input, the drive can restart directly without cycling the RUN signal.

2 Configuration and Inverter settings

Required configuration:

- GA700 in Closed Loop Vector control with PG-X3 or PG-B3 option board
- 3 track pulse encoder, matching the selected feedback option board.

2.1.1 Customized Parameters

The parameters are preset for a 1024 ppr encoder. Adapt in case of other encoder resolutions.

Especially for high speed spindle motors, modifications might be needed, e. g. for the PI Start Frequency q1-03 or q1-04.

Parameter	Parameter Value	Unit	Parameter Name	Parameter description
q1-01	10.24	0.01 = 1 encoder pulse	F1-01 (encoder PPR value)	Sets the number of pulses, generated by one encoder track. Set the same value as in F1-01.
q1-02	20.48	0.01 = 1 quadrature count	Target Position	Sets the target orientation as number of quadrature pulses in positive direction after Z pulse. 1 quadrature count means 4 encoder pulses as the pulse counter counts edges of the 2 encoder tracks.
q1-03	1.00%	% of Fmax (E1-04)	PI Start Frequency – Low Inertia	Set the motor speed at which the position controller shall take over control of the frequency reference. When closing DI8 input, the drives sets 0Hz as frequency reference. Once that the speed falls below q1-02, the PI controller is activated. q1-03 is active, when DI7 is open.
q1-04	0.50%	% of Fmax (E1-04)	PI Start Frequency – High Inertia	Same as q1-03 but for High Inertia. q1-04 is active, when DI7 is closed.
q1-05	30%	% of 25.00	PI Gain – High Inertia	DI7 closed: q1-05 is active as DWEZ PI controller gain. Set the value as percentage of the maximum possible DWEZ PI gain 25.00.
q1-06	20%	% of 25.00	PI Gain – Low Inertia	DI7 open: q1-06 is active as DWEZ PI controller gain. Set the value as percentage of the maximum possible DWEZ PI gain 25.00.

Parameter	Parameter Value	Unit	Parameter Name	Parameter description
q1-07	0.0% (ramp times = 0 s when activated)	% of active acceleration / deceleration time	Positioning Decel. Time Factor	Once that the position controller took over control, the active deceleration (and acceleration) time will be multiplied by this factor. Increasing this value, will cause longer ramp times. Initial setting: ramp disabled while positioning. Note: When closing DI6, this factor will be applied, independent from the rotor orientation function and will be applied to deceleration and acceleration times! Therefore, use this input carefully.
q1-08	0.3	0.1 = 1 encoder pulse (quad. counts)	Allowable Position Deviation	Set maximum allowable deviation from the orientation target that can be tolerated by the application. Orientation Ready-Input (DO1) will close, when the momentary position is in the range “target ± q1-08”. A higher value will close DO1 faster, but the drive may still be busy running to the position while it is closed.
q3-01	0.1	s	In-Position time	The Orientation Ready output (DO1 = LOG 3) closes, when the position is within the allowable deviation for the set time.
q6-06	80%	% of E1-04	PI Limit	Limits max. speed from PI controller
q6-07	1.00		PI Output Gain	Factor to PI controller output

2.1.2 Customized Monitors

DWEZ Monitor	Unit	Purpose
U8-07	0.01 = 1 quadrature count	**Position** Provides the current rotor position in quadrature counts after the Z pulse. 4x the number in F1-01 would mean one complete revolution.
U8-09	0.01 = 1 quadrature count	**PI Controller Input (position error)** Difference between target position (q1-02) and actual position (NUM 2). Can be positive and negative. Same as NUM 4.

DWEZ Monitor	Unit	Purpose
U8-21	% of E1-04	**PI Controller Output** Output of DWEZ PI control function, used for generating the speed reference for the case that Position Control Active signal (LOG 2) is true. Same as NUM 6.

2.1.3 Customized I/O

As default, the DWEZ inputs DI1 to DI8 are assigned to the related drive input terminals S1 to S8. By changing the setting of the H1 parameters, these assignments can be disabled or changed to other input terminals. Note, that the program will not work when removing the assignments. Initializing the drive by setting A1-03 = 2220 will set the defaults, given in the manual.

DWEZ Block	Inverter Terminal	Purpose
Input Terminals		
DI5	S5	**Integral Enable** As default, the integral part of the PI controller is disabled (fixed to zero). For using PI control instead of only P control, close DI5. The inverter value of DI5 is connected to the PI controllers input “Integral Reset”
DI6	S6	**Accel. and Decel. Time Zero** Multiplies the currently used ramp times by q1-07. This will be done independent from the rotor orientation function. This might be used in case that orientation should be managed by a PLC via the speed reference command.

DWEZ Block	Inverter Terminal	Purpose
DI7	S7	**Closed: High Inertia** DI7 closed: - DWEZ PI gain is q1-05 - ASR gain is C5-03 - PI Start Frequency is q1-04 DI7 open: - DWEZ PI gain is q1-06 - ASR gain is C5-01 - Motor speed for activating DWEZ PI controller is q1-03
DI8	S8	**Closed: Orientation active** When closing this input, the drive will decelerate from the current motor speed. The frequency reference will be set to zero at first As soon as the motor speeds falls below q1-03 (and q1-04, respectively), the frequency reference is defined by the DWEZ PI controller. When releasing DI8, the drive reaccelerates to the standard frequency reference.
Output Terminals		
DO1	M1/M2	**Orientation Ready** Closed: The current rotor position is within the range “target position (q1-03) ± allowable deviation (q1-04)
DO2	M3/M4	**Position Control Active** Closed: The drive is currently orienting the rotor and the position controller is active)

3 Limitations

- When activating the function for switching 2 different controller gain sets for high and low inertia tools, it is not possible, to use C5-07 for setting a motor speed depending on speed controller gain. For using the ASR gain switching frequency C5-07, set q2-31 = F. With this, digital input DI7 will have no influence to the ASR.
- Input DI6 provides the possibility to set the deceleration time to zero, e. g. for tapping applications done with an external PLC. This input will lower deceleration and acceleration time by the given factor.
- After switching on the supply power, the rotor must pass at least once the angular position, at that the Z pulse occurs. An orientation with the first RUN command after powering up might not work. Reason: The pulse counter which is used for position control will start from zero after powering on the drive or after downloading the DWEZ program. It will be reset to 0 when the Z pulse occurs. Therefore, in case that no Z pulse is connected, the rotor position in the moment when powering on the drive would be the reference position.
- The principle for defining the assumes that the rotor is not moving more than half a revolution within one millisecond. If this would happen, the pulse counter could not be evaluated correctly.
- Tests showed that especially cheap encoders might cause problems: The frequency of the pulse signal might still be okay, but some pulse edges are detected inaccurate. This would cause the drives pulse counter and therefore the rotor position to become incorrect.