AKD2G Controlled Stop and Holding Brake Timing

Rev. A | Jimmy Coleman | 7/12/2023

Description:
The AKD2G drive can stop motion according to the controlled stop parameters and control the holding brake engage/disengage timing using any of the following methods:

- Activating an action configured for controlled stop
- Turning off the hardware enable
- Issuing a software disable command (AXIS#.DIS or fieldbus disable)
- Many fault conditions trigger a controlled stop

Note that turning off the STO will not follow the controlled stop sequence. The STO will immediately disable the drive. It will not control the brake timing. The brake will engage as soon as it is able after the power stage disables.

There is an inherent delay during engaging a holding brake due to the brake being engaged by spring action. If the brake timing is not applied in a vertical load application, the load will fall.

If the brake is engaged without decelerating the motor to a stop (or low speed), the brake will engage while the motor is moving and subsequently damage the brake. Engaging the brake at speed can cause the brake to lose its holding ability.

Vertical Axis:
An application involving a load that is acted upon by gravity, meaning the load will fall if the motor loses power, is commonly known as a "Vertical Axis". We commonly refer to vertical axis applications when discussing controlled stop and holding brake functions. However, these functions are also critical for an axis that is acted upon by any external force, not just gravity.

Action Configuration:
Configure an action as one of the following controlled stop functions:

- Controlled stop then disable with re-enable
- Controlled stop then disable
- Controlled stop and stay enabled

Controlled stop then disable with re-enable: This action performs a controlled deceleration to the low-speed threshold and disables the drive. When the action condition is reversed (DIN turned back on), the drive will enable again.

Controlled stop then disable: This action performs a controlled deceleration to the low-speed threshold and disables the drive. When the action condition is reversed (DIN turned back on), the drive will remain disabled. A separate command must be given to software enable the drive.

Controlled stop and stay enabled: This action performs a controlled deceleration to a stop and leaves the drive enabled.

Note: Brake timing is applied in the two controlled stop functions that disable the drive.

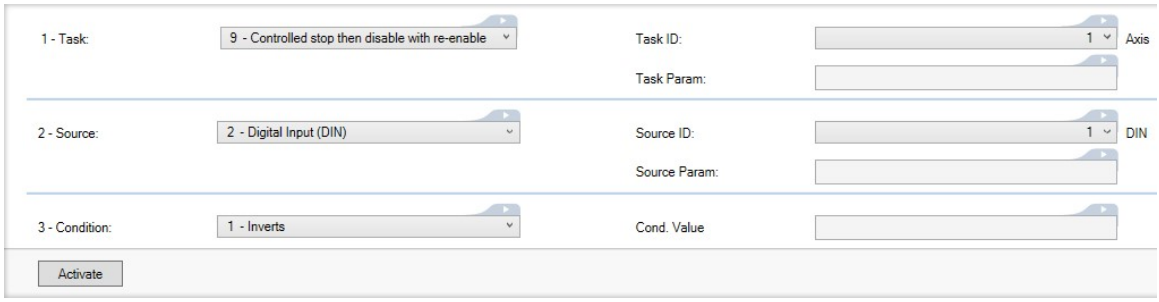
Setting up the Action:

1. Set the action task to one of the controlled stop functions and the task ID to the axis number.

2. Set the action source to “Digital Input (DIN)” and the source ID to the digital input number. (Another source could be used, but digital input is the most common and practical way to trigger a controlled stop.)

3. Set the condition to “Inverts”, so that the controlled stop will be triggered when the digital input goes low (fail safe). (It could be configured as “Follows”, but that is not normally recommended.)

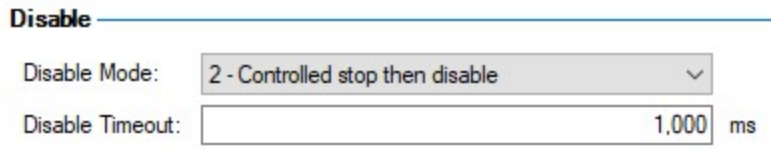
4. Activate the action and save to device.



Controlled Stop Configuration:
To ensure that the drive completes a controlled stop and engages the brake, make the following settings:

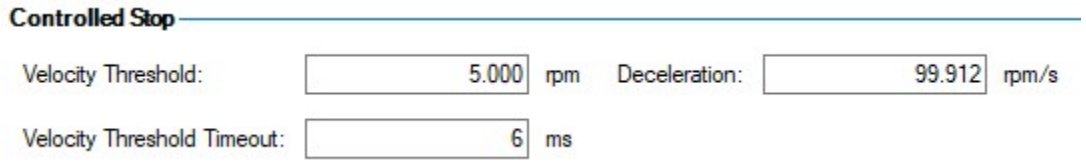
Parameter	Value	Explanation
AXIS#.DISMODE	2	Controlled stop then disable
AXIS#.DISTO	1000 ms (default)	long enough for AXIS#.CS.DEC and AXIS#.ZEROT
AXIS#.ZEROV	5 rpm (default)	low enough speed to not damage brake
AXIS#.CS.DEC	application dependent	stop motor before AXIS#.DISTO expires
AXIS#.ZEROT	6 ms (default)	engage brake quickly after reaching velocity threshold
AXIS#.MOTOR.TBRAKEAPP	hardware dependent	engage brake before drive disables
AXIS#.MOTOR.TBRAKERLS	hardware dependent	enable drive and delay prior to accepting motion commands

Disable Mode settings on the Enable/Disable screen:

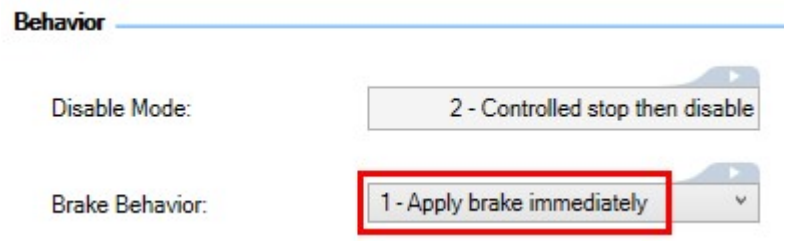


Mode "3 – Controlled stop then dynamic brake" can also be used. It will function as expected, but dynamic braking is not practical with a holding brake.

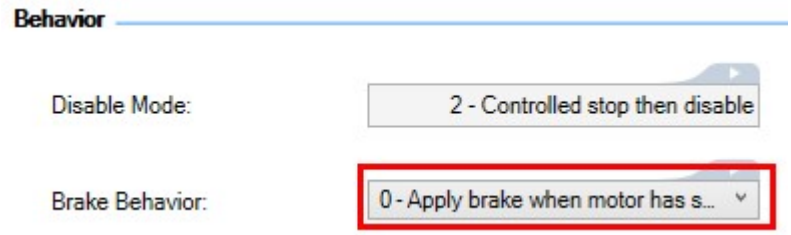
Controlled Stop settings on the Enable/Disable screen:



Brake setting for a vertical axis or any axis being acted upon by an external force:
“Apply brake immediately”



Brake setting for a horizontal axis that is not being acted upon by an external force:
“Apply brake when motor has stopped”



Brake timing settings:

Functionality:
Action configured for “Controlled stop then disable with re-enable” and the condition is “Inverts”.

Digital Input:
When the digital input is turned off, the controlled stop action is triggered.
Input ON (closed circuit): normal operation with the motor running
Input OFF (open circuit): controlled stop active, motor will be stopped and drive disabled
Input turned back ON: drive is re-enabled

Deceleration:
The motor will decelerate at a rate of AXIS#.CS.DEC to a velocity threshold (AXIS#.ZEROV).

Velocity Timeout:
When the velocity threshold is reached, the velocity threshold timeout (AXIS#.ZEROT) starts counting. The actual velocity must stay below the velocity threshold (AXIS#.ZEROV) for the velocity threshold timeout (AXIS#.ZEROT) to continue counting. If an external force causes the motor to exceed the velocity threshold (AXIS#.ZEROV), then the velocity threshold timeout (AXIS#.ZEROT) is reset and will start counting down when the speed drops below the velocity threshold again.

After the velocity threshold timeout (AXIS#.ZEROT) has completed counting down, the drive will engage the holding brake and/or disable. The default value of AXIS#.ZEROT is 6 ms. In general, a short time is best, but a longer time can be used to make sure the motor is stabilized at low speed prior to engaging the holding brake.

Disable Timeout:
There is also another timer involved. The disable timeout (AXIS#.DISTO) starts counting as soon as the controlled stop is triggered. The controlled stop deceleration (AXIS#.CS.DEC) and the velocity threshold timeout (AXIS#.ZEROT) must be completed before the disable timeout completes, or the drive will fault with F6005 (emergency timeout occurred). The disable timeout (AXIS#.DISTO) must be set to an appropriate value to account for the time it takes to decelerate from running speed and the velocity threshold timeout (AXIS#.ZEROT).

Brake Timing:
Upon issuing a disable command (or controlled stop), the drive will remain enabled for the time of AXIS#.MOTOR.TBRAKEAPP to allow time for the brake to engage. This allows enough time for the holding brake to lose power and engage before the drive disables motor power.

AXIS#.MOTOR.TBRAKERLS defines the time delay between the drive enabling and when motion commands can be accepted. When the drive is enabled, the brake will release within about 10ms. From the time the drive enables, it will wait for the time of AXIS#.MOTOR.TBRAKERLS before any motion commands will be accepted. If a motion command is issued during this time delay, the command will be executed after the delay has expired.

Sequence (controlled stop):

1. Digital input goes low (open circuit) triggering the action
2. Action starts the controlled stop function
3. Motor decelerates at AXIS#.CS.DEC
4. Speed drops below AXIS#.ZEROV
5. AXIS#.ZEROT timer starts counting down (speed must remain below threshold)
6. AXIS#.ZEROT timer completes
7. Brake engages
8. AXIS#.MOTOR.TBRAKEAPP timer counts down
9. Drive disables

Sequence (re-enable):

1. Digital input goes high (open circuit) triggering the action
2. Action triggers the re-enable function
3. Drive enables
4. Brake disengages
5. AXIS#.MOTOR.TBRAKERLS timer counts down
6. Motion command is accepted

Controlled Stop then Dynamic Brake:
The disable mode can also be configured to #4 (Controlled Stop then Dynamic Brake). The drive will decelerate the motor using the commanded deceleration rate of AXIS#.CS.DEC. After the velocity reaches AXIS#.ZEROV and the AXIS#.ZEROT timer completes, the brake is engaged, and the brake timing is applied. Then the drive switches into dynamic braking. At this point, the brake is engaged, so it doesn't really matter whether the drive is disabled or in dynamic braking.

STO:
When the STO is turned off, the motor will coast (freewheel). Deceleration depends entirely on external forces. The motor has no power, and the output power stage of the drive is completely switched off. There is no controlled stop or dynamic braking. If there is a vertical load or other external force applied, then the motor will be driven by the external force immediately after the drive disables. The holding brake will not engage in time to prevent motion and will probably not be able to stop a falling load. The holding brake will sustain damage if the brake engages while the motor is moving.

Software Enable:
The "Disable" button in Workbench will execute a disable based on the disable mode selected in the Enable/Disable screen (DRV.DISMODE). If the disable mode is set to "controlled stop", then the software enable will behave the same as the controlled stop action.

Fieldbus control:
Disabling the drive via a fieldbus can have the same effect as the Disable button in Workbench. It can do a controlled stop and apply the brake timing. Note that some fieldbus state machines have multiple stop and disable functions. Some will do a

controlled stop while others could have different effects. It is important to study the fieldbus state machine to understand the details of each function.

Fault Conditions:
Some fault conditions will activate a controlled stop or dynamic braking , but other fault conditions will cause the motor to disable immediately. If the drive disables immediately, the motor will coast freely, and a vertical load will fall. If the motor is moving faster than the controlled stop velocity threshold, the motor will not decelerate, and the brake will not engage. The load will continue to fall. To prevent a vertical load from falling, set AXIS#.MOTOR.BRAKEIMM = 1. This will cause the brake to engage immediately, regardless of the speed, whenever the drive disables in a condition that doesn't control the deceleration.

Note: Setting AXIS#.MOTOR.BRAKEIMM = 1 will not cause the brake to engage immediately during a normal Controlled Stop function. The motor will be allowed to decelerate to the velocity threshold before the brake is engaged. But it will engage the brake immediately during any disable condition that does not control the deceleration, such as STO or a fault condition.

Damaging a Holding Brake:
With AXIS#.MOTOR.BRAKEIMM = 1, there is concern about damaging the brake by engaging the brake while the motor is still moving. It is necessary for vertical load applications to keep the load from falling in the event of a fault condition. But it will damage the holding brake. Depending on the load inertia and speed, the brake may or may not be able to stop the load if it is already moving. The brake is designed to hold a load, not to stop a moving load. If the brake is engaged while the motor is moving, the friction surfaces will start to glaze over and lose some of the holding torque. This damage is permanent.

Manual Control:
The brake can be manually engaged and disengaged by using the parameter AXIS#.MOTOR.BRAKECONTROL. A value of zero allows the drive to control the brake. Setting it to 1 will force the brake to release. Setting it to 2 will force the brake to engage. Also, an action can be configured for “Release brake on axis”. When this action is triggered, the brake will release while the drive is disabled.