CASCADIA ⚙ MOTION

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Inverter Discharge Process

Revision 0.9

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1   Introduction

1.1   Purpose

The Cascadia Motion inverters contain a substantial amount of capacitance on the DC bus. The capacitors are internally discharged by a resistor at a very slow rate. To avoid excess power dissipation the resistors are sized such that they will discharge the capacitors from maximum voltage to a level below 60V in less than 5 minutes.

For some applications it is necessary to discharge the internal capacitors faster than 5 minutes. The inverter has the ability to do this under certain conditions.

The inverter can discharge the DC bus capacitors by injecting a small amount of current into the motor that is connected. The internal capacitors can be discharged even if the motor is not connected, but at a slower rate.

When this feature is activated the inverter will inject a current into the motor that is equal to 5% of the value set for the Iq current limit (this is an EEPROM parameter). The current injected is set in the D-axis and should not normally cause any rotation of the motor.

The time it takes to discharge the capacitors will vary depending on the motor attached, the particular Iq limit, and the DC voltage. An example scenario is the discharge of the PM150DZ, the time to discharge is 0.8 seconds from 700V to less than 60V when connected to a BorgWarner HVH250-90S motor.

The active discharge process described here requires that the inverter be functioning correctly and that it still have 12V power. It will not function if the inverter loses 12V power.

The purpose of this user manual is to provide information regarding the setup of the active discharge function. The active discharge can be activated in both VSM mode and in CAN mode.

1.2   Scope

This document describes different scenarios under which the controller will have the capacitors on the DC voltage side actively discharged. These scenarios include:

1. Ignition is turned off in key switch mode 1
2. A discharge command is sent through the CAN heartbeat command message in CAN mode
3. A fault occurs

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2   Discharging the Inverter

Following table defines the states used in the discharge process:

State	Description
0	Discharge disabled
1	Discharge sequence enabled (not actively discharging yet)
2	Speed check (Waiting for speed to go below 75 RPM)
3	Discharge active (inverter is injecting current into the motor)
4	Discharge complete

The Discharge State is shown in the GUI with the following parameter:

Inverter_Discharge_State (Address 0x87)

The Discharge State can also be found in the CAN broadcast message (default CAN ID 0xAA). It is located in byte 4, bits 5-7. Refer to the CAN manual for more details.

2.1   Mandatory Conditions

Inverter discharge will take place only when all of the following conditions are true:

1. Discharge Enable EEPROM is set to a value of 1 or 2:

Mode	Description
0	Discharge Disabled
1	Discharge is enabled without any faults: If Inverter Discharge Enabled EEPROM is set to 1, the discharge will <u>not</u> take place when a fault occurs. Shown as value [0 1] in the table below.
2	Discharge is enabled with faults: If Inverter Discharge Enabled EEPROM is set to 2, the discharge will automatically take place when a fault occurs. Shown as value [1 0] in the table below.

This parameter is located with parameters, Pre-charge Bypassed EEPROM and Relay Output EEPROM.

2. Motor speed must be below 75 RPM. This condition is checked only after one of the events that trigger the discharge take place.

2.2   Inverter Discharge Triggers

Following events will trigger the discharge process and a discharge command is set:

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1. Ignition is turned off in Key Switch Mode 1

2. Discharge command is issued through CAN Heartbeat Command message in CAN mode

3. A POST or RUN fault occurs and Inverter Discharge Mode EEPROM is set to 2.

Once, the discharge command is issued, motor speed is checked. If it is below the threshold (75 RPM), discharge process will begin.

2.3   Inverter Discharge Complete

As soon as the Inverter Discharge Mode is set to 'Discharge Active' (3), a timer will start and also the DC voltage is monitored. If 9 seconds elapse or the DC voltage falls below 30-V, the discharge process will stop and the Inverter Discharge Mode is set to 'Discharge Complete' (4).

Once the discharge is complete, it will not be reset until one of the following events take place:
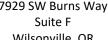
1. After ignition input goes low, the power will eventually be recycled and the discharge process will be reset automatically.

2. A Discharge Disable command is issued through CAN if the discharge process was initiated by Discharge Enable CAN command.

3. Clear the faults if there is a fault. Occasionally, a "DC Low Voltage Threshold" fault may get set during the discharge process.

2.4   Inverter Discharge with Precharge Bypassed

In certain cases, inverter discharge is allowed when Precharge is bypassed. However, it transfers the responsibility of controlling all outputs to the user. The discharge process needs to have Precharge and Main contactors shut off before initiating the discharge process properly. User must do that.

Moreover, if the key switch mode is 1 (ignition mode), user must also control the OK output in order to take away the 12-V power after discharge is complete.

NOTE: Missing cases in the table below indicate a value of 3 for the Discharge Mode EEPROM parameter which is an invalid option.

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Case #	Precharge Bypass EEPROM	Key Switch Mode EEPROM	VSM/CAN Mode EEPROM	Discharge Mode EEPROM		Discharge Enable?	Ignition is turned off	CAN Discharge Command is sent	A fault occurrs	Comments
0	0	0	0	**0**	**0**	**No**				Discharge EEPROM is set to 0
1	0	0	**0**	0	1	**Yes**		X		Discharge is controlled by CAN command
2	0	0	**0**	1	0	**Yes**		X	X	CAN command or a fault can initiate discharge process.
4	0	0	1	**0**	**0**	**No**				Discharge EEPROM is set to 0
5	0	**0**	**1**	**0**	**1**	**No**				No trigger present to initiate discharge.
6	0	0	1	**1**	**0**	**Yes**			X	A fault can initiate discharge process.
8	0	1	0	**0**	**0**	**No**				Discharge EEPROM is set to 0
9	0	**1**	**0**	0	1	**Yes**	X	X		Turning key switch to off or CAN command can initiate discharge process.
10	0	**1**	**0**	**1**	**0**	**Yes**	X	X	X	Turning key switch to off, CAN discharge command, or a fault can initiate the discharge process.
12	0	1	1	**0**	**0**	**No**				Discharge EEPROM is set to 0
13	0	**1**	1	0	1	**Yes**	X			Turning ignition key to off can initiate the discharge process.
14	0	**1**	1	**1**	**0**	**Yes**	X		X	Turning key switch to off or a fault may initiate discharge process.
16	**1**	0	0	0	0	**No**				Discharge EEPROM is set to 0
17	**1**	0	**0**	0	1	**Yes**		X		**Discharge is allowed. However, the user needs to control Main and Precharge outputs before starting the discharge process.**
18	**1**	0	**0**	1	0	**Yes**		X	X	
20	**1**	0	1	0	0	**No**				Discharge EEPROM is set to 0
21	**1**	0	1	0	1	**No**				**In VSM mode with precharge bypassed, Main and Precharge output are under user configuration.**
22	**1**	0	1	1	0	**No**				
24	**1**	1	0	0	0	**No**				Discharge EEPROM is set to 0
25	**1**	1	**0**	0	1	**Yes**	X	X		**Ignition mode is 1 but all outputs including OK output are under user control. After discharge is complete, user needs to turn off OK output to shut down the inverter completely.**
26	**1**	1	**0**	1	0	**Yes**	X	X	X	
28	**1**	1	1	0	0	**No**				Discharge EEPROM is set to 0
29	**1**	1	1	0	1	**No**				**In VSM mode with precharge bypassed, Main and Precharge output are under user configuration.**
30	**1**	1	1	1	0	**No**				

[1] Valid values for Discharge Enable EEPROM value are [0 0] = 0, [0 1] = 1, and [1 0] = 2.

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Revision History

Version	Description of Versions / Changes	Updated by	Date
0.1	Initial version	Azam Khan	11/05/2012
0.2	Updated the mandatory condition that in VSM mode, pre-charge must be bypassed. If pre-charge is not bypassed, inverter cannot be discharged.	Azam Khan	11/05/2012
0.3	Added the option to enable discharge process with or without a fault.	Azam Khan	11/06/2012
0.4	Changed the value of Discharge Enabled EEPROM to 2 from 1 in section 2.2 #1.	Azam Khan	06/04/2014
0.5	Updated the process to replace Discharge Flags with Discharge State parameter that can be monitored through the GUI and is also available through the CAN broadcast.	Azam Khan	06/25/2014
0.6	Added details for using the discharge process with Precharge bypass enabled.	Azam Khan	06/26/2014
0.7	Reviewed for minor corrections	Azam Khan	07/17/2014
0.8	Minor updates.	Chris Brune	7/11/2018
0.9	Updates to Cascadia Motion. Minor clarifications.	Chris Brune	3/23/2021