DTC P0AA1 - Precharge Circuit Malfunction
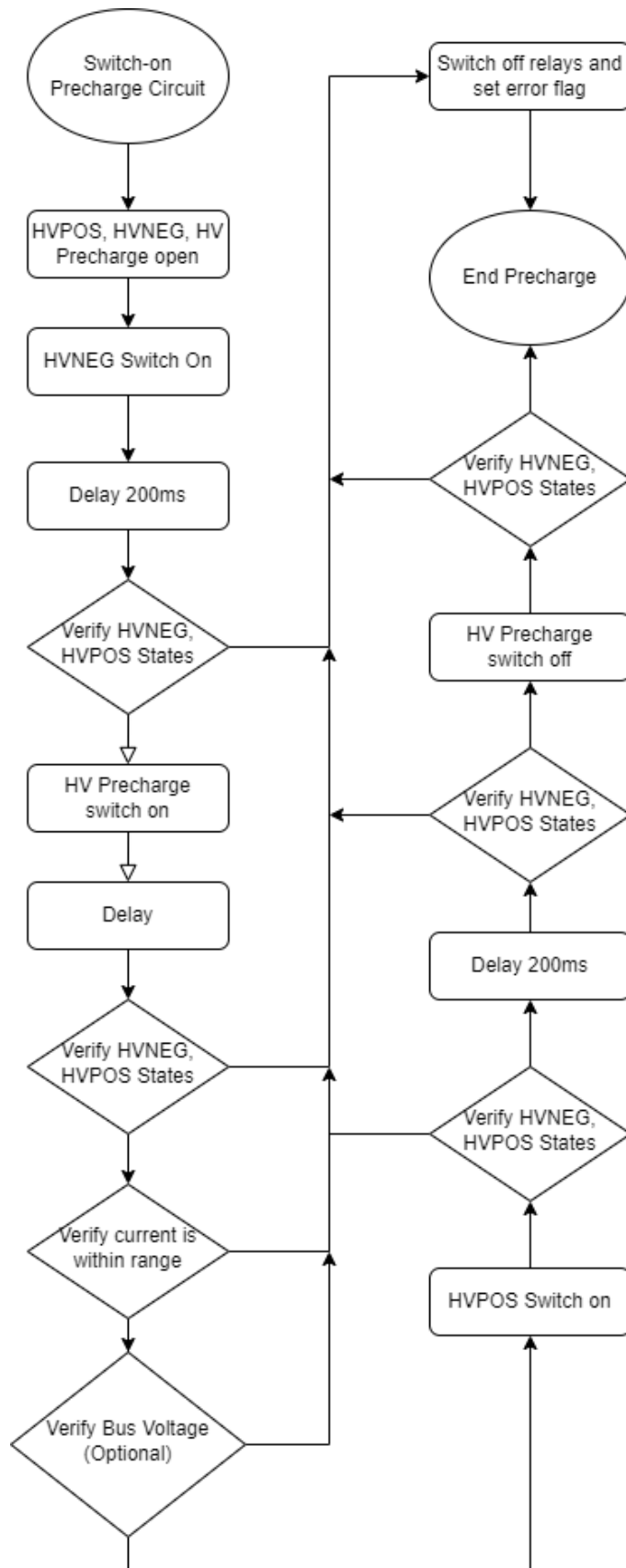
Product Family	Fault Supported	Earliest Firmware Supported
Orion BMS [Original] (24 - 180 Cell)	**NO**	**N/A**
Orion BMS 2 (24 - 180 Cell)	**YES**	**v3.6.2**
Orion JR [Original] (16 Cell)	**NO**	**N/A**
Orion JR 2 (16 Cell)	**YES**	**v3.7.0**

FAULT DESCRIPTION

This fault covers a number of potential failure modes or abnormal behavior during the high voltage battery pack pre-charge sequence. This function is fully optional, but if enabled the BMS will sequentially enable the configured primary contactor outputs to allow current to bleed through a resistor temporarily before fully engaging to prevent damaging inrush. The exact sequence details can vary based on the application however, so please contact the manufacturer for details and availability on this process.

Fault Code	Fault Description	Possible Trouble Area
P0AA1: Subcode 100	Battery Negative Contactor stuck OFF	● HV Negative Contactor Assembly ● Main I/O Wire Assembly
P0AA1: Subcode 101	Battery Negative Contactor stuck ON	● HV Negative Contactor Assembly ● Main I/O Wire Assembly
P0AA1: Subcode 102	Battery Positive Contactor stuck OFF	● HV Positive Contactor Assembly ● Main I/O Wire Assembly

P0AA1: Subcode 103	Battery Positive Contactor stuck ON	- HV Positive Contactor Assembly - Main I/O Wire Assembly
P0AA1: Subcode 110	Battery Current Too High After Precharge	- Precharge Relay Assembly - Main Application Control Logic
P0AA1: Subcode 111	DC Bus Voltage Failed To Equalize	Precharge Resistor Assembly
P0AA1: Subcode 114	DC Bus Voltage Present Before Precharge Started	HV Positive / Negative Contactor Assembly
P0AA1: Subcode 200	Primary Contactors Opened Under Load Too Many Times	HV Positive / Negative Contactor Assembly
P0AA1: Subcode 201	Precharge Configuration Error - Cannot Enable HV Negative Without HV Positive	Main Application Control Logic
P0AA1: Subcode 202	Precharge Configuration Error - Cannot Assign HV Negative and HV Positive To Same Output	Main Application Control Logic

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┌─────────────────┐                          ┌─────────────────────┐
│   Switch-on     │                          │  Switch off relays  │
│ Precharge Circuit│                         │  and set error flag │
└────────┬────────┘                          └──────────┬──────────┘
         │                                              │
         ▼                                              ▼
┌─────────────────┐                          ┌─────────────────────┐
│ HVPOS, HVNEG, HV│                          │                     │
│ Precharge open  │                          │    End Precharge    │
└────────┬────────┘                          └──────────▲──────────┘
         │                                              │
         ▼                                              │
┌─────────────────┐                               Verify HVNEG,
│ HVNEG Switch On │                               HVPOS States
└────────┬────────┘                                    ▲
         │                                             │
         ▼                                   ┌─────────────────────┐
┌─────────────────┐                          │   HV Precharge      │
│   Delay 200ms   │                          │    switch off       │
└────────┬────────┘                          └──────────▲──────────┘
         │                                              │
         ▼                                       Verify HVNEG,
    Verify HVNEG,  ─────────────────┐            HVPOS States
    HVPOS States                    │                  ▲
         │                          │                  │
         ▼                          │          ┌─────────────────────┐
┌─────────────────┐                 │          │    Delay 200ms      │
│   HV Precharge  │                 │          └──────────▲──────────┘
│   switch on     │                 │                     │
└────────┬────────┘                 │              Verify HVNEG,
         │                          │              HVPOS States
         ▼                          │                     ▲
┌─────────────────┐                 │          ┌─────────────────────┐
│     Delay       │                 │          │   HVPOS Switch on    │
└────────┬────────┘                 │          └──────────▲──────────┘
         │                          │                     │
         ▼                          │                     │
    Verify HVNEG,  ─────────────────┤                     │
    HVPOS States                    │                     │
         │                          │                     │
         ▼                          │                     │
  Verify current is ────────────────┤                     │
  within range                      │                     │
         │                          │                     │
         ▼                          │                     │
  Verify Bus Voltage ───────────────┴─────────────────────┘
  (Optional)
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FAULT BEHAVIOR

This fault will trigger **Precharge Failsafe** which inhibits the primary designated outputs (protected by precharge) from closing.

FAULT THRESHOLDS

Fault will trigger when **ONE** of the following conditions are satisfied	(a) **OR** (b) **OR** (c) **OR** (d) **OR** (e) **OR** (f) **OR** (g)
(a) Battery Negative contactor is stuck OFF	The designated battery negative contactor output is determined to be stuck OFF for more than 100ms when it should be controlled ON by the BMS. This is determined by a corresponding multi-purpose input measurement that the BMS uses to check the output status of the contactor. **NOTE:** This function requires Battery Negative contactor status input to be used and enabled in order to operate.
(b) Battery Negative contactor is stuck ON	The designated battery negative contactor output is determined to be stuck ON for more than 100ms when it should be controlled OFF by the BMS. This is determined by a corresponding multi-purpose input measurement that the BMS uses to check the output status of the contactor. **NOTE:** This function requires Battery Negative contactor status input to be used and enabled in order to operate.
(c) Battery Positive contactor is stuck OFF	The designated battery positive contactor output is determined to be stuck OFF for more than 100ms when it should be controlled ON by the BMS. This is determined by a corresponding multi-purpose input measurement that

	the BMS uses to check the output status of the contactor. **NOTE:** This function requires Battery Positive contactor status input to be used and enabled in order to operate.
(d) Battery Positive contactor is stuck ON	The designated battery positive contactor output is determined to be stuck ON for more than 100ms when it should be controlled OFF by the BMS. This is determined by a corresponding multi-purpose input measurement that the BMS uses to check the output status of the contactor. **NOTE:** This function requires Battery Positive contactor status input to be used and enabled in order to operate.
(e) Battery Current Too High After Precharge	The measured current leaving the battery pack is above the programmed threshold (default is 1.0A) after the Pre-charge relay has been active for the programmed amount of time (default is 2 seconds). This condition could indicate either a failed or improperly sized pre-charge relay, or that the application is starting to draw current from the pack before precharge has completed. **NOTE:** This function requires a current sensor to be connected and enabled on the BMS to operate. It also must be enabled in the configuration settings.
(f) DC Bus Voltage Failed To Equalize	This subcode will be set if the BMS determines that the main application DC bus voltage has failed to be successfully precharged or equalized to be roughly equal to the battery pack voltage (precharge failed to succeed). **IMPORTANT NOTE:** This functionality requires an external voltage sensor to operate, or the DC bus voltage to be transmitted to the BMS via CANBUS or

	other communication mediums. The BMS itself does not have internal hardware to determine this voltage directly.
(g) Primary Contactors Opened under load too many times	The BMS can track how many times the primary output contactors (the ones backed by the precharge circuit) have opened while current is higher than a programmable threshold. This allows the BMS to monitor the expected lifespan of the contactor, as opens under load can severely detract from total cycle lifespan. If this count exceeds a programmable threshold, the BMS will inhibit the precharge sequence from initiating until the contactors have been serviced or replaced (and the corresponding counter reset).

DIAGNOSTIC STEPS

1.	**Consult implementation / application level design requirements.**
	Due to the complex nature of this function and the many ways it may differ or vary between different applications and implementations, it is difficult to offer generalized diagnostic or troubleshooting steps.
	There are a few places that can be obviously investigated:
	- Verify the wiring for the various assemblies is intact and not compromised. If a sense wire for a contactor is compromised, it may prevent the contactor status from being correctly read. Or if a control line to a contactor is compromised, it may prevent the output from properly activating. - Verify proper operation of the contactors and relays in use. If a contactor or relay fails, it may be stuck on or off permanently and would need to be replaced. - Verify the configuration settings are appropriate for the application and that appropriate equipment was sourced.
	SAFETY NOTE: Do NOT attempt to bypass or manually override the precharge sequence to test without taking appropriate safety precautions. Contactors and relays can easily weld shut if they close under too great of a current, or if a precharge resistor has failed it may blow open energetically.

| 2. | **Download the freeze frame for the fault code using the BMS Utility.**

The BMS will normally produce a freeze frame on the "Diagnostic Trouble Codes" screen in the BMS Utility when this fault code occurs that contains a comprehensive list of BMS data parameters at the time the fault occurred. **It is strongly recommended that the freeze frame be downloaded from the BMS and saved to disk before the fault is cleared again** as this data may assist in the future if further diagnostics are required. <u>Additionally this freeze frame data may be requested by Technical Support if further assistance is required.</u>

NOTE: Only Fault Codes with a (F) next to them have freeze frame data available for download. If there is no (F) next to the fault, there is no stored freeze frame available and this step can be skipped.

Steps to download the Freeze Frame:

1) Connect to the BMS using the Orion BMS utility.
2) Click the "Diagnostic Trouble Codes" tab at the top.
3) Select the correct fault code by clicking on the ID on the left side of the screen to initiate the Freeze Frame retrieval.
4) Once the retrieval process is complete, click the "Export (CSV)" button to save the freeze frame data to the computer disk. |
|---|---|
| 3. | **Contact technical support.**

Please contact the company or reseller that the BMS was originally purchased from for additional questions, warranty claims, repair requests and technical support. |