

AMS CAN Protocol

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The CAN protocol used between AMS and Master Controller The interface between the Car and AMS.

Base Address: 0x300

Messages

Base address offset: 0x000 - AMS Status (In car)

| Parameter | Value |
|---------------------|-----------------------------------|
| Direction | AMS -> Master |
| Transmission Rate | Periodically: 100ms and Aperiodic |
| Size [bits : bytes] | 8 : 1 |

| Variable Name | Offset [bit] | Length [bit] | Value Type | Unit | Description |
|----------------------|--------------|--------------|------------|------|--|
| AMS status HIGH byte | 0 | 8 | usign_t | | bit 8-15 of the AMS status bytes. See table XX for specification |
| AMS status Low byte | 8 | 8 | usign_t | | bit 0-7of the AMS status bytes. See table XX for specification |
| Volt_min | 16 | 8 | usign_t | - | Lowest cell voltage |
| Temp_max | 24 | 8 | usign_t | 1C | Maximum cell temp |
| SOC | 32 | 8 | - | 1% | Overall State Of Carge |
| Counter | 40 | 8 | usign_t | - | Counter to detect heartbeat and package delevery |
| Relay Error | 48 | 8 | usign_t | - | AUX relay status the moment an error occur in DRIVE state - see table "Relay Error" for specifications |

Base address offset: 0x001 - AMS Status (In charger)

| Parameter | Value |
|---------------------|-----------------------------------|
| Direction | AMS -> Charger Node |
| Transmission Rate | Periodically: 100ms and Aperiodic |
| Size [bits : bytes] | 32 : 4 |

| Variable Name | Offset [bit] | Length [bit] | Value Type | Unit | Description |
|-----------------|--------------|--------------|------------|------|--------------------------------------|
| Status | 0 | 16 | usign_t | | |
| SOC | 16 | 8 | usign_t | 1% | Overall State Of Carge |
| Charger Current | 24 | 8 | usign_t | 0.1A | Actual charging current |
| Turn on charger | 32 | 1 | usign_t | | Turn on/off charger (0 = off, 1= on) |

Base address offset: 0x005 - CAR Status

| Parameter | Value |
|---------------------|--------------------|
| Direction | Master -> AMS |
| Transmission Rate | Periodically: 50ms |
| Size [bits : bytes] | 16 : 2 |

| Variable Name | Offset [bit] | Length [bit] | Value Type | Unit | Description |
|---------------|--------------|--------------|------------|------|---|
| CMD_status | 0 | 8 | usign_8 | | Command Status byte. See "Car command" section above for specifications |
| Counter | 8 | 8 | usign_8 | | Counter to detect heartbeat and package delivery |

Base address offset: 0x011 - Cell voltages

| Parameter | Value |
|---------------------|-------------------------|
| Direction | AMS -> Master & Charger |
| Transmission Rate | Periodically: 1000ms |
| Size [bits : bytes] | 64 : 8 |
| Bank ID | [1->5] |
| Group ID | [0->3] |

There are 14 discharge cell temperatures pr LT6813 device, equal to 28 cell temps per slave board. Therefore there are 5 group ID's. Depending on the group ID, different cell temperatures are sent.

| Group ID | Cell voltage number send |
|----------|--------------------------|
| 0 | Cell [1-7] |
| 1 | Cell [8-14] |
| 2 | Cell [15-21] |
| 3 | Cell [22-28] |

| Variable Name | Offset [bit] | Length [bit] | Value Type | Unit | Description |
|----------------|--------------|--------------|------------|------------------|-------------------------------------|
| BankID | 0 | 8 | uint | | Bit[7:5]=Bank ID, Bit[0:2]=Group ID |
| Cell Voltage 1 | 8 | 8 | 20mV | | Voltage for cell |
| Cell Voltage 2 | 16 | 8 | 20mV | Voltage for cell | |
| Cell Voltage 3 | 24 | 8 | 20mV | Voltage for cell | |
| Cell Voltage 4 | 32 | 8 | 20mV | Voltage for cell | |
| Cell Voltage 5 | 40 | 8 | 20mV | Voltage for cell | |
| Cell Voltage 6 | 48 | 8 | 20mV | Voltage for cell | |
| Cell Voltage 7 | 56 | 8 | 20mV | Voltage for cell | |

Base address offset: 0x012 - Cell temperatures

| Parameter | Value |
|---------------------|-------------------------|
| Direction | AMS -> Master & Charger |
| Transmission Rate | Periodically: 1000ms |
| Size [bits : bytes] | 48 : 6 |
| Bank ID | [1->5] |
| Group ID | [0->1] |

There are 5 cell temperatures pr device, equal to 10 cell temps per slave board. Therefore there are two groups ID's. Depending on the group ID, different cell temperatures are sent.

| Group ID | Cell voltage number send |
|----------|--------------------------|
| 0 | Cell [1-5] |
| 1 | Cell [6-10] |

| Variable Name | Offset [bit] | Length [bit] | Value Type | Unit | Description |
|--------------------|--------------|--------------|------------|--------|-------------------------------------|
| BankID/GroupID | 0 | 8 | uint | | Bit[7:5]=Bank ID, Bit[0:2]=Group ID |
| Cell Temperature 1 | 8 | 8 | int | 1 degC | Temperature for cell |
| Cell Temperature 2 | 16 | 8 | int | 1 degC | Temperature for cell |
| Cell Temperature 3 | 24 | 8 | int | 1 degC | Temperature for cell |
| Cell Temperature 4 | 32 | 8 | int | 1 degC | Temperature for cell |
| Cell Temperature 5 | 40 | 8 | int | 1 degC | Temperature for cell |

Base address offset: 0x013 - Discharge Cell temperatures

| Parameter | Value |
|---------------------|----------------------|
| Direction | AMS -> Charger |
| Transmission Rate | Periodically: 1000ms |
| Size [bits : bytes] | 48 : 8 |
| Bank ID | [1->5] |
| Group ID | [0->1] |

There are 7 discharge cell temperatures pr LT6813 device, equal to 14 cell temps per slave board. Therefore there are two group ID's. Depending on the group ID, different cell temperatures are sent.

| Group ID | Cell voltage number send |
|----------|--------------------------|
| 0 | Cell [1-7] |
| 1 | Cell [8-14] |

| Variable Name | Offset [bit] | Length [bit] | Value Type | Unit | Description |
|------------------------------|--------------|--------------|------------|--------|-------------------------------------|
| BankID/GroupID | 0 | 8 | uint | | Bit[7:5]=Bank ID, Bit[0:2]=Group ID |
| Discharge cell temperature 1 | 8 | 8 | int | 1 degC | Temperature for cell |

| Variable Name | Offset [bit] | Length [bit] | Value Type | Unit | Description |
|------------------------------|--------------|--------------|------------|--------|----------------------|
| Discharge cell temperature 2 | 16 | 8 | int | 1 degC | Temperature for cell |
| Discharge cell temperature 3 | 24 | 8 | int | 1 degC | Temperature for cell |
| Discharge cell temperature 4 | 32 | 8 | int | 1 degC | Temperature for cell |
| Discharge cell temperature 5 | 40 | 8 | int | 1 degC | Temperature for cell |
| Discharge cell temperature 6 | 48 | 8 | int | 1 degC | Temperature for cell |
| Discharge cell temperature 7 | 56 | 8 | int | 1 degC | Temperature for cell |

Base address offset: 0x014 - AMS Error

| Parameter | Value |
|---------------------|-------------------------|
| Direction | AMS -> Master & Charger |
| Transmission Rate | Aperiodic(event) |
| Size [bits : bytes] | 24 : 3 |

| Variable Name | Offset [bit] | Length [bit] | Value Type | Unit | Description |
|---------------|--------------|--------------|------------|------|--|
| AMS Error ID | 0 | 8 | usign_t | | bit 8-15 of the AMS status bytes. See table XX for specification |
| AMS time tick | 8 | 16 | usign_t | | bit 8-15 of the AMS status bytes. See table XX for specification |

Base address offset: 0x010 - Charger commands

| Parameter | Value |
|---------------------|--------------------|
| Direction | Charger -> AMS |
| Transmission Rate | Periocially: 100ms |
| Size [bits : bytes] | 24 : 3 |

| Variable Name | Offset [bit] | Length [bit] | Value Type | Unit | Description |
|---------------|--------------|--------------|------------|------|--|
| Start | 0 | 2 | usign_t | | Start stop charging (0 = no command, 1 = start, 2 = stop) |
| AMS time tick | 8 | 16 | usign_t | | bit 8-15 of the AMS status bytes. See table XX for specification |

Base address offset: 0x050 - Override charge current

| Parameter | Value |
|---------------------|----------------|
| Direction | Charger -> AMS |
| Transmission Rate | Aperiodic |
| Size [bits : bytes] | 8 : 1 |

| Variable Name | Offset [bit] | Length [bit] | Value Type | Unit | Description |
|----------------|--------------|--------------|------------|------|----------------|
| Charge current | 0 | 8 | usign_t | 0.1A | Charge current |

Base address offset: 0x051 - Override bank count

| Parameter | Value |
|---------------------|----------------|
| Direction | Charger -> AMS |
| Transmission Rate | Aperiodic |
| Size [bits : bytes] | 8 : 1 |

| Variable Name | Offset [bit] | Length [bit] | Value Type | Unit | Description |
|---------------|--------------|--------------|------------|------|-------------|
| Bank count | 0 | 8 | usign_t | - | Bank count |

Shunt

- 0x411
- 0x521 IVT_Msg_Result_I MuxID 8bit MsgCount 4bit Error 4bit Current Measurement in mA 32bit
- 0x522 IVT_Msg_Result_U1 MuxID 8bit MsgCount 4bit Error 4bit Voltage Measurement1 in mV 32bit
- 0x523 IVT_Msg_Result_U2 MuxID 8bit MsgCount 4bit Error 4bit Voltage Measurement2 in mV 32bit
- 0x526 IVT_Msg_Result_W MuxID 8bit MsgCount 4bit Error 4bit Voltage Measurement2 in W 32bit
- 0x527 IVT_Msg_Result_As MuxID 8bit MsgCount 4bit Error 4bit A*s Measurement in C 32bit
- 0x528 IVT_Msg_Result_Wh MuxID 8bit MsgCount 4bit Error 4bit Energy Measurement in W*h 32bit

AMS- Status

The status of the AMS is a two-byte value as shown below. The values are active high.

| Bit | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 |
|-------|------|------|-----------|-----------|-----------|----------------|-----------|-----------|
| Value | AIR- | AIR+ | Precharge | Warn_Volt | Warn_Temp | HVDC_INTERLOCK | IMD_Error | AMS_Error |

| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|-------|---|---|------------------|---|---|---|---------------|---|
| Value | [| | Bank count[5:7] | [| | | AMS State[0:4 |] |

BIT [0:4] - AMS State: State of the AMS Controller

BIT [5:7] - Bank count: Number of Bank identified by the AMS

BIT 8 - AMS_ERROR: If set, an error has occurred in the AMS. The error message is sent as a separate message asynchronous.

BIT 9 - IMD_Error: if set, an IMD error has occurred. The error message is sent as a separate message asynchronous.

BIT 10 - HVDC_INTERLOCK:

BIT 11 - Warn_Temp: Warning that the temperature is close to the limits.

BIT 12 - Warn_Volt: Warning that the voltage is close to the limits.

BIT 13 - Precharge: Reflects the value of the precharge relay. If 1 the relay is closed.

BIT 14 - AIR-: Reflects the value of the AIR- relay. If high, the relay is closed.

BIT 15 - AIR+: Reflects the value of the AIR relay. If high, the relay is closed.

AMS States

| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|-------|------------|-------------|---|---|---|---|---|---|
| NAME | value[dec] | Description | | | | | | |
| ----- | -- | ----- | | | | | | |

| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---------------|---|---|---|---|---|---|---|---|
| IDLE | 1 | The AMS is idle | | | | | | |
| SC_ENABLED | 2 | SC is enabled | | | | | | |
| TS_ACTIVE | 3 | TS is active, but no current is allowed | | | | | | |
| DRIVE | 4 | Ready to drive | | | | | | |
| ERROR | 5 | A Drive error ouccured | | | | | | |
| INIT_CHARGING | 6 | Setting up charging | | | | | | |
| PRECHARGING | 7 | Precharing | | | | | | |
| CHARGING | 8 | The charge algorithm is runnig | | | | | | |
| CHARGE_ERROR | 9 | A charging error ocured | | | | | | |

Relay Error

If the bit is high, the relay is closed, otherwise it is open

| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|-------|-----|-----|-----|-----|-----|-----------|------|------|
| Value | --- | --- | --- | --- | --- | Precharge | AIR+ | AIR- |

Car- Status

| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|-------|---|-----------------|---|---|---|----------|---|---|
| Value | [| Bank count[4:7] |] | [| | CMD[0:3] | |] |

BIT [0:3] - CMD: Car Commands. See table below. **BIT [4:7] - Bank count:** bank count that master controller(car) is setting to the AMS.

Car Commands

Car commands are the commands from the Car to the AMS. Each command has a unique command ID. The available commands are:

| Command name | CMD id[dec] | Description |
|--------------------|-------------|--|
| CMD_ENABLE_SC | 1 | Signal the AMS to turn on the safety chain |
| CMD_ENABLE_TS | 2 | Signal the AMS to turn on the tractive system |
| CMD_ENABLE_Drive | 3 | Signal the AMS to go in drive mode |
| CMD_ABORT | 4 | Signal the AMS to shutdown TS,SC and go to idle |
| CMD_SET_BANK_COUNT | 5 | Tell the AMS how many bank there should be connected |
| CMD_SYNC_TIME | 6 | Signal to sync a tick counter in the AMS |

AMS Errors

| Error name | Error id[dec] | Description |
|-----------------------------|---------------|--|
| ERROR_AMS_CELL_VOLTAGE_LOW | 1 | One or more of the cell voltages are to low |
| ERROR_AMS_CELL_VOLTAGE_HIGH | 2 | One or more of the cell voltages are to high |
| ERROR_AMS_CELL_TEMP_LOW | 3 | One or more of the cell temperatures are to low |
| ERROR_AMS_CELL_TEMP_HIGH | 4 | One or more of the cell temperature are to high |
| ERROR_AMS_LTC6813_COMM | 5 | Communication to the LTC6813(Cell monitoring) chips failed |
| ERROR_AMS_SHUNT_COMM | 6 | Communication to the shunt failed |

| Error name | Error id[dec] | Description |
|--------------------------------------|---------------|--|
| ERROR_AMS_UNABLE_TO_OPEN_SC | 7 | Unable to open safety circuit |
| ERROR_AMS_UNABLE_TO_CLOSE_SC | 8 | Unable to close safety circuit |
| ERROR_AMS_UNABLE_TO_OPEN_AIR- | 9 | Unable to open AIR- relay |
| ERROR_AMS_UNABLE_TO_CLOSE_AIR- | 10 | Unable to close AIR- relay |
| ERROR_AMS_UNABLE_TO_OPEN_AIR+ | 11 | Unable to open AIR+ relay |
| ERROR_AMS_UNABLE_TO_CLOSE_AIR+ | 12 | Unable to close AIR+ relay |
| ERROR_AMS_UNABLE_TO_OPEN_PRE+ | 13 | Unable to open precharge relay |
| ERROR_AMS_UNABLE_TO_CLOSE_PRE+ | 14 | Unable to close precharge relay |
| ERROR_AMS_PRE_TIMEOUT | 15 | Precharge timeout |
| ERROR_AMS_UNEXPECTED_CHARGE_RATE | 16 | The charge rate is not within the valid specs of the battery |
| ERROR_AMS_BANK_COUNT_MISMATCH | 17 | The specified bank count from the Car does not match the measured cells by the AMS |
| ERROR_AMS_UNEXSPECPTED_TS_CURRENT | 18 | TS Current while in TS active. No current allowed in this state |
| ERROR_AMS_RELAY_FAILD | 19 | Relay was not in the right position. |
| ERROR_AMS_SC_BROKEN | 20 | The safety circuit was broken doing operation |
| AMS_UNFIT_CHARGE_VOLTAGE | 21 | $V_{BAT} > V_{TS}$. |
| AMS_MONITOR_ERROR | 22 | The battery monitor has detected a problem |
| AMS_CHARGEING_DISCHARGE_TEMP_TIMEOUT | 23 | Timeout waiting for discharge temps to lower its temperature |

The above parameters are converted to message protocols. Some of the parameters are getting their own message.