

FMEA Report

Component / Function	Related FTA Event(s)	Potential Failures	Comment on Failure Entry	Top Level Effect	Comment on failure effects	Potential Failure Effects	Potential Failure Causes	Current Design Controls Prevention	Current Design Controls Detection	D × O
BMS										
Master Controller										
[F-23] Balance battery	(none)	[MF257] Does not do balancing		• [H003] Battery limited usable capacity • [H006] Battery unable to charge • [H009] Battery limited lifetime • [H002] Vehicle unavailable		PK: Vehicle Level Functions FU: [F-17] Balance battery MF: [MF018] Does not do battery balancing	EL: Master Controller FM: [FM202] Non functional			

							EL: Master Controll er FM: [FM221] Control loop hangin g / delayed			
							EL: AFEs FU: [F-59] Provide temper ature and voltage informa tion to master MF: [MF401] Does not commu nicate			

		[MF258] Overbalances the battery		• [H003] Battery limited usable capacity • [H001] Battery gases / smoke / thermal runaway • [H007] Battery rapid discharge • [H002] Vehicle unavailable		PK: Vehicle Level Functions FU: [F-17] Balance battery MF: [MF019] Overbalances the battery	EL: Master Controller FM: [FM221] Control loop hanging / delayed			
		[MF259] Underbalances / does not fully balance the battery		• [H003] Battery limited usable capacity • [H009] Battery limited lifetime • [H002] Vehicle unavailable		PK: Vehicle Level Functions FU: [F-17] Balance battery MF: [MF020] Underbalances the battery / does not fully balance the battery	EL: Master Controller FM: [FM221] Control loop hanging / delayed			

		[MF260] Balances incorrect cells		• [H003] Battery limited usable capacity • [H006] Battery unable to charge • [H009] Battery limited lifetime		PK: Vehicle Level Functions FU: [F-17] Balance battery MF: [MF021] Balances the wrong cells	8					
		[MF265] Erratic / incorrect balancing control frequency		[H003] Battery limited usable capacity		PK: Vehicle Level Functions FU: [F-17] Balance battery MF: [MF026] Balancing switch control is performed at a different or erratic frequency than specified	6	EL: Master Controller FM: [FM220] Clock fault				

							EL: Master Controller FM: [FM221] Control loop hanging / delayed			
		[MF266] Activates balancing when not intended		• [H003] Battery limited usable capacity • [H009] Battery limited lifetime		PK: Vehicle Level Functions FU: [F-17] Balance battery MF: [MF022] Starts balancing earlier than required	€			
						PK: Vehicle Level Functions FU: [F-17] Balance battery MF: [MF023] Starts balancing later than required	€			

					PK: Vehicle Level Function s FU: [F-17] Balance battery MF: [MF024] Stops balanci ng earlier than require d	€				
					PK: Vehicle Level Function s FU: [F-17] Balance battery MF: [MF025] Stops balanci ng later than require d	€				

[F-24] Send / receive data on CAN	(none)	[MF267] CAN non functional / unable to send or receive data	• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H002] Vehicle unavailable • [H008] Exposure to high voltage	PK: Vehicle Level Functions FU: [F-18] Send / receive data via CAN MF: [MF012] Does not relay battery information to the vehicle	& EL: Master Controller FM: [FM202] Non functional				
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					PK: Supporting Functions FU: [F-4] Notify user about critical fault conditions MF: [MF113]] Does not notify user about any or some critical faults	EL: (Master Controller FM: [FM221]] Control loop hanging / delayed			
					PK: Supporting Functions FU: [F-2] Wakeup BMS on external command MF: [MF247]] Does NOT wake up BMS when command received	EL: SBC FM: [FM254]] 5V undervoltage			

					PK: Supporting Functions FU: [F-3] Communicate with charger MF: [MF118] Does not provide battery information to charger	&EL: SBC FM: [FM256] 5V overvoltage			
					PK: Supporting Functions FU: [F-3] Communicate with charger MF: [MF124] Authentication fails	&EL: CAN Transceiver FM: [FM258] No operation			

					PK: Vehicle Level Functions FU: [F-19] Battery connection / disconnection on request MF: [MF243]] Does not connect battery on request	EL: CAN Transceiver FM: [FM427]] Transmitter fail			
					PK: Vehicle Level Functions FU: [F-19] Battery connection / disconnection on request MF: [MF250]] Does not disconnect battery on request	EL: CAN Transceiver FM: [FM428]] Receiver fail			

							EL: CAN Transci ever FM: [FM429] System stuck in sleep mode			
							EL: CAN Transci ever FM: [FM430] CANL or CANH driver biased domina nt indefini tely			
							EL: CAN Transci ever FM: [FM432] Reports erroneo us fault conditi on			
							EL: MCU FM: [FM457] Wrong CRC and/or EDC			

							EL: CAN Transceiver FM: [FM295] Erratic			
		[MF268] Provides garbage data		• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H007] Battery rapid discharge • [H008] Exposure to high voltage • [H002] Vehicle unavailable		PK: Vehicle Level Functions FU: [F-18] Send / receive data via CAN MF: [MF017] Provides incorrect information	8 EL: Master Controller PO: Current sense : Analog FM: [FM008] Erratic or noisy			

					PK: Vehicle Level Functions FU: [F-18] Send / receive data via CAN MF: [MF238]] Data missing / partial information provided	&EL: SBC FM: [FM254]] 5V undervoltage			
					PK: Supporting Functions FU: [F-3] Communicate with charger MF: [MF124]] Authentication fails	&EL: MCU FM: [FM290]] Wrong CRC and/or EDC			

					PK: Supporting Functions FU: [F-3] Communicate with charger MF: [MF119] Provides incorrect information about battery to charger	&EL: CAN Transceiver FM: [FM295] Erratic			
					PK: Supporting Functions FU: [F-4] Notify user about critical fault conditions MF: [MF114] False alarm	&			

						PK: Supporting Functions FU: [F-4] Notify user about critical fault conditions MF: [MF113] Does not notify user about any or some critical faults	1 (				
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		[MF269] Provides outdated information	• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [[F-3] Communicate with charger] [MF126] - Delay in charger authentication • [H007] Battery rapid discharge • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-18] Send / receive data via CAN MF: [MF016] Provides outdated information	&EL: Master Controller FM: [FM214] ERRATIC or continuously resetting			
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					PK: Supporting Functions FU: [F-3] Communicate with charger MF: [MF126] Delay in charger authentication	- EL: SBC FM: [FM254] 5V undervoltage			
					PK: Supporting Functions FU: [F-3] Communicate with charger MF: [MF124] Authentication fails	& EL: CAN Transceiver FM: [FM295] Erratic			

					PK: Supporting Functions FU: [F-3] Communicate with charger MF: [MF120] Provides outdated information to charger	1 (				
					PK: Supporting Functions FU: [F-4] Notify user about critical fault conditions MF: [MF116] Delayed reporting of notification	1 (				

		[MF270] Erratic frequency of transmission	• [[F-18] Send / receive data via CAN] [MF014] Provide information at a lower frequency than required • [H006] Battery unable to charge • [[F-4] Notify user about critical fault conditions] [MF117] Unstable alarm detection and/or trigger • [[F-18] Send / receive data via CAN] [MF013] Provide information at	PK: Vehicle Level Functions FU: [F-18] Send / receive data via CAN MF: [MF013] Provide information at a higher frequency than required	- EL: Master Controller FM: [FM214] ERRATIC or continuously resetting			
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				a higher frequen cy than require d • [H008] Exposu re to high voltage • [H002] Vehicle unavail able						
					PK: Vehicle Level Functio ns FU: [F-18] Send / receive data via CAN MF: [MF014] Provide s informa tion at a lower frequen cy than require d	-	EL: Master Controll er FM: [FM220] Clock fault			

					PK: Supporting Functions FU: [F-4] Notify user about critical fault conditions MF: [MF117] Unstable alarm detection and/or trigger	- EL: Master Controller FM: [FM221] Control loop hanging / delayed			
					PK: Supporting Functions FU: [F-3] Communicate with charger MF: [MF124] Authentication fails	& EL: SBC FM: [FM254] 5V undervoltage			

					PK: Supporting Functions FU: [F-3] Communicate with charger MF: [MF119] Provides incorrect information about battery to charger	&EL: CAN Transceiver FM: [FM295] Erratic			
					PK: Vehicle Level Functions FU: [F-19] Battery connection / disconnection on request MF: [MF243] Does not connect battery on request	&			

					PK: Vehicle Level Functions FU: [F-19] Battery connection / disconnection on request MF: [MF246] Erratic / unstable HV control behaviour				
[F-25] Estimate battery SOC	(none)	[MF271] Does not perform state estimation at all		• [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H002] Vehicle unavailable • [H008] Exposure to high voltage	PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF001] NO disconnection when required	EL: Master Controller FM: [FM202] Non functional			

						PK: Supporting Functions FU: [F-16] Estimate battery SOC, SOH, SOP MF: [MF027]] Does not perform state estimation	4 EL: Master Controller FM: [FM221] Control loop hanging / delayed			
							EL: MCU FM: [FM289]] Wrong thermistor measurement			
							EL: Battery thermistors FM: [FM282]] Wrong temperature measurement			
							EL: Battery thermistors FM: [FM350]] Thermistor short circuit			

							EL: Battery thermis tors FM: [FM353] Thermi stor open circuit			
							EL: Battery thermis tors FM: [FM356] Thermi stor shorted to contact			

		[MF272] Estimated SOC is higher than actual		• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H009] Battery limited lifetime • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF135] UNINTENDED disconnection	EL: Master Controller FM: [FM221] Control loop hanging / delayed			
						PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF003] EARLY disconnection	EL: Master Controller PO: Current sense : Analog FM: [FM007] Lower than actual			

						PK: Supporting Functions FU: [F-16] Estimate battery SOC, SOH, SOP MF: [MF028] Estimated SOC or SOH is more than actual	& EL: Master Controller PO: Current sense : Analog FM: [FM009]] Non-linear			
							EL: Power Distribution PO: Current sense : Analog FM: [FM161]] Incorrect measurement			
							EL: Current sensor FM: [FM206]] Timing fault			
							EL: AFE FM: [FM247]] Wrong battery temperature measurement			

							EL: MCU FM: [FM289] Wrong thermis tor measur ement			
							EL: Battery thermis tors FM: [FM282] Wrong temper ature measur ement			

		[MF273] Estimated SOC is lower than actual	• [H003] Battery limited usable capacity • [H005] Battery suddenly unable to discharge / sudden loss of power • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H002] Vehicle unavailable		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF003] EARLY disconnection	&EL: Master Controller FM: [FM221] Control loop hanging / delayed			
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						PK: Supporting Functions FU: [F-16] Estimate battery SOC, SOH, SOP MF: [MF029] Estimated SOC or SOH is less than actual	& EL: Master Controller PO: Current sense : Analog FM: [FM006] Higher than actual			
							EL: Master Controller PO: Current sense : Analog FM: [FM009] Non-linear			
							EL: Power Distribution PO: Current sense : Analog FM: [FM161] Incorrect measurement			

							EL: Current sensor FM: [FM206] Timing fault			
							EL: AFE FM: [FM247] Wrong battery temper ature measur ement			
							EL: MCU FM: [FM289] Wrong thermis tor measur ement			
							EL: Battery thermis tors FM: [FM282] Wrong temper ature measur ement			

		[MF274] SOC estimation is outdated	• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H007] Battery rapid discharge • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF002] DELAY in disconnection	EL: (Master Controller FM: [FM214] ERRATIC or continuously resetting			
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						PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF003] EARLY disconnection	&EL: Master Controller FM: [FM220] Clock fault			
						PK: Supporting Functions FU: [F-16] Estimate battery SOC, SOH, SOP MF: [MF030] State estimation is outdated	&EL: Master Controller FM: [FM221] Control loop hanging / delayed			
							EL: MCU FM: [FM289] Wrong thermistor measurement			

							EL: Battery thermis tors FM: [FM282] Wrong temper ature measur ement			
		[MF279] Erratic SOC esti mati on		• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H007] Battery rapid discharge • [H008] Exposure to high voltage		PK: Vehicle Level Functio ns FU: [F-20] Emerge ncy Discon nect MF: [MF004] UNSTA BLE or erratic disconn ection	EL: (Master Controll er FM: [FM214] ERRATI C or continu ously resettin g			

						PK: Supporting Functions FU: [F-16] Estimate battery SOC, SOH, SOP MF: [MF031]] State estimation is erratic or unstable	EL: Master Controller FM: [FM221]] Control loop hanging / delayed			
							EL: Master Controller PO: Current sense : Analog FM: [FM008]] Erratic or noisy			
							EL: MCU FM: [FM289]] Wrong thermistor measurement			

							EL: Battery thermis tors FM: [FM282] Wrong temper ature measur ement			
[F-26] Detect overte mpera ture conditi on	(none)	[MF2 81] Does not dete ct overt emp eratu re condi tion		• [H001] Battery gases / smoke / thermal runawa y • [H002] Vehicle unavail able • [H008] Exposu re to high voltage		PK: Vehicle Level Functio ns FU: [F-20] Emerge ncy Discon nect MF: [MF001] NO disconn ection when require d	1 EL: (Master Controll er FM: [FM202] Non function al			
						PK: Support ing Functio ns FU: [F-21] Detect overte mperat ure conditi on MF: [MF047] Does NOT detect overte mperat ure conditi on	1 EL: (Master Controll er FM: [FM221] Control loop hangin g / delayed			

							EL: AFEs FU: [F-59] Provide temper ature and voltage informa tion to master MF: [MF401] Does not commu nicate			
							EL: AFE FM: [FM247] Wrong battery temper ature measur ement			
							EL: Battery thermis tors FM: [FM282] Wrong temper ature measur ement			
							EL: Battery thermis tors FM: [FM350] Thermi stor short circuit			

							EL: Battery thermis tors FM: [FM353] Thermi stor open circuit			
							EL: Battery thermis tors FM: [FM356] Thermi stor shorted to contact			
							EL: MCU FM: [FM289] Wrong thermis tor measur ement			

		[MF282] Over temperature detected at HIGHER than required threshold		• [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF002] DELAY in disconnection	EL: AFEs FU: [F-59] Provide temperature and voltage information to master MF: [MF437] Incorrect data transmitted			
						PK: Supporting Functions FU: [F-21] Detect overtemperature condition MF: [MF048] Battery over-temperature protection is maintained at a HIGHER than required threshold	EL: AFEs FM: [FM247] Wrong battery temperature measurement			

							EL: Battery thermis tors FM: [FM282] Wrong temper ature measur ement			
							EL: MCU FM: [FM289] Wrong thermis tor measur ement			

		[MF283] Over temperature detected at LOWER than required threshold	• [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF003] EARLY disconnection	&EL: AFEs FU: [F-59] Provide temperature and voltage information to master MF: [MF437] Incorrect data transmitted			
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						PK: Supporting Functions FU: [F-21] Detect overtemperature condition MF: [MF048] Battery over-temperature protection is maintained at a HIGHER than required threshold	EL: AFE FM: [FM247] Wrong battery temperature measurement			
							EL: Battery thermistors FM: [FM282] Wrong temperature measurement			
							EL: MCU FM: [FM289] Wrong thermistor measurement			

		[MF284] Premature over temperature detection		• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnection MF: [MF135] UNINTENDED disconnection	EL: (Master Controller FM: [FM220] Clock fault			
						PK: Vehicle Level Functions FU: [F-20] Emergency Disconnection MF: [MF003] EARLY disconnection	EL: Master Controller PO: Shunt temperature : Analog FM: [FM002] Higher than actual			

						PK: Supporting Functions FU: [F-21] Detect overtemperature condition MF: [MF242] Detects overtemperature EARLIER than required	& EL: AFE FM: [FM247] Wrong battery temperature measurement			
							EL: Battery thermistors FM: [FM282] Wrong temperature measurement			
							EL: MCU FM: [FM289] Wrong thermistor measurement			

		[MF285] Delayed over temperature detection		• [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF002] DELAY in disconnection	EL: (Master Controller FM: [FM220] Clock fault			
						PK: Supporting Functions FU: [F-21] Detect overtemperature condition MF: [MF050] DELAYED detection of overtemperature condition	EL: (Master Controller FM: [FM221] Control loop hanging / delayed			

							EL: Master Controller PO: Shunt temperature : Analog FM: [FM003] Lower than actual			
							EL: AFE FM: [FM247] Wrong battery temperature measurement			
							EL: Battery thermistors FM: [FM282] Wrong temperature measurement			
							EL: MCU FM: [FM289] Wrong thermistor measurement			

		[MF286] Unstable or erratic detection		[H005] Battery suddenly unable to discharge / sudden loss of power [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF004] UNSTABLE or erratic disconnection	EL: (Master Controller FM: [FM214]) ERRATIC or continuously resetting			
						PK: Supporting Functions FU: [F-21] Detect overtemperature condition MF: [MF051] UNSTABLE or erratic detection	EL: (Master Controller FM: [FM220]) Clock fault			
							EL: Master Controller FM: [FM221] Control loop hanging / delayed			

							EL: Master Controller PO: Shunt temperature : Analog FM: [FM004] Erratic or noisy			
							EL: AFEs FU: [F-59] Provide temperature and voltage information to master MF: [MF427] Noisy communication			
							EL: Battery thermistors FM: [FM282] Wrong temperature measurement			
							EL: MCU FM: [FM289] Wrong thermistor measurement			

[F-27] Detect under temper ature conditi on	(none)	[MF2 87] Does not dete ct unde rtem perat ure condi tion		• [H001] Battery gases / smoke / thermal runawa y • [H009] Battery limited lifetime • [H007] Battery rapid dischar ge • [H002] Vehicle unavail able • [H008] Exposu re to high voltage		PK: Vehicle Level Functio ns FU: [F-20] Emerge ncy Discon nect MF: [MF001] NO disconn ection when require d	EL: (Master Controll er FM: [FM202] Non functio nal			
						PK: Support ing Functio ns FU: [F-13] Detect under temperat ure conditi on MF: [MF053] Does NOT detect under temperat ure conditi on	EL: (Master Controll er FM: [FM221] Control loop hangin g / delayed			

							EL: AFEs FU: [F-59] Provide temper ature and voltage informa tion to master MF: [MF401] Does not commu nicate			
							EL: AFE FM: [FM247] Wrong battery temper ature measur ement			
							EL: Battery thermis tors FM: [FM282] Wrong temper ature measur ement			
							EL: Battery thermis tors FM: [FM350] Thermi stor short circuit			

							EL: Battery thermis tors FM: [FM353] Thermi stor open circuit			
							EL: Battery thermis tors FM: [FM356] Thermi stor shorted to contact			
		[MF288] Dete cts unde rtem perat ure at HIGH ER than requi red thres hold		• [H006] Battery unable to charge • [H005] Battery suddenl y unable to dischar ge / sudden loss of power • [H002] Vehicle unavail able		PK: Vehicle Level Functio ns FU: [F-20] Emerge ncy Disconn ect MF: [MF003] EARLY disconn ection	EL: AFEs FU: [F-59] Provide temper ature and voltage informa tion to master MF: [MF437] Incorre ct data transmi tted			

						PK: Supporting Functions FU: [F-13] Detect under temperature condition MF: [MF054] Under temperature detected at HIGHER than required threshold	& EL: AFE FM: [FM247] Wrong battery temperature measurement			
							EL: Battery thermistors FM: [FM282] Wrong temperature measurement			

		[MF289] Detects under temperature at LOWER than required threshold	• [H006] Battery unable to charge • [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF002] DELAY in disconnection	EL: (AFEs FU: [F-59] Provide temperature and voltage information to master MF: [MF437] Incorrect data transmitted			
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						PK: Supporting Functions FU: [F-13] Detect undertemperature condition MF: [MF055] Under temperature detected at LOWER than required threshold	EL: AFE FM: [FM247] Wrong battery temperature measurement			
							EL: Battery thermistors FM: [FM282] Wrong temperature measurement			

		[MF290] Premature under temperature detection		• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H002] Vehicle unavailable		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF003] EARLY disconnection	&EL: Master Controller FM: [FM220] Clock fault			
						PK: Supporting Functions FU: [F-13] Detect under temperature condition MF: [MF241] Detects under temperature EARLIER than required	&EL: AFE FM: [FM247] Wrong battery temperature measurement			

							EL: Battery thermis tors FM: [FM282] Wrong temper ature measur ement			
		[MF2 91] Dela yed unde rtem perat ure dete ction		• [H001] Battery gases / smoke / thermal runawa y • [H007] Battery rapid dischar ge • [H002] Vehicle unavail able • [H008] Exposu re to high voltage		PK: Vehicle Level Functio ns FU: [F-20] Emerge ncy Discon nect MF: [MF002] DELAY in disconn ection	EL: (Master Controll er FM: [FM220] Clock fault			

						PK: Supporting Functions FU: [F-13] Detect undertemperature condition MF: [MF239] DELAYED detection of undertemperature condition	EL: (Master Controller FM: [FM221] Control loop hanging / delayed			
							EL: AFE FM: [FM247] Wrong battery temperature measurement			
							EL: Battery thermistors FM: [FM282] Wrong temperature measurement			

		[MF292] Unstable or erratic detection		• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF004] UNSTABLE or erratic disconnection	EL: (Master Controller FM: [FM214]) ERRATIC or continuously resetting			
						PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF135] UNINTENDED disconnection	EL: (Master Controller FM: [FM220]) Clock fault			

						PK: Supporting Functions FU: [F-13] Detect undertemperature condition MF: [MF240] UNSTABLE or erratic detection	EL: Master Controller FM: [FM221] Control loop hanging / delayed			
							EL: AFEs FU: [F-59] Provide temperature and voltage information to master MF: [MF427] Noisy communication			
							EL: Battery thermistors FM: [FM282] Wrong temperature measurement			

[F-28] Detect overvoltage condition	(none)	[MF293] Does not detect overvoltage condition		• [H001] Battery gases / smoke / thermal runaway • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF001] NO disconnection when required	EL: (Master Controller FM: [FM202] Non functional			
						PK: Supporting Functions FU: [F-12] Detect overvoltage condition MF: [MF057] Does NOT detect overvoltage condition	EL: (Master Controller FM: [FM221] Control loop hanging / delayed			

							EL: AFEs FU: [F-59] Provide temperature and voltage information to master MF: [MF401]] Does not communicate			
							EL: AFE FM: [FM246]] Wrong cell voltage measurement			
		[MF294] Detects at HIGHER than required threshold		• [H001] Battery gases / smoke / thermal runaway • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF002]] DELAY in disconnection	EL: AFEs FU: [F-59] Provide temperature and voltage information to master MF: [MF437]] Incorrect data transmitted			

					PK: Supporting Functions FU: [F-12] Detect overvoltage condition MF: [MF058] Detects fault at a HIGHER than required threshold	EL: AFE (FM: [FM246]) Wrong cell voltage measurement			
		[MF295] Detects at LOWER than required threshold		• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H002] Vehicle unavailable	PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF003] EARLY disconnection	EL: AFEs FU: [F-59] Provide temperature and voltage information to master MF: [MF437] Incorrect data transmitted			

					PK: Supporting Functions FU: [F-12] Detect overvoltage condition MF: [MF059] Detects overvoltage protection at LOWER than required threshold	EL: AFE FM: [FM246] Wrong cell voltage measurement			
		[MF296] Premature detection		• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H002] Vehicle unavailable • [H008] Exposure to high voltage	PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF135] UNINTENDED disconnection	EL: Master Controller FM: [FM220] Clock fault			

					PK: Supporting Functions FU: [F-12] Detect overvoltage condition MF: [MF061] Detects overvoltage condition EARLIER than required	& EL: AFE FM: [FM246] Wrong cell voltage measurement			
					PK: Supporting Functions FU: [F-12] Detect overvoltage condition MF: [MF059] Detects overvoltage protection at LOWER than required threshold	&			

		[MF297] Delayed detection		• [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF002] DELAY in disconnection	EL: (Master Controller FM: [FM220] Clock fault			
						PK: Supporting Functions FU: [F-12] Detect overvoltage condition MF: [MF062] Detects overvoltage condition LATER than required	EL: (Master Controller FM: [FM221] Control loop hanging / delayed			

						EL: AFE FM: [FM246] Wrong cell voltage measurement			
		[MF298] Unstable or erratic detection		• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF135] UNINTENDED disconnection	EL: Master Controller FM: [FM214] ERRATIC or continuously resetting		
						PK: Supporting Functions FU: [F-12] Detect overvoltage condition MF: [MF063] UNSTABLE overvoltage condition detection	EL: Master Controller FM: [FM220] Clock fault		

							EL: Master Controller FM: [FM221] Control loop hanging / delayed			
							EL: AFEs FU: [F-59] Provide temperature and voltage information to master MF: [MF427] Noisy communication			
							EL: AFE FM: [FM246] Wrong cell voltage measurement			

[F-29] Detect under voltage condition	(none)	[MF299] Does not detect	• [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H002] Vehicle unavailable • [H008] Exposure to high voltage	PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF001] NO disconnection when required	EL: (Master Controller FM: [FM202] Non functional				
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						PK: Supporting Functions FU: [F-11] Detect undervoltage condition MF: [MF064]] Does NOT detect undervoltage condition	EL: (Master Controller FM: [FM221]] Control loop hanging / delayed			
							EL: AFEs FU: [F-59] Provide temperature and voltage information to master MF: [MF401]] Does not communicate			
							EL: AFE FM: [FM246]] Wrong cell voltage measurement			

		[MF300] Detects at HIGHER than required threshold		• [H005] Battery suddenly unable to discharge / sudden loss of power • [H002] Vehicle unavailable		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF003] EARLY disconnection	&EL: AFEs FU: [F-59] Provide temperature and voltage information to master MF: [MF437] Incorrect data transmitted			
						PK: Supporting Functions FU: [F-11] Detect undervoltage condition MF: [MF065] Undervoltage detected at HIGHER than required threshold	&EL: AFE FM: [FM246] Wrong cell voltage measurement			

		[MF301] Detects at LOWER than required threshold	• [H006] Battery unable to charge • [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF002] DELAY in disconnection	EL: (AFEs FU: [F-59] Provide temperature and voltage information to master MF: [MF437] Incorrect data transmitted			
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					PK: Supporting Functions FU: [F-13] Detect under temperature condition MF: [MF055] Under temperature detected at LOWER than required threshold	EL: AFE (FM: [FM246]) Wrong cell voltage measurement			
		[MF302] Premature detection		[H006] Battery unable to charge [H005] Battery suddenly unable to discharge / sudden loss of power [H002] Vehicle unavailable	PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF003] EARLY disconnection	EL: Master Controller (FM: [FM220]) Clock fault			

					PK: Supporting Functions FU: [F-13] Detect undertemperature condition MF: [MF241] Detects undertemperature EARLIER than required	EL: AFE FM: [FM246] Wrong cell voltage measurement			
		[MF303] Delayed detection		• [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H002] Vehicle unavailable • [H008] Exposure to high voltage	PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF002] DELAY in disconnection	EL: Master Controller FM: [FM220] Clock fault			

						PK: Supporting Functions FU: [F-11] Detect undervoltage condition MF: [MF069] DELAYED Undervoltage detection	EL: (Master Controller FM: [FM221]) Control loop hanging / delayed		
							EL: AFE FM: [FM246] Wrong cell voltage measurement		
		[MF304] Erratic or unstable detection		• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF004] UNSTABLE or erratic disconnection	EL: (Master Controller FM: [FM214]) ERRATIC or continuously resetting		

					PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF135] UNINTE NDED disconn ection	EL: (Master Controller FM: [FM220]] Clock fault			
					PK: Support ing Functions FU: [F-13] Detect under temperature condition MF: [MF240]] UNSTA BLE or erratic detection	EL: (Master Controller FM: [FM221]] Control loop hanging / delayed			

							EL: AFEs FU: [F-59] Provide temper ature and voltage informa tion to master MF: [MF427] Noisy commu nicatio n			
							EL: AFE FM: [FM246] Wrong cell voltage measur ement			

[F-30] Detect open cell connection	(none)	[MF305] Does not detect		• [H003] Battery limited usable capacity • [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H008] Exposure to high voltage • [H002] Vehicle unavailable		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF001] NO disconnection when required	EL: (Master Controller FM: [FM202] Non functional			
						PK: Supporting Functions FU: [F-10] Detect open cell connection MF: [MF071] Does NOT detect open cell connection	EL: (Master Controller FM: [FM221] Control loop hanging / delayed			

							EL: AFEs FU: [F-59] Provide temper ature and voltage informa tion to master MF: [MF401] Does not commu nicate			
							EL: AFE FM: [FM246] Wrong cell voltage measur ement			

		[MF306] Incorrect cell identified		• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H008] Exposure to high voltage • [H002] Vehicle unavailable		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF001] NO disconnection when required	1 EL: AFE (FM: [FM246] Wrong cell voltage measurement			
						PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF135] UNINTENDED disconnection	1			

		[MF307] Premature or false detection		• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF135] UNINTENDED disconnection	EL: (Master Controller FM: [FM220] Clock fault			
							EL: AFE FM: [FM246] Wrong cell voltage measurement			
		[MF308] Delayed detection		• [H001] Battery gases / smoke / thermal runaway • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF002] DELAY in disconnection	EL: (Master Controller FM: [FM220] Clock fault			

						PK: Supporting Functions FU: [F-10] Detect open cell connection MF: [MF256] DELAY in detection	EL: (Master Controller FM: [FM221] Control loop hanging / delayed		
							EL: AFE FM: [FM246] Wrong cell voltage measurement		
		[MF309] Erratic detection		[H005] Battery suddenly unable to discharge / sudden loss of power [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF004] UNSTABLE or erratic disconnection	EL: (Master Controller FM: [FM214] ERRATIC or continuously resetting		

						PK: Supporting Functions FU: [F-10] Detect open cell connection MF: [MF073] UNSTABLE or erratic open cell detection	EL: Master Controller FM: [FM220] Clock fault			
							EL: Master Controller FM: [FM221] Control loop hanging / delayed			
							EL: AFE FM: [FM246] Wrong cell voltage measurement			

[F-31] Notify user about critical faults	(none)	[MF310] Does not notif y		[H008] Exposu re to high voltage		PK: Suppor ting Functio ns FU: [F-4] Notify user about critical fault conditi ons MF: [MF113]] Does not notify user about any or some critical faults	EL: Master Controll er FM: [FM202]] Non functio nal			
							EL: Master Controll er FM: [FM221]] Control loop hangin g / delayed			

		[MF311] Delayed notification		[H008] Exposure to high voltage		PK: Supporting Functions FU: [F-4] Notify user about critical fault conditions MF: [MF116] Delayed reporting of notification	EL: Master Controller FM: [FM220] Clock fault			
							EL: Master Controller FM: [FM221] Control loop hanging / delayed			
							EL: Master Controller PO: Current sense : Analog FM: [FM007] Lower than actual			

							EL: Master Controller PO: Current sense : Analog FM: [FM009]] Non- linear			
		[MF312] Premature or False notification		[[F-4] Notify user about critical fault conditions] [MF115]] Premature or false alarm notification		PK: Supporting Functions FU: [F-4] Notify user about critical fault conditions MF: [MF115]] Premature or false alarm notification	- EL: Master Controller FM: [FM220]] Clock fault			
							EL: Master Controller PO: Current sense : Analog FM: [FM006]] Higher than actual			

							EL: Master Controller PO: Current sense : Analog FM: [FM009]] Non- linear			
		[MF313] Erratic detection		[[F-4] Notify user about critical fault conditi ons] [MF117]] Unstabl e alarm detecti on and/ or trigger		PK: Support ing Function s FU: [F-4] Notify user about critical fault conditi ons MF: [MF117]] Unstabl e alarm detecti on and/ or trigger	- EL: Master Controller FM: [FM220]] Clock fault			
							EL: Master Controller PO: Current sense : Analog FM: [FM008]] Erratic or noisy			

[F-32] Perform BMS self diagnostics	(none)	[MF314] Does not perform self diagnostics		• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H008] Exposure to high voltage • [H002] Vehicle unavailable		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF135] UNINTENDED disconnection	EL: (Master Controller FM: [FM202] Non functional			
						PK: Vehicle Level Functions FU: [F-19] Battery connection / disconnection on request MF: [MF246] Erratic / unstable HV control behavior	EL: (Master Controller FM: [FM221] Control loop hanging / delayed			

						PK: Vehicle Level Functions FU: [F-18] Send / receive data via CAN MF: [MF238] Data missing / partial informa tion provide d	8				
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		[MF315] Incorrectly identifies faults	• [H006] Battery unable to charge • [H003] Battery limited usable capacity • [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H008] Exposure to high voltage • [H002] Vehicle unavailable		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF135] UNINTENDED disconnection	EL: (Master Controller PO: Current sense : Analog FM: [FM009] Non-linear			
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					PK: Vehicle Level Functions FU: [F-19] Battery connection / disconnection on request MF: [MF246] Erratic / unstable HV control behaviour	1 (				
					PK: Vehicle Level Functions FU: [F-17] Balance battery MF: [MF021] Balance s the wrong cells	8				
					EL: Master Controller FM: [FM460] Wrong data / wrong action	1 (				

		[MF316] Delayed diagnosis / diagnosis after occurrence of malfunction		• [H003] Battery limited usable capacity • [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H002] Vehicle unavailable • [H008] Exposure to high voltage	No failure case associated	EL: Master Controller FM: [FM460] Wrong data / wrong action	EL: Master Controller FM: [FM220] Clock fault			
						EL: Master Controller FM: [FM221] Control loop hanging / delayed				

		[MF317] Erratic diagnosis		• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H008] Exposure to high voltage • [H002] Vehicle unavailable		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF004] UNSTABLE or erratic disconnection	EL: (Master Controller FM: [FM214]] ERRATIC or continuously resetting			
						PK: Vehicle Level Functions FU: [F-19] Battery connection / disconnection on request MF: [MF246] Erratic / unstable HV control behaviour	EL: (Master Controller FM: [FM220]] Clock fault			

						PK: Vehicle Level Functions FU: [F-18] Send / receive data via CAN MF: [MF238]] Data missing / partial informa tion provide d	&EL: Master Controll er PO: Current sense : Analog FM: [FM008]] Erratic or noisy			
[F-33] Comm unicat e with charg er	(none)	[MF3 18] Does not com muni cate with charg er at all		• [H003] Battery limited usable capacit y • [H006] Battery unable to charge • [H009] Battery limited lifetime • [H002] Vehicle unavail able		PK: Vehicle Level Functions FU: [F-17] Balance battery MF: [MF018]] Does not do battery balanci ng	&EL: Master Controll er FM: [FM202]] Non functio nal			

					PK: Supporting Functions FU: [F-3] Communicate with charger MF: [MF118] Does not provide battery information to charger	& EL: Master Controller FM: [FM221] Control loop hanging / delayed			
					PK: Supporting Functions FU: [F-3] Communicate with charger MF: [MF124] Authentication fails	&			
		[MF319] Incorrect data transmission or reception		[H006] Battery unable to charge	PK: Supporting Functions FU: [F-3] Communicate with charger MF: [MF124] Authentication fails	&			

					PK: Supporting Functions FU: [F-3] Communicate with charger MF: [MF119] Provides incorrect information about battery to charger	&				
		[MF320] Erratic / communication at incorrect frequency		[H006] Battery unable to charge	PK: Supporting Functions FU: [F-3] Communicate with charger MF: [MF124] Authentication fails	&EL: Master Controller FM: [FM214] ERRATIC or continuously resetting				

						PK: Supporting Functions FU: [F-3] Communicate with charger MF: [MF118] Does not provide battery information to charger	& EL: Master Controller FM: [FM220] Clock fault			
							EL: Master Controller FM: [FM221] Control loop hanging / delayed			

[F-34] Wake up BMS on external command	(none)	[MF321] Does not wake up		• [H006] Battery unable to charge • [H002] Vehicle unavailable		PK: Supporting Functions FU: [F-2] Wakeup BMS on external command MF: [MF247] Does NOT wake up BMS when command received	EL: BMS PO: Ignition status : CAN FM: [FM086] Message loss			
							EL: Master Controller FM: [FM202] Non functional			
							EL: Master Controller FM: [FM221] Control loop hanging / delayed			

		[MF322] Goes into deep sleep mode instead of to normal mode		• [H006] Battery unable to charge • [H002] Vehicle unavailable		PK: Supporting Functions FU: [F-2] Wakeup BMS on external command MF: [MF247] Does NOT wake up BMS when command received	& EL: BMS PO: Ignition status : CAN FM: [FM098] Message corrupted			
		[MF323] Delayed wake up		[H006] Battery unable to charge		PK: Supporting Functions FU: [F-2] Wakeup BMS on external command MF: [MF248] DELAY in BMS Wakeup more than desired or expected	& EL: Master Controller FM: [FM220] Clock fault			

							EL: Master Controller FM: [FM221] Control loop hanging / delayed			
		[MF324] Erratic behaviour		[[F-2] Wakeup BMS on external command] [MF249] Erratic behaviour or wakeup		PK: Supporting Functions FU: [F-2] Wakeup BMS on external command MF: [MF249] Erratic behaviour or wakeup	- EL: BMS PO: Ignition status : CAN FM: [FM098] Message corrupted			
							EL: Master Controller FM: [FM214] ERRATIC or continuously resetting			
							EL: Master Controller FM: [FM220] Clock fault			

[F-35] Emergency disconnect	(none)	[MF325] Does not disconnect		• [H001] Battery gases / smoke / thermal runaway • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF001] NO disconnection when required	EL: BMS PO: Contact or commands : CAN FM: [FM096] Message corrupted			
							EL: BMS PO: Contact or commands : CAN FM: [FM111] Message loss			
							EL: Master Controller FM: [FM202] Non functional			
							EL: Master Controller FM: [FM214] ERRATIC or continuously resetting			

							EL: Master Controller FM: [FM221] Control loop hanging / delayed			
							EL: AFEs FU: [F-59] Provide temperature and voltage information to master MF: [MF401] Does not communicate			
							EL: Contact ors FM: [FM404] Shorted close			
		[MF326] Premature disconnection		• [H005] Battery suddenly unable to discharge / sudden loss of power • [H002] Vehicle unavailable		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF003] EARLY disconnection	EL: Master Controller FM: [FM214] ERRATIC or continuously resetting			

							EL: Master Controller FM: [FM220] Clock fault			
							EL: Master Controller PO: Shunt temperature : Analog FM: [FM002] Higher than actual			
							EL: Master Controller PO: Current sense : Analog FM: [FM006] Higher than actual			
							EL: Master Controller PO: Current sense : Analog FM: [FM009] Non- linear			

		[MF327] Delayed disconnection		• [H001] Battery gases / smoke / thermal runaway • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF002] DELAY in disconnection	EL: Master Controller FM: [FM214] ERRATIC or continuously resetting			
							EL: Master Controller FM: [FM220] Clock fault			
							EL: Master Controller FM: [FM221] Control loop hanging / delayed			
							EL: Master Controller PO: Shunt temperature : Analog FM: [FM003] Lower than actual			

							EL: Master Controller PO: Current sense : Analog FM: [FM009] Non- linear			
		[MF328] Erratic or unstable disconnection		• [H005] Battery suddenly unable to discharge / sudden loss of power • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF004] UNSTABLE or erratic disconnection	EL: BMS PO: Contact or commands : CAN FM: [FM096] Message corrupted			
							EL: BMS PO: Contact or commands : CAN FM: [FM110] Message timing fault			

							EL: Master Controller FM: [FM214] ERRATIC or continuously resetting			
							EL: Master Controller FM: [FM220] Clock fault			
							EL: Master Controller PO: Current sense : Analog FM: [FM008] Erratic or noisy			
							EL: MCU FM: [FM291] Erratic FET / Contact or operation			

[F-36] Control precharge switch	(none)	[MF339] Does not control		• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H008] Exposure to high voltage • [H002] Vehicle unavailable	Main controller might fail, BMS might detect false short-circuit	PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF135] UNINTENDED disconnection	EL: (BMS PO: Ignition status : CAN FM: [FM086] Message loss			
						PK: Supporting Functions FU: [F-7] Control FETs MF: [MF091] UNSTABLE or erratic control	EL: (Master Controller FM: [FM202] Non functional			

							EL: Master Controller FM: [FM214] ERRATIC or continuously resetting			
							EL: Master Controller FM: [FM221] Control loop hanging / delayed			
							EL: Power Distribution PO: Pack- side voltage : Analog FM: [FM157] No data			

							EL: AFEs FU: [F-59] Provide temperature and voltage information to master MF: [MF401]] Does not communicate			
		[MF340] Premature open / close of precharge switch		• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H008] Exposure to high voltage • [H002] Vehicle unavailable	No impact on precharge close . Premature open can cause actor weld / False SCD trigger	PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF135] UNINTENDED disconnection	1 EL: (Master Controller FM: [FM220]] Clock fault			

						PK: Supporting Functions FU: [F-7] Control FETs MF: [MF091] UNSTABLE or erratic control	EL: Power Distribution PO: Pack-side voltage : Analog FM: [FM157]] No data			
							EL: Power Distribution PO: Pack-side voltage : Analog FM: [FM156]] Incorrect measurement			
		[MF341] Delayed open / close of precharge switch			No safety impact		EL: Master Controller FM: [FM214]] ERRATIC or continuously resetting			
							EL: Master Controller FM: [FM220]] Clock fault			

							EL: Master Controll er FM: [FM221] Control loop hangin g / delayed			
							EL: Power Distribu tion PO: Pack- side voltage : Analog FM: [FM157] No data			
							EL: Power Distribu tion PO: Pack- side voltage : Analog FM: [FM156] Incorre ct measur ement			

		[MF342] Close prec harg e switc h befor e grou nd switc h			Pack volta ge feed back read out unst able mom entar ily, but no safet y impa ct		EL: Master Controll er FM: [FM220] Clock fault			
							EL: Power Distribu tion PO: Pack- side voltage : Analog FM: [FM157] No data			
							EL: Power Distribu tion PO: Pack- side voltage : Analog FM: [FM156] Incorre ct measur ement			

		[MF343] Opens precharge switch before closing positive switch			BMS might detect false SCD		EL: Master Controller FM: [FM220] Clock fault			
							EL: Power Distribution PO: Pack-side voltage : Analog FM: [FM157] No data			
							EL: Power Distribution PO: Pack-side voltage : Analog FM: [FM156] Incorrect measurement			

		[MF344] Erratic / unstable precharge control		• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF135] UNINTENDED disconnection	EL: (Master Controller FM: [FM214] ERRATIC or continuously resetting			
						PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF004] UNSTABLE or erratic disconnection	EL: (Master Controller FM: [FM220] Clock fault			

							EL: Power Distribu tion PO: Pack- side voltage : Analog FM: [FM160] Noisy data			
[F-37] Estimate internal resistance	(none)	[MF329] Does not estimate		[H005] Battery suddenly unable to discharge / sudden loss of power		PK: Support ing Functions FU: [F-1] Estimate internal resistance MF: [MF251] Does not perform IR estimation at all	EL: Master Controller FM: [FM202] Non functional			
							EL: Master Controller FM: [FM214] ERRATIC or continuously resetting			

							EL: Master Controll er FM: [FM221] Control loop hangin g / delayed			
							EL: Power Distribu tion PO: IR Measur ement Control : GPIO FM: [FM168] Does not control			
							EL: Power Distribu tion PO: IR Measur ement Control : GPIO FM: [FM228] Fails in open			

							EL: AFEs FU: [F-59] Provide temperature and voltage information to master MF: [MF401]] Does not communicate			
		[MF330] Estimates higher than actual		• [H003] Battery limited usable capacity • [H005] Battery suddenly unable to discharge / sudden loss of power • [H009] Battery limited lifetime		PK: Supporting Functions FU: [F-1] Estimate internal resistance MF: [MF253]] Estimates IR higher than actual	8 EL: Master Controller PO: Current sense : Analog FM: [FM007]] Lower than actual			
							EL: Master Controller PO: Current sense : Analog FM: [FM009]] Non-linear			

							EL: Power Distribu tion PO: IR Measur ement Control : GPIO FM: [FM169] Delay in open / close			
		[MF3 31] Esti mate s lower than actu al		[H005] Battery suddenl y unable to dischar ge / sudden loss of power		PK: Support ing Functio ns FU: [F-1] Estimat e internal resista nce MF: [MF252] Estimat es IR lower than actual	8 EL: Master Controll er PO: Current sense : Analog FM: [FM006] Higher than actual			
							EL: Master Controll er PO: Current sense : Analog FM: [FM009] Non- linear			

							EL: Power Distribu tion PO: IR Measur ement Control : GPIO FM: [FM169] Delay in open / close			
		[MF3 33] Esti mate s at incor rect time / frequ ency		• [H005] Battery suddenl y un able to dis char ge / sudden loss of power • [H002] Vehicle unavail able		PK: Suppor ting Functio ns FU: [F-1] Estimat e inter nal resis tance MF: [MF255] Estimat es when it should not estimat e	8 EL: Master Controll er FM: [FM214] ERRATI C or continu ously resetting			
							EL: Master Controll er FM: [FM220] Clock fault			

							EL: Master Controller PO: Current sense : Analog FM: [FM008] Erratic or noisy			
							EL: Current sensor FU: [F-53] Measure insulation resistance MF: [MF360] Measures at incorrect time			
[F-38] Estimate insulation resistance	(none)	[MF334] Does not estimate					EL: Master Controller FM: [FM202] Non functional			
							EL: Master Controller FM: [FM214] ERRATIC or continuously resetting			

							EL: Power Distribu tion PO: Insulati on measur ement control : GPIO FM: [FM164] Does not control			
							EL: Power Distribu tion PO: Insulati on measur ement control : GPIO FM: [FM209] Fails in open			
		[MF3 35] Esti mate s high er than actu al					EL: Master Controll er PO: Current sense : Analog FM: [FM007] Lower than actual			

							EL: Master Controll er PO: Current sense : Analog FM: [FM009] Non- linear			
							EL: Power Distribu tion PO: IR Measur ement Control : GPIO FM: [FM229] Fails in close			
							EL: Power Distribu tion PO: Insulati on measur ement control : GPIO FM: [FM165] Delay in open / close			

							EL: Power Distribu tion PO: Insulati on measur ement control : GPIO FM: [FM210] Fails in close			
		[MF3 36] Esti mate s lower than actu al					EL: Master Controll er PO: Current sense : Analog FM: [FM006] Higher than actual			
							EL: Master Controll er PO: Current sense : Analog FM: [FM009] Non- linear			
							EL: Power Distribu tion PO: IR Measur ement Control : GPIO FM: [FM229] Fails in close			

							EL: Power Distribu tion PO: Insulati on measur ement control : GPIO FM: [FM165] Delay in open / close			
							EL: Power Distribu tion PO: Insulati on measur ement control : GPIO FM: [FM210] Fails in close			
		[MF3 37] Esti mate s at incor rect time / frequ ency					EL: Master Controll er FM: [FM214] ERRATI C or continu ously resettin g			
							EL: Master Controll er FM: [FM220] Clock fault			

							EL: Master Controller PO: Current sense : Analog FM: [FM008] Erratic or noisy			
							EL: Current sensor FU: [F-53] Measure insulation resistance MF: [MF360] Measures at incorrect time			
[F-39] Estimate battery SOH	(none)	[MF275] Does not perform SOH estimation at all		[H009] Battery limited lifetime		PK: Supporting Functions FU: [F-16] Estimate battery SOC, SOH, SOP MF: [MF027] Does not perform state estimation	4 EL: Master Controller FM: [FM202] Non functional			

							EL: Master Controller FM: [FM214] ERRATIC or continuously resetting			
							EL: AFEs FU: [F-59] Provide temperature and voltage information to master MF: [MF401] Does not communicate			
							EL: MCU FM: [FM289] Wrong thermistor measurement			
							EL: Battery thermistors FM: [FM282] Wrong temperature measurement			

							EL: Battery thermis tors FM: [FM350] Thermi stor short circuit			
							EL: Battery thermis tors FM: [FM353] Thermi stor open circuit			
							EL: Battery thermis tors FM: [FM356] Thermi stor shorted to contact			

		[MF276] Estimated SOH is higher than actual		• [H006] Battery unable to charge • [H009] Battery limited lifetime • [H002] Vehicle unavailable		PK: Supporting Functions FU: [F-16] Estimate battery SOC, SOH, SOP MF: [MF028] Estimated SOC or SOH is more than actual	EL: Master Controller PO: Current sense : Analog FM: [FM009] Non-linear			
							EL: Power Distribution PO: Current sense : Analog FM: [FM161] Incorrect measurement			
							EL: Current sensor FM: [FM206] Timing fault			
							EL: AFE FM: [FM247] Wrong battery temperature measurement			

							EL: MCU FM: [FM289] Wrong thermis tor measur ement			
							EL: Battery thermis tors FM: [FM282] Wrong temper ature measur ement			

		[MF277] Estimated SOH is less than actual		• [H003] Battery limited usable capacity • [H005] Battery suddenly unable to discharge / sudden loss of power • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H002] Vehicle unavailable		PK: Supporting Functions FU: [F-16] Estimate battery SOC, SOH, SOP MF: [MF029] Estimated SOC or SOH is less than actual	&EL: Master Controller PO: Current sense : Analog FM: [FM009] Non-linear			
							EL: Power Distribution PO: Current sense : Analog FM: [FM161] Incorrect measurement			

							EL: Current sensor FM: [FM206] Timing fault			
							EL: AFE FM: [FM247] Wrong battery temper ature measur ement			
							EL: MCU FM: [FM289] Wrong thermis tor measur ement			
							EL: Battery thermis tors FM: [FM282] Wrong temper ature measur ement			

		[MF278] SOH estimation is outdated		• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H007] Battery rapid discharge • [H002] Vehicle unavailable		PK: Supporting Functions FU: [F-16] Estimate battery SOC, SOH, SOP MF: [MF030] State estimation is outdated	EL: MCU FM: [FM289] Wrong thermistor measurement			
							EL: Battery thermistors FM: [FM282] Wrong temperature measurement			

		[MF280] Erratic SOH estimation		• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H007] Battery rapid discharge • [H002] Vehicle unavailable		PK: Supporting Functions FU: [F-16] Estimate battery SOC, SOH, SOP MF: [MF030] State estimation is outdated	& EL: Master Controller FM: [FM214] ERRATIC or continuously resetting			
							EL: MCU FM: [FM289] Wrong thermistor measurement			
							EL: Battery thermistors FM: [FM282] Wrong temperature measurement			

[F-51] Contr ol HV power path switch	(none)	[MF3 45] Does not contr ol		• [H006] Battery unable to charge • [H005] Battery suddenl y unable to dischar ge / sudden loss of power • [H001] Battery gases / smoke / thermal runawa y • [H008] Exposu re to high voltage • [H002] Vehicle unavail able		PK: Vehicle Level Functio ns FU: [F-20] Emerge ncy Discon nect MF: [MF001] NO disconn ection when require d	EL: (BMS PO: Ignition status : CAN FM: [FM086] Messag e loss			
						PK: Vehicle Level Functio ns FU: [F-20] Emerge ncy Discon nect MF: [MF135] UNINTE NDED disconn ection	EL: (Master Controll er FM: [FM202] Non functio nal			

						PK: Supporting Functions FU: [F-7] Control FETs MF: [MF084]] Does NOT control some or all of switches	EL: (Master Controller FM: [FM214]] ERRATIC or continuously resetting			
							EL: Master Controller FM: [FM221]] Control loop hanging / delayed			
							EL: Master Controller PO: FET Control : GPIO FM: [FM133]] Does not control at all			

							EL: Master Controller PO: FET Control : GPIO FM: [FM137]] Fails in open			
							EL: Power Distribution PO: FET control : GPIO FM: [FM150]] No contact or control			
		[MF346] Delayed opening of HV switch		• [H001] Battery gases / smoke / thermal runaway • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF002]] DELAY in disconnection	1 EL: Master Controller FM: [FM221]] Control loop hanging / delayed			

							EL: Master Controll er PO: Shunt temper ature : Analog FM: [FM003] Lower than actual			
							EL: Master Controll er PO: FET Control : GPIO FM: [FM135] Too long to open			
							EL: Power Distribu tion PO: FET control : GPIO FM: [FM213] Delay in actuati on			

		[MF347] Delayed closing of HV switch		• [H006] Battery unable to charge • [H001] Battery gases / smoke / thermal runaway • [H008] Exposure to high voltage • [H002] Vehicle unavailable		PK: Supporting Functions FU: [F-7] Control FETs MF: [MF090] DELAYED connection / disconnection of switches	EL: Master Controller FM: [FM221] Control loop hanging / delayed			
							EL: Master Controller PO: FET Control : GPIO FM: [FM136] Too long to close			
							EL: Power Distribution PO: FET control : GPIO FM: [FM213] Delay in actuation			

		[MF348] Premature opening of HV switch		[H005] Battery suddenly unable to discharge / sudden loss of power [H002] Vehicle unavailable	Can cause positive contactor welding	PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF003] EARLY disconnection	EL: Master Controller PO: Shunt temperature : Analog FM: [FM002] Higher than actual			
							EL: Master Controller PO: FET Control : GPIO FM: [FM137] Fails in open			
							EL: Power Distribution PO: Shunt temperature : Analog FM: [FM154] Incorrect measurement			

							EL: Power Distribu tion PO: Shunt temper ature : Analog FM: [FM158] Noisy data			
		[MF3 49] Prem ature closi ng of HV switc h		• [H001] Battery gases / smoke / thermal runaway • [H008] Exposure to high voltage • [H002] Vehicle unavailable	Can caus e HV sensi ng issue s	EL: MOSFE Ts FM: [FM071] Failed in short	EL: (Master Controll er PO: FET Control : GPIO FM: [FM138] Fails in close			
							EL: Power Distribu tion PO: Shunt temper ature : Analog FM: [FM154] Incorre ct measur ement			

							EL: Power Distribu tion PO: Shunt temper ature : Analog FM: [FM158] Noisy data			
		[MF350] Close s HV switc h befor e prec hargi ng is comp lete		• [H001] Battery gases / smoke / thermal runaway • [H002] Vehicle unavailable • [H008] Exposure to high voltage	Can caus e cont actor weldi ng	PK: Vehicle Level Functio ns FU: [F-20] Emerge ncy Discon nect MF: [MF001] NO disconn ection when require d	EL: (Master Controll er PO: FET Control : GPIO FM: [FM138] Fails in close			
							EL: Power Distribu tion PO: Pack- side voltage : Analog FM: [FM156] Incorre ct measur ement			

		[MF351] Opens HV switch before current is below safe threshold		[H001] Battery gases / smoke / thermal runaway [H002] Vehicle unavailable [H008] Exposure to high voltage	Will cause contactor welding	PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF001] NO disconnection when required	EL: (Master Controller PO: FET Control : GPIO FM: [FM137] Fails in open			
		[MF352] Erratic / unstable HV switch control		[H005] Battery suddenly unable to discharge / sudden loss of power [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF004] UNSTABLE or erratic disconnection	EL: (Master Controller FM: [FM214] ERRATIC or continuously resetting			
							EL: Master Controller FM: [FM220] Clock fault			

							EL: Master Controll er PO: Shunt temper ature : Analog FM: [FM004] Erratic or noisy			
							EL: Master Controll er PO: FET Control : GPIO FM: [FM218] Erratic output control			
							EL: Power Distribu tion PO: FET control : GPIO FM: [FM151] Erratic control			

							EL: Power Distribu tion PO: Shunt temper ature : Analog FM: [FM154] Incorre ct measur ement			
							EL: Power Distribu tion PO: Shunt temper ature : Analog FM: [FM158] Noisy data			
							EL: Power Distribu tion PO: Pack- side voltage : Analog FM: [FM156] Incorre ct measur ement			

							EL: Power Distribu tion PO: Pack- side voltage : Analog FM: [FM160] Noisy data			
							EL: MCU FM: [FM456] Erratic FET / Contact or operati on			
[F113] Detect overc urrent conditi on	(none)	[MF4 78] Does not dete ct		• [H001] Battery gases / smoke / thermal runawa y • [H007] Battery rapid dischar ge • [H002] Vehicle unavail able • [H008] Exposu re to high voltage		PK: Vehicle Level Functio ns FU: [F-20] Emerge ncy Discon nect MF: [MF001] NO disconn ection when require d	1 EL: (Master Controll er PO: Current sense : Analog FM: [FM005] No reading			

						PK: Supporting Functions FU: [F-9] Detect overcurrent condition MF: [MF074]] Does NOT detect overcurrent condition	EL: (Power Distribution PO: Current sense : Analog FM: [FM161]] Incorrect measurement			
							EL: AFEs FU: [F-59] Provide temperature and voltage information to master MF: [MF401]] Does not communicate			

		[MF480] Detects at higher than required threshold		• [H001] Battery gases / smoke / thermal runaway • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF002] DELAY in disconnection	EL: (Master Controller PO: Current sense : Analog FM: [FM009] Non-linear			
							EL: Power Distribution PO: Current sense : Analog FM: [FM161] Incorrect measurement			

		[MF482] Detects at lower than required threshold		• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H002] Vehicle unavailable		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF003] EARLY disconnection	&EL: Master Controller PO: Current sense : Analog FM: [FM009] Non-linear			
						PK: Supporting Functions FU: [F-9] Detect overcurrent condition MF: [MF076] Overcurrent detected at LOWER than required threshold	&EL: Power Distribution PO: Current sense : Analog FM: [FM161] Incorrect measurement			

		[MF484] False detection		• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF135] UNINTENDED disconnection	EL: (Power Distribution PO: Current sense : Analog FM: [FM161] Incorrect measurement			
						PK: Supporting Functions FU: [F-9] Detect overcurrent condition MF: [MF079] UNSTABLE or erratic detection				

		[MF486] Premature detection		• [H005] Battery suddenly unable to discharge / sudden loss of power • [H002] Vehicle unavailable		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF003] EARLY disconnection	EL: Master Controller PO: Current sense : Analog FM: [FM006] Higher than actual			
							EL: Master Controller PO: Current sense : Analog FM: [FM009] Non-linear			
							EL: Power Distribution PO: Current sense : Analog FM: [FM161] Incorrect measurement			

		[MF488] Delayed detection		• [H001] Battery gases / smoke / thermal runaway • [H007] Battery rapid discharge • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF002] DELAY in disconnection	EL: (Master Controller PO: Current sense : Analog FM: [FM007] Lower than actual			
						PK: Supporting Functions FU: [F-9] Detect overcurrent condition MF: [MF078] DELAYED overcurrent condition detection	EL: (Master Controller PO: Current sense : Analog FM: [FM009] Non-linear			

						EL: Power Distribu tion PO: Current sense : Analog FM: [FM161] Incorre ct measur ement			
		[MF4 90] Errat ic beha viour		• [H005] Battery suddenly unable to discharge / sudden loss of power • [H008] Exposure to high voltage		PK: Vehicle Level Function s FU: [F-20] Emerge ncy Discon nect MF: [MF004] UNSTA BLE or erratic disconn ection	EL: (Master Controll er PO: Current sense : Analog FM: [FM008] Erratic or noisy		
						PK: Support ing Function s FU: [F-9] Detect overcur rent conditi on MF: [MF079] UNSTA BLE or erratic detecti on			

[F114] Detect short circuit condition	(none)	[MF479] Does not detect		• [H001] Battery gases / smoke / thermal runaway • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF001] NO disconnection when required	EL: Master Controller PO: Current sense : Analog FM: [FM005] No reading			
							EL: Power Distribution PO: Current sense : Analog FM: [FM161] Incorrect measurement			
							EL: AFEs FU: [F-59] Provide temperature and voltage information to master MF: [MF401] Does not communicate			

		[MF481] Detects at higher than required threshold		• [H001] Battery gases / smoke / thermal runaway • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF002] DELAY in disconnection	EL: Master Controller PO: Current sense : Analog FM: [FM009] Non-linear			
							EL: Power Distribution PO: Current sense : Analog FM: [FM161] Incorrect measurement			
		[MF483] Detects at lower than required threshold		• [H005] Battery suddenly unable to discharge / sudden loss of power • [H002] Vehicle unavailable		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF003] EARLY disconnection	EL: Master Controller PO: Current sense : Analog FM: [FM009] Non-linear			

							EL: Power Distribu tion PO: Current sense : Analog FM: [FM161] Incorre ct measur ement			
		[MF4 85] False dete ction		• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H008] Exposure to high voltage		PK: Vehicle Level Function FU: [F-20] Emergency Disconnect MF: [MF135] UNINTE NDED disconn ection	1 EL: (Power Distribu tion PO: Current sense : Analog FM: [FM161] Incorre ct measur ement			
		[MF4 87] Prem ature dete ction		• [H005] Battery suddenly unable to discharge / sudden loss of power • [H002] Vehicle unavailable		PK: Vehicle Level Function FU: [F-20] Emergency Disconnect MF: [MF003] EARLY disconn ection	8 EL: Master Controll er PO: Current sense : Analog FM: [FM006] Higher than actual			

							EL: Master Controller PO: Current sense : Analog FM: [FM009]] Non- linear			
							EL: Power Distribu tion PO: Current sense : Analog FM: [FM161]] Incorre ct measur ement			
		[MF489] Delayed detection		• [H001] Battery gases / smoke / thermal runaway • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF002]] DELAY in disconnection	EL: Master Controller PO: Current sense : Analog FM: [FM007]] Lower than actual			

							EL: Master Controller PO: Current sense : Analog FM: [FM009]] Non- linear			
							EL: Power Distribu tion PO: Current sense : Analog FM: [FM161]] Incorre ct measur ement			
		[MF4 91] Erratic behaviour		• [H005] Battery suddenl y unable to dischar ge / sudden loss of power • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF004]] UNSTA BLE or erratic disconn ection	EL: Master Controller PO: Current sense : Analog FM: [FM008]] Erratic or noisy			
Power Distrib ution										
MOSF ETs										

[F-41] Perform precharge	(none)	[MF383] Does not perform precharge		• [H001] Battery gases / smoke / thermal runaway • [H008] Exposure to high voltage • [H002] Vehicle unavailable		EL: MOSFETs FM: [FM071] Failed in short	1				
		[MF384] Closes precharge before ground			No failure						
		[MF385] Premature open / close of precharge switch		• [H001] Battery gases / smoke / thermal runaway • [H008] Exposure to high voltage • [H002] Vehicle unavailable	Might cause positive contactor welding	EL: MOSFETs FM: [FM071] Failed in short	1	EL: Master Controller FM: [FM220] Clock fault			

		[MF386] Delayed open / close of precharge switch			No safety risk		EL: Master Controller FM: [FM220] Clock fault			
							EL: Power Distribution PO: Pack-side voltage : Analog FM: [FM157] No data			
		[MF387] Closes precharge switch before ground switch			No safety risk		EL: Master Controller FM: [FM220] Clock fault			
							EL: Power Distribution PO: Pack-side voltage : Analog FM: [FM157] No data			

		[MF388] Opens precharge switch before closing positive switch		• [H001] Battery gases / smoke / thermal runaway • [H008] Exposure to high voltage • [H002] Vehicle unavailable	There might be load at the output which could cause positive switch failure	EL: MOSFETs FM: [FM071] Failed in short	] EL: (Master Controller FM: [FM220] Clock fault			
							EL: Power Distribution PO: Pack-side voltage : Analog FM: [FM157] No data			

		[MF389] Erratic / unstable precharge control		• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H008] Exposure to high voltage • [H002] Vehicle unavailable		EL: MOSFETs FM: [FM071] Failed in short	EL: (Master Controller FM: [FM220] Clock fault			
						EL: MOSFETs FM: [FM219] Erratic or unstable switching	EL: (Power Distribution PO: Pack-side voltage : Analog FM: [FM160] Noisy data			

[F-52] Control current flow through HV lines	(none)	[MF390] Does not control		• [H006] Battery unable to charge • [H001] Battery gases / smoke / thermal runaway • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF001] NO disconnection when required	EL: BMS PO: Pack -ve : Power FM: [FM139] Shorted to pack positive			
						PK: Vehicle Level Functions FU: [F-19] Battery connection / disconnection on request MF: [MF243] Does not connect battery on request	EL: BMS PO: Pack +ve : Power FM: [FM144] Shorted to pack negative			

						PK: Vehicle Level Functions FU: [F-19] Battery connection / disconnection on request MF: [MF250]] Does not disconnect battery on request	EL: Master Controller PO: FET Control : GPIO FM: [FM133]] Does not control at all			
							EL: Master Controller PO: FET Control : GPIO FM: [FM137]] Fails in open			
							EL: Power Distribution PO: FET control : GPIO FM: [FM150]] No contact or control			

							EL: FET / Contact or Driver FM: [FM242] Output stuck high			
		[MF3 91] Prem ature open ing of HV switc h		• [H005] Battery suddenl y unable to dischar ge / sudden loss of power • [H002] Vehicle unavail able		PK: Vehicle Level Functio ns FU: [F-20] Emerge ncy Discon nect MF: [MF003] EARLY disconn ection	EL: Master Controll er FM: [FM220] Clock fault			
							EL: Master Controll er PO: FET Control : GPIO FM: [FM137] Fails in open			
							EL: Power Distribu tion PO: Pack- side voltage : Analog FM: [FM157] No data			

		[MF392] Premature closing of HV switch		• [H001] Battery gases / smoke / thermal runaway • [H008] Exposure to high voltage • [H002] Vehicle unavailable		EL: MOSFETs FM: [FM071] Failed in short	EL: Master Controller FM: [FM220] Clock fault			
							EL: Master Controller PO: FET Control : GPIO FM: [FM138] Fails in close			
		[MF393] Closes HV switch before precharging is complete		• [H001] Battery gases / smoke / thermal runaway • [H008] Exposure to high voltage • [H002] Vehicle unavailable		EL: MOSFETs FM: [FM071] Failed in short	EL: Master Controller FM: [FM220] Clock fault			

						EL: Master Controll er PO: FET Control : GPIO FM: [FM138] Fails in close				
		[MF3 94] Open s HV switc h befor e curre nt is belo w safe thres hold		• [H006] Battery unable to charge • [H001] Battery gases / smoke / thermal runawa y • [H008] Exposu re to high voltage • [H002] Vehicle unavail able		EL: MOSFE Ts FM: [FM072] Failed in open	& EL: Master Controll er FM: [FM220] Clock fault			
						EL: MOSFE Ts FM: [FM071] Failed in short	1			

		[MF395] Erratic / unstable HV switch control		• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H008] Exposure to high voltage • [H002] Vehicle unavailable		EL: MOSFETs FM: [FM219] Erratic or unstable switching	EL: (Master Controller FM: [FM220]] Clock fault			
						EL: MOSFETs FM: [FM071]] Failed in short	EL: (Master Controller PO: Shunt temperature : Analog FM: [FM004]] Erratic or noisy			

						EL: MOSFETs FM: [FM072] Failed in open	& EL: Power Distribution PO: FET control : GPIO FM: [FM151] Erratic control			
							EL: FET / Contact or Driver FM: [FM245] Insufficient close current			
							EL: FET / Contact or Driver FM: [FM243] Erratic operation			
							EL: FET / Contact or Driver FM: [FM244] Insufficient open current			

		[MF462] Delayed opening		• [H001] Battery gases / smoke / thermal runaway • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF002] DELAY in disconnection	EL: (Master Controller PO: FET Control : GPIO FM: [FM135]] Too long to open			
							EL: Power Distribution PO: FET control : GPIO FM: [FM213]] Delay in actuation			

		[MF463] Delayed closing		[H006] Battery unable to charge [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-19] Battery connection / disconnection on request MF: [MF245] DELAY in connection or disconnection	EL: Master Controller PO: FET Control : GPIO FM: [FM136] Too long to close			
							EL: Power Distribution PO: FET control : GPIO FM: [FM213] Delay in actuation			
Current sensor										

[F-42] Measure battery voltage	(none)	[MF353] Does not measure		• [H006] Battery unable to charge • [H003] Battery limited usable capacity • [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H002] Vehicle unavailable		PK: Supporting Functions FU: [F-14] Measure battery voltage MF: [MF037]] Does NOT sense battery or cell voltage	EL: (Power Distribution PO: HV measurement control : GPIO FM: [FM166]] Does not control			
							EL: Power Distribution PO: HV measurement control : GPIO FM: [FM207]] Fails in open			

							EL: Current sensor FM: [FM081] Loss of commu nicatio n			
							EL: Current sensor FM: [FM205] Non functio nal			
							EL: Resisto r divider : PACK+ FM: [FM392] Resisto r short to ground			
							EL: Resisto r divider : PACK+ FM: [FM396] Resisto r short to positive			
							EL: Resisto r divider : BAT+ FM: [FM390] Resisto r short to positive			

							EL: Resistor divider : BAT+ FM: [FM389] Resistor short to ground			
		[MF354] Measures higher than actual		• [H003] Battery limited usable capacity • [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H009] Battery limited lifetime • [H007] Battery rapid discharge		PK: Supporting Functions FU: [F-14] Measure battery voltage MF: [MF038] Senses / reports HIGHER voltage than actual	& EL: Power Distribution PO: Pack-side voltage : Analog FM: [FM156] Incorrect measurement			

							EL: Power Distribu tion PO: IR Measur ement Control : GPIO FM: [FM229] Fails in close			
							EL: Power Distribu tion PO: HV measur ement control : GPIO FM: [FM167] Delay in open / close			
							EL: Power Distribu tion PO: Insulati on measur ement control : GPIO FM: [FM210] Fails in close			
							EL: BJB IC FM: [FM328] Higher than actual PACK+ measur ement			

							EL: Resistor divider : PACK+ FM: [FM278] Wrong resistor values			
							EL: Resistor divider : PACK+ FM: [FM361] Higher measurement than usual			
							EL: Resistor divider : BAT+ FM: [FM359] Higher measurement than usual			
							EL: Resistor divider : BAT+ FM: [FM276] Wrong resistor values			

		[MF355] Measures lower than actual	• [H003] Battery limited usable capacity • [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H002] Vehicle unavailable		PK: Supporting Functions FU: [F-14] Measure battery voltage MF: [MF039] Senses / reports LOWER battery voltage than actual	EL: (Power Distribution PO: Pack-side voltage : Analog FM: [FM156] Incorrect measurement			
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							EL: Power Distribu tion PO: IR Measur ement Control : GPIO FM: [FM229] Fails in close			
							EL: Power Distribu tion PO: HV measur ement control : GPIO FM: [FM167] Delay in open / close			
							EL: Power Distribu tion PO: Insulati on measur ement control : GPIO FM: [FM210] Fails in close			
							EL: BJB IC FM: [FM334] Lower than actual PACK+ measur ement			

							EL: Resistor divider : PACK+ FM: [FM278] Wrong resistor values			
							EL: Resistor divider : PACK+ FM: [FM391] Lower measurement than usual			
							EL: Resistor divider : BAT+ FM: [FM360] Lower measurement than usual			
							EL: Resistor divider : BAT+ FM: [FM276] Wrong resistor values			

		[MF356] Erratic / noisy measurement	• [H003] Battery limited usable capacity • [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H002] Vehicle unavailable • [H008] Exposure to high voltage	PK: Supporting Functions FU: [F-14] Measure battery voltage MF: [MF040] ERRATIC sensed / reported cell or battery voltage values	1				
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[F-53] Measure insulation resistance	(none)	[MF357] Does not measure					EL: Power Distribution PO: IR Measurement Control : GPIO FM: [FM168]] Does not control			
							EL: Power Distribution PO: Insulation measurement control : GPIO FM: [FM164]] Does not control			
							EL: Power Distribution PO: Insulation measurement control : GPIO FM: [FM209]] Fails in open			
							EL: Current sensor FM: [FM081]] Loss of communication			

							EL: Current sensor FM: [FM205] Non functio nal			
		[MF3 58] Meas ures high er than actu al					EL: Power Distribu tion PO: IR Measur ement Control : GPIO FM: [FM229] Fails in close			
							EL: Power Distribu tion PO: HV measur ement control : GPIO FM: [FM208] Fails in close			
							EL: Power Distribu tion PO: Insulati on measur ement control : GPIO FM: [FM165] Delay in open / close			

							EL: BJB IC FM: [FM330] Higher than actual negativ e insulati on resista nce measur ement			
							EL: BJB IC FM: [FM327] Higher than actual positive insulati on resista nce measur ement			
		[MF3 59] Meas ures lower than actu al					EL: Power Distribu tion PO: IR Measur ement Control : GPIO FM: [FM229] Fails in close			

							EL: Power Distribu tion PO: HV measur ement control : GPIO FM: [FM208] Fails in close			
							EL: Power Distribu tion PO: Insulati on measur ement control : GPIO FM: [FM165] Delay in open / close			
							EL: BJB IC FM: [FM332] Lower than actual positive insulati on resista nce measur ement			

						EL: BJB IC FM: [FM333] Lower than actual negativ e insulati on resista nce measur ement			
		[MF360] Measures at incorrect time		• [H005] Battery suddenly unable to discharge / sudden loss of power • [[F-38] Estimate insulation resistance] [MF337] Estimates at incorrect time / frequency • [H002] Vehicle unavailable		EL: Master Controller FU: [F-37] Estimate internal resistance MF: [MF333] Estimates at incorrect time / frequency	8		

						EL: Master Controller FU: [F-38] Estimate insulation resistance MF: [MF337] Estimates at incorrect time / frequency	-				
		[MF366] Noisy measurement									
[F-54] Measure battery internal resistance	(none)	[MF361] Does not measure		[H005] Battery suddenly unable to discharge / sudden loss of power		PK: Supporting Functions FU: [F-1] Estimate internal resistance MF: [MF251] Does not perform IR estimation at all	& EL: Power Distribution PO: IR Measurement Control : GPIO FM: [FM228]] Fails in open				

							EL: Current sensor FM: [FM081] Loss of commu nicatio n			
							EL: Current sensor FM: [FM205] Non functio nal			
		[MF3 62] Meas ures high er than actu al		• [H003] Battery limited usable capacit y • [H005] Battery suddenl y unable to dischar ge / sudden loss of power • [H009] Battery limited lifetime		PK: Suppor ting Functio ns FU: [F-1] Estimat e internal resista nce MF: [MF253] Estim ates IR higher than actual	EL: Power Distribu tion PO: IR Measur ement Control : GPIO FM: [FM169] Delay in open / close			
							EL: Power Distribu tion PO: HV measur ement control : GPIO FM: [FM208] Fails in close			

		[MF363] Measures lower than actual		[H005] Battery suddenly unable to discharge / sudden loss of power		PK: Supporting Functions FU: [F-1] Estimate internal resistance MF: [MF252] Estimates IR lower than actual	& EL: Power Distribution PO: IR Measurement Control : GPIO FM: [FM169] Delay in open / close			
							EL: Power Distribution PO: HV measurement control : GPIO FM: [FM208]] Fails in close			
		[MF364] Measures at incorrect time			Will impact link voltage measurement and insulation voltage measurement readings					

		[MF365] Noisy measurement			No safety impact					
[F-48] Measure battery current	(none)	[MF367] Does not measure		• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H007] Battery rapid discharge • [H002] Vehicle unavailable		PK: Supporting Functions FU: [F-22] Measure battery current MF: [MF041] Does NOT sense battery current	EL: (Current sensor FM: [FM081] Loss of communication			

						PK: Supporting Functions FU: [F-16] Estimate battery SOC, SOH, SOP MF: [MF030]] State estimation is outdated	& EL: Current sensor FM: [FM205]] Non functional			
							EL: Short-circuit detection FM: [FM269]] No operation			
							EL: Shunt resistor FM: [FM261]] Shunt short circuit			

		[MF368] Measures higher than actual	• [H006] Battery unable to charge • [H003] Battery limited usable capacity • [H005] Battery suddenly unable to discharge / sudden loss of power • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H002] Vehicle unavailable		PK: Supporting Functions FU: [F-22] Measure battery current MF: [MF042] Senses / reports HIGHER current than actual	&EL: Power Distribution PO: Shunt temperature : Analog FM: [FM149]] No data			
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					PK: Supporting Functions FU: [F-16] Estimate battery SOC, SOH, SOP MF: [MF029] Estimated SOC or SOH is less than actual	& EL: Power Distribution PO: Current sense : Analog FM: [FM161] Incorrect measurement			
					PK: Supporting Functions FU: [F-16] Estimate battery SOC, SOH, SOP MF: [MF028] Estimated SOC or SOH is more than actual	& EL: Current sensor FU: [F-49] Measure shunt temperature MF: [MF371] Does not measure			

							EL: Current sensor FU: [F-49] Measure shunt temperature MF: [MF372] Measures higher than actual			
							EL: Short- circuit detection FM: [FM366] Delayed short- circuit trigger			
							EL: BJB IC FM: [FM263] Higher than actual current measurement			
							EL: Shunt resistor FM: [FM262] Shunt incorrect value			

		[MF369] Measures lower than actual	• [H006] Battery unable to charge • [H003] Battery limited usable capacity • [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H002] Vehicle unavailable		PK: Supporting Functions FU: [F-22] Measure battery current MF: [MF043] Senses / reports LOWER current than actual	EL: (Power Distribution PO: Current sense : Analog FM: [FM161] Incorrect measurement			
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					PK: Supporting Functions FU: [F-16] Estimate battery SOC, SOH, SOP MF: [MF029] Estimated SOC or SOH is less than actual	&EL: Current sensor FU: [F-49] Measure shunt temperature MF: [MF371] Does not measure			
					PK: Supporting Functions FU: [F-16] Estimate battery SOC, SOH, SOP MF: [MF028] Estimated SOC or SOH is more than actual	&EL: Current sensor FU: [F-49] Measure shunt temperature MF: [MF373] Measures lower than actual			

							EL: Short-circuit detecti on FM: [FM302] Premat ure / false short- circuit trigger			
							EL: BJB IC FM: [FM325] Lower than actual current measur ement			
							EL: Shunt resistor FM: [FM262] Shunt incore ct value			

		[MF370] Noisy measurement		• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H007] Battery rapid discharge • [H008] Exposure to high voltage		PK: Supporting Functions FU: [F-16] Estimate battery SOC, SOH, SOP MF: [MF031] State estimation is erratic or unstable	1 (				
						PK: Supporting Functions FU: [F-22] Measure battery current MF: [MF045] ERRATIC sensed / reported battery current	1 (				

[F-49] Measure shunt temperature	(none)	[MF371] Does not measure	• [H006] Battery unable to charge • [H003] Battery limited usable capacity • [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H002] Vehicle unavailable	EL: Current sensor FU: [F-48] Measure battery current MF: [MF368] Measures higher than actual	&EL: Current sensor FM: [FM081]] Loss of communication				
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						EL: Current sensor FU: [F-48] Measure battery current MF: [MF369] Measures lower than actual	EL: Current sensor FM: [FM205] Non functional			
							EL: Shunt Thermistor FM: [FM347] Thermistor open circuit			
							EL: Shunt Thermistor FM: [FM348] Thermistor short circuit			
							EL: Shunt Thermistor FM: [FM349] Thermistor shorted to contact			

		[MF372] Measures higher than actual		• [H006] Battery unable to charge • [H003] Battery limited usable capacity • [H005] Battery suddenly unable to discharge / sudden loss of power • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H002] Vehicle unavailable		EL: Current sensor FU: [F-48] Measure battery current MF: [MF368] Measures higher than actual	&EL: BJB IC FM: [FM326] Higher than actual shunt temperature measurement			
							EL: Shunt Thermistor FM: [FM346] Wrong temperature measurement			

		[MF373] Measures lower than actual	• [H006] Battery unable to charge • [H003] Battery limited usable capacity • [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H002] Vehicle unavailable		EL: Current sensor FU: [F-48] Measure battery current MF: [MF369] Measures lower than actual	] EL: BJB IC FM: [FM331] Lower than actual shunt temperature measurement			
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							EL: Shunt Thermistor FM: [FM346] Wrong temperature measurement			
		[MF374] Noisy measurement								
[F-50] Communicate with Master controller	(none)	[MF375] Does not communicate		• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime		PK: Supporting Functions FU: [F-22] Measure battery current MF: [MF041] Does NOT sense battery current	1 EL: (Current sensor FM: [FM081]] Loss of communication			

					PK: Supporting Functions FU: [F-1] Estimate internal resistance MF: [MF251]] Does not perform IR estimation at all	8 EL: Current sensor FM: [FM205]] Non functional			
					PK: Supporting Functions FU: [F-16] Estimate battery SOC, SOH, SOP MF: [MF027]] Does not perform state estimation	4 EL: TPL Isolation : BJB FM: [FM424]] Complete isolation breakdown			

							EL: TPL Isolation : BJB FM: [FM425] Partial isolation breakdown or degradation			
							EL: TPL Isolation : BJB FM: [FM426]] Open circuit			
							EL: TPL Transceiver FM: [FM252]] No operation			
							EL: TPL Transceiver FM: [FM296]] Erratic			
							EL: TPL Transceiver FM: [FM318]] Higher than set baud rate			

							EL: TPL Transceiver FM: [FM449] Incorrect register address access			
							EL: Isolation : TPL FM: [FM418] Complete isolation breakdown			
							EL: Isolation : TPL FM: [FM419] Partial isolation breakdown or degradation			
							EL: Isolation : TPL FM: [FM420] Open circuit			
		[MF376] Noisy communication					EL: BJB IC FM: [FM264] Wrong CRC and/or EDC			

							EL: TPL Transci ever FM: [FM296] Erratic			
		[MF3 77] Incor rect data trans mitte d					EL: TPL Transci ever FM: [FM296] Erratic			
							EL: BJB IC FM: [FM264] Wrong CRC and/or EDC			
		[MF3 78] Outd ated data provi ded					EL: TPL Transci ever FM: [FM296] Erratic			

[F-55] Measure link voltage	(none)	[MF379] Does not measure		• [H006] Battery unable to charge • [H003] Battery limited usable capacity • [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H002] Vehicle unavailable		PK: Supporting Functions FU: [F-14] Measure battery voltage MF: [MF037] Does NOT sense battery or cell voltage	EL: BMS PO: Pack +ve : Power FM: [FM224] Open connection			
							EL: BMS PO: Pack -ve : Power FM: [FM223] Open connection			

							EL: Power Distribu tion PO: HV measur ement control : GPIO FM: [FM166] Does not control			
							EL: Power Distribu tion PO: HV measur ement control : GPIO FM: [FM207] Fails in open			
							EL: Current sensor FM: [FM081] Loss of commu nicatio n			
							EL: Current sensor FM: [FM205] Non functio nal			

							EL: Resisto r divider : FUSE+ FM: [FM394] Resisto r short to ground			
							EL: Resisto r divider : FUSE+ FM: [FM398] Resisto r short to positive			

		[MF380] Measures higher than actual		• [H003] Battery limited usable capacity • [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H009] Battery limited lifetime • [H007] Battery rapid discharge		PK: Supporting Functions FU: [F-14] Measure battery voltage MF: [MF038] Senses / reports HIGHER voltage than actual	&EL: Power Distribution PO: IR Measurement Control : GPIO FM: [FM229] Fails in close			
							EL: Power Distribution PO: HV measurement control : GPIO FM: [FM167] Delay in open / close			

							EL: Power Distribu tion PO: Insulati on measur ement control : GPIO FM: [FM210] Fails in close			
							EL: BJB IC FM: [FM329] Higher than actual FUSE+ measur ement			
							EL: Resisto r divider : FUSE+ FM: [FM280] Wrong resistor values			
							EL: Resisto r divider : FUSE+ FM: [FM362] Higher measur ement than usual			

		[MF381] Measures lower than actual	• [H003] Battery limited usable capacity • [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H002] Vehicle unavailable	PK: Supporting Functions FU: [F-14] Measure battery voltage MF: [MF039] Senses / reports LOWER battery voltage than actual	EL: (Power Distribution PO: IR Measurement Control : GPIO FM: [FM229]] Fails in close			
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							EL: Power Distribu tion PO: HV measur ement control : GPIO FM: [FM167] Delay in open / close			
							EL: Power Distribu tion PO: Insulati on measur ement control : GPIO FM: [FM210] Fails in close			
							EL: BJB IC FM: [FM335] Lower than actual FUSE+ measur ement			
							EL: Resisto r divider : FUSE+ FM: [FM280] Wrong resistor values			

							EL: Resistor divider : FUSE+ FM: [FM364] Lower measurement than usual			
		[MF382] Noisy measurement					EL: BMS PO: Pack +ve : Power FM: [FM224]] Open connection			
							EL: BMS PO: Pack -ve : Power FM: [FM223]] Open connection			
[F112] Detect short-circuit condition	(none)	[MF465] Does not detect		• [H001] Battery gases / smoke / thermal runaway • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF001]] NO disconnection when required	EL: Power Distribution PO: Current sense : Analog FM: [FM161]] Incorrect measurement			

							EL: Current sensor FM: [FM081]] Loss of commu nicatio n			
							EL: Current sensor FM: [FM205]] Non functio nal			
		[MF467] Dete cts at high er than requi red thres hold		• [H001] Battery gases / smoke / thermal runawa y • [H002] Vehicle unavail able • [H008] Exposu re to high voltage		PK: Vehicle Level Functio ns FU: [F-20] Emerge ncy Discon nect MF: [MF002]] DELAY in disconn ection	1 EL: (Power Distribu tion PO: Current sense : Analog FM: [FM161]] Incorre ct measur ement			
		[MF469] Dete cts at lower than requi red thres hold		• [H005] Battery suddenl y unable to dischar ge / sudden loss of power • [H002] Vehicle unavail able		PK: Vehicle Level Functio ns FU: [F-20] Emerge ncy Discon nect MF: [MF003]] EARLY disconn ection	8 EL: Power Distribu tion PO: Current sense : Analog FM: [FM161]] Incorre ct measur ement			

		[MF470] False detection		• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF135] UNINTENDED disconnection	EL: Power Distribution PO: Current sense : Analog FM: [FM161] Incorrect measurement			
		[MF473] Premature detection		• [H005] Battery suddenly unable to discharge / sudden loss of power • [H002] Vehicle unavailable		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF003] EARLY disconnection	EL: Power Distribution PO: Current sense : Analog FM: [FM161] Incorrect measurement			

		[MF475] Delayed detection		• [H001] Battery gases / smoke / thermal runaway • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF002] DELAY in disconnection	EL: Power Distribution PO: Current sense : Analog FM: [FM161] Incorrect measurement			
		[MF477] Erratic behaviour		• [H005] Battery suddenly unable to discharge / sudden loss of power • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF004] UNSTABLE or erratic disconnection				

[F111] Detect overcurrent condition	(none)	[MF464] Does not detect		• [H001] Battery gases / smoke / thermal runaway • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF001] NO disconnection when required	EL: (Power Distribution PO: Current sense : Analog FM: [FM161] Incorrect measurement			
							EL: Current sensor FM: [FM081] Loss of communication			
							EL: Current sensor FM: [FM205] Non functional			

		[MF466] Detects at higher than required threshold	• [H001] Battery gases / smoke / thermal runaway • [H002] Vehicle unavailable • [H008] Exposure to high voltage	PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF002] DELAY in disconnection	EL: Power Distribution PO: Current sense : Analog FM: [FM161] Incorrect measurement			
		[MF468] Detects at lower than required threshold	• [H005] Battery suddenly unable to discharge / sudden loss of power • [H002] Vehicle unavailable	PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF003] EARLY disconnection	EL: Power Distribution PO: Current sense : Analog FM: [FM161] Incorrect measurement			

		[MF471] False detection		• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF135] UNINTENDED disconnection	EL: Power Distribution PO: Current sense : Analog FM: [FM161] Incorrect measurement			
		[MF472] Premature detection		• [H005] Battery suddenly unable to discharge / sudden loss of power • [H002] Vehicle unavailable		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF003] EARLY disconnection	EL: Power Distribution PO: Current sense : Analog FM: [FM161] Incorrect measurement			

		[MF474] Delayed detection		• [H001] Battery gases / smoke / thermal runaway • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF002] DELAY in disconnection	EL: Power Distribution PO: Current sense : Analog FM: [FM161] Incorrect measurement			
		[MF476] Erratic behaviour		• [H005] Battery suddenly unable to discharge / sudden loss of power • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF004] UNSTABLE or erratic disconnection				
AFEs										

[F-47] Detect cell voltage based faults	(none)	[MF396] Does not detect	• [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H002] Vehicle unavailable • [H008] Exposure to high voltage	PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF001] NO disconnection when required	EL: AFE (FM: [FM246]) Wrong cell voltage measurement				
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					PK: Supporting Functions FU: [F-12] Detect overvoltage condition MF: [MF057]] Does NOT detect overvoltage condition	1 (				
					PK: Supporting Functions FU: [F-11] Detect undervoltage condition MF: [MF064]] Does NOT detect undervoltage condition	1 (				

		[MF403] Detects protection at a HIGHER than required threshold		• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF002] DELAY in disconnection	1 EL: AFE (FM: [FM246] Wrong cell voltage measurement			
						PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF003] EARLY disconnection	8			

					PK: Vehicle Level Function FU: [F-20] Emergency Disconnect MF: [MF135] UNINTE NDED disconn ection	1 (				
					PK: Support ing Function FU: [F-12] Detect overvol tage conditi on MF: [MF058] Detects fault at a HIGHE R than require d thresho ld	1 (				

						PK: Support ting Functio ns FU: [F-11] Detect underv oltage conditi on MF: [MF065] Underv oltage detecte d at HIGHE R than require d thresho ld	8				
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		[MF404] Detects protection at a LOWER than required threshold	• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF003] EARLY disconnection	& EL: AFE FM: [FM246] Wrong cell voltage measurement			
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					PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF002] DELAY in disconnection	1 (				
					PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF135] UNINTE NDED disconnection	1 (				

					PK: Supporting Functions FU: [F-12] Detect overvoltage condition MF: [MF059] Detects overvoltage protection at LOWER than required threshold	8				
					PK: Supporting Functions FU: [F-11] Detect undervoltage condition MF: [MF066] Undervoltage detected at LOWER than required threshold	10				

		[MF407] Premature detection	• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H007] Battery rapid discharge • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF135] UNINTENDED disconnection	EL: AFE FM: [FM246] Wrong cell voltage measurement			
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					PK: Supporting Functions FU: [F-12] Detect overvoltage condition MF: [MF061] Detects overvoltage condition EARLIER than required	8				
					PK: Supporting Functions FU: [F-11] Detect undervoltage condition MF: [MF068] Undervoltage detected EARLIER than expected	8				

		[MF408] Delayed detection		• [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF002] DELAY in disconnection	EL: AFE (FM: [FM246]) Wrong cell voltage measurement			
						PK: Supporting Functions FU: [F-12] Detect overvoltage condition MF: [MF062] Detects overvoltage condition LATER than required	EL: AFE (FM: [FM367]) Delayed cell voltage measurement			

						PK: Supporting Functions FU: [F-11] Detect undervoltage condition MF: [MF069] DELAYED Undervoltage detection	EL: AFE (FM: [FM368] Delayed analog measurements		
		[MF411] Erratic or unstable detection		[H005] Battery suddenly unable to discharge / sudden loss of power [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF004] UNSTABLE or erratic disconnection	EL: AFE (FM: [FM246] Wrong cell voltage measurement		
							EL: AFE (FM: [FM317] Erratic		

[F-40] Detect temperature based faults	(none)	[MF397] Does not detect		• [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF001] NO disconnection when required	EL: AFE (FM: [FM247] Wrong battery temperature measurement			
						PK: Supporting Functions FU: [F-21] Detect overtemperature condition MF: [MF047] Does NOT detect overtemperature condition				

						PK: Supporting Functions FU: [F-13] Detect undertemperature condition MF: [MF053] Does NOT detect undertemperature condition	1 (				
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		[MF405] Detects protection at a HIGHER than required threshold	• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF002] DELAY in disconnection	EL: AFE (FM: [FM247]) Wrong battery temperature measurement			
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					PK: Vehicle Level Function s FU: [F-20] Emergency Disconnect MF: [MF003] EARLY disconn ection	8				
					PK: Support ing Function s FU: [F-21] Detect over-temperat ure conditi on MF: [MF048] Battery over-temper ature protecti on is maintai ned at a HIGHE R than require d thresho ld	10				

						PK: Supporting Functions FU: [F-13] Detect under temperature condition MF: [MF054] Under temperature detected at HIGHER than required threshold	8				
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		[MF406] Detects protection at a LOWER than required threshold	• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF002] DELAY in disconnection	EL: AFE (FM: [FM247] Wrong battery temperature measurement			
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					PK: Vehicle Level Function s FU: [F-20] Emergency Disconnect MF: [MF003] EARLY disconn ection	8				
					PK: Support ing Function s FU: [F-21] Detect over-temperat ure conditi on MF: [MF049] Battery over-temper ature protecti on is maintai ned at a LOWER than require d thresho ld	8				

					PK: Supporting Functions FU: [F-13] Detect under temperature condition MF: [MF055] Under temperature detected at LOWER than required threshold				
		[MF409] Premature detection		• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H002] Vehicle unavailable	PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF003] EARLY disconnection	EL: AFE FM: [FM247] Wrong battery temperature measurement			

					PK: Supporting Functions FU: [F-21] Detect overtemperature condition MF: [MF242] Detects overtemperature EARLIER than required	8				
					PK: Supporting Functions FU: [F-13] Detect undertemperature condition MF: [MF241] Detects undertemperature EARLIER than required	8				

		[MF410] Delayed detection		• [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF002] DELAY in disconnection	EL: AFE (FM: [FM247]) Wrong battery temperature measurement			
						PK: Supporting Functions FU: [F-21] Detect overtemperature condition MF: [MF050] DELAYED detection of overtemperature condition	EL: AFE (FM: [FM368]) Delayed analog measurements			

					PK: Supporting Functions FU: [F-13] Detect undertemperature condition MF: [MF239] DELAYED detection of undertemperature condition				
		[MF412] Erratic or unstable detection		[H005] Battery suddenly unable to discharge / sudden loss of power [H008] Exposure to high voltage	PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF004] UNSTABLE or erratic disconnection	EL: AFE FM: [FM247] Wrong battery temperature measurement			

					PK: Supporting Functions FU: [F-21] Detect overtemperature condition MF: [MF051] UNSTABLE or erratic detection	1 EL: AFE (FM: [FM317] Erratic			
					PK: Supporting Functions FU: [F-13] Detect undertemperature condition MF: [MF240] UNSTABLE or erratic detection	1			

[F-56] Contr ol balanc ing circuit	(none)	[MF3 98] Does not contr ol		• [H003] Battery limited usable capacit y • [H006] Battery unable to charge • [H009] Battery limited lifetime • [H002] Vehicle unavail able		PK: Vehicle Level Functio ns FU: [F-17] Balance battery MF: [MF018] Does not do battery balanci ng	&				
		[MF4 28] Over bala nces the batte ry			No failur e asso ciate d with over bala ncing		EL: AFE FM: [FM249] Undesir ed balanci ng				
		[MF4 30] Bala nces the wron g cells		• [H003] Battery limited usable capacit y • [H006] Battery unable to charge • [H009] Battery limited lifetime		PK: Vehicle Level Functio ns FU: [F-17] Balance battery MF: [MF021] Balance s the wrong cells	& EL: AFE FM: [FM249] Undesir ed balanci ng				

							EL: AFE FM: [FM250] Partial balanci ng			
		[MF4 31] Start s bala ncing earli er than requi red		[H003] Battery limited usable capacit y		PK: Vehicle Level Functio ns FU: [F-17] Balance battery MF: [MF022] Starts balanci ng earlier than require d	€			
		[MF4 32] Stop s bala ncing earli er than requi red		• [H003] Battery limited usable capacit y • [H009] Battery limited lifetime		PK: Vehicle Level Functio ns FU: [F-17] Balance battery MF: [MF024] Stops balanci ng earlier than require d	€ EL: AFE FM: [FM250] Partial balanci ng			

		[MF433] Starts balancing later than required		[H003] Battery limited usable capacity	PK: Vehicle Level Functions FU: [F-17] Balance battery MF: [MF023] Starts balancing later than required	EL: AFE FM: [FM250] Partial balancing			
		[MF434] Stops balancing later than required		[H003] Battery limited usable capacity	PK: Vehicle Level Functions FU: [F-17] Balance battery MF: [MF025] Stops balancing later than required				

		[MF435] Balancing switch control is performed at a different or erratic frequency than specified		[H003] Battery limited usable capacity		PK: Vehicle Level Functions FU: [F-17] Balance battery MF: [MF026] Balancing switch control is performed at a different or erratic frequency than specified	EL: AFE FM: [FM317] Erratic			
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[F-57] Measure cell voltages	(none)	[MF399] Does not measure	• [H006] Battery unable to charge • [H003] Battery limited usable capacity • [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H002] Vehicle unavailable	PK: Supporting Functions FU: [F-14] Measure battery voltage MF: [MF037] Does NOT sense battery or cell voltage	EL: AFE (FM: [FM246]) Wrong cell voltage measurement				
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		[MF421] Senses / reports HIGHER voltage than actual	• [H003] Battery limited usable capacity • [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H009] Battery limited lifetime • [H007] Battery rapid discharge		PK: Supporting Functions FU: [F-14] Measure battery voltage MF: [MF038] Senses / reports HIGHER voltage than actual	& EL: AFE FM: [FM246] Wrong cell voltage measurement			
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		[MF422] Senses / reports LOWER battery voltage than actual	• [H003] Battery limited usable capacity • [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H002] Vehicle unavailable	PK: Supporting Functions FU: [F-14] Measure battery voltage MF: [MF039] Senses / reports LOWER battery voltage than actual	EL: AFE (FM: [FM246] Wrong cell voltage measurement			
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		[MF426] ERRATIC sensed / reported cell or battery voltage values	• [H003] Battery limited usable capacity • [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H002] Vehicle unavailable • [H008] Exposure to high voltage	PK: Supporting Functions FU: [F-14] Measure battery voltage MF: [MF040] ERRATIC sensed / reported cell or battery voltage values	EL: AFE (FM: [FM246] Wrong cell voltage measurement			
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							EL: AFE FM: [FM317] Erratic			
							EL: AFE FM: [FM367] Delayed cell voltage measurement			
[F-58] Measure battery temperature	(none)	[MF400] Does not measure		• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H002] Vehicle unavailable		PK: Supporting Functions FU: [F-15] Measure battery temperature MF: [MF032] Does NOT sense battery temperature	EL: AFE FM: [FM247] Wrong battery temperature measurement			

		[MF423] Senses / reports HIGHER temperature than actual	• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H002] Vehicle unavailable		PK: Supporting Functions FU: [F-15] Measure battery temperature MF: [MF033] Senses / reports HIGHER temperature than actual	& EL: AFE FM: [FM247] Wrong battery temperature measurement			
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		[MF424] Senses / reports LOWER temperature than actual	• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H002] Vehicle unavailable	PK: Supporting Functions FU: [F-15] Measure battery temperature MF: [MF034] Senses / reports LOWER temperature than actual	EL: AFE (FM: [FM247] Wrong battery temperature measurement			
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		[MF425] ERRATIC sensed / reported temperature		• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H007] Battery rapid discharge • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Supporting Functions FU: [F-15] Measure battery temperature MF: [MF036] ERRATIC sensed / reported temperature	EL: AFE FM: [FM247] Wrong battery temperature measurement			
							EL: AFE FM: [FM317] Erratic			

[F-59] Provide temperature and voltage information to master	(none)	[MF401] Does not communicate	• [H003] Battery limited usable capacity • [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H002] Vehicle unavailable • [H008] Exposure to high voltage	EL: Master Controller FU: [F-26] Detect overtemperature condition MF: [MF281] Does not detect overtemperature condition	EL: Daisy Chain Isolation : AFE FM: [FM423] Open circuit				
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					EL: Master Controller FU: [F-27] Detect undertemperature condition MF: [MF287] Does not detect undertemperature condition	EL: Daisy Chain Isolation : AFE FM: [FM421] Complete isolation breakdown			
					EL: Master Controller FU: [F-28] Detect overvoltage condition MF: [MF293] Does not detect overvoltage condition	EL: AFE FM: [FM248] Wrong CRC and/or EDC			

					EL: Master Controller FU: [F-29] Detect undervoltage condition MF: [MF299]] Does not detect	EL: AFE (FM: [FM251]] No data or no operation			
					EL: Master Controller FU: [F-30] Detect open cell connection MF: [MF305]] Does not detect	EL: (Daisy Chain Isolation : AFE FM: [FM422]] Partial isolation breakdown or degradation			
					EL: Master Controller FU: [F-23] Balance battery MF: [MF257]] Does not do balancing	EL: TPL Isolation : AFE FM: [FM415]] Complete isolation breakdown			

					EL: Master Controller FU: [F-39] Estimate battery SOH MF: [MF275]] Does not perform SOH estimation at all	4 EL: TPL Isolation : AFE FM: [FM416]] Partial isolation breakdown or degradation			
					EL: Master Controller FU: [F-37] Estimate internal resistance MF: [MF329]] Does not estimate	8 EL: TPL Isolation : AFE FM: [FM417]] Open circuit			
					EL: Master Controller FU: [F-36] Control precharge switch MF: [MF339]] Does not control	1 EL: (TPL Transceiver FM: [FM252]] No operation			

					EL: Master Controller FU: [F-35] Emergency disconnect MF: [MF325]] Does not disconnect	EL: Transceiver FM: [FM296] Erratic			
					EL: Master Controller FU: [F113] Detect overcurrent condition MF: [MF478]] Does not detect	EL: Transceiver FM: [FM318] Higher than set baud rate			
					EL: Master Controller FU: [F114] Detect short circuit condition MF: [MF479]] Does not detect	EL: Transceiver FM: [FM449] Incorrect register address access			

							EL: Isolation : TPL FM: [FM418] Complete isolation breakdown			
							EL: Isolation : TPL FM: [FM419] Partial isolation breakdown or degradation			
							EL: Isolation : TPL FM: [FM420] Open circuit			
		[MF427] Noisy communication		• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H008] Exposure to high voltage		EL: Master Controller FU: [F-27] Detect undertemperature condition MF: [MF292] Unstable or erratic detection	EL: AFE (FM: [FM317] Erratic			

					EL: Master Controller FU: [F-26] Detect overtemperature condition MF: [MF286] Unstable or erratic detection	EL: Transceiver FM: [FM296] Erratic			
					EL: Master Controller FU: [F-28] Detect overvoltage condition MF: [MF298] Unstable or erratic detection				

						EL: Master Controll er FU: [F-29] Detect underv oltage conditi on MF: [MF304] Erratic or unstabl e detecti on	1 (				
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		[MF437] Incorrect data transmitted	• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H002] Vehicle unavailable • [H008] Exposure to high voltage		EL: Master Controller FU: [F-26] Detect overtemperature condition MF: [MF282] Overtemperature detected at HIGHER than required threshold	EL: AFE (FM: [FM317]) Erratic			
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					EL: Master Controller FU: [F-26] Detect overtemperature condition MF: [MF283] Overtemperature detected at LOWER than required threshold	EL: AFE (FM: [FM247]) Wrong battery temperature measurement			
					EL: Master Controller FU: [F-27] Detect undertemperature condition MF: [MF288] Detects undertemperature at HIGHER than required threshold	EL: TPL Transceiver (FM: [FM296]) Erratic			

					EL: Master Controller FU: [F-27] Detect underte mperat ure conditi on MF: [MF289] Detects underte mperat ure at LOWER than require d thresho ld	1				
					EL: Master Controller FU: [F-28] Detect overvol tage conditi on MF: [MF294] Detects at HIGHE R than require d thresho ld	1				

					EL: Master Controller FU: [F-28] Detect overvol tage conditi on MF: [MF295] Detects at LOWER than require d thresho ld	8				
					EL: Master Controller FU: [F-29] Detect underv oltage conditi on MF: [MF300] Detects at HIGHE R than require d thresho ld	8				

						EL: Master Controller FU: [F-29] Detect undervoltage condition MF: [MF301] Detects at LOWER than required threshold				
		[MF439] Delayed or outdated data provided					EL: AFE FM: [FM317] Erratic			
							EL: AFE FM: [FM367] Delayed cell voltage measurement			
							EL: AFE FM: [FM368] Delayed analog measurements			

							EL: TPL Transceiver FM: [FM296]] Erratic			
[F-60] Provide fault information to master	(none)	[MF402] Does not communicate		• [H001] Battery gases / smoke / thermal runaway • [H002] Vehicle unavailable • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF001]] NO disconnection when required	EL: Daisy Chain Isolation : AFE FM: [FM423]] Open circuit			
							EL: Daisy Chain Isolation : AFE FM: [FM421]] Complete isolation breakdown			
							EL: AFE FM: [FM248]] Wrong CRC and/or EDC			

							EL: AFE FM: [FM251]] No data or no operati on			
							EL: Daisy Chain Isolatio n : AFE FM: [FM422]] Partial isolatio n breakd own or degrad ation			
							EL: TPL Isolatio n : AFE FM: [FM415]] Comple te isolatio n breakd own			
							EL: TPL Isolatio n : AFE FM: [FM416]] Partial isolatio n breakd own or degrad ation			

							EL: TPL Isolation : AFE FM: [FM417]] Open circuit			
							EL: TPL Transceiver FM: [FM252]] No operation			
							EL: TPL Transceiver FM: [FM296]] Erratic			
							EL: TPL Transceiver FM: [FM318]] Higher than set baud rate			
							EL: TPL Transceiver FM: [FM449]] Incorrect register address access			

							EL: Isolation : TPL FM: [FM418] Complete isolation breakdown			
							EL: Isolation : TPL FM: [FM419] Partial isolation breakdown or degradation			
							EL: Isolation : TPL FM: [FM420] Open circuit			
		[MF436] Noisy communication					EL: AFE FM: [FM317] Erratic			
							EL: TPL Transceiver FM: [FM296] Erratic			

		[MF438] Incorrect data transmitted		• [H006] Battery unable to charge • [H005] Battery suddenly unable to discharge / sudden loss of power • [H008] Exposure to high voltage		PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF135] UNINTENDED disconnection	EL: AFE FM: [FM317] Erratic			
							EL: AFE FM: [FM247] Wrong battery temperature measurement			
							EL: TPL Transceiver FM: [FM296] Erratic			
		[MF440] Delayed or outdated data provided					EL: AFE FM: [FM317] Erratic			

							EL: AFE FM: [FM367] Delayed cell voltage measurement			
							EL: AFE FM: [FM368] Delayed analog measurements			
							EL: TPL Transceiver FM: [FM296] Erratic			
Power Supply										
[F-43] Supply power for low voltage analog systems	(none)	[MF4 41] Does not supply power		[H002] Vehicle unavailable	BMS non functional	EL: BMS FM: [FM236] BMS non- functional	8			

		[MF445] Provides higher than required voltage		[H002] Vehicle unavailable	Might cause damage to downstream components unless there is voltage protection	EL: BMS FM: [FM237] BMS damaged	8				
		[MF446] Provides less than required voltage		[H002] Vehicle unavailable	Contactor actuation might be improper, loss of internal communication, erratic behaviour suspected on all controllers	EL: BMS FM: [FM236] BMS non-functional	8				

		[MF47] Provides lower than required current	Will cause voltage dip	• [H006] Battery unable to charge • [H003] Battery limited usable capacity • [H005] Battery suddenly unable to discharge / sudden loss of power • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H002] Vehicle unavailable	Improper controller actuation, delays in actuation, erratic behaviour, controller resetting	EL: BMS FM: [FM236] BMS non-functional	8				
						EL: BMS FM: [FM238] Resetting or erratic	8				

						EL: BMS FM: [FM239] Internal data loss or corruption	8				
		[MF448] Noisy or erratic power supply		• [H006] Battery unable to charge • [H003] Battery limited usable capacity • [H005] Battery suddenly unable to discharge / sudden loss of power • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H002] Vehicle unavailable	Erratic internal communication, controller resetting, memory corruption, contactor weld	EL: BMS FM: [FM238] Resetting or erratic	8				

					EL: BMS FM: [FM236] BMS non- functio nal	8				
					EL: BMS FM: [FM239] Intern al data loss or corrupti on	8				

		[MF452] Insufficient load regulation	Will cause voltage dip	• [H006] Battery unable to charge • [H003] Battery limited usable capacity • [H005] Battery suddenly unable to discharge / sudden loss of power • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H002] Vehicle unavailable	Erratic internal communication, controller resetting, memory corruption, contactor weld	EL: BMS FM: [FM236] BMS non-functional	8				
						EL: BMS FM: [FM238] Resetting or erratic	8				

						EL: BMS FM: [FM239] Internal data loss or corruption	8				
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[F-44] Monitor input power quality	(none)	[MF442] Does not perform quality monitoring	These failures are only applicable in case where both, input AND output quality monitoring fail	• [H006] Battery unable to charge • [H003] Battery limited usable capacity • [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H008] Exposure to high voltage • [H002] Vehicle unavailable	Unexpected / sudden power outs, memory corruption, contactor weld	EL: BMS FM: [FM238] Resetting or erratic	8					
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						EL: BMS FM: [FM239] Internal data loss or corruption	8				
						EL: Master Controller FM: [FM240] Flash memory corruption	8				
						EL: MOSFETs FM: [FM071] Failed in short	10				

		[MF49] False diagnosis of input power quality	These failures are only applicable in case where both, input AND output quality monitoring fail	• [H006] Battery unable to charge • [H003] Battery limited usable capacity • [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H008] Exposure to high voltage • [H002] Vehicle unavailable	Unexpected / sudden power outs, controller weld, delayed protection	EL: BMS FM: [FM238] Resetting or erratic	8				
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					EL: BMS FM: [FM239] Internal data loss or corruption	8				
					EL: MOSFETs FM: [FM071] Failed in short	10				
					EL: Master Controller FM: [FM240] Flash memory corruption	8				
		[MF450] Delayed detection of poor input power quality	These failures are only applicable in case where both, input AND output quality monitoring fail		Unexpected / sudden power outs, memory corruption. But there is no timing safety requirement					

		[MF4 53] Erratic or unstable or false detection	These failures are only applicable in case where both, input AND output quality monitoring fail		Unexpected / sudden power outs, memory corruption					
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[F-45] Monitor output power quality	(none)	[MF443] Does not perform quality monitoring	• [H006] Battery unable to charge • [H003] Battery limited usable capacity • [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H008] Exposure to high voltage • [H002] Vehicle unavailable	Unexpected / sudden power outs, memory corruption	EL: BMS FM: [FM238] Resetting or erratic	8				
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						EL: MOSFE Ts FM: [FM071] Failed in short	1 0				
						EL: MOSFE Ts FM: [FM073] Does not actuate	1 0				
						EL: Master Controll er FM: [FM240] Flash memor y corrupti on	8				

		[MF451] False diagnosis of output power quality	• [H006] Battery unable to charge • [H003] Battery limited usable capacity • [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H008] Exposure to high voltage • [H002] Vehicle unavailable	Unexpected / sudden power outs	EL: BMS FM: [FM238] Resetting or erratic	8				
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					EL: BMS FM: [FM239] Internal data loss or corruption	8				
					EL: Master Controller FM: [FM240] Flash memory corruption	8				
					EL: MOSFETs FM: [FM071] Failed in short	10				
		[MF454] Erratic or unstable detection			Unexpected / sudden power outs, memory corruption					

[F-46] Perform external watch dog function for controller	(none)	[MF44] Does not perform watchdog control		• [[F-18] Send / receive data via CAN] [MF014] Provide information at a lower frequency than required • [H006] Battery unable to charge • [H003] Battery limited usable capacity • [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H009] Battery	BMS non-functional, no communication, no response to external commands	PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF001] NO disconnection when required	1				
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				limited lifetime • [H002] Vehicle unavailable • [H008] Exposure to high voltage						
					PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF002] DELAY in disconnection	1				
					PK: Vehicle Level Functions FU: [F-19] Battery connection / disconnection on request MF: [MF243] Does not connect battery on request	8				

					PK: Vehicle Level Function FU: [F-19] Battery connection / disconnection on request MF: [MF245] DELAY in connection or disconnection	1 0				
					PK: Vehicle Level Function FU: [F-18] Send / receive data via CAN MF: [MF012] Does not relay battery information to the vehicle	8				

					PK: Vehicle Level Functions FU: [F-18] Send / receive data via CAN MF: [MF014] Provide s informa tion at a lower frequen cy than require d	-				
					PK: Vehicle Level Functions FU: [F-17] Balance battery MF: [MF018]] Does not do battery balanci ng	8				

		[MF455] Premature watchdog trigger	• [H006] Battery unable to charge • [H003] Battery limited usable capacity • [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H008] Exposure to high voltage • [H002] Vehicle unavailable	BMS reset, memory corruption, contactor weld	EL: BMS FM: [FM238] Resetting or erratic	8				
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					EL: Master Controller FM: [FM240] Flash memory corruption	8				
					EL: MOSFETs FM: [FM071] Failed in short	1				
		[MF456] Delayed watchdog trigger		• [H006] Battery unable to charge • [H001] Battery gases / smoke / thermal runaway • [H002] Vehicle unavailable • [H008] Exposure to high voltage	PK: Vehicle Level Functions FU: [F-20] Emergency Disconnect MF: [MF002] DELAY in disconnection	1				

					PK: Vehicle Level Function FU: [F-19] Battery connection / disconnection on request MF: [MF243] Does not connect battery on request	8				
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		[MF457] Erratic or unstable watchdog trigger	• [H006] Battery unable to charge • [[F-4] Notify user about critical fault conditions] [MF117] Unstable alarm detection and/or trigger • [H001] Battery gases / smoke / thermal runaway • [[F-38] Estimate insulation resistance] [MF337] Estimates at incorrect time / frequency • [H009] Battery limited lifetime • [[F-3]	Erratic internal communication, controller resetting, memory corruption, contactor weld	EL: BMS FM: [FM238] Resetting or erratic	8				
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				Communicate with charger] [MF126] Delay in charger authentication • [H007] Battery rapid discharge • [H008] Exposure to high voltage • [H002] Vehicle unavailable • [[F-18] Send / receive data via CAN] [MF013] Provides information at a higher frequency than required • [[F-18] Send / receive data via CAN] [MF014						
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				] Provide s informa tion at a lower frequen cy than require d • [H003] Battery limited usable capacit y • [[F-2] Wakeu p BMS on externa l comma nd] [MF249] Erratic behavio ur or wakeup • [H005] Battery suddenl y unable to dischar ge / sudden loss of power • [[F-38] Estimat e insulati on resista nce] [MF334] Does not							
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				estimate • [[F-36] Control precharge switch] [MF341] Delayed open / close of precharge switch						
					EL: Master Controller FM: [FM214] ERRATIC or continuously resetting	1				
					EL: Master Controller FM: [FM240] Flash memory corruption	8				
					EL: MOSFETs FM: [FM071] Failed in short	1				

		[MF458] Unintended watchdog trigger	• [H006] Battery unable to charge • [H003] Battery limited usable capacity • [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H008] Exposure to high voltage • [H002] Vehicle unavailable	Erratic internal communication, controller resetting, memory corruption, contactor weld	EL: BMS FM: [FM238] Resetting or erratic	8				
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					EL: BMS FM: [FM239] Internal data loss or corruption	8				
					EL: Master Controller FM: [FM240] Flash memory corruption	8				
					EL: MOSFETs FM: [FM071] Failed in short	10				
[F-61] Provide power supply quality information to Master	(none)	[MF459] Does not communicate			Unexpected / sudden power outs, memory corruption, contactor weld					

		[MF4 60] Nois y com muni catio n			Unex pect ed / sudd en powe r outs, mem ory corru ption , cont actor weld					
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		[MF461] Delayed information relay to master	• [H006] Battery unable to charge • [H003] Battery limited usable capacity • [H005] Battery suddenly unable to discharge / sudden loss of power • [H001] Battery gases / smoke / thermal runaway • [H009] Battery limited lifetime • [H007] Battery rapid discharge • [H008] Exposure to high voltage • [H002] Vehicle unavailable	Unexpected / sudden power outs, memory corruption, contactor weld	EL: Master Controller FM: [FM240] Flash memory corruption	8				
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						EL: MOSFE Ts FM: [FM071] Failed in short	1 (				
						EL: BMS FM: [FM238] Resetti ng or erratic	8				
		[MF4 92] Incor rect infor mati on			No safet y impa ct		EL: SBC FM: [FM311] Wrong CRC and/or EDC				