Sendyne®

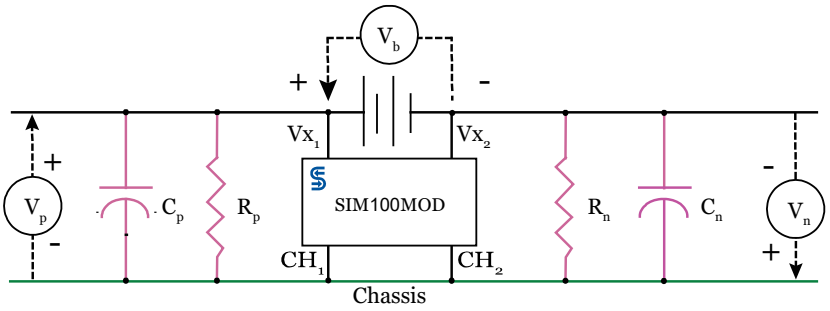
SIM100 CAN Protocol Reference Manual

VERSION: 0.8A

Sendyne SIM100 CAN Protocol Implementation

Features

- CAN 2.0B extended frame format
- 500 kbit/s or 250 kbit/s



SIM100 isolation monitoring reference diagram

General message format

The Sendyne SIM100 communicates with the host system through a command-response protocol. Communications are initiated by the host issuing a message with extended ID 0xA100101, followed by a one byte multiplexor (`Request_mux`) indicating the type of operation (read, write or command) to be performed. Depending on the type of operation either more or no data may follow as shown in the following table.

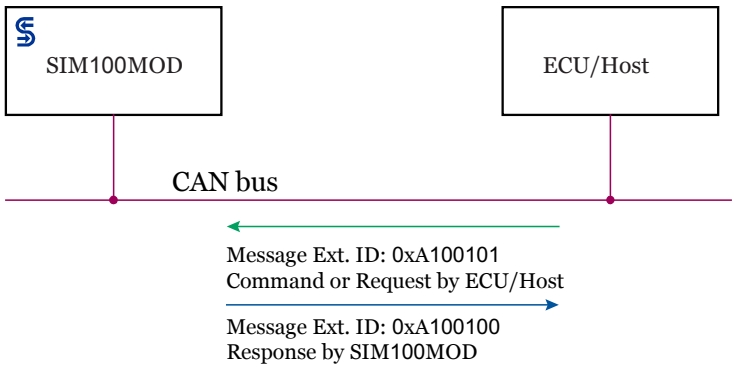
Request from Host:

Ext. ID	byte 0	byte 1	byte 2
0xA100101	`Request_mux`		

If the multiplexor value `Request_mux` specifies a request for reading a signal, the SIM100 will respond with Ext. ID 0xA100100 followed by a multiplexor byte `OpCode_mux` with the same value as the multiplexor of the request message and any data pertinent to the transaction. If the value of `Request_mux` specifies a command the SIM100 will execute the command.

SIM100 response:

Ext. ID	byte 0	byte 1	byte 2
0xA100100	`OpCode_mux`		



Data types

SIM100 data can have the length of a bit, byte, 2-bytes or 4-bytes depending on the content of the transaction. The data types can be a flag, an ASCII character, a signed or an unsigned integer; they are documented in each signal description.

Signals and Signal Groups

Data communicated in messages are defined as signals. A signal can be a flag, ASCII characters, a signed or an unsigned integer. They are defined in the signal section of this document. Signal groups consist of a collection of signals defined in the signal groups section of this document. Signals and signal group names are represented with a blue Courier font in this document.

Byte ordering

In case of multi-byte data the order of bytes within each message is specified in signal definition as a big endian (Motorola) or little endian (Intel).

Big endian (MOTOROLA) data bytes order

byte n	byte n+1	byte n+2	byte n+3
MSB	Data	Data	LSB

Little endian (INTEL) data bytes order

byte n	byte n+1	byte n+2	byte n+3
LSB	Data	Data	MSB

Host message multiplexor

In a host originating message byte 0 is the multiplexor specifying the type of operation (read, write or command).

Requests from the host to the SIM100

Ext. ID	byte 0	byte 1	byte 2
0xA100101	`Request_mux`	Data	Data

Host request multiplexor values

The following table lists the valid `Request_mux` values:

`SIM100_Request_mux`

Value	*Name*	*Data bytes*	*Description*
Manufacturer's data requests			
0x01	Request Part name 0	None	Request signal `Part_name_0`
0x02	Request Part name 1	None	Request signal `Part_name_1`
0x03	Request Part name 2	None	Request signal `Part_name_2`
0x04	Request Part name 3	None	Request signal `Part_name_3`
0x05	Request Version 0	None	Request signal `Version_0`
0x06	Request Version 1	None	Request signal `Version_1`
0x07	Request Version 2	None	Request signal `Version_2`
0x08	Request Serial number 0	None	Request signal `Serial_number_0`
0x09	Request Serial number 1	None	Request signal `Serial_number_1`
0x0A	Request Serial number 2	None	Request signal `Serial_number_2`
0x0B	Request Serial number 3	None	Request signal `Serial_number_3`
SIM100 state control commands			
0x62	Turn excitation pulse off	4	SIM100 shall turn off excitation voltage pulse
0xC1	Restart SIM100	4	SIM100 shall restart
0xF0	Set max battery design voltage	2	SIM100 will set max battery design voltage
Data reporting requests			
0x60	Request Vn high resolution	None	Request signal `Vn_hi_res`
0x61	Request Vp high resolution	None	Request signal `Vp_hi_res`
0x80	Request Temperature	None	Request signal `Temperature`
0xE0	Request Isolation state	None	Request signal group ≈`isolation_state`
0xE1	Request Isolation resistances	None	Request signal group ≈`isolation_resistances`
0xE2	Request Isolation capacitances	None	Request signal group ≈`isolation_capacitances`
0xE3	Request Voltages *V*p and *V*n	None	Request signal group ≈`voltages_Vp_and_Vn`
0xE4	Request Battery voltage *V*b	None	Request signal group ≈`battery_voltage`
0xE5	Request Error flags	None	Request signal group ≈`Error_flags`

SIM100 response multiplexor values

A message from SIM100 is always transmitted as a response to a message from the host. Byte 0 of SIM100 messages is the `OpCode_mux` multiplexor of the message. Its value is the same value as the host's message multiplexor.

Responses from SIM100 to host

Ext. ID	byte 0	byte 1	byte 2
0xA100100	`OpCode_mux`	Data	Data

The following table lists the valid `OpCode_mux` values in SIM100 responses. Signals preceded with a double tilde (`≈`) symbol represent signal groups (a collection of signals) which are defined later in this document.

`OpCode_mux`

Value	*Name*	*Data bytes*	*Signals (`~`) and signal groups (`≈`)*
Manufacturer's data			
0x01	Part name 0	4	`~Part_name_0`
0x02	Part name 1	4	`~Part_name_1`
0x03	Part name 2	4	`~Part_name_2`
0x04	Part name 3	4	`~Part_name_3`
0x05	Version 0	4	`~Version_0`
0x06	Version 1	4	`~Version_1`
0x07	Version 2	4	`~Version_2`
0x08	Serial number 0	4	`~Serial_number_0`
0x09	Serial number 1	4	`~Serial_number_1`
0x0A	Serial number 2	4	`~Serial_number_2`
0x0B	Serial number 3	4	`~Serial_number_3`
Environmental			
0x80	Temperature	4	`~Temperature`
Isolation state			
0x60	Vn high resolution	4	`~Vn_hi_res`
0x61	Vp high resolution	4	`~Vp_hi_res`
0xE0	Isolation state	7	`≈Status_bits + ≈isolation_state`
0xE1	Isolation resistances	7	`≈Status_bits + ≈isolation_resistances`
0xE2	Isolation capacitances	7	`≈Status_bits + ≈isolation_capacitances`
0xE3	Voltages Vp and Vn	7	`≈Status_bits + ≈voltages_Vp_and_Vn`
0xE4	Battery voltage Vb	7	`≈Status_bits + ≈battery_voltage`
0xE5	Error flags	2	`≈Status_bits + ≈Error_flags`
0xF0	Max battery design voltage	2	`~Max_battery_working_voltage`

SIM100 signals

The following table defines the available signals of SIM100.

SIM100 signals

Signal Name	*Length [Bits]*	*Byte Order*	*Value Type*	*Unit*	*Value Table*	*Comment*
Cn	16	M	U	nF	-	Estimated value of capacitances Cn.
Cn_uncertainty	8	M	U	%	-	Cn estimate uncertainty expressed in %
Cp	16	M	U	nF	-	Estimated values of capacitance Cp.
Cp_uncertainty	8	M	U	%	-	Cp estimate uncertainty expressed in %
Electrical_isolation	16	M	U	Ω/V	-	Minimum resistance per Volt isolation path between the IT system and the chassis. The value is calculated based on the battery's Vb_max Voltage.
Electrical_isolation_uncertainty	8	M	U	%	-	Electrical isolation uncertainty expressed in %
Energy_stored	16	M	U	mJ	-	This is the maximum energy that can be stored in the Y capacitors between the battery and chassis at the maximum working voltage.
Energy_stored_uncertainty	8	M	U	%	-	Energy stored uncertainty expressed in %
Err_CH	1	-	B		-	0 - CH1 and CH2 (chassis) connections are good 1 - Connection to chassis broken.
Err_Vexi	1	-	B		-	0 - Excitation voltage level is correct 1 – Excitation voltage level out of range
Err_Vpwr	1	-	B		-	0 - Power supply level is good 1 – Power supply level out of range
Err_Vx1	1	-	B		-	0 - VX1 connection is good (SIM100 to battery positive terminal connection) 1 – VX1 connection broken
Err_Vx2	1	-	B		-	0 - VX2 connection is good (SIM100 to battery negative terminal connection) 1 – VX2 connection broken
Err_VxR	1	-	B		-	0 - VX1 and VX2 connections are correct 1 – VX1 and VX2 connections are reversed
Excitation_pulse_off	32	M	U		*	Sending data 0xDEADBE1F with SIM_Request_mux = 0x62 disables the excitation pulse of the SIM100. In order to re-enable it a Restart message has to be sent.
Hardware_Error	1	-	B		-	0 – No hardware error 1 – A hardware error was detected
High_Battery_Voltage	1	-	B		-	0 – Observed battery voltage is less than the programmed Max_battery_working_voltage value 1 – Observed battery voltage is higher than Max_battery_working_voltage
High_Uncertaintly	1	-	B		-	0 – Uncertainty of calculated values is less than 5% 1 – Uncertainty is higher than 5%

Signal Name	*Length [Bits]*	*Byte Order*	*Value Type*	*Unit*	*Value Table*	*Comment*
Isolation_status_bits	2	-	B		-	00 – Isolation status OK 10 – Warning 11 - Fault
Low_Battery_Voltage	1	-	B		-	0 – Observed battery voltage higher than 15 V 1 – Observed battery voltage less than 15 V
Max_battery_working_voltage	16	M	U	V	-	Maximum battery operating voltage (in Volts) written to Vb_max
No_New_Estimates	1	M	U		-	0 – The flag is zero when new and unread isolation values have been calculated 1 – No new estimates
Part_name0	32	I	A		-	The first ASCII characters of part name 1/4
Part_name_1	32	I	A		-	ASCII representation of part name 2/4
Part_name_2	32	I	A		-	ASCII representation of part name 3/4
Part_name_3	32	I	A		-	ASCII representation of part name 4/4
Restart	32	M	U		*	Signal to restart the operation of SIM100. Use data value 0x1234567.
Rn	16	M	U	kΩ	-	Estimate of total resistance between negative rail and chassis
Rn_uncertainty	8	M	U	%	-	Rn estimate uncertainty in %
Rp	16	M	U	kΩ	-	Estimate of total resistance between positive rail and chassis
Rp_uncertainty	8	M	U	%	-	Rp estimate uncertainty
Serial_number_0	32	I	U		-	Unit serial number, 1/4
Serial_number_1	32	I	U		-	Unit serial number, 2/4
Serial_number_2	32	I	U		-	Unit serial number, 3/4
Serial_number_3	32	I	U		-	Unit serial number, 4/4
Temperature	32	M	S	m°C	-	Temperature in milli Celsius
Vb	16	M	U	V	-	Reports voltage of the monitored IT power system. The reported value is averaged and updated every100 ms.
Vb_max	16	M	U	V	-	Maximum value of IT power supply voltage. It is the maximum between Max_battery_voltage and the maximum actual value recorded by SIM100MOD.
Vb_max_uncertainty	8	M	U	%	-	Vb_max uncertainty in % (if Vb_max is the recorded value)
Vb_uncertainty	8	M	U	%	-	Vb uncertainty in %
Version_0	32	I	A		-	The first 4 ASCII characters of SW version, 1/3
Version_1	32	I	A		-	SW version, 2/3
Version_2	32	I	A		-	SW version, 3/3
Vn	16	M	S	V	-	Potential between negative IT system power rail and chassis. Dynamic value includes excitation voltage effect.
Vn_uncertainty	8	M	S	%	-	Vn uncertainty in %
Vn_hi_res	32	M	S	µV		Potential between negative IT system power rail and chassis. It is averaged over 1 s and updated every 500 ms. Dynamic value includes excitation voltage effect.

Signal Name	*Length [Bits]*	*Byte Order*	*Value Type*	*Unit*	*Value Table*	*Comment*
Vp	16	M	S	V	-	Potential between positive IT system power rail and chassis. Dynamic value includes excitation voltage effect.
Vp_uncertainty	8	M	S	%	-	Vp uncertainty in %
Vp_hi_res	32	M	S	µV		Potential between positive IT system power rail and chassis. It is averaged over 1 s and updated every 500 ms. Dynamic value includes excitation voltage effect.

U – unsigned integer
S – signed integer
B – Boolean
A – ASCII
M – Motorola byte order (big endian)
I – Intel byte order (little endian)
* - indicates that a value table (data) is associated with the signal

SIM100 signal groups

Status_bits

The Status_bits byte is a collection of signal bits that provides concentrated information for the state of the isolation system as well as of the proper operation of SIM100. The Status_bits signal group forms the first data byte in the following message reports of the SIM100:

OpCode_mux	Report
0xE0	Isolation state
0xE1	Isolation resistances
0xE2	Isolation capacitances
0xE3	Voltages Vp and Vn
0xE4	Battery voltage Vb
0xE5	Error flags

The layout of the signal bits within the Status_bits signal group is shown below:

≈Status_bits

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
HE	NE	HU	-	HV	LV	IS1	IS0

Status bits

bit	*Symbol*	*Signal*	*Description*
7	HE	Hardware_Error	0 – No hardware error 1 – Hardware error. The host should perform a "Read SIM100 Error Flags" operation in order to resolve the issue
6	NE	No_New_Estimates	0 – The flag is zero when new and unread isolation values have been calculated. 1 – Isolation values have not been updated since the last read. This may happen when a host requests to read isolation values while the SIM100 is in the middle of a calculation. In this case the SIM100 will return the most recent calculated values.
5	HU	High_Uncertainty	0 – Uncertainty of calculated values is less than 5% 1 – Uncertainty values are higher than 5%. The uncertainty values always accompany reported data.
4	-	Undefined	Reserved for future use; this bit always has a value of zero
3	HV	High_Battery_Voltage	0 – Observed battery voltage is less than the specified Max_battery_working_voltage. 1 – The observed battery voltage value is higher than the specified Max_battery_working_voltage value. The flag will be set if the Max_battery_working_voltage register has not been set, or if the set value is less than the maximum observed battery voltage value. If this flag is set, isolation resistance and stored energy will be calculated based on the maximum observed battery voltage.
2	LV	Low_Battery_Voltage	0 – Observed battery voltage higher than 15 V 1 – Observed battery voltage less than 15 V. This flag is also set when battery is disconnected.
1-0	IS1-IS0	Isolation_status_bits	00 – Isolation status OK 10 – Warning. Isolation resistance < 500 Ohm/V limit. 11– Isolation fault. Isolation resistance <100 Ohm/V limit.

The following signal groups are defined and used in SIM100 messages

Isolation state

≈isolation_state

Start byte	*Signal*
2	Electrical_isolation
4	Electrical_isolation_uncertainty
5	Energy_stored
7	Energy_stored_uncertainty

Isolation resistances

≈isolation_resistances

Start byte	*Signal*
2	Rp
4	Rp_uncertainty
5	Rn
7	Rn_uncertainty

Isolation capacitances

≈isolation_capacitances

Start byte	*Signal*
2	Cp
4	Cp_uncertainty
5	Cn
7	Cn_uncertainty

Voltages Vp and Vn

≈voltages_Vp_and_Vn

Start byte	*Signal*
2	Vp
4	Vp_uncertainty
5	Vn
7	Vn_uncertainty

Battery voltage

≈battery_voltage

Start byte	*Signal*
2	Vb
4	Vb_uncertainty
5	Vb_max
7	Vb_max_uncertainty

Error flags

The Error_flags byte is a collection of one bit signals which are updated during the continuous self-checking of SIM100. If any of these flags is set, the signal bit Hardware_error in the Status_bits will be set.

≈Error_flags

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
Err_Vx2	Err_Vx1	Err_CH	Err_VxR	Err_Vexi	Err_Vpwr	-	-

Error flags

Bit	*Symbol*	*Signal*	*Description*
7	V_{X2}	Err_Vx2	0 – V_{X2} connection is good (SIM100 to battery negative terminal) 1 – V_{X2} connection is broken
6	V_{X1}	Err_Vx1	0 – V_{X1} connection is good (SIM100 to battery positive terminal) 1 – V_{X1} connection is broken
5	CH	Err_CH	0 – CH_1 and CH_2 connections are good (chassis connections) 1 – CH_1 or CH_2 connection is broken
4	VxR	Err_VxR	0 – V_{X1} and V_{X2} connection are correct 1 – V_{X1} and V_{X2} connection are reversed
3	V_{EXI}	Err_Vexi	0 – Excitation voltage level is correct 1 – Excitation voltage level is out of specs
2	V_{PWR}	Err_Vpwr	0 – Power supply level is good 1 – Power supply level is out of range
1-0		Not used	Reserved

Messages

Data requests from host to SIM100

This group consists of single byte messages issued by the host in order to poll the SIM100 for data. The SIM100 will respond to each one of these requests by sending a multiplexed message with the same multiplexor value as the multiplexor of the request followed by the signal group data requested.

Ext. ID	byte 0
0xA100101	Request_mux

SIM100_Request_mux

Value	*Name*	*Data bytes*	*Description*
Manufacturer's data requests			
0x01	Request Part name 0	None	Request signal Part_name_0
0x02	Request Part name 1	None	Request signal Part_name_1
0x03	Request Part name 2	None	Request signal Part_name_2
0x04	Request Part name 3	None	Request signal Part_name_3
0x05	Request Version 0	None	Request signal Version_0
0x06	Request Version 1	None	Request signal Version_1
0x07	Request Version 2	None	Request signal Version_2
0x08	Request Serial number 0	None	Request signal Serial_number_0
0x09	Request Serial number 1	None	Request signal Serial_number_1
0x0A	Request Serial number 2	None	Request signal Serial_number_2
0x0B	Request Serial number 3	None	Request signal Serial_number_3
Data reporting requests			
0x60	Request Vn high resolution	None	Request signal Vn_hi_res
0x61	Request Vp high resolution	None	Request signal Vp_hi_res
0x80	Request Temperature	None	Request signal Temperature
0xE0	Request Isolation state	None	SIM100 will report "Isolation state"
0xE1	Request Isolation resistances	None	SIM100 will report "Isolation resistances"
0xE2	Request Isolation capacitances	None	SIM100 will report "Isolation capacitances"
0xE3	Request Voltages *V*p and *V*n	None	SIM100 will report "Voltage *V*p and *V*n"
0xE4	Request Battery voltage *V*b	None	SIM100 will report "Battery Voltage"
0xE5	Request Error flags	None	SIM100 will report "Error flags"

Manufacturer's data requests

Request part name

SIM100 part name consists of 16 ASCII characters. The host can retrieve the part name through four message transactions. Each of the four `Part_name_N` signals is 32 bits (4 characters) arranged in Intel byte order.

Request_mux	*Name*	*Data bytes*	*Description*
0x01	Request Part name 0	None	Request signal `Part_name_0`
0x02	Request Part name 1	None	Request signal `Part_name_1`
0x03	Request Part name 2	None	Request signal `Part_name_2`
0x04	Request Part name 3	None	Request signal `Part_name_3`

Request from host:

Ext. ID	`Request_mux`
0xA100101	`0x0N`

Where N can be 1, 2, 3 or 4

Response from SIM100:

Ext. ID	`OpCode_mux`	byte 1-4
0xA100101	`0x0N`	`Part_name_(N-1)`

Where N can be 1, 2, 3 or 4

The SIM100 part name can be formed by concatenating the four signals

SIM100 Part Name			
`Part_name_3`	`Part_name_2`	`Part_name_1`	`Part_name_0`

Request firmware version number

SIM100 version number consists of 12 ASCII characters. The host can retrieve the version number through three message transactions. Each of the three `Version_N` signals is 32 bits (4 characters) arranged in Intel byte order.

Request_mux	*Name*	*Data bytes*	*Description*
0x05	Request version 0	None	Request signal `Version_0`
0x06	Request version 1	None	Request signal `Version_1`

0x07	Request version 2	None	Request signal `Version_2`

Request rom host:

Ext. ID	`Request_mux`
0xA100101	`0x0N`

Where N can be 5,6, or 7

Response from SIM100:

Ext. ID	`OpCode_mux`	byte 1-3
0xA100100	`0x0N`	`Version_(N-5)`

Where N can be 5,6, or 7

The SIM100 firmware version can be formed by concatenating the three signals

SIM100 Version		
`Version _0`	`Version _1`	`Version_2`

Request serial number

Serial number is unique for every SIM100 MCUs and consists of 128 bits. The host can retrieve the serial number through four message transactions. Each of the four `Serial_number_N` signals is 32 bits arranged in Intel byte order.

Request_mux	*Name*	*Data bytes*	*Description*
0x08	Request Serial number 0	None	Request signal `Serial_number_0`
0x09	Request Serial number 1	None	Request signal `Serial_number_1`
0x0A	Request Serial number 2	None	Request signal `Serial_number_2`
0x0B	Request Serial number 3	None	Request signal `Serial_number_3`

Request rom host:

Ext. ID	`Request_mux`
0xA100101	`0x0N`

Where N can be 8, 9, A or B

Response from SIM100:

Ext. ID	OpCode_mux	byte 1-4
0xA100100	0x0N	Serial_number_(N-8)

Where N can be 8, 9, A or B

The SIM100 serial number can be formed by concatenating the four signals as follows:

SIM100 Serial number			
Serial_number_3	Serial_number_2	Serial_number_1	Serial_number_0

Data reporting requests

Request temperature

SIM100MOD monitors environmental temperature and can communicate it to the host through the Temperature 32 bit signed integer signal (mCelsius units). The Temperature signal byte order is Motorola (Big endian).

To read Temperature the host sends:

Request from host:

Ext. ID	Request_mux
0xA100101	0x80

SIM100 response:

Ext. ID	OpCode_mux	byte 1-4
0xA100100	0x80	Temperature

Request isolation state

The “Request isolation state” and its response is intended to provide in a single message an overview of the safety state of the isolation system. The “Request isolation state” message of the host is as follows:

Request from Host:

Ext. ID	Request_mux
0xA100101	0xE0

On “Request isolation state” the SIM100 will respond with a message composed of two “signal groups”, the ≈Status_bits and ≈isolation_state.

Response from SIM100:

Ext. ID	OpCode_mux	byte 1	bytes 2-7
0xA100100	0xE0	≈Status_bits	≈isolation_state

The ≈Status_bits signal group is a collection of flags described in the “SIM100 signal groups” section of this document. They provide information on whether a warning or fault condition has occurred, on the success or failure of SIM100’s self-check, as well as other information related to the quality of the estimates and the voltage conditions of the IT system and should be checked in each communication in order to validate the estimates provided.

The ≈isolation_state signal group provides the following information:

Signal	*Byte#*	*Units*	*Description*
Electrical_isolation	2-3	Ω/V	This value corresponds to the *minimum* resistance path between the positive or negative rail and chassis. It is calculated as: min(Rp, Rn)/Vb_max, where min(Rp, Rn) is the minimum isolation resistance between the positive or negative rail and chassis. If the “warning” or “fault” Isolation_status_bits are set the host should check the ≈isolation_resistances signal group for the presence of a hazardous symmetrical fault.
Electrical_isolation_uncertainty	4	%	Uncertainty of Electrical_isolation estimate
Energy_stored	5-6	mJ	Maximum stored energy at Vb_max in mJ. Energy_stored is calculated as: 0.5 * (Cp+Cn) * Vb_max^2
Energy_stored_uncertainty	7	%	Uncertainty of Energy_stored estimate

Request isolation resistances

The “Request isolation resistances” and its response is intended to provide individual estimates for the isolation resistance values between the positive and negative power rails and the chassis. Besides cross-checking these estimates against pre-programmed fault values, in case of a warning or fault condition, by checking these values the host can determine if there is a symmetrical fault. A symmetrical fault can lead to high temperatures and power loss and unlike single faults is not controllable. The “Request isolation resistances” format is as follows:

Request from host:

Ext. ID	Request_mux
0xA100101	0xE1

On “Request isolation resistances” the SIM100 will respond with a message composed of two “signal groups”, the **≈Status_bits** and **≈isolation_resistances**.

Response from SIM100:

Ext. ID	OpCode_mux	byte 1	Byte 2-7
0xA100100	0xE1	≈Status_bits	≈isolation_resistances

The **≈Status_bits** signal group is a collection of flags described in the “SIM100 signal groups” section of this document and as with any isolation state related message they should be checked to validate the estimates, the condition of the SIM100 and the presence of any warnings or alerts.

The **≈isolation_resistances** signal group provides the following information:

Signal	*Byte#*	*Units*	*Description*
Rp	2-3	kΩ	Estimate for the total resistance between the positive power rail and chassis
Rp_uncertainty	4	%	Uncertainty of Rp estimate
Rn	5-6	kΩ	Estimate for the total resistance between the negative power rail and chassis
Rn_uncertainty	7	%	Uncertainty of Rn estimate

Request isolation capacitances

The “Request isolation capacitances” message and the SIM100 response is intended to provide individual estimates for the isolation capacitance values between the positive and negative power rails and the chassis. SIM100 utilizes these values to calculate potentially hazardous energy stored. The “Request isolation capacitances” format is as follows:

Request from host:

Ext. ID	Request_mux
0xA100101	0xE2

On “Request isolation capacitances” the SIM100 will respond with a message composed of two “signal groups”, the **≈Status_bits** and **≈isolation_capacitances**.

SIM100 response:

Ext. ID	OpCode_mux	byte 1	Byte 2-7
0xA100100	0xE2	≈Status_bits	≈isolation_capacitances

The ≈Status_bits signal group is a collection of flags described in the “SIM100 signal groups” section of this document and as with any isolation state related message they should be checked to validate the estimates, the condition of the SIM100 and the presence of any warnings or alerts.

The ≈isolation_capacitances signal group provides the following information:

Signal	*Byte#*	*Units*	*Description*
Cp	2-3	nF	Estimate for the total capacitance between the positive power rail and chassis.
Cp_uncertainty	4	%	Uncertainty of Cp estimate
Cn	5-6	nF	Estimate for the total capacitance between the negative power rail and chassis.
Cn_uncertainty	7	%	Uncertainty of Cn estimate

Voltages Vp and Vn

The "Request voltages Vp and Vn" message and the SIM100 response is intended to provide individual measurements for the voltages between the positive and negative power rails and the chassis. Vp and Vn values are updated and can be sampled every 10 ms. If they are sampled at a lower frequency the voltage values will represent the average value between successive reads. The sampled values of Vp and Vn include the effect of the excitation voltage pulse of SIM100. The sum of Vp+Vn provides the battery voltage Vb. The "Request voltages Vp and Vn" format is as follows:

Request from host:

Ext. ID	Request_mux
0xA100101	0xE3

On "Request voltages Vp and Vn" the SIM100 will respond with a message composed of two "signal groups", the **≈Status_bits** and **≈voltages_Vp_and_Vn**.

SIM100 response:

Ext. ID	OpCode_mux	byte 1	bytes 2-7
0xA100100	0xE3	≈Status_bits	≈voltages_Vp_and_Vn

The **≈Status_bits** signal group is a collection of flags described in the "SIM100 signal groups" section of this document and as with any isolation state related message they should be checked to validate the estimates, the condition of the SIM100 and the presence of any warnings or alerts.

The **≈voltages_Vp_and_Vn** signal group provides the following information:

Signal	*Byte#*	*Units*	*Description*
Vp	2-3	V	Measured voltage between the positive power rail and chassis
Vp_uncertainty	4	%	Uncertainty of Vp measurement
Vn	5-6	V	Measured voltage between the negative power rail and chassis
Vn_uncertainty	7	%	Uncertainty of Vn measurement

Battery voltage

The “Request battery voltage” message and the SIM100 response is intended to provide a measurements for the battery voltage and its maximum value. The battery voltage value Vb is updated every 100 ms and corresponds to the average of the measurements over this period. The maximum battery voltage value Vb_max is the maximum value between the `Max_battery_working_voltage` value and the maximum actual Vb value recorded by SIM100 since power-on or reset. Default value of `Max_battery_working_voltage` is zero. If the `Max_battery_working_voltage` is not set by the host then Vb_max will be tracking the maximum value measured by SIM100. The Vb_max value is utilized by SIM100 to determine a warning or fault condition and set the appropriate flags in **`≈Status_bits.`**
The “Request voltages Vp and Vn” format is as follows:

Request from host:

Ext. ID	`Request_mux`
0xA100101	`0xE4`

On “Request voltages Vp and Vn” the SIM100 will respond with a message composed of two “signal groups”, the `≈Status_bits` and `≈battery_voltage`.

SIM100 response:

Ext. ID	`OpCode_mux`	byte 1	bytes 2-7
0xA100100	`0xE4`	`≈Status_bits`	`≈battery_voltage`

The **`≈Status_bits`** signal group is a collection of flags described in the “SIM100 signal groups” section of this document and as with any isolation state related message they should be checked to validate the estimates, the condition of the SIM100 and the presence of any warnings or alerts.

The **`≈battery_voltage`** signal group provides the following information:

Signal	*Byte#*	*Units*	*Description*
`Vb`	`2-3`	V	Measured DC power supply voltage
`Vb_uncertainty`	`4`	%	Uncertainty of Vb measurement
`Vb_max`	`5-6`	V	Maximum between `Max_battery_working_voltage` and measured Vb voltage since power-on or reset.
`Vb_max_uncertainty`	`7`	%	Uncertainty of Vb_max if it represents measured value

Error flags

The “Request error flags” message and the SIM100 response is intended to provide diagnostic information derived during the self-test of SIM100. This message should be invoked by the host anytime the `Hardware_Error` flag in the **`≈Status_bits`** signal group is set. The “Request error flags” format is as follows:

Request from host:

Ext. ID	`Request_mux`
0xA100101	`0xE5`

On “Request error flags” the SIM100 will respond with a message composed of two “signal groups”, the `≈Status_bits` and `≈Error_flags`.

SIM100 response:

Ext. ID	`OpCode_mux`	byte 1	Byte 2
0xA100100	`0xE5`	`≈Status_bits`	`≈Error_flags`

The **`≈Status_bits`** signal group is a collection of flags described in the “SIM100 signal groups” section of this document and as with any isolation state related message they should be checked to validate the estimates, the condition of the SIM100 and the presence of any warnings or alerts.

The **`≈Error_flags`** signal group provides the following information:

Signal	*Bit#*	*Units*	*Description*
`Err_Vx2`	7	Boolean	Set if connection to negative power rail is broken
`Err_Vx1`	6	Boolean	Set if connection to positive power rail is broken
`Err_CH`	5	Boolean	Set if connection to Chassis is broken
`Err_VxR`	4	Boolean	Set if connection to power rails is reversed
`Err_Vexi`	3	Boolean	Set if excitation voltage is out of range
`Err_Vpwr`	2	Boolean	Set if SIM100 power supply is out of range
`Reserved`	1-0		Reserved

Request Vn high resolution

The SIM100MOD monitors the voltage between the negative power rail of the IT system and chassis and can report the value with 32-bit accuracy. The value reported is the average value over the last second and it is updated every 500 ms. The reported value includes the effects of the excitation signal. The `Vn_hi_res` 32-bit signed integer (µV units) signal byte order is Motorola (Big endian).

To read `Vn_hi_res` the host sends:

Request from host:

Ext. ID	`Request_mux`
0xA100101	`0x60`

SIM100 response:

Ext. ID	`OpCode_mux`	byte 1-4
0xA100100	`0x60`	`Vn_hi_res`

Request Vp high resolution

The SIM100MOD monitors the voltage between the positive power rail of the IT system and chassis and can report the value with 32-bit accuracy. The value reported is the average value over the last second and it is updated every 500 ms. The reported value includes the effects of the excitation signal. The `Vp_hi_res` 32-bit signed integer (µV units) signal byte order is Motorola (Big endian).

To read `Vp_hi_res` the host sends:

Request from host:

Ext. ID	`Request_mux`
0xA100101	`0x61`

SIM100 response:

Ext. ID	`OpCode_mux`	byte 1-4
0xA100100	`0x61`	`Vp_hi_res`

SIM100 state control commands from Host

Restart

The “Restart” command forces the SIM100 to enter a power-on state. Specifically:

- Clears all flags in ≈Status_bits signal group
- Clears all flags in ≈Error_flags signal group
- Clears all isolation state estimates
- Reloads from flash memory Max_battery_working_voltage into Vb_max

After a “Restart” command the SIM100 will perform self-check and will produce new estimates and update flags within 5 s.

The “Restart” command is as follows:

Ext. ID	Request_mux	Byte 1	Byte 2	Byte 3	Byte 4
0xA100101	0xC1	0x01	0x23	0x45	0x67

Turn excitation pulse off

The “Turn excitation pulse off” disables the excitation pulse of SIM100 and suspends its isolation monitoring function. The purpose of this command is to prevent SIM100 from interfering with another insulation monitoring device which is currently active. For example, if the SIM100 operates in a vehicle the “Turn excitation pulse off” command shall be used when and while the vehicle is attached to a DC quick charging station. While the excitation pulse is turned off measurements will not be valid and the relevant error flags will be set. The SIM100 shall resume its isolation monitoring function through the issuance of a “Restart” command.

The “Turn excitation pulse off” command is as follows:

Ext. ID	Request_mux	Byte 1	Byte 2	Byte 3	Byte 4
0xA100101	0x62	0xDE	0xAD	0xBE	0x1F

Set Max battery working voltage

The “Set Max battery working voltage” sets the `Vb_max` to the provided `Max_battery_working_voltage` value, which is used for estimating warning and fault conditions in the isolation system. The `Vb_max` value will change upwards to the maximum measured `Vb` value. The “`Max_battery_working_voltage`” value is stored in flash and it is restored into `Vb_max` after power-on or a “Restart” message. After a new `Max_battery_working_voltage` is set, a “Restart” command has to be issued in order for the new value to take effect.

The transaction is as follows:

Request from Host:

Ext. ID	`Request_mux`	Bytes 1-2
0xA100101	`0xF0`	`Max_battery_working_voltage`

Response from SIM100:

Ext. ID	`Request_mux`	Bytes 1-2
0xA100100	`0xF0`	`Max_battery_working_voltage`

Sample SIM100 transaction

Set battery Maximum Working Voltage

In this sample transaction the host sets the Maximum Working Voltage of the battery to 600 Volts

Request from Host

Ext. ID	byte 0	byte 1	byte 2
0xA100101	0xF0	0x02	0x58

Response from SIM100

Ext. ID	byte 0	byte 1	byte 2
0xA100100	0xF0	0x02	0x58

Read isolation state

In this example the host requests the isolation state of the IT system. The SIM100 responds with new data indicating minimum electrical isolation of 550 Ω/V with uncertainty of 2% and maximum energy stored in capacitors under maximum working voltage of 80 mJ with uncertainty of 4%.

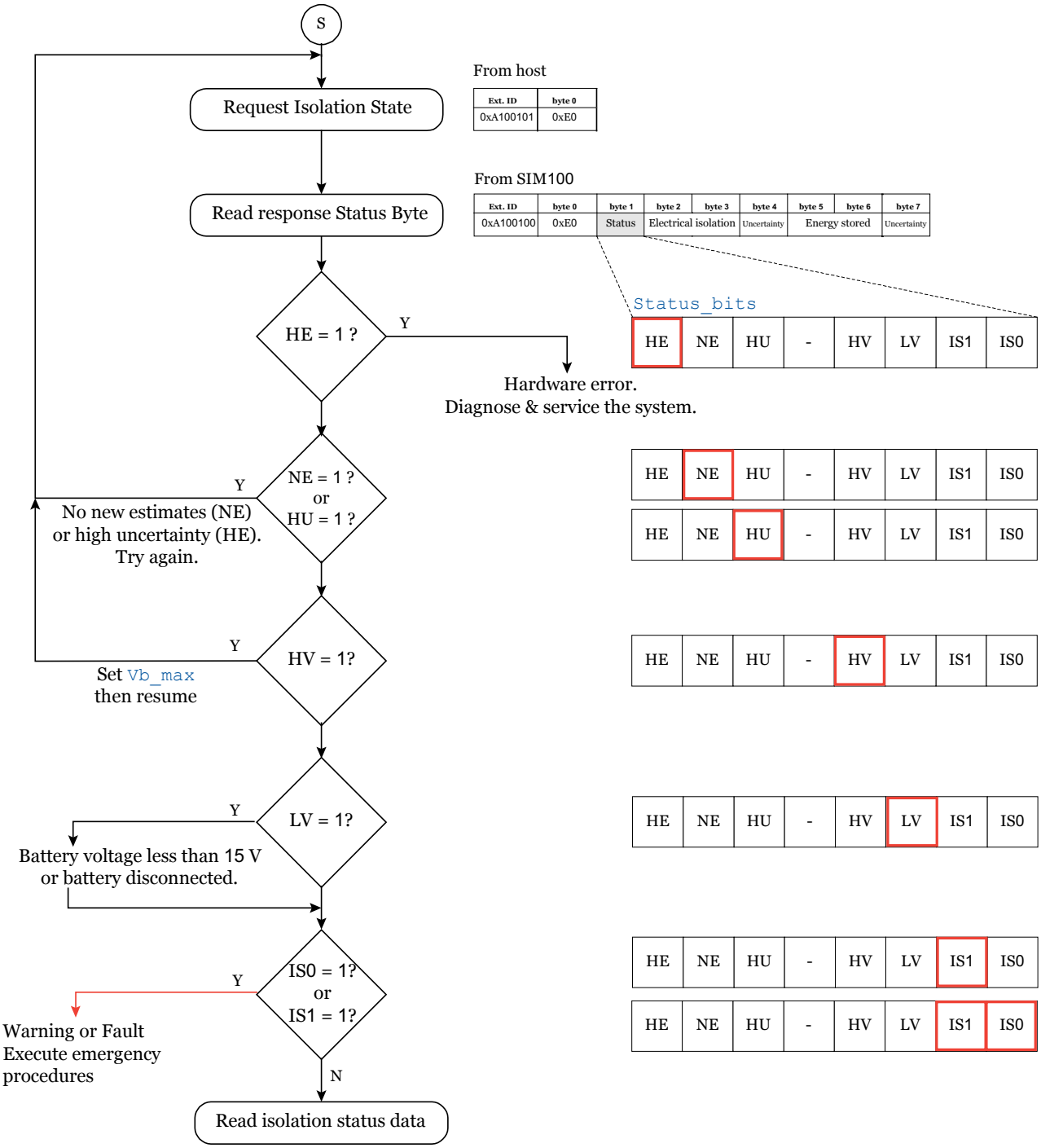
Request from Host

Ext. ID	byte 0
0xA100101	0xE0

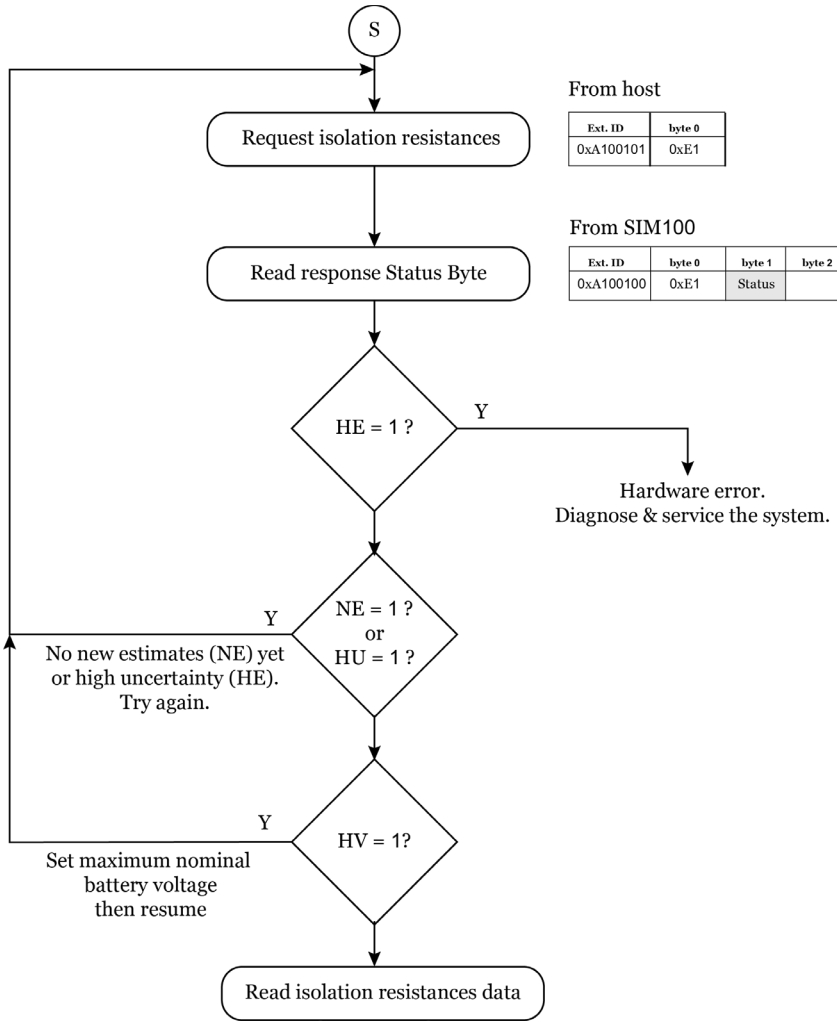
Response from SIM100

Ext. ID	byte 0	byte 1	byte 2	byte 3	byte 4	byte 5	byte 6	byte 7
0xA100100	0xE0	0x00	0x02	0x26	0x02	0x00	0x50	0x04

Read Status_bits typical flowchart



"Request isolation resistances" typical flowchart



From host

Ext. ID	byte 0
0xA100101	0xE1

From SIM100

Ext. ID	byte 0	byte 1	byte 2	byte 3	byte 4	byte 5	byte 6	byte 7
0xA100100	0xE1	Status	Rp		Uncertainty	Rn		Uncertainty

Revision history

V 0.8a	3/2020	Corrected Ext. ID response code **0xA100100** appearing in several places incorrectly as **0xA100101**
V 0.8	12/2019	Documented Vn_hi_res and Vp_hi_res signals and associated messages
V 0.7	10/2019	Corrected “Excitation_pulse_off” and “Restart” messages byte ordering classification from Intel to Motorola.
V 0.6	5/2019	Documented Excitation pulse off command. Reorganized the protocol document
V 0.5		Corrected subscripts of Cs & Rs in Fig 1.
V 0.4		SIM100 reports isolation resistances estimates with low voltage present. Prior versions were reporting parallel combination. Clarify behavior when a short is detected (all estimates set to zero).
V 0.3		Defined isolation status bits into Status Byte
V 0.2a		Corrected Serial number encoding description to Hex.
v 0.2		Added flowcharts for typical operations. Description of “Request isolation resistances” when battery is disconnected or below 15 Volts.
v 0.1		Initial release