UART Interface Description SVM41

Evaluation Board for SGP40 and SGP41 – Indoor Air Quality Sensor for VOC and NO_x Measurements

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1 General Considerations

Settings as mentioned in **Table 1** have to be used when communicating with SVM41 sensor module via UART interface.

Parameter	Rating
Baud rate	115'200 bits s^{-1}
Data bits	8
Parity	None
Stop bit	1

Table 1 UART settings.

2 Physical Layer

The SVM41 has separate RX and TX lines with unipolar logic levels. A transmitted byte looks as in **Figure 1**.

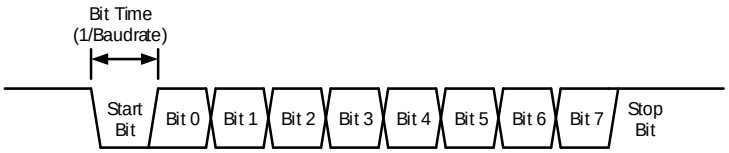

Figure 1 Transmitted byte.

3 SHDLC Frame Layer

On top of the UART interface, the SVM41 uses the very powerful and easy-to-implement SHDLC[1] protocol. It is a serial communication protocol based on a master/slave architecture. The SVM41 acts as the slave device. Data is transferred in logical units called frames. Every transfer is initiated by the master sending a MOSI[2] frame. The slave will respond to the MOSI frame with a slave response, or MISO[3] frame. The two types of frames are shown in **Figure 2**.

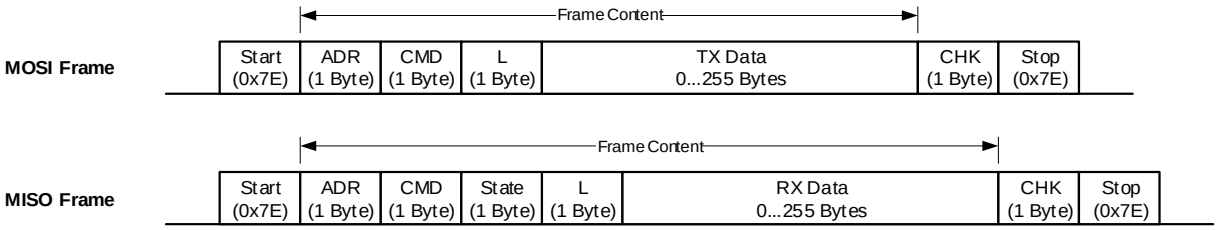

Figure 2 MOSI and MISO frames structure.

3.1 Start/Stop Byte and Byte-Stuffing

The 0x7E character is sent at the beginning and at the end of the frame to signalize frame start and stop. If this byte 0x7E occurs anywhere else in the frame, it must be replaced by two other bytes (byte-stuffing). This also applies to the characters 0x7D, 0x11, and 0x13. Use **Table 2** for byte-stuffing.

Original data byte	Transferred data bytes
0x7E	0x7D, 0x5E
0x7D	0x7D, 0x5D
0x11	0x7D, 0x31
0x13	0x7D, 0x33

Table 2 Reference table for byte-stuffing.

Example: Data to send = [0x43, 0x11, 0x7F] → Data transmitted = [0x43, 0x7D, 0x31, 0x7F].

3.2 Address

The slave device address is always 0.

3.3 Command

In the MOSI frame the command tells the device what to do with the transmitted data. In the MISO frame, the slave just returns the received command.

3.4 Length

Length of the “TX Data” or “RX Data” field (before byte-stuffing).

3.5 State

The MISO frame contains a state byte, which allows the master to detect communication and execution errors.

[1] Sensirion High-Level Data Link Control.
[2] Master Out Slave In. Frame direction from master to slave.
[3] Master In Slave Out. Frame direction from slave to master.

b7	b6	b5	b4	b3	b2	b1	b0
device error flag	execution error code						

Figure 3 Status byte structure.

The first bit (b7) indicates that at least one of the error flags is set in the Device Status Register. The "Execution error code" signalizes all errors which occur while processing the frame or executing the command. The following table shows the error codes which can be reported from the device. Note that some of these errors are system internal errors which require additional knowledge to be understood. In case of a problem, they will help Sensirion to localize and solve the issue.

Error code		**Description**
Dec.	**Hex.**	
0	0x00	No error. Processing and execution of the command was successful.
1	0x01	Wrong data length for this command (too much or little data)
2	0x02	Unknown command
3	0x03	No access right for command
4	0x04	Illegal command parameter or parameter out of allowed range
40	0x28	Internal function argument out of range
67	0x43	Command not allowed in current state

Table 3 Reference table for error codes.

3.6 Data

The data has a usable size of [0…255] bytes (original data before byte-stuffing). The meaning of the data content depends on the command. The data in the frames is transmitted in big-endian order (MSB first). If subcommands are used for the command the first byte will be used to define the subcommand.

3.7 Checksum

The checksum is built before byte-stuffing and checked after removing stuffed bytes from the frame. The checksum is defined as follows:

1. Sum all bytes between start and stop (without start and stop bytes).
2. Take the least significant byte of the result and invert it. This will be the checksum.

For a MOSI frame use Address, Command, Length, and Data to calculate the checksum.
For a MISO frame use Address, Command, State, Length, and Data to calculate the checksum.

Example: start measurement (MOSI frame without start/stop and without byte-stuffing).

ADR	CMD	L	TX data	CHK
0x02	0x43	0x04	[0x64, 0xA0, 0x22, 0xFC]	0x94

The checksum is calculated as shown in **Table 4**.

Parameter	Hex. code
ADR	0x02
CMD	0x43
L	0x04
Data 0	0x64
Data 1	0xA0
Data 2	0x22
Data 3	0xFC
Sum of all bytes	0x26B
LSB of sum	0x6B
Inverted (= checksum)	**0x94**

Table 4 Checksum calculation.

4 UART Commands

Table 5 shows an overview of the available UART commands.

Command	Send command during
svm41_start_measurement	idle mode
svm41_get_signals	measure mode
svm41_get_raw_signals	measure mode
svm41_stop_measurement	measure mode
svm41_get_temperature_offset	idle or measure mode
svm41_set_temperature_offset	idle mode
svm41_get_voc_parameters	idle or measure mode
svm41_set_voc_parameters	idle mode
svm41_get_nox_parameters	idle or measure mode
svm41_set_nox_parameters	idle mode
svm41_store_input_parameters	idle or measure mode
svm41_get_voc_states	measure mode
svm41_set_voc_states	idle mode
svm41_get_device_version	idle or measure mode
svm41_reset_device	idle or measure mode

Table 5 UART commands available for SVM41.

4.1 Start Measurement

Command	*svm41_start_measurement*	
Description	This command triggers the operation mode of all sensors. It must be called once prior to the *svm41_get_signals* or *svm41_get_raw_signals* commands, respectively. Per default the SVM41 starts in idle mode after powering up.	
Command hex. code	0x00	
Max. response time	50 ms	
Post processing time	0 ms	
MOSI Data	**Byte number**	**Description**
	0	uint8 subcommand, must be set to 0x00
MISO Data	None	

Table 6 Description of the UART start measurement command.

Data	Hex. code
MOSI	0x7E 0x00 0x00 0x01 0x00 0xFE 0x7E
MISO	0x7E 0x00 0x00 0x00 0x00 0xFF 0x7E

Table 7 Example frames for UART start measurement command.

4.2 Get Signals

Command	*svm41_get_signals*	
Description	This command reads out relative humidity, temperature as well as VOC and NO_x Index. It returns 8 bytes.	
Command hex. code	0x03	
Max. response time	50 ms	
Post processing time	0 ms	
MOSI Data	**Byte number**	**Description**
	0	uint8 subcommand, must be set to 0x10
MISO Data	**Byte number**	**Description**
	0, 1	int16 provides the relative humidity (in % RH) compensated for the temperature offset with a scaling factor of 100, *e.g.*, an output of +2'500 corresponds to +25.00 % RH.
	2, 3	int16 provides the temperature (in °C) with a scaling factor of 200, *e.g.*, an output of +5'000 corresponds to +25.00 °C.
	4, 5	int16 provides the VOC Index (no unit) with a scaling factor of 10, *e.g.*, an output of +250 corresponds to a VOC Index of +25.0.
	6, 7	int16 provides the NO_x Index (no unit) with a scaling factor of 10, *e.g.*, an output of +250 corresponds to a VOC Index of +25.0.

Table 8 Description of the UART get signals command.

Data	Hex. code
MOSI	0x7E 0x00 0x03 0x01 0x10 0xEB 0x7E
MISO	0x7E 0x00 0x03 0x00 0x08 0x18 0x33 0x12 0x8D 0x01 0xC2 0x00 0x0A 0x3D 0x7E

Table 9 Example frames for UART get signals command.

4.3 Get Raw Signals

Command	*svm41_get_raw_signals*	
Description	This command reads out relative humidity and temperature which are not compensated for temperature offset and the VOC and NO_x raw signals (proportional to the logarithm of the resistance of the MOX layer). It returns 16 bytes.	
Command hex. code	0x03	
Max. response time	50 ms	
Post processing time	0 ms	
MOSI Data	**Byte number**	**Description**
	0	uint8 subcommand, must be set to 0x0D
MISO Data	**Byte number**	**Description**
	0, 1	int16 provides the uncompensated relative humidity (in % RH) with a scaling factor of 100, *e.g.*, an output of +2'500 corresponds to +25.00 % RH.
	2, 3	int16 provides the uncompensated temperature (in °C) with a scaling factor of 200, *e.g.*, an output of +5'000 corresponds to +25.00 °C.
	4, 5	uint16 directly provides the VOC raw signal SRAW_VOC (in ticks) without scaling.
	6, 7	uint16 directly provides the NO_x raw signal SRAW_NOX (in ticks) without scaling.

Table 10 Description of the UART get raw signals command.

Data	**Hex. code**
MOSI	0x7E 0x00 0x03 0x01 0x0D 0xEE 0x7E
MISO	0x7E 0x00 0x03 0x00 0x08 0x17 0x2F 0x7D 0x33 0x62 0x79 0x78 0x48 0x98 0x68 0x7E

Table 11 Example frames for UART get signals command.

4.4 Stop Measurement

Command	*svm41_stop_measurement*
Description	This command stops the operation mode of all sensors and returns the SVM41 to idle mode.
Command hex. code	0x01
Max. response time	50 ms
Post processing time	0 ms
MOSI Data	None
MISO Data	None

Table 12 Description of the UART stop measurement command.

Data	Hex. code
MOSI	0x7E 0x00 0x01 0x00 0xFE 0x7E
MISO	0x7E 0x00 0x01 0x00 0x00 0xFE 0x7E

Table 13 Example frames for UART stop measurement command.

4.5 Get Temperature Offset for RHT Measurements

Command	*svm41_get_temperature_offset*	
Description	This command reads out the current temperature offset used for the compensation of RHT measurements by returning 2 bytes.	
Command hex. code	0x60	
Max. response time	50 ms	
Post processing time	0 ms	
MOSI Data	**Byte number**	**Description**
	0	uint8 subcommand, must be set to 0x01
MISO Data	**Byte number**	**Description**
	0, 1	int16 provides the temperature offset (in °C) with a scaling factor of 200, *e.g.*, an output of +400 corresponds to +2.00 °C. Default is 0 °C.

Table 14 Description of the UART get temperature offset command.

Data	Hex. code
MOSI	0x7E 0x00 0x60 0x01 0x01 0x9D 0x7E
MISO	0x7E 0x00 0x60 0x00 0x02 0x00 0x00 0x9D 0x7E

Table 15 Example frames for UART get temperature offset command. Result based on default settings.

4.6 Set Temperature Offset for RHT Measurements

Command	*svm41_set_temperature_offset*	
Description	This command sets the temperature offset used for the compensation of subsequent RHT measurements when sent together with 2 bytes.	
Command hex. code	0x60	
Max. response time	50 ms	
Post processing time	0 ms	
MOSI Data	**Byte number**	**Description**
	0	uint8 subcommand, must be set to 0x81
	1, 2	int16 provides the temperature offset (in °C) with a scaling factor of 200, *e.g.*, an output of +400 corresponds to +2.00 °C. Default is 0 °C.
MISO Data	None	

Table 16 Description of the UART set temperature offset command.

Data	**Hex. code**
MOSI	0x7E 0x00 0x60 0x03 0x81 0x00 0x00 0x1B 0x7E
MISO	0x7E 0x00 0x60 0x00 0x00 0x9F 0x7E

Table 17 Example frames for UART set temperature offset command based on default settings.

4.7 Get Parameters of VOC Algorithm

Command	*svm41_get_voc_parameters*	
Description	This command reads out the current six parameters used for the VOC Algorithm returning 12 bytes.	
Command hex. code	0x60	
Max. response time	50 ms	
Post processing time	0 ms	
MOSI Data	**Byte number**	**Description**
	0	uint8 subcommand, must be set to 0x0D
MISO Data	**Byte number**	**Description**
	0, 1	int16 directly provides VOC Index (no unit) value representing the average conditions. Default is VOC Index = 100. Range is 1–250.
	2, 3	int16 directly provides learning time (in h) which is used by the VOC Algorithm to estimate its offset from the history. Events longer than approx. twice the learning time will be forgotten. Default is 12 h. Range is 1–1’000 h.
	4, 5	int16 directly provides learning time (in h) which is used by the VOC Algorithm to estimate its gain from the history. Events longer than approx. twice the learning time will be forgotten. Default is 12 h. Range is 1–1’000 h.
	6, 7	int16 directly provides maximum gating duration (in min). During this period, the estimator of the VOC Algorithm states is frozen when the VOC Index is very high. Default is 180 min. 0 disables this feature. Range is 0–3’000 min.
	8, 9	int16 directly provides initial standard deviation (no unit) used during start-up of the sensor. During start-up period, a lower value boosts VOC events while a higher value decreases VOC events. Default is 50. Range is 10–5’000.
	10, 11	int16 directly provides the gain factor to amplify or to attenuate the VOC Index output. Default is 230. Range is 1–1’000.

Table 18 Description of the UART get VOC parameters command.

Data	**Hex. code**
MOSI	0x7E 0x00 0x60 0x01 0x0D 0x91 0x7E
MISO	0x7E 0x00 0x60 0x00 0x0C 0x00 0x64 0x00 0x0C 0x00 0x0C 0x00 0xB4 0x00 0x32 0x00 0xE6 0x4B 0x7E

Table 19 Example frames for UART get VOC parameters command returning default parameters.

4.8 Set Parameters of VOC Algorithm

Command	*svm41_set_voc_parameters*	
Description	This command sets the six parameters used for the VOC Algorithm when sent together with 12 bytes.	
Command hex. code	0x60	
Max. response time	50 ms	
Post processing time	0 ms	
MOSI Data	**Byte number**	**Description**
	0	uint8 subcommand, must be set to 0x8D
	1, 2	int16 directly provides VOC Index (no unit) value representing the average conditions. Default is VOC Index = 100. Range is 1–250.
	3, 4	int16 directly provides learning time (in h) which is used by the VOC Algorithm to estimate its offset from the history. Events longer than approx. twice the learning time will be forgotten. Default is 12 h. Range is 1–1’000 h.
	5, 6	int16 directly provides learning time (in h) which is used by the VOC Algorithm to estimate its gain from the history. Events longer than approx. twice the learning time will be forgotten. Default is 12 h. Range is 1–1’000 h.
	7, 8	int16 directly provides maximum gating duration (in min). During this period, the estimator of the VOC Algorithm states is frozen when the VOC Index is very high. Default is 180 min. 0 disables this feature. Range is 0–3’000 min.
	9, 10	int16 directly provides initial standard deviation (no unit) used during start-up of the sensor. During start-up period, a lower value boosts VOC events while a higher value decreases VOC events. Default is 50. Range is 10–5’000.
	11, 12	int16 directly provides the gain factor to amplify or to attenuate the VOC Index output. Default is 230. Range is 1–1’000.
MISO Data	None	

Table 20 Description of the UART set VOC parameters command.

Data	**Hex. code**
MOSI	0x7E 0x00 0x60 0x0D 0x8D 0x00 0x64 0x00 0x0C 0x00 0x0C 0x00 0xB4 0x00 0x32 0x00 0xE6 0xBD 0x7E
MISO	0x7E 0x00 0x60 0x00 0x00 0x9F 0x7E

Table 21 Example frames for UART set VOC parameters command based on default parameters.

4.9 Get Parameters of NO_x Algorithm

Command	*svm41_get_nox_parameters*	
Description	This command reads out the current six parameters used for the NO_x Algorithm returning 12 bytes.	
Command hex. code	0x60	
Max. response time	50 ms	
Post processing time	0 ms	
MOSI Data	**Byte number**	**Description**
	0	uint8 subcommand, must be set to 0x0E
MISO Data	**Byte number**	**Description**
	0, 1	int16 directly provides VOC Index (no unit) value representing the average conditions. Default is NO_x Index = 1. Range is 1–250.
	2, 3	int16 directly provides learning time (in h) which is used by the NO_x Algorithm to estimate its offset from the history. Events longer than approx. twice the learning time will be forgotten. Default is 12 h. Range is 1–1'000 h.
	4, 5	int16 directly provides learning time (in h) which would be used by the NO_x Algorithm to estimate its gain from the history; however, it has no impact on the NO_x Index output. This parameter is still in place for consistency reasons with the *svm41_get/set_voc_parameters* commands. This parameter must always be set to 12 hours (0x00 0x0C).
	6, 7	int16 directly provides maximum gating duration (in min). During this period, the estimator of the NO_x Algorithm states is frozen when the NO_x Index is very high. Default is 720 min. 0 disables this feature. Range is 0–3'000 min.
	8, 9	int16 directly provides initial standard deviation (no unit) which would be used during start-up of the sensor; however, it has no impact on the NO_x Index output. This parameter is still in place for consistency reasons with the *svm41_get/set_voc_parameters* commands. This parameter must always be set to 50 (0x00 0x32).
	10, 11	int16 directly provides the gain factor to amplify or to attenuate the NO_x Index output. Default is 230. Range is 1–1'000.

Table 22 Description of the UART get NO_x parameters command.

Data	**Hex. code**
MOSI	0x7E 0x00 0x60 0x01 0x0E 0x90 0x7E
MISO	0x7E 0x00 0x60 0x00 0x0C 0x00 0x01 0x00 0x0C 0x00 0x0C 0x02 0xD0 0x00 0x32 0x00 0xE6 0x90 0x7E

Table 23 Example frames for UART get NO_x parameters command returning default parameters.

4.10 Set Parameters of NO_x Algorithm

Command	*svm41_set_nox_parameters*	
Description	This command sets the six parameters used for the NO_x Algorithm when sent together with 12 bytes.	
Command hex. code	0x60	
Max. response time	50 ms	
Post processing time	0 ms	
MOSI Data	**Byte number**	**Description**
	0	uint8 subcommand, must be set to 0x8E
	1, 2	int16 directly provides VOC Index (no unit) value representing the average conditions. Default is NO_x Index = 1. Range is 1–250.
	3, 4	int16 directly provides learning time (in h) which is used by the NO_x Algorithm to estimate its offset from the history. Events longer than approx. twice the learning time will be forgotten. Default is 12 h. Range is 1–1'000 h.
	5, 6	int16 directly provides learning time (in h) which would be used by the NO_x Algorithm to estimate its gain from the history; however, it has no impact on the NO_x Index output. This parameter is still in place for consistency reasons with the *svm41_get/set_voc_parameters* commands. This parameter must always be set to 12 hours (0x00 0x0C).
	7, 8	int16 directly provides maximum gating duration (in min). During this period, the estimator of the NO_x Algorithm states is frozen when the NO_x Index is very high. Default is 720 min. 0 disables this feature. Range is 0–3'000 min.
	9, 10	int16 directly provides initial standard deviation (no unit) which would be used during start-up of the sensor; however, it has no impact on the NO_x Index output. This parameter is still in place for consistency reasons with the *svm41_get/set_voc_parameters* commands. This parameter must always be set to 50 (0x00 0x32).
	11, 12	int16 directly provides the gain factor to amplify or to attenuate the NO_x Index output. Default is 230. Range is 1–1'000.
MISO Data	None	

Table 24 Description of the UART set NO_x parameters command.

Data	**Hex. code**
MOSI	0x7E 0x00 0x60 0x0D 0x8E 0x00 0x01 0x00 0x0C 0x00 0x0C 0x02 0xD0 0x00 0x32 0x00 0xE6 0x01 0x7E
MISO	0x7E 0x00 0x60 0x00 0x00 0x9F 0x7E

Table 25 Example frames for UART set NO_x parameters command based on default parameters.

4.11 Store Input Parameters to Non-Volatile Memory

Command	*svm41_store_input_parameters*	
Description	This command stores all parameters previously sent to the slave *via* the *svm41_set_temperature_offset* and/or the *svm41_set_voc_parameters* and/or *svm41_set_nox_parameters* commands to the non-volatile memory of SVM41. These parameters will not be erased during reset and will be used by the corresponding algorithms after start-up. To reset the storage to factory settings the master has to set all parameters to the default values followed by a subsequent call of the *svm41_store_input_parameters* command.	
Command hex. code	0x60	
Max. response time	500 ms	
Post processing time	0 ms	
MOSI Data	**Byte number**	**Description**
	0	uint8 subcommand, must be set to 0x80
MISO Data	None	

Table 26 Description of the UART store input parameters command.

Data	**Hex. code**
MOSI	0x7E 0x00 0x60 0x01 0x80 0x1E 0x7E
MISO	0x7E 0x00 0x60 0x00 0x00 0x9F 0x7E

Table 27 Example frames for UART store input parameters command.

4.12 Get States of VOC Algorithm

Command	*svm41_get_voc_states*	
Description	This command reads out the states of VOC Algorithm by returning 8 bytes. These values can be used to set the states (using the *svm41_set_voc_states* command) after resuming sensor operation, *e.g.*, after a short interruption by skipping the initial learning phase of the VOC Algorithm.	
Command hex. code	0x61	
Max. response time	50 ms	
Post processing time	0 ms	
MOSI Data	**Byte number**	**Description**
	0	uint8 subcommand, must be set to 0x08
MISO Data	**Byte number**	**Description**
	0 … 7	uint8[8] array of 8 bytes providing the states of the VOC Algorithm.

Table 28 Description of the UART get VOC states command.

Data	Hex. code
MOSI	0x7E 0x00 0x61 0x01 0x08 0x95 0x7E
MISO	0x7E 0x00 0x61 0x00 0x08 0x00 0x00 0x00 0x00 0x00 0x32 0x00 0x00 0x64 0x7E

Table 29 Example frames for UART get VOC states command.

4.13 Set States of VOC Algorithm

Command	*svm41_set_voc_states*	
Description	This command sets the states of the VOC Algorithm when sent together with 8 bytes, which were retrieved by the *svm41_get_voc_states* command before. This can be used when resuming sensor operation, *e.g.*, after a short interruption by skipping the initial learning phase of the VOC Algorithm.	
Command hex. code	0x61	
Max. response time	50 ms	
Post processing time	0 ms	
MOSI Data	**Byte number**	**Description**
	0	uint8 subcommand, must be set to 0x88
	1 … 8	uint8[8] array of 8 bytes setting the states of the VOC Algorithm.
MISO Data	None	

Table 30 Description of the UART set VOC states command.

Data	Hex. code
MOSI	0x7E 0x00 0x61 0x09 0x88 0x00 0x00 0x00 0x00 0x00 0x32 0x00 0x00 0xDB 0x7E
MISO	0x7E 0x00 0x61 0x00 0x00 0x9E 0x7E

Table 31 Example frames for UART set VOC states command.

4.14 Get Version of Device

Command	*svm41_get_device_version*	
Description	This command returns information on the hardware, firmware, and protocol in 7 bytes.	
Command hex. code	0xD1	
Max. response time	50 ms	
Post processing time	0 ms	
MOSI Data	None	
MISO Data	**Byte number**	**Description**
	0	uint8 provides the major version number of the firmware.
	1	uint8 provides the minor version number of the firmware.
	2	bool provides the debug state of the firmware.
	3	uint8 provides the major version number of the hardware.
	4	uint8 provides the minor version number of the hardware.
	5	uint8 provides the major version number of the protocol.
	6	uint8 provides the minor version number of the protocol.

Table 32 Description of the UART get device version command.

Data	**Hex. code**
MOSI	0x7E 0x00 0xD1 0x00 0x2E 0x7E
MISO	0x7E 0x00 0xD1 0x00 0x07 0x03 0x01 0x00 0x03 0x00 0x01 0x00 0x1F 0x7E

Table 33 Example frames for UART get device version command.

4.15 Reset Device

Command	*svm41_reset_device*
Description	This command performs a reset of the device and restarts the SVM41 in idle mode. Prior to executing the reset, the device will acknowledge the call. If the command is sent with broadcast, the reset is executed directly after the reception of the command. All previously set parameters sent by *svm41_set_temperature_offset*, *svm41_set_voc_parameters*, *svm41_set_nox_parameters*, and *svm41_set_voc_states* commands will be lost. The temperature offset and the parameters of both VOC and NO_x Algorithms can be stored to the non-volatile memory of SVM41 by calling the *svm41_store_input_parameters* command.
Command hex. code	0xD3
Max. response time	50 ms
Post processing time	100 ms
MOSI Data	None
MISO Data	None

Table 34 Description of the UART reset device command.

Data	Hex. code
MOSI	0x7E 0x00 0xD3 0x00 0x2C 0x7E
MISO	0x7E 0x00 0xD3 0x00 0x00 0x2C 0x7E

Table 35 Example frames for UART reset device command.

Revision History

Date	Version	Page(s)	Changes
October, 2021	1.0	All	Initial release
December 2021	1.1	All	Editorial amendments
		13	Descriptions of bytes 4, 5 and 8, 9 in **Table 22** revised
		14	Descriptions of bytes 5, 6 and 9, 10 in **Table 24** revised

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