

Technical Description SEK-SVM40

Evaluation Kit for SGP40 – Indoor Air Quality Sensor for VOC Measurements

- Sensor module equipped with SGP40 and SHT40
- On-board microcontroller for signal processing
- I²C and UART interface with digital output signals
- USB-UART cable, jumper wire cable set
- Power supply 3.0–5.5 V
- Plug-and-play for fast evaluation and prototyping



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1 General Description

Specifications can be found in the corresponding datasheets of both components SGP40 and SHT40. The SVM40 as part of the evaluation kit SEK-SVM40 serves as reference design for integrating SGP40, SHTxx, and Sensirion's VOC Algorithm to obtain the VOC Index signal as processed by the on-board microcontroller. It supports all features of both components and automatically takes care of humidity compensation of the SGP40 raw signal as well as of temperature offset compensation of the SHT40 sensor. **Figure 1** visualizes how the signal processing is performed on the SVM40.

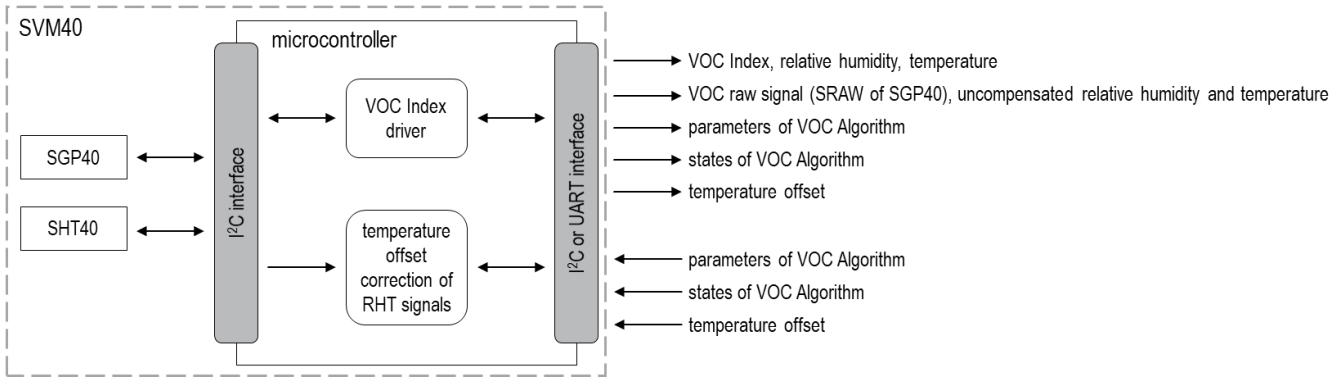


Figure 1 Schematic of the signal processing and interface on SVM40.

2 Specifications

2.1 Electrical Specifications

Table 1 lists electrical specifications of the SVM40. The SVM40 supports both I²C “standard-mode”¹ and UART.²

Parameter	Symbol	Values			Unit	Comments
		Min.	Typ.	Max.		
Supply voltage ³	V _{DD}	3.0	3.3 or 5.0	5.5	V	Minimal voltage must be guaranteed also for the maximum supply current specified in this table.
Idle current	I _{DD}	–	2.0	3.0	mA	at 3.3 V supply voltage The idle mode is activated after power-up as well as after calling either the <i>svm40_stop_measurement</i> or the <i>svm40_device_reset</i> command.
Average supply current during measurement		–	5.0	7.5	mA	at 3.3 V supply voltage
Communication	–	Digital 2-wire interface, I ² C or UART				

Table 1 Electrical specifications.

2.2 Timing Specifications

Timings in Table 2 refer to the power up and reset of the device and do not reflect the usefulness of the readings.

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Power-up time	t _{PU}	After hard reset, V _{DD} ≥ 3.0 V	–	25	100	ms
I ² C clock frequency	f _{I2C}	–	–	–	100	kHz
UART baud rate	f _{UART}	–	–	115'200	–	bits s ⁻¹
Recommended read-out interval	–	–	0.5	1	60	s

Table 2 Timing specifications.

2.3 Recommended Operating and Storage Conditions

Please, refer to the *SGP40 Datasheet*. To ensure an optimal performance of the SVM40 also consider the *Handling and Assembly Instructions* for both *SGPxx Gas Sensors* and *SHTxx Humidity Sensors* as well as the corresponding *Design-in Guides*.

¹ I²C standard described in http://www.nxp.com/documents/user_manual/UM10204.pdf. See *I²C Interface Description SEK-SVM40*.

² Universal Asynchronous Receiver Transmitter. See *UART Interface Description SEK-SVM40*.

³ Any supply voltage as defined by the min./max. range may be used for continuous operation of the sensor. The typical value specifies the supply voltage at which outgoing quality control is performed.

2.4 Absolute Minimum and Maximum Ratings

Stress levels beyond those listed in **Table 3** may cause permanent damage to the device. Exposure to minimum/maximum rating conditions for extended periods may affect sensor performance and reliability of the device.

Parameter	Rating
Supply voltage V_{DD}	-0.3 to +5.5 V
Short-term storage temperature range ⁴	-40 to +70 °C
Operating temperature range	-20 to +55 °C
Short-term storage humidity range ⁴	0 to 80 % (non-condensing)
Operating humidity range	0 to 90 % (non-condensing)

Table 3 Absolute minimum and maximum ratings.

2.5 Hardware Interface Specifications

The SVM40 sensor module is equipped with a serial communication interface. The interface connector Molex 5055670671 is located at the side of the sensor adjacent. The UART-USB cable and the jumper wire cable delivered in the SEK-SVM40 are equipped with the corresponding female plug, *i.e.*, Molex 5055650601. In **Table 4** a description of the pin layout is given. The SVM40 offers both a UART and an I²C interface. I²C was originally designed to connect two chips on a PCB. When the sensor is connected to the main PCB *via* a cable, particular attention must be paid to electromagnetic interference and crosstalk. Use as short as possible (≤ 10 cm) and/or well shielded connection cables such as the jumper wire cable part of the SEK-SVM40. Alternatively, it is recommended to use the UART interface instead, which is more robust against electromagnetic interference, especially with long connection cables.

Pin	Name	Comments
1	VDD	Supply voltage
2	GND	Ground
3	RX	UART: receiving pin for communication
	SDA	I ² C: serial data, bidirectional
4	TX	UART: transmitting pin for communication
	SCL	I ² C: Serial clock, bidirectional
5	SEL	Interface select: <ul style="list-style-type: none"> • Leave floating or pull to VDD to select UART • Pull to GND to select I²C
6	NC	Do not connect

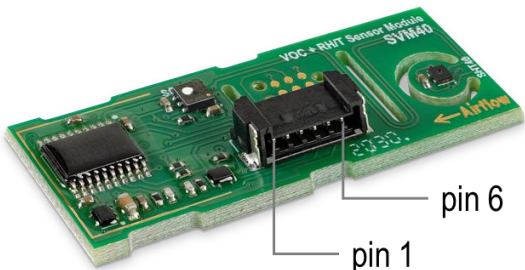


Table 4 Pin assignment of the Molex connector. Pin colors match with assignment of the jumper wire cables, which is delivered together with the SEK-SVM40.

⁴ Short-term storage refers to temporary conditions during, *e.g.*, transport.

A typical I²C application circuit is shown in **Figure 2**. Both SCL and SDA lines are open drain I/Os. They must be connected to external pull-up resistors (e.g., R_p = 10 kΩ). Important notice: to correctly select I²C as interface, the interface select pin (SEL) must be pulled to GND before or at the same time the sensor is powered up.

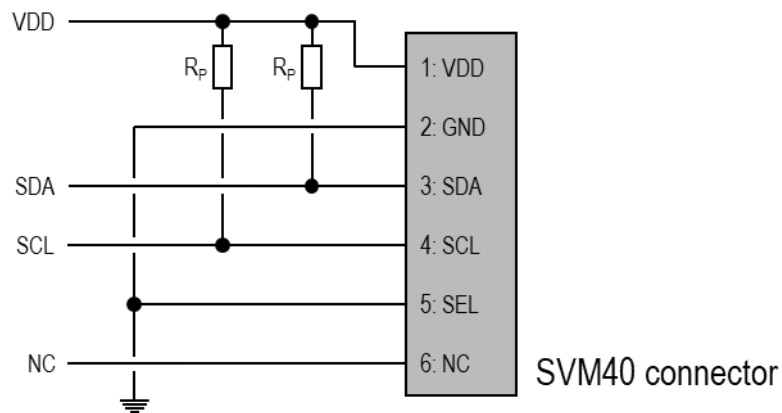


Figure 2 Typical I²C application circuit to connect the SVM40 sensor module.

A typical UART application circuit is shown in **Figure 3**.

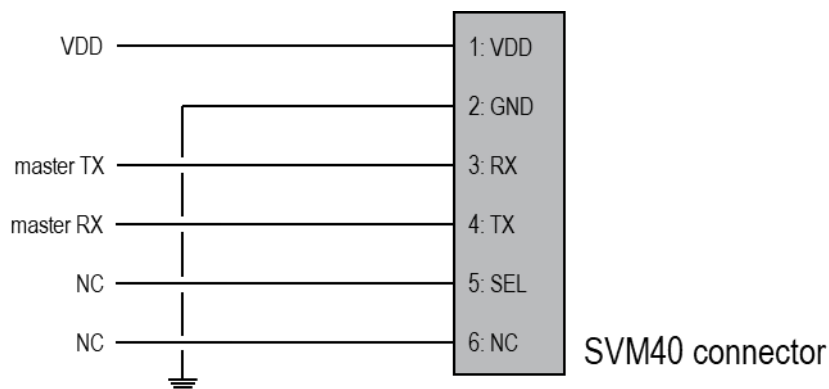


Figure 3 Typical UART application circuit to connect the SVM40 sensor module.

3 Sensor Output Signal Description

3.1 Start-up Behavior

The sensor starts powering-up after reaching the power-up threshold voltage of 3.0 V and enters idle mode after max. 100 ms. In this state, the SVM40 is ready to receive commands by the master.

3.2 Performing a Measurement

To perform a measurement, the measure mode of SVM40 has to be activated from idle mode by calling the *svm40_start_measurement* command. The measure mode remains active until either sending the *svm40_stop_measurement* or *svm40_device_reset* command or until a hard reset is executed. During measure mode, the SVM40 performs a measurement every second irrespective of the sampling interval applied by the master to get the resulting data. Once in measure mode and after waiting for the specified time, either *svm40_get_signals* (**Figure 4**) or *svm40_get_raw_signals* (**Figure 5**) command can be called to retrieve sensor data after another waiting time. The master will always send back the latest result of the measurement. In case of *svm40_get_signals*, the SVM40 will respond with three 16-bit words followed by one CRC byte each in case of I²C and with 3x two 8-bit bytes in case of UART. The first word/two bytes represent(s) the VOC Index (**Figure 6**), the second one(s) represent(s) relative humidity, and the last one(s) represent(s) temperature. In case of *svm40_get_signals*, the previous set of data is followed by another three 16-bit words followed by one CRC byte each in case of I²C or 3x two 8-bit bytes in case of UART, respectively. In this subsequent set of data, the fourth word/2 bytes represent(s) the raw signal of SGP40 (SRAW) which is proportional to the logarithm of the sensor resistance, the fifth one(s) represent(s) uncompensated relative humidity, and the sixth one(s) represent(s) the uncompensated temperature.

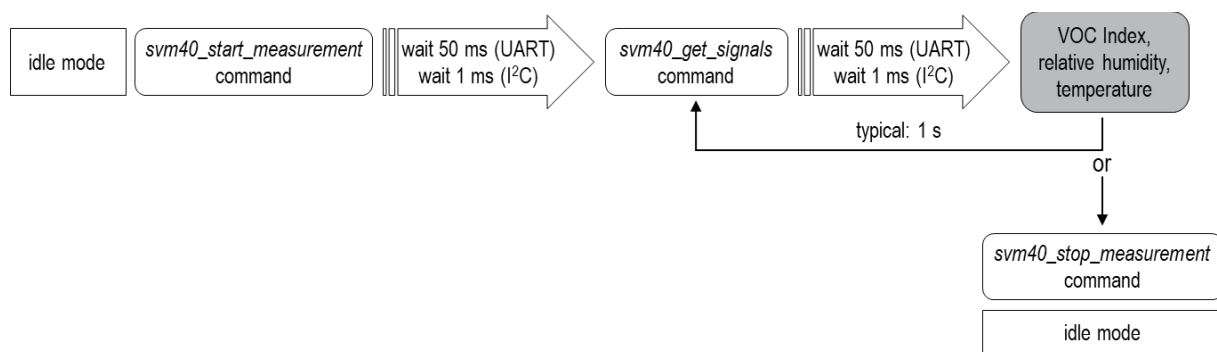


Figure 4 Process flow for performing a standard measurement with the SVM40 to receive VOC Index, relative humidity, and temperature.

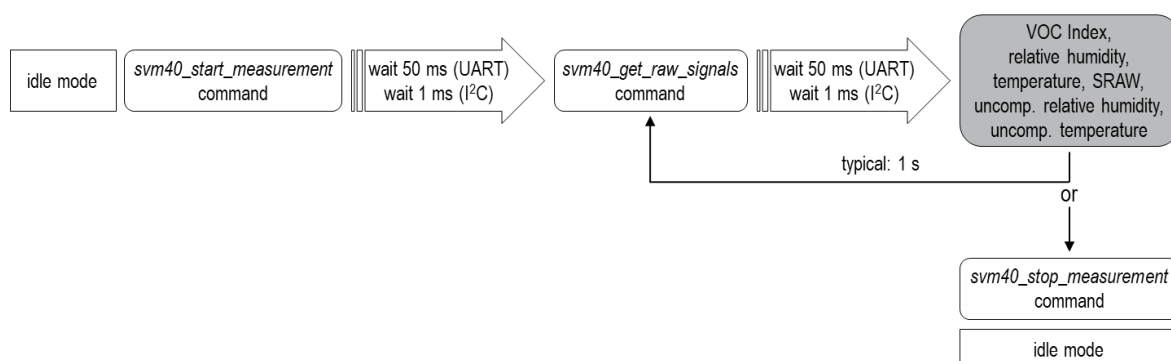


Figure 5 Process flow for performing a measurement including raw signals with the SVM40 to receive VOC Index, relative humidity, temperature, SGP40 raw signal (SRAW), uncompensated relative humidity, and uncompensated temperature.

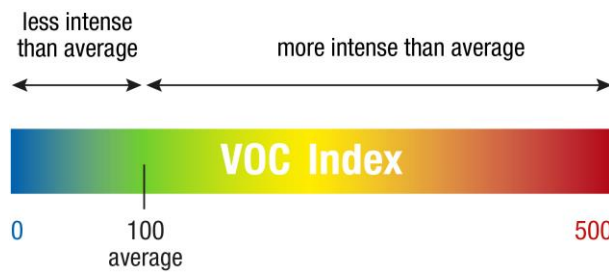


Figure 6 Explanation of the VOC Index scale.

3.3 Using the Temperature Offset for Compensating RHT Measurements

The SVM40 provides the possibility to compensate relative humidity and temperature signals of the SHT40 by setting a temperature offset which can be caused by self-heating of the PCB and/or other environmental influences (such as design-ins). Current temperature offset can be read out by sending the *svm40_get_temperature_offset* command at any time during idle or measure mode (**Figure 7** top). After the specified waiting time, the SVM40 will respond with one word of data followed by one CRC byte in case of I²C or with two 8-bit bytes in case of UART representing the currently used temperature offset value. To set the offset value, use the *svm40_set_temperature_offset* command during idle mode only (**Figure 7** bottom) by appending one word of data followed by one CRC byte in case of I²C or two bytes in case of UART, respectively, representing the desired temperature offset value. After waiting for the specified time, the master may send the *svm40_start_measurement* command to initialize the measure mode. All RHT signals subsequently received *via svm40_get_signals* are now automatically compensated. The temperature offset is not stored permanently on the SVM40. Hence, after startup and reset the parameter must be set again if still needed. To store the parameter permanently the *svm40_store_input_parameters* command must be used (see Section 3.5 Storing Input Parameters to Non-Volatile Memory).

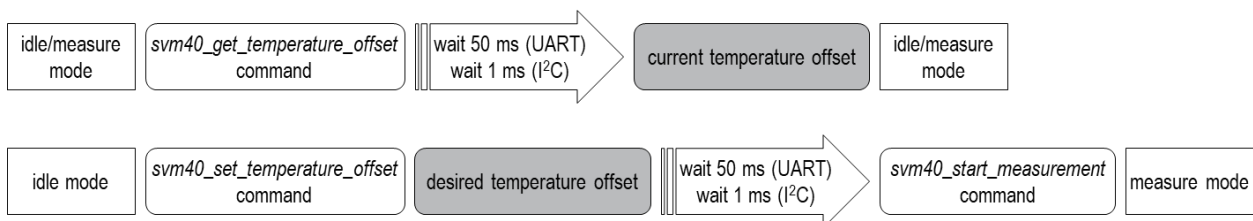


Figure 7 Implementation of the temperature offset correction for RHT signals on the SVM40.

3.4 Using the Tunability Feature of the VOC Algorithm

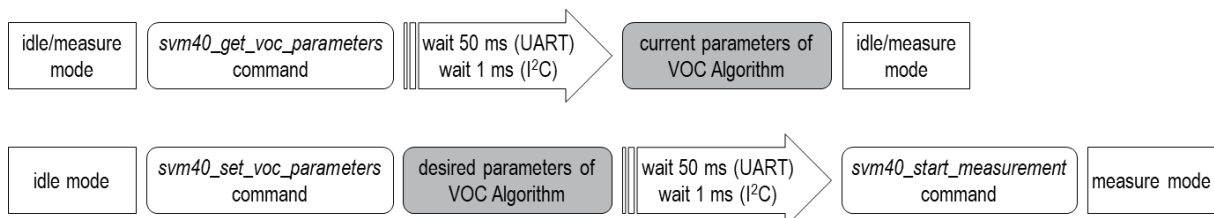


Figure 8 Implementation of the tunability feature for the VOC Algorithm on SVM40.

The SVM40 interface provides the possibility to tune the VOC Algorithm by a set of four different parameters. Current parameters (as listed in **Table 5**) can be read out during both idle and measure mode by sending the *svm40_get_voc_parameters* command (**Figure 8** top). After the specified waiting time, the SVM40 replies with four 16-bit words of data followed by one CRC byte each in case of I²C or with 4x two 8-bit bytes in case of UART. The first word/two bytes represent(s) the VOC Index which is used to

map the average conditions. The second one(s) represent(s) learning time which is used by the VOC Algorithm as a rolling window to continuously estimate its states from the history. Events longer than approx. twice the learning time will be forgotten. The third one(s) represent(s) the maximum gating duration. During this period, the estimator of the VOC Algorithm states is frozen when the VOC Index is very high. The last one(s) represent(s) initial standard deviation used during start-up of the sensor. Consequently, a lower value boosts VOC events while a higher value decreases VOC events during the start-up phase and might simultaneously impact device-to-device variation. The same parameters can be set in the same order by the master by calling the *svm40_set_voc_parameters* command (**Figure 8** bottom). All set parameters are not stored permanently on the SVM40. Hence, after startup and reset parameters must be set again if still needed. To store the parameters permanently the *svm40_store_input_parameters* command must be used (see Section 3.5 Storing Input Parameters to Non-Volatile Memory).

Parameter	Meaning	Default	Min.	Max.	Unit
average VOC Index	VOC Index value to which the average conditions shall be mapped.	100	1	250	–
learning time	Period as rolling window used by the VOC Algorithm to estimate its states from history. Events longer than approx. twice the learning time will be forgotten.	12	1	72	h
maximum gating duration	During this period, the estimator of the VOC Algorithm states is frozen when the VOC Index is very high. If the VOC Index remains high, the VOC Algorithm will start to adapt its states after this period to this new situation. 0 disables this feature.	180	0	720	min
initial standard deviation	Initial standard deviation is used during start-up of the sensor and VOC Algorithm. During this period, a lower value boosts VOC events while a higher value decreases VOC events which will have an impact on device-to-device variation.	50	10	500	–

Table 5 List of tunable parameters of the VOC Algorithm.

3.5 Storing Input Parameters to Non-Volatile Memory

The temperature offset used for compensating the RHT signals via the *svm40_set_temperature_offset* command as well as the parameters used for tuning the VOC Algorithm via the *svm40_set_voc_parameters* command can be permanently stored to the non-volatile memory of SVM40 by calling the *svm40_store_input_parameters* command and a subsequent waiting for max. 500 ms (**Figure 9**). For this, at least one of the set commands must be called before. The store command can be called at any time and during both idle and measure mode. After any hard or soft reset the corresponding algorithms will use the stored parameters. To set the storage back to factory settings, the master must overwrite all parameters applying the same set of commands while using the default values (see interface descriptions).

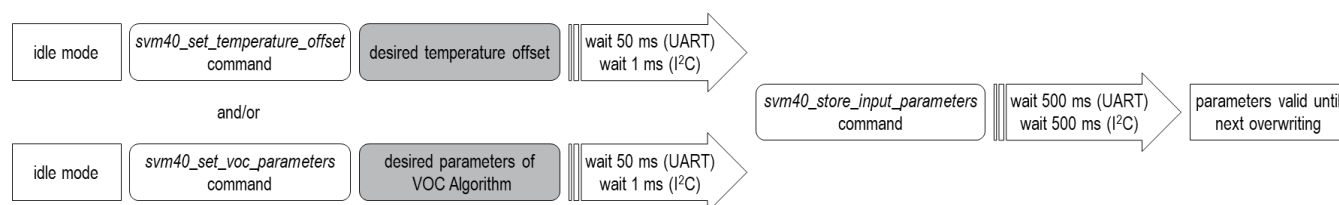


Figure 9 How to store the temperature offset used for compensating RHT signals and parameters of the VOC Algorithm to the non-volatile memory of SVM40.

3.6 Using the Memory Feature of the VOC Algorithm

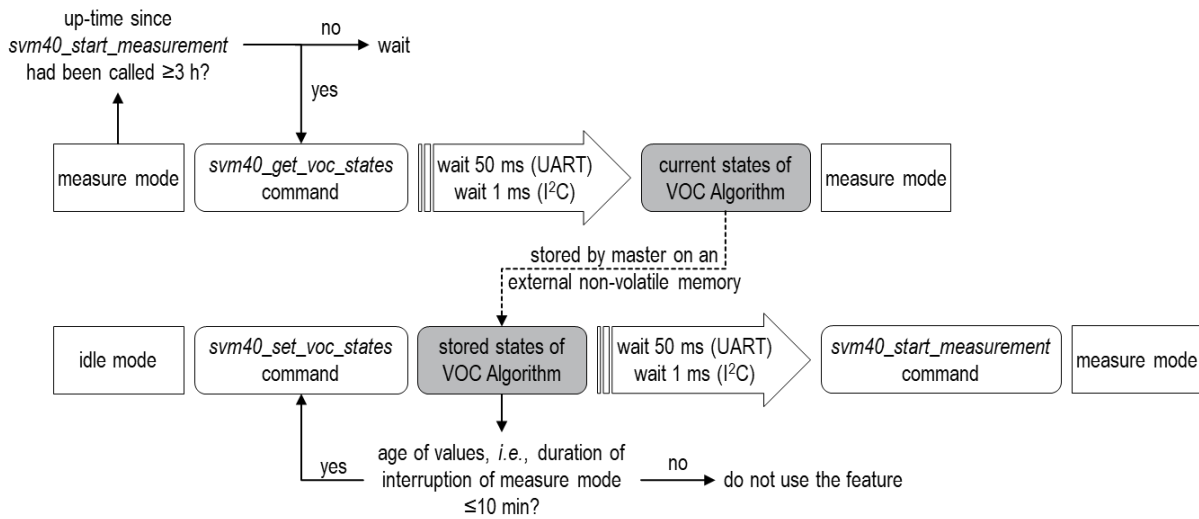


Figure 10 Implementation of the memory feature for the VOC Algorithm on SVM40.

The SVM40 allows the master to store the current states of the VOC Algorithm to resume operation with the same states after an interruption (e.g., after a blackout). This will skip the initial learning phase of the VOC Algorithm (i.e., the first 90 min after sending the `svm40_start_measurement` command while staying in measure mode). To use this feature, the master needs to send the `svm40_get_voc_states` command not until the measure mode has been run for at least 3 h (**Figure 10**). After the specified waiting time, the SVM40 responds with four 16-bit words followed by one CRC byte each in case of I²C or with eight 8-bit bytes in case of UART which contain the states of the VOC Algorithm. These values must be stored by the master on an external non-volatile memory together with an absolute timestamp. Once the SVM40 is powered-up and in idle mode again, the master may send the `svm40_set_voc_states` command together with the stored states back to the slave. This should be executed only when the stored parameters are not older than 10 minutes. After the specified waiting time, the master may call the `svm40_start_measurement` command to enter the measure mode again. The VOC Algorithm will now use the states sent by the slave to provide the VOC Index. Note: the states sent via the `svm40_set_voc_states` command are only considered for the very beginning after restarting the measure mode. After that, the estimator will continuously adapt the states on the rolling window as given by the learning time (see Section 3.4 Using the Tunability Feature of the VOC Algorithm).

3.7 Resetting the Device

The SVM40 can be reset by either hard reset or by sending the `svm40_device_reset` command. In the latter case, the slave will first reply and after max. 100 ms the SVM40 restarts and enters the idle mode. All previously stored parameters (by the `svm40_set_temperature_offset`, `svm40_set_voc_parameters`, and `svm40_set_voc_states` commands) will be erased upon resetting the device. The temperature offset and the VOC Algorithm parameters can be stored to the non-volatile memory of SVM40 by calling the `svm40_store_input_parameters` command.

Revision History

Date	Version	Page(s)	Changes
December, 2020	1.0	All	Initial release
January, 2021	1.1	All 9	Minor amendments Table 5 added

Headquarters and Subsidiaries

Sensirion AG

Laubisruestr. 50
CH-8712 Staefa ZH
Switzerland

phone: +41 44 306 40 00
fax: +41 44 306 40 30
info@sensirion.com
www.sensirion.com

Sensirion Taiwan Co. Ltd

phone: +886 3 5506701
info@sensirion.com
www.sensirion.com

Sensirion Inc., USA

phone: +1 312 690 5858
info-us@sensirion.com
www.sensirion.com

Sensirion Japan Co. Ltd.

phone: +81 3 3444 4940
info-jp@sensirion.com
www.sensirion.com/jp

Sensirion Korea Co. Ltd.

phone: +82 31 337 7700~3
info-kr@sensirion.com
www.sensirion.com/kr

Sensirion China Co. Ltd.

phone: +86 755 8252 1501
info-cn@sensirion.com
www.sensirion.com/cn

To find your local representative, please visit www.sensirion.com/distributors