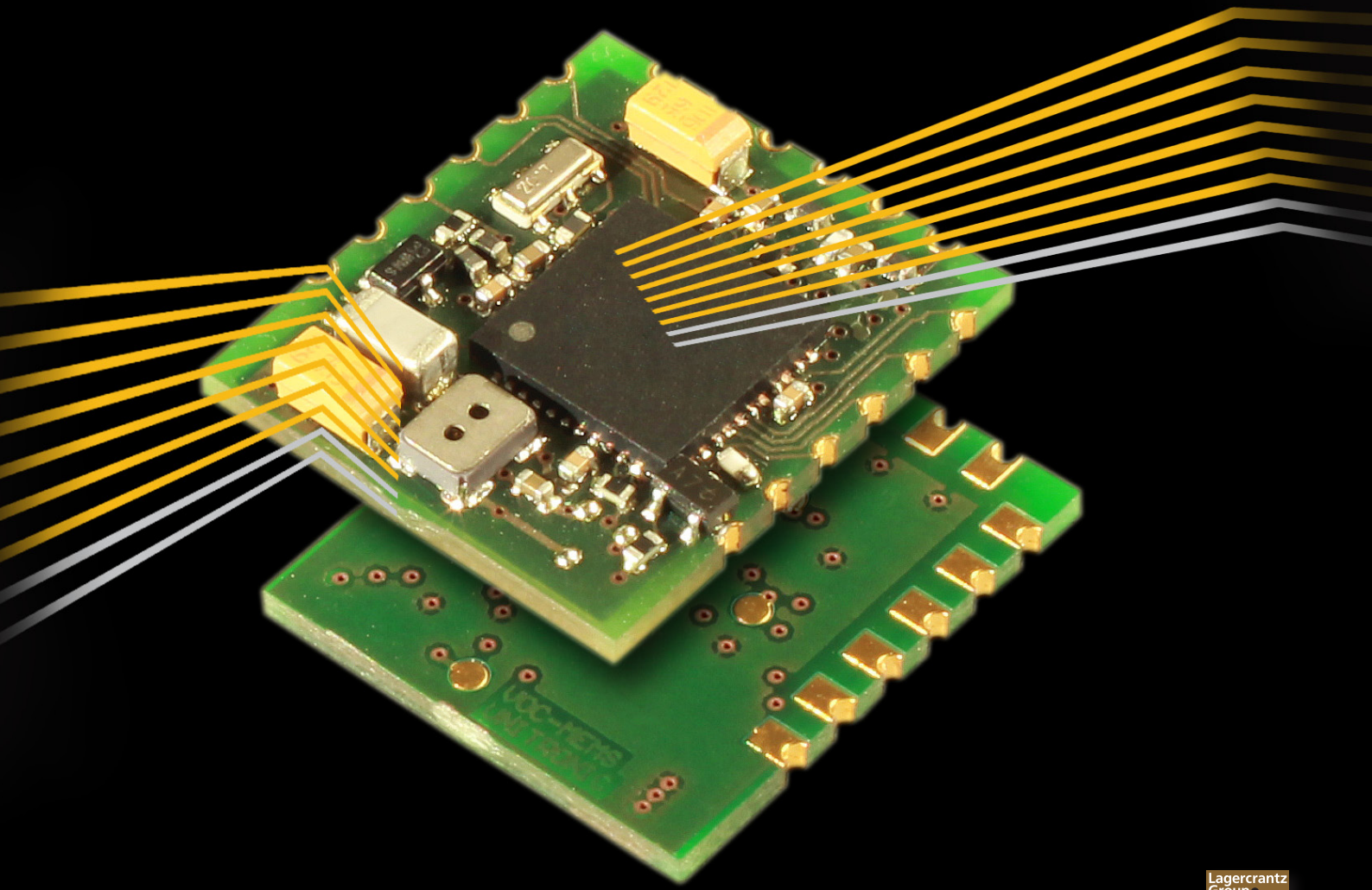
UNITRONIC

# USM-MEMS-VOC

## UNITRONIC Sensor module for measuring indoor air quality

Datasheet



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# 1. Introduction

The UNITRONIC Sensor Module (USM-MEMS-VOC is based on the innovative and highly stable TGS 8100 MEMS semiconductor sensor from Figaro. In contrast to conventional evaluation methods, the USM-MEMS-VOC uses the charge carrier motion of the sensor element rather than its ohmic resistance. This method not only guarantees a very rapid response to changes, it also enables faster recovery times. The sensor can detect a wide variety of volatile substances such as carbon monoxide, toluene and ethanol.

UNITRONIC has developed the sensor modules for easier implementation of gas sensing technology in customer applications. The module allows taking full advantage of the very quick response times and measurement cycles of the gas sensor while measuring gases with a high degree of precision. As a result, using the USM-MEMS-VOC sensor module, the customer don't need to take care about signal processing of the sensor element and don't need additional equipment to perform sensor calibration. The time to market will forge ahead faster than implementing conventional sensors only.

One objective of the following USM-VOC sensor system concept is to provide automated ventilation control working in combination with a climate control system. Such a system can adjust the room's ventilation in accordance with the level of harmful gasses or odors in the air. The system will increase comfort and reduce exposure to unhealthy substances for people in the respective building. Furthermore, the system makes ventilation and air-conditioning systems operate more energy-efficiently..

An optional temperature and humidity sensing element can be connected to the USM-MEMs-VOC module to perform temperature and humidity compensations and measurements.

USM-MEMS-VOC sensor system features:

- Cost-effective, Low Power <13,6mA
- Detection of common volatile organic compounds (VOCs)
- Extremely simple installation
- High sensitivity, Long-term stability
- Smallest dimension, 17mm x 15mm x 3mm
- SMD component part
- Interface for connecting external Temperature and Humidity sensor
- Automatic Base-Level Adjustment
- Optional customization

The air quality sensor can, for instance, provide information to a climate control system about the air quality in commonly used rooms.

# 2. Technical description

## 2.1 General concepts

Metal oxide-based semiconductor gas sensors based on the Taguchi principle were invented in the 1960's. This technology was first developed and manufactured for industrial applications by Figaro.
All oxidizing and reducible gases cause a chemical reaction in Taguchi sensors that can be analyzed electronically, providing very reliable results. The gas-sensitive semiconductors used are normally heated metal oxides such as tin dioxide (SnO2) on an aluminum oxide or ceramic substrate.

Combining advanced Micro Electro Mechanical Systems technology (MEMS) with Figaro's 50+ years of extensive experience in metal oxide type gas sensing sensors, Figaro has developed a new indoor air quality sensor with the lowest power consumption and the smallest size of any sensor in the market. With its excellent durability and stability, TGS8100 is ideal for applications such as air cleaners, air conditioners and ventilation fan activation in home and office settings.

Due to miniaturization of its sensing chip through use of MEMS technology, TGS8100 is housed in a standard surface mounting package, making it suitable for mass produced devices.

## 2.2 UNITRONIC concept for the USM-MEMS-VOC module

USM-MEMS-VOC modules include already the sensor element as well as the sensor signal processing. They can be used in the application without any additional effort. The module, measuring size is only 17mm x 15mm as SMD component part, designed for 1,8V supply voltage and can be easily integrated into customer's own circuits and applications thanks to analogue (PWM), digital as well serial (UART) outputs. The USM-MEMS-VOC enables applications such as:

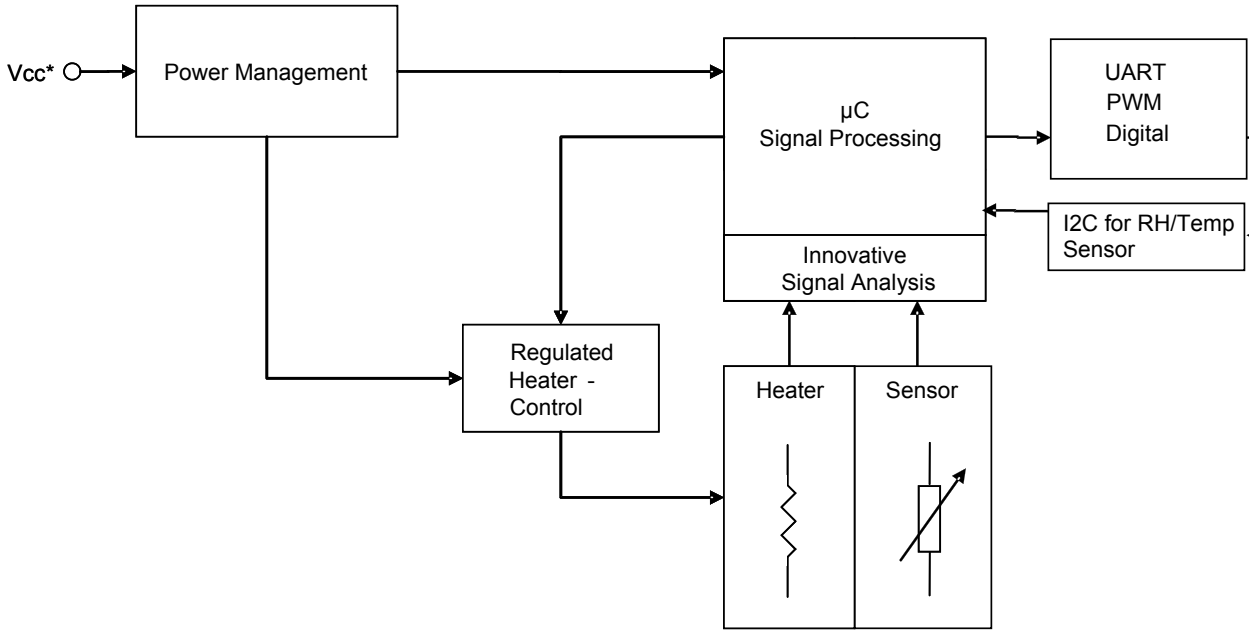
- Rapid event detection
- On-demand ventilation
- Air quality monitoring

A range of additional features such as humidity and temperature control can be enabled using optional external temperature & humidity sensor.

# 2. Technical description

## 2.3 USM-MEMS-VOC block diagram

Illustration 1 shows the architecture of the USM-MEMS-VOC sensor module.




## 2.4 Power Supply

The module operates on 1,8V DC

## 2.5 Outputs

Depending on the specific requirements, there are a number of different output options including the following:

- UART
- Analog, PWM output
- Digital, for instance to switch relays. The switching thresholds are configured for 25%, 50% and 75% of measured level.

# 2. Technical description

## 2.6 Key interfaces of the USM-MEMS-VOC

### 2.6.1 Power Supply Vcc

The module is supplied with 1,8V DC power via pin 7. The current consumption of the USM-MEMS-VOC module is <13,6mA

### 2.6.2 UART

The UART interface provides bidirectional communication. This is the primary interface for communicating with the sensor module.
Baud rate: 38400 bps, 8 data bits, no parity, 1 stop bit.

### 2.6.3 Digital Outputs

A total of three digital outputs are available. The ports are low active and can supply currents of up to 15 mA maximum. The switching thresholds of the digital outputs are configured for 25%, 50% and 75% from measured air quality level.

### 2.6.4 Analogue Output

The analogue output is providing a PWM signal (185Hz) which is proportional changing with the concentration of the air quality signal.

### 2.6.4 I2C interface for external temperature and humidity sensor

On the I2C Interface an external temperature and humidity sensor can be connected. The supplier of the suitable sensor is the company:

- Measurement Specialties Inc. with the sensor HTU21D

This sensor can be connected direct to the USM-MEMS-VOC module.

The USM-MEMS-VOC module can also operate with Sensirion sensors SHT21 and SHT25. However, the two sensors can operate with >2,5V power supply. Therefore an additional level converter will be necessary to ensure properly function.

### 2.6.5 SPI interface

SPI interface is optionally available. (customised software adaption will be needed)

# 3. Electrical characteristics

## 3.1 Pin assignment

| Pinbelegung | Bezeichnung | Type | Beschreibung |
|---|---|---|---|
| 1 | GND | PWR | Power Ground |
| 2 | SCL | I/O | I²C Port, Clock |
| 3 | ~SS | I/O | SPI Port, Chip Select (optional) |
| 4 | SDI | I/O | SPI Port, Data In (optional) |
| 5 | SDO | O | SPI Port, Data Out (optional) |
| 6 | SCK | O | SPI Port, Clock (optional) |
| 7 | Vcc | PWR | Power Supply, 1,8V DC |
| 8 | PWM | O | Analog Output, PWM (puls wide modulation) |
| 9 | RxD | I | UART (data receive) |
| 10 | TxD | O | UART (data transmit) |
| 11 | ConfigPin 1 | I/O | Not Used |
| 12 | ConfigPin 2 | I/O | Not Used |
| 13 | D1 | O | Digital Out, D1 |
| 14 | D2 | O | Digital Out, D2 |
| 15 | D3 | O | Digital Out, D3 |
| 16 | NReset | I | Reset, Low Active |
| 17 | SDA | I/O | I²C Port, Data |
| 18 | GND | PWR | Power Ground |

## 3.2 Voltages and Currents

| Parameter | Bezeichnung | Min | Typ | Max | Einheit |
|---|---|---|---|---|---|
| Power Supply Voltage | Vcc | 1,78 | 1,8 | 1,82 | V |
| Power Consumption | Vcc | | 13,6 | | mA |
| Digital Output | D1, D2, D3 | | | 10 | mA |
| PWM Output | PWM | 0 | | 1,8 | V |
| PWM Output Current | PWM | | | 10 | mA |
| PWM Frequency | PWM | | 185 | | Hz |
| Operation Temperature | | -10 | | +50 | °C |
| Storage Temperature | | -20 | | +60 | °C |
| TTL Level | I/O | | 1,8 | 1,82 | V |

# 4. Sensor technology

The USM-MEMS-VOC uses a TGS 8100 tin-dioxide semiconductor sensor that is sensitive to reducible gases and vapors.

The sensing element is comprised of a sensing chip and an integrated heater formed on a silicon substrate using MEMS technology, and a metal-oxide semiconductor layer formed on the sensing chip. The device is housed in a surface-mount ceramic package. Due to miniaturization of the sensing chip, TGS 8100 requires a heater power consumption of only 15mW, and is suitable for low-power equipment and battery-operated instruments. In the presence of detectable gas, sensor conductivity increases depending on gas concentration in the air. A simple electrical circuit can convert the change in conductivity to an output signal which corresponds to the gas concentration.
The TGS 8100 has high sensitivity to low concentrations of gaseous air contaminants such as cigarette smoke and cooking odors. By utilizing the change ratio of sensor resistance from the resistance in clean air as relative response, human perception of air contaminants can be simulated and practical air quality control can be achieved.

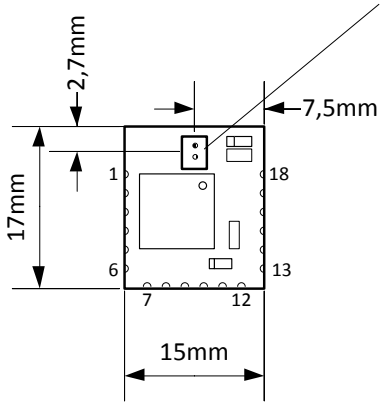
An innovative evaluation method is used to interpret the data from the sensor layer. In contrast to conventional evaluation methods, the charge carrier motion of the sensor element is used instead of the ohmic resistance of the gas sensor. This allows an event to be recognized more quickly and clearly while also decreasing the sensor‘s recovery time.

# 5. Mechanical characteristics

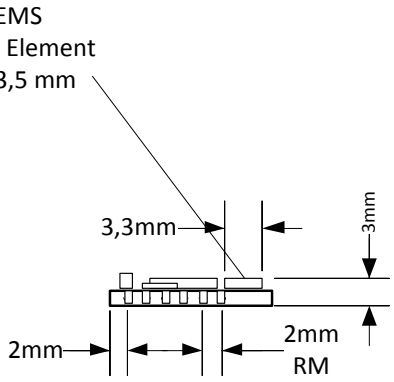
The USM-MEMS-VOC module has the following mechanical dimensions:

- Length: 17mm +/- 0.5mm
- Width: 15mm +/- 0.5mm
- Height: 3 +/- 0.5mm

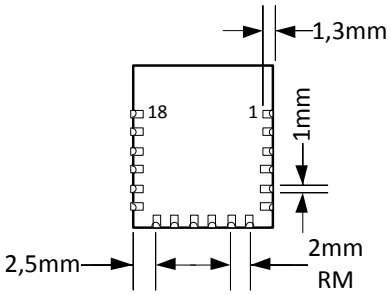
USM-MEMS-VOC
Top View




USM-MEMS-VOC
Side View




USM-MEMS-VOC
Bottom View



# 6. UART Protocol

## 6.1 General Settings

Baud rate: 38400
Date bytes: 8
Stop bits: 1
Parity: None

## 6.2 Command Overview

- START_USM 0x31
- STOP_USM 0x32
- EXECUTE_RESET 0x33

## 6.3 Acknowledge Overview

- ACK_SET_RESET 0x41

## 6.3 Acknowledge Overview

| Byte 0 | Byte 1 | Byte 2 | Byte 3 | Byte 4 | Byte 5 | Byte 6 |
|---|---|---|---|---|---|---|
| ADR L | ADR H | LEN | CMD | 00 | 00 | CRC |

With

ADR: Device ID

ADR H: 16 Bit Address High byte

ADR L: 16 Bit Address Low byte

LEN: 8 Bit length of the message (from CMD included, until CRC exclusive)

CMD: 8 Bit command

CRC: 8 Bit CRC 8 of the data bytes Byte 4 – Byte 4+n (Polynomial 0xB7)

Example for the continuous output of the sensor data from the module with the address 0x01:

| Byte 0 | Byte 1 | Byte 2 | Byte 3 | Byte 4 | Byte 5 | Byte 6 |
|---|---|---|---|---|---|---|
| 01 | 00 | 03 | 31 | 00 | 00 | 00 |

# 6. UART Protocol

## 6.4 Start USM

| Byte 0 | Byte 1 | Byte 2 | Byte 3 | Byte 4 | Byte 5 | Byte 6 |
|---|---|---|---|---|---|---|
| ADR L | ADR H | 03 | 31 | 00 | 00 | CRC |

Continuous output of the sensor value with the interval of 100ms:

| Byte 0 | Byte 1 | Byte 2 | Byte 3 | Byte 4 | Byte 5 | Byte 6 |
|---|---|---|---|---|---|---|
| ADR L | ADR H | 0B | 02 | SEN L | SEN H | TEMP L |
| **Byte 7** | **Byte 8** | **Byte 9** | **Byte 10** | **Byte 11** | **Byte 12** | **Byte 13** |
| TEMP H | HUM L | HUM H | PROZ L | PROZ H | STATUS | D_OUT |
| **Byte 14** | | | | | | |
| CRC | | | | | | |

With:

SEN H, SEN L: 16 Bit Sensor Value (Raw Data)

TEMP H, TEMP L: 16 Bit Temperature Value [°C/10] (for ex.: 205 = 20,5 °C)

HUM H, HUM L: 16 Bit Relative Humidity Value [%/10] (for ex.: 205 = 20,5 %)

PROZ H, PROZ L: 16 Bit Percentage Value respective to configured Air Quality Value (for. Ex.: 10 = 10%)

**[This information represents „Air quality“, as for example:**

**0% = „very bad air“**

**30% = „bad air“**

**70% = „acceptable air“**

**100% = „good air“**

STATUS: 8 Bit Status (active when „Demand Control“ is enable only)

| Bit 0 | Bit 1 | Bit 2 | Bit 3 | Bit 4 | Bit 5 | Bit 6 | Bit 7 |
|---|---|---|---|---|---|---|---|
| Sensor < Switch level | Humidity > Switch level | Temp > Switch level | Byte 0 \|\| 1 \|\| 2 | NA | NA | NA | NA |

D_OUT: 8 bit state of the digital outputs:

| Bit 0 | Bit 1 | Bit 2 | Bit 3 | Bit 4 | Bit 5 | Bit 6 | Bit 7 |
|---|---|---|---|---|---|---|---|
| D1 | D2 | D3 | NA | NA | NA | NA | NA |

# 6. UART Protocol

## 6.5 Stop USM

| Byte 0 | Byte 1 | Byte 2 | Byte 3 | Byte 4 | Byte 5 | Byte 6 |
|---|---|---|---|---|---|---|
| ADR L | ADR H | 03 | 32 | 00 | 00 | CRC |

Continuous output of the protocol data will be stopped

## 6.6 Execute Reset

| Byte 0 | Byte 1 | Byte 2 | Byte 3 | Byte 4 | Byte 5 | Byte 6 |
|---|---|---|---|---|---|---|
| ADR L | ADR H | 03 | 33 | 00 | 00 | CRC |

The module executes a reset and responds as following:

| Byte 0 | Byte 1 | Byte 2 | Byte 3 | Byte 4 | Byte 5 | Byte 6 |
|---|---|---|---|---|---|---|
| ADR L | ADR H | 03 | 41 | 00 | 00 | CRC |

After reset the protocol data output is disabled.

## 6.7 CRC Calculation C Code

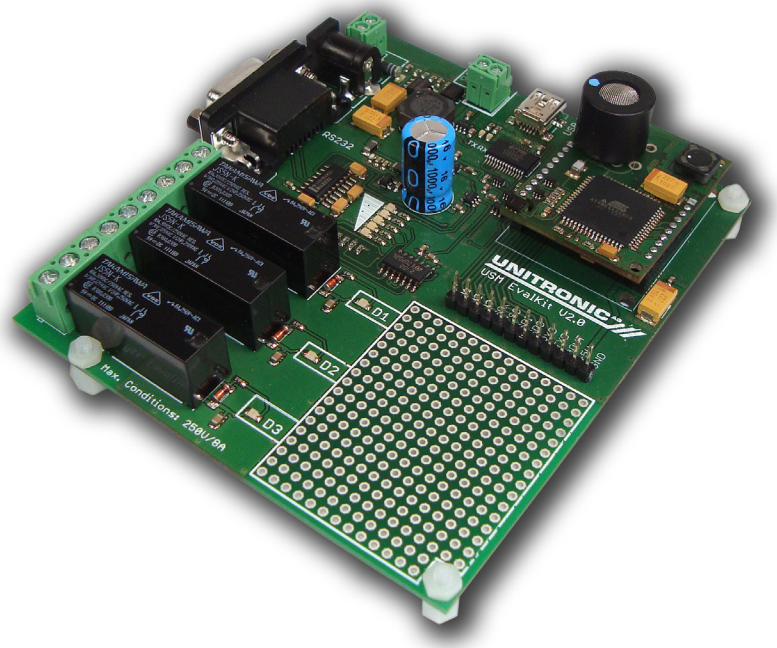
```
int8_t crc8bit(uint8_t *byteptr, uint16_t items)
{
    int16_t i;
    uint8_t b;
    uint8_t crc8=0;
    uint8_t byte;
    uint8_t hbit=0;
    uint8_t hbit_source=0;

    for(i=0;i<items;i++)
        {
        byte=*byteptr++;
        for(b=0;b<8;b++)
        {
            hbit=(crc8 & 0x80) ? 1 : 0;
```

# 6. UART Protocol

```
            hbit_source=(byte & 0x80) ? 1 : 0;
            if(hbit!=hbit_source)
            {
                                                    crc8=(crc8<<1) ^ 0xB7;
            }
            else{
                                                            crc8=crc8<<1;
            }
            byte=byte<<1;
        }
    }
    return crc8;
}
```

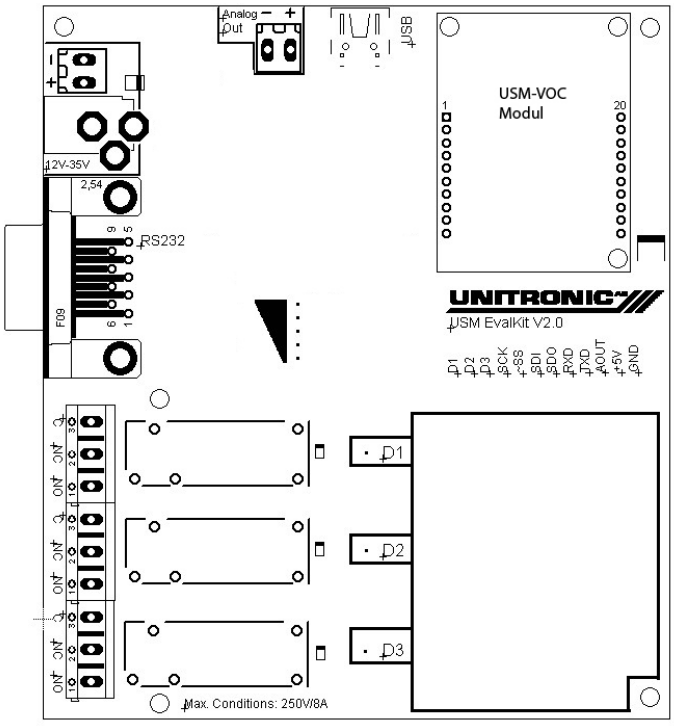
# 7. Evaluation Board




## 6.1 Pin configuration

The evaluation board power supply can range from 10 to 35V. The serial data are available via RS 232 (F09) or USB interface.

The control strip is clearly labeled. Here, the digital and analogue output from the USM-MEMS-VOC can be captured. In addition, LEDs assigned to the respective signals display their current output statuses. The software that accompanies the development board allows users to evaluate the sensitivity of the sensor or the switching thresholds of the digital outputs, for instance. The software provides a graphic representation of the measurements. It can export the results to an Excel file for subsequent analysis. Additional information is provided in the user manual of the Evaluation Kit.



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**UNITRONIC GmbH:**

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Additional information can be found on our web page.