HVSUP01
Composite I2C sensor
for
radiation detector (GM) tubes

User Manual

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Introduction

The HVSUP01 sensor provides simple and flexible interface between a host processor and a radiation detector tube. The device requires minimal external components and its properties can be configured via I2C interface. The low current consumption of the sensor makes it ideal for building ultra low power radiation detector devices.

HIGH VOLTAGE WARNING

The sensor is producing high voltage during normal operation.
Its pins, including any electrically conductive device that is connected to its terminals, must not be touched while the device is operational.
The high voltage terminals shall be shorted after powering off the device, to make sure that no high voltage charge remains in the sensor.

Features

- 3V input
- 400-600V output voltage, digitally adjustable
- low input current typ. <60uA at 400V output and no load
- 24 bits pulse counter
- Timer with crystal oscillator to trigger Wake-up output
- Built-in output current limiting resistor 4.5MOhm
- I2C slave interface max 400kHz
- I2C address is 0x6E (7bits)

Technical specifications

Electrical parameters

Absolute ratings	**Value**
Supply voltage Vcc	2.6V – 3.5V
Output Voltage	400V-600V digitally adjustable
Output resistance	4.5MOhm
Maximum voltage on digital I/O pins	Supply voltage + 0.2V

Typical parameters @ 3V input voltage	
Output Voltage accuracy @no load	+/-3V
Standby current consumption with output disabled	5uA
Standby current consumption @400V no load	60uA
Standby current consumption @500V no load	90uA
Standby current consumption @600V no load	120uA
Inrush current at starting the high voltage stage	300mA @ 40ms

Timing parameters

Typical parameters at 3V input voltage	
Pulse width of TRIG output	approx. 1 msec
Wake-up timeout accuracy	+/- 30ppm
I2C interface clock frequency	max 400kHz
Detected pulses per second	0...5000
I2C clock stretching	max 10ms
Voltage ramp-up time	approx. 50 sec

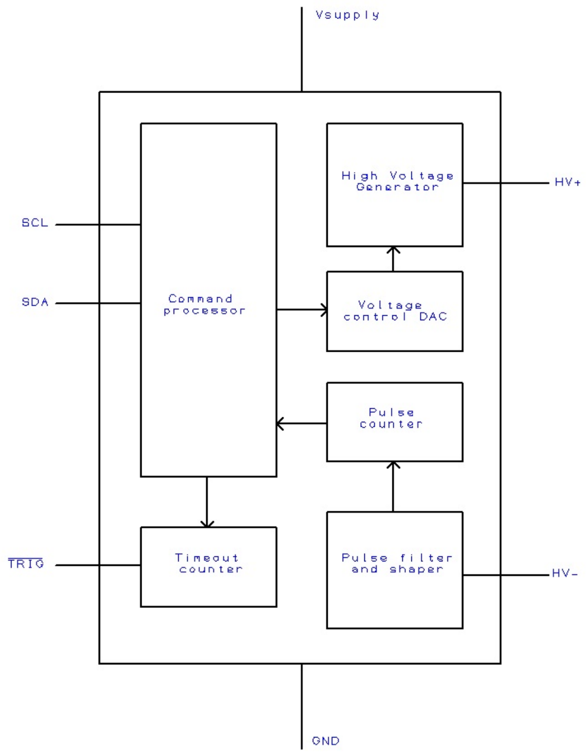
Environmental conditions

Absolute ratings	
Operational temperature	-20°C ... 50°C
Storage temperature	-20°C ... 70°C
Relative Humidity	10%..90% non-condensing

Operation

General behavior

The device is an I2C slave peripheral that can output high voltage. It is intended to count the detected pulses of a connected GM tube. The sensor contains all signal shaping circuit that is necessary for accurate and error-free detection of the pulses.



1. Drawing: Block diagram

Configuration

The device has two configurable parameters: the output voltage and the timeout.

Output voltage

The voltage is a 16bits parameter with valid range from 400V to 600V. The given value is the output of the high voltage front-end. Setting the voltage out of the allowed range will turn off the high voltage generator, while the rest of the device, e.g. timeout and pulse counter, remains functional.

The default value of the parameter is zero, i.e. the high voltage generator is turned off. For proper functionality the value shall be configured to the operational voltage of the connected GM tube.

Timeout

The timeout is a 16 bits parameter in seconds. Setting the parameter to a value different than zero will generate an active low signal on the TRIG pin of the device. Parameter zero will turn off the TRIG signaling.

The default value of the parameter is zero.

Reading pulse count

The pulse count value is a 24bits number. It is incremented by every pulse from the attached GM tube. The number of pulses for a given radiation level is characteristic for each GM tube.

If the timeout is set to zero then the counter value reflects the number of pulses since the last readout. If the timeout is non-zero then the value is reflecting the number of pulses in the previous complete timeout period, and remains the same until a new timeout occurs.

Reading factory data

Firmware version

The value is a 16 bits number, with MSB denoting the major and LSB denoting the minor software version.

Hardware version

The value is a 16 bits number, with MSB denoting the major and LSB denoting the minor hardware version.

Serial number

The value is a 32 bits number that is unique for each device.

Typical operation

The sensor can be connected to a 3V compliant I2C bus directly. The digital pins of the device are not 5V tolerant!

Proper pull-up resistors shall be connected to the SCL and SDA lines, typically 4.7KOhm is sufficient. The open-drain TRIG pin can be optionally connected to the wake-up, interrupt or reset pin of the MCU. This may be beneficial if the host MCU is put in deep sleep mode between measurements. The HVSUP01 device can ensure that the host MCU is woken up periodically by pulling down the TRIG pin for about 1ms, after the timeout elapses.

Digital interface

I2C (SCL and SDA)

The device can be interfaced to an I2C master host that supports Standard and Fast Mode communication. The sensor has a set of registers that can be read and written. The registers can be accessed either individually or in group. The I2C bus specification is not detailed here. For further reference see [1]

The device can be accessed at the I2C address 0x6E. The address cannot be modified.

The I2C command processor of the sensor evaluates the register changes after each STOP condition. Therefore it is recommended to write the configuration parameters in atomic 16bits steps or consecutive registers in one 32bits step.

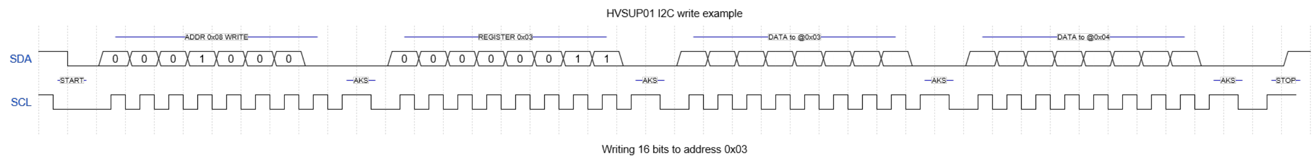
Application hint: Although modifying individual register bytes is possible, it may lead to undesired functionality. For example, if the timeout value 0x00FF is changed to 0x0101 in two steps then writing an individual 0x01 to LSB while the MSB is still 0x00, would trigger a wake-up request at the next second instead of 257 seconds.

Access of the device

The registers of the device appear like an array of bytes. The desired register can be selected by a one byte address value that is written to the device. This may be followed by a sequence of write or read requests.

Writing data to the device

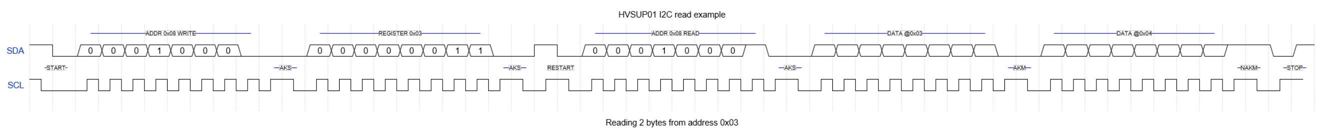
Several consecutive bytes can be written with a single write sequence, followed by a STOP. The picture below demonstrates and example, where two bytes are written to the register address 0x03 (timeout register).



2. Drawing: I2C write

Reading data from the device

Several consecutive bytes can be read then with a single read sequence that is terminated by a NACK from the host, followed by a STOP sequence. The picture below demonstrates and example, where two bytes are read from the register address 0x03 (timeout register).



3. Drawing: I2C read

Clock stretching

In order to maintain reliable communication in the specified I2C clock range, the device is using clock stretching. This is completely transparent to the host application in most cases. If the host is using software emulation for I2C communication, it might be necessary to set the clock stretch timeout explicitly. Observe the value specified in chapter Timing parameters.

TRIG output

The TRIG pin is a configurable open-drain output. The device is setting the pin to active LOW for 1 millisecond, with the period that is defined by the timeout register value.

Memory map

Address	Register	Read/Write	Value after power-up
0x00	PulseCount[7..0]	Read only	0
0x01	PulseCount[15..8]	Read only	0
0x02	PulseCount[23..16]	Read only	0
0x03	Timeout[7..0]	Read - Write	0
0x04	Timeout[15..8]	Read - Write	0
0x05	Voltage[7..0]	Read - Write	0
0x06	Voltage[15..8]	Read - Write	0
0x07	HW Version [7..0]	Read only	varies[1]
0x08	HW Version [15..8]	Read only	varies
0x09	Firmware Version [7..0]	Read only	varies
0x0A	Firmware Version [15..8]	Read only	varies
0x0B	Serial Number[7..0]	Read only	varies
0x0C	Serial Number[15..8]	Read only	varies
0x0D	Serial Number[23..16]	Read only	varies
0x0E	Serial Number[31..24]	Read only	varies

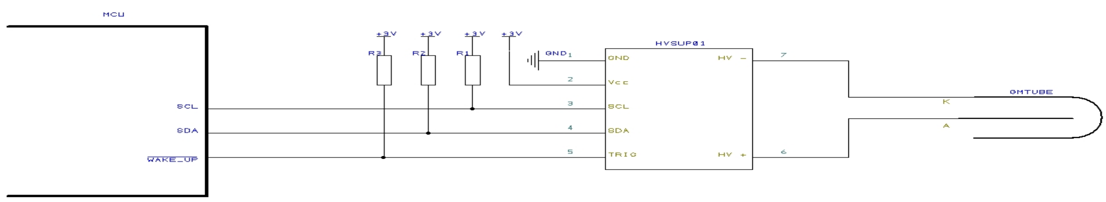
Endianness

All register values are stored in little endian byte order.

[1] The HW, Firmware and Serial number values designate a given device, hence there is no fix default value

Connection setup

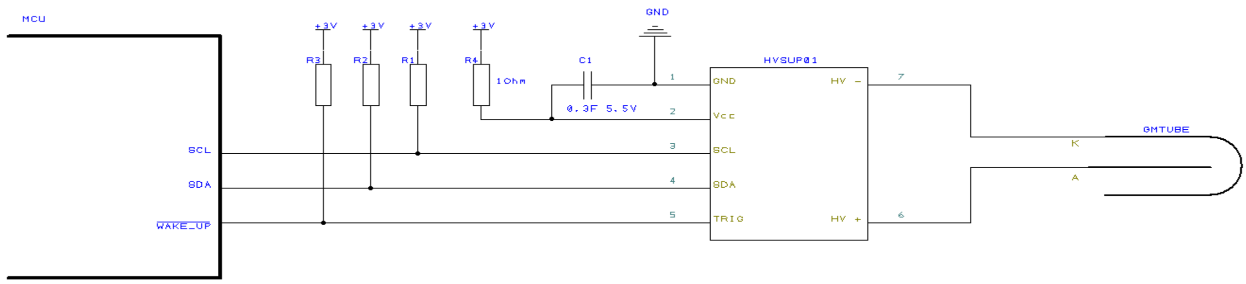
A typical connection is demonstrated on picture 4 below.



4. Drawing: Typical connection

Power supply

During normal operation the sensor is generating very short, high current pulses on the power input. If the circuit is powered from a low power LDO rated less than 400mA, then it is suggested to connect a relatively large capacitor (e.g. 0.3F supercap) between Vcc and GND and connect a series resistor in a few Ohms range between the LDO and the capacitor. See picture 5 below.



5. Drawing: Typical connection with weak power supply

Detector noise

The High Voltage front-end contains filtering and signal shaping features to eliminate most electrical noise that could influence the measurement. Large noise signal on the terminals of the sensor can still negatively affect the pulse count value. Therefore it is recommended to ensure that the connection between the device and the detector tube is as short as possible. If the distance between the sensor and the tube is longer than 15-30cm then shielded cable can be used with two inner conductors.

Package

The sensor is available in epoxy filled ABS package.

Pin configuration

Bottom view of the device with pin numbers:

[Warning: Draw object ignored]6.
Drawing: Pin numbering

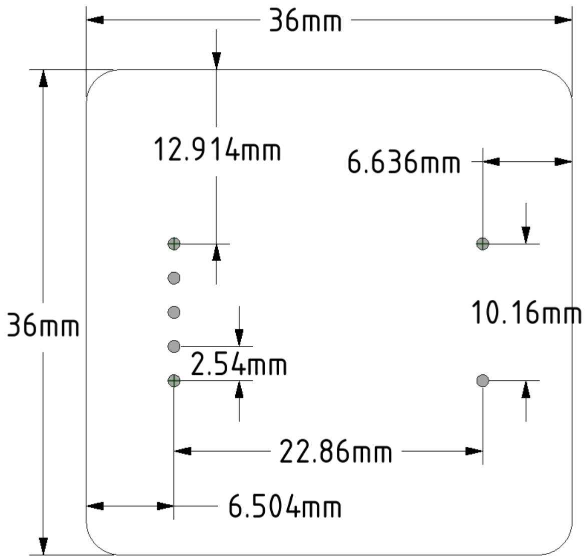
Pin number	**Pin function**
1	GND
2	Vcc
3	SCL
4	SDA
5	TRIG
6	HV +
7	HV -

Outline dimensions

All dimensions are in millimeters.

Length x width	36 mm x 36 mm
Height without pins	15 mm
Height with pins	21.5 mm
Pin width	0.64 mm x 0.64 mm

Pin placement dimensions



7. Drawing: Mechanical drawing

Soldering and assembly recommendations

The HVSUP01 sensor is primarily suitable for manual soldering. The pins are gold plated which provides excellent electrical connection when used with solder-less breadboards, too.

The device is not suitable for any assembly process that could expose the encapsulation to temperatures higher than 80 °C or 176 °F.

References

1.	I2C-bus specification and user manual

Legal disclaimer

The HVSUP01 sensor is intended for educational purpose only.

The sensor may not fit for use in environment and purpose where the malfunction of the device could lead to bodily harm or property damage.

The user of the device understands and agrees that the prototyping sensor has not been fully certified, therefore its output data must not be used for quantitative judgment of potentially high radiation.

It is the user's responsibility to determine whether the product fits for the intended use in the prototyping environment.

The author of this project shall not be liable to any damages related to use of the device.

The sensor is not a Finished Appliance. In case the equipment is used as part of a Finished Appliance then the user of the device must take responsibility for galvanic insulation from the environment and to follow regulatory guidelines, for example CE marking.

RoHS compliance

Although the device has been built from RoHS compliant parts with RoHS compliant assembly process, no formal statement is given here about RoHS compliance.

