e2v

MiCS-OZ-47
Ozone Sensing Head with Smart Transmitter PCB

FEATURES

- Ozone, temperature and humidity* monitoring.
- Drift compensation with dual sensor principle.
- Temperature and humidity* compensation.
- PWM output.
- RS-232 – TTL interface.
- Supplied with dual ozone sensor, configured and calibrated.
- Special ranges supplied on request

*MiCS-OZ-47H is equipped with temperature and humidity sensors; the basic version has the temperature sensor only.

GENERAL DESCRIPTION

MiCS ozone sensors have been available for several years, as the sensor only. To date OEMs have been responsible for any local signal conditioning and the transmitter circuitry. The MiCS-OZ-47 module has been designed to be integrated easily by OEMs for applications such as environmental monitoring.

The MiCS-OZ-47 is a microprocessor based PCB module designed for ozone sensing applications. The raw signal input from the sensor is processed digitally by the microprocessor, which also stores information such as temperature, humidity, calibration data, the range and lifetime of the sensor.

The device can be configured to deliver the ozone readings as a PWM output or binary output for alarm threshold (>50 ppb). The MiCS-OZ-47 can also be interrogated digitally via RS232-TTL, with information such as alarm threshold, fault conditions, calibration information etc being available from the microprocessor registers.

The OZ-47 module is built around an 8-bit micro-controller. It provides binary output (PWM) and a serial interface Rx/Tx to facilitate communication.

By default the module is factory calibrated. Calibration validity depends on the cycle time and the cumulated time of operation.

SPECIFICATIONS

Sensing elements	MiCS-4614 (dual ozone gas sensor)
Signal outputs	PWM
Digital input/output	RS232-TTL
Power supply	3.3 – 10 Vdc, nominal 5.0 V
Current consumption: at 5 V at 3.3 V	TBD
Microprocessor	8-bit
Range	20 to 200 ppb (special range on request) 0 100% RH (humidity sensor) -40 to 123.8 °C (-40 to 254.9 °F) (temperature sensor)
Accuracy	±20 ppb ±4.5% RH ±0.5 °C
Lifetime	3 years (minimum)
Response time	6 minutes (typical but depends on cycle time)
Temperature range	10 to 40 °C (calibration limited)
Humidity range	20 - 90% RH, non condensing
Calibration	digitally via RS232

MiCS-OZ-47 is not ATEX approved

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COMMUNICATION INTERFACE

The micro-controllers of the module and a motherboard can be directly connected with no interface circuit via their UART with TTL levels.

Configuration is:

- 19 200 bauds
- 8 data bits
- 1 stop bit
- no parity

TX is the signal, which goes out of the OZ-47.
RX is the signal, which enters the OZ-47.

OZ-47 is equipped with a four pin female connector. Poka-Yoke is done with hole in the PCB close to pin #1.

Pin	Function
1	Vbat
2	RX
3	TX
4	GND

COMMUNICATION PROTOCOL

All strings start with an opening bracket "**{**" 8123d, 0x7B) and end with a closing bracket "**}**" (125d, 0x7D).

String length is a maximum of 32 characters in emission and reception.

All the data placed between the two brackets have to be comprised between character "space" (32d, 0x20) and the code 127d (0x7F).

String Decomposition

Each string compounds like this:

{	Function code	x	x	x	x	x	x	x	}

First octet is always a function code. All binary data are coded like this:

MSB first.
Each group of 4 bits is coded in ASCII. Hex value '0' gives code "0" (48d, 0 x 3**0**), hex value '9' gives code "9" (57d, 0x3**9**), hex value 'A' gives code ":" (58d, 0x3**A**), hex value 'F' gives code "?" (63d, 0x3**F**).

Application Note

To send hexadecimal value 0x7F:

```
// unsigned char Nb = 0x7F;
// unsigned char ByteH;
// unsigned char ByteL;
ByteH = (Nb >> 4) | 0x30;
ByteL = (Nb & 0x0F) | 0x30;
// Send ByteH followed with ByteL;
```

To convert received ASCII string « ; 5 » (59d 53d, 0x3B 0x35):

```
// unsigned char Nb;
// unsigned char ByteH = 0x3B;
// unsigned char ByteL = 0x35;
Nb = (ByteH << 4) | (ByteL & 0x0F);
```

Process is the same with a 16-bit value.

PREDEFINED FUNCTIONS

Measurement

Master	{	M	}															
OZ-47	{	M	$O3_{1h}$	$O3_1l$	$O3_{2h}$	$O3_{2l}$	$Rs1_{hl}$	$Rs1_{lh}$	$Rs1_{ll}$	$Rs2_{hl}$	$Rs2_{lh}$	$Rs2_{ll}$	T_{hl}	T_{lh}	T_{ll}	H_h	H_l	}

Note: This function collects last measurement and is a trigger for measurement if calibration mode is active. This means that data collected are the one from the previous {M} sent to OZ-47.

Example
Motherboard sends:
{K} // OZ-47 is set in calibration mode

OZ-47 responds with:
{K}// OZ-47 always repeats master command

Motherboard sends:
{M} // Request for a measurement

OZ-47 responds with:
{M00000240472<024}// Measurement string, ozone concentration
// is set to 0 in calibration mode

Operation Status

Master	{	C	M	Heater of sensor 1	Heater of sensor 2	Overheating of sensors	}
OZ-47	{	C	M	Heater of sensor 1	Heater of sensor 2	Overheating of sensors	}

This command drives the heating of the ozone gas sensors. In initial mode (after reset), only sensor 1 is operated. Timing for preheat and cycling can be configured (see configuration section).

Heater of sensor can be: “A” (stopped) or “M” (powered)
Overheating can be: “A” (stopped) or “M” (powered)

Command State

Master	{	E	}					
OZ-47	{	E	Module status	Module operation	Status of heater 1	Status of heater 2	Status of overheating	}

This command collects the status of the module.
Module status: Check sensors behaviour and send “N” normal or “D” defect
Module operation: “A” (sleep mode not implemented at the moment) or “M” (standard power)

Status of heater 1 can be: “A” (stopped) or “M” (powered)
Status of heater 2 can be: “A” (stopped) or “M” (powered)
Status of overheating can be: “A” (stopped) or “M” (powered)

Diagnostic

Master	{	A	}		
OZ-47	{	A	Diag sensor#1	Diag sensor#2l	}

If diag OK then {A00}, if diagnostic is detecting that at least one of the two ozone sensors is defect (out of range) then {A??}.

Calibration Mode

Master	{	K	}
OZ-47	{	K	}

Set module in calibration mode, this mode is useful to collect calibration data, i.e. measurement is done after each {M} request. The ozone concentrations are not displayed in this mode.

Automatic Mode

Master	{	S	}
OZ-47	{	S	}

In this mode the module is independent from an external time reference. It is using its own clock to perform measurement on a programmable regular basis. Measurements are not sent automatically and must be requested with a {M} command.

Top Clock Mode

Master	{	T	Timeh	Timel	}
OZ-47	{	T	}		

In this mode the module is dependent from an external time reference. When the cumulated time sent in the command {Txx} is overflowing the programmed measurement period, the module performs a measurement. The refreshed measurements data must be requested with a {M} command.

Example
Motherboard sends:
{T05} // OZ-47 is set in top clock mode and store 5
// in the time accumulator

OZ-47 responds with:
{T}// OZ-47 always repeats master command

Motherboard sends:
{T05} // OZ-47 adds 5 to the time accumulator
// (0x0A in time accumulator)

OZ-47 responds with:
{T}// OZ-47 always repeats master command
…etc.

When time accumulator > Time between measurement (gTimer_delay) then a measurement is performed and if mother board sends:
{M} // Request for a measurement

Fresh measurement is available.
OZ-47 responds with:
{M5:5?23?43;2<064}

Read Data

Master	{	R	Page number	Register number	}								
OZ-47	{	R	Page number	Register number	Byte0h	Byte0l	Byte1h	Byte1l	Byte2h	Byte2l	Byte3h	Byte3l	}

Reads data from specified register at specified memory page.

Write Data

Master	{	W	Page number	Register number	Byte0h	Byte0l	Byte1h	Byte1l	Byte2h	Byte2l	Byte3h	Byte3l	}
OZ-47	{	W	Page number	Register number	Byte0h	Byte0l	Byte1h	Byte1l	Byte2h	Byte2l	Byte3h	Byte3l	}

Writes data to specified register at specified memory page.

The whole page has to be erased in case of new register settings.

Erase Page

Master	{	X	Page number	}
OZ-47	{	X	Page number	}

Erases specified memory page.

As the EEPROM is emulated it is not possible to delete only one register; whole page has to be erased in case of new register settings.

MEASUREMENT READINGS

The gas sensor is a micro-machined silicon structure equipped with a sensitive resistance R_S placed on top of a heating resistance R_h. The sensitive element is a tin dioxide (SnO_2) thin layer.

The impedance characteristics of the SnO_2 semi-conductor are altered through reactions with the oxidizing gases present in the air. The detection mechanism can be modelled the following way:

$$O_3 + e^- \rightarrow O^- + O_2$$

In this sensitive layer oxidising reaction, e- is a conduction electron in the SnO_2 layer and O- is a surface oxygen ion. The result of this oxidation is a reduction of the electron flow and thus an increase in the electric resistance of R_S. This reaction is totally reversible.

The sensor probe is equipped with a load resistance playing the role of voltage divider.

The ozone concentration is computed as the measured resistance R_S adjusted with the calibration and the temperature compensation parameters.

Resistance values are measured by reading microprocessor ADC and then sent on the serial bus within the measurement string:

Nibble name	$Rs1_{hl}$	$Rs1_{lh}$	$Rs1_{ll}$	$Rs2_{hl}$	$Rs2_{lh}$	$Rs2_{ll}$
Coded value	0	6	?	1	:	2
Hex value	0	6	F	1	A	2
Dec value	111			418		

Rs_1 = 111 kΩ
Rs_2 = 418 kΩ

Resistance range is from 1 kΩ up to 5 MΩ according to ozone concentration and temperature/humidity conditions.

Temperature and humidity are measured and digital values are sent to the MiCS-OZ-47 micro and then sent on the serial bus within the measurement string:

Nibble name	T_{hl}	T_{lh}	T_{ll}	H_h	H_l
Coded value	2	;	=	3	2
Hex value	2	B	D	3	2
Dec value	701			50	

Temperature = (Temperature measured /10) – 40 = (701/10) – 40 = 30.1°C

Temperature is coded between 0 and 1638 (-40 °C to 123.8 °C)

RH = 50%

SENSOR RESPONSE

The ozone sensor shows a large temperature dependency as the sensing resistance changes with temperature. Thus for accurate measurement temperature compensation is needed.

To perform the temperature compensation, the resistance is related to the reference temperature at 25 °C using the equation below:

$$R_{S@25°C}\ [k\Omega] = R_{S@T} * EXP[K*(T - 25\ °C)]$$

With:

$R_{S@T}$: calculated resistance at the measured temperature
T: actual temperature in °C
K: temperature coefficient, kT in the register list

Linearity

Based on the ozone sensor resistance at 25 °C, the ozone concentration can be calculated.

The characteristic response curve of the sensor with ozone is defined with third-order polynomial function. The quasi-linear shape leads to very low values for the third- and second-order parameters.

The ozone concentration is then calculated as follows:

$$Ozone\ [ppb] = X3*R_S^3 + X2*R_S^2 + X1*R_S + X0$$

Ozone concentration is defined according to calibration session between 0 and 250 ppb. The data transmitted is then coded with two characters O3_1h and O3_1l (same for the second sensor) to cover the 8 bits of data (from "**00**" to "**?:**").

Nibble name	$O3_{1h}$	$O3_1l$	$O3_{2h}$	$O3_{2l}$
Coded value	5	;	5	?
Hex value	5	B	5	F
Dec value	91		95	

Ozone concentration sensor1 = 91 ppb.
Ozone concentration sensor2 = 95 ppb.

The humidity compensation method is currently under preparation.

CONFIGURATION

The module can be configured with internal register settings.

DEC address	HEX address	Register Name	Page	index coeff	String	Default value or example
0	0	ID Byte[0]:Lot_Number (00 to 255) ID Byte[1]:Cell_Number (00 to 255) ID Byte[2]:Calibration_Week (01 to 52) ID Byte[3]:Calibration_Year (00 to 99)		0	**{W0000011407}**	ID Byte[0]:Lot_Number: 0 ID Byte[1]:Cell_Number: 0 ID Byte[2]:Calibration_Week: #20 ID Byte[3]:Calibration_Year: 07
4	4	X0_1		1	**{W0136029<=6}**	1.95E-06
8	8	X1_1		2	**{W02;:<:2:1?}**	-1.54E-03
12	C	X2_2		3	**{W033?3509>6}**	7.07E-01
16	10	X3_3		4	**{W04;?<09:>0}**	-1.50E+00
20	14	kT_1		5	**{W053<<<<<<=}**	0.025
24	18	kRH_1		6	**{W06}**	Not used for the moment
28	1C	X0_2		7	**{W073327;139}**	3.90E-08
32	20	X1_2		8	**{W08;819?=92}**	-3.67E-05
36	24	X2_2	PAGE#0	9	**{W093=?31<28}**	1.19E-01
40	28	X3_2		A	**{W0:<1213?9<}**	-1.01E+01
44	2C	kT_2		B	**{W0;3<<<<<<=}**	0.025
48	30	kRH_2		C	**{W0<}**	Not used for the moment
52	34	gTimer_preheat gAuto_calib		D	**{W0=3<??}**	60 seconds preheating at power up if "00" recalibration, if "??" (255) no recalibration
56	38	Byte[0]:gT_Offset_A_ON Byte[1]:gT_Offset_AB_ON		E	**{W0>5491}**	8.4 °C (84) (0x54) 14.5 °C (145) (0x91)
60	3C	Byte[0]: gTimer_delay Byte[1]:gTimer_cycle[0] Byte[2]:gTimer_cycle[1] Byte[3]:gTimer_pulse		F	**{W0?3<05821>}**	gTimer_delay:60 seconds "3<" gTimer_cycle:1410 minutes (0x582) (23h30) gTimer_pulse: 30 minutes (0x1E)
64	40	offset_mem offset_verif		0	**{W107?7?}**	Ozone offset: 0 ppb => (0x7F) 1 ppb => (0x80) -1 ppb => (0x7E)
68	44	NOT USED		1		FFFFFFFF
72	48	NOT USED		2		FFFFFFFF
76	4C	NOT USED		3		FFFFFFFF
80	50	NOT USED		4		FFFFFFFF
84	54	NOT USED		5		FFFFFFFF
88	58	NOT USED	PAGE#1	6		FFFFFFFF
92	5C	NOT USED		7		FFFFFFFF
96	60	NOT USED		8		FFFFFFFF
100	64	NOT USED		9		FFFFFFFF
104	68	NOT USED		A		FFFFFFFF
108	6C	NOT USED		B		FFFFFFFF
112	70	NOT USED		C		FFFFFFFF
116	74	NOT USED		D		FFFFFFFF
120	78	NOT USED		E		FFFFFFFF
124	7C	NOT USED		F		FFFFFFFF
128	80	gOffset		0	**{W207?}**	Ozone offset: 0 ppb => (0x7F) 1 ppb => (0x80) -1 ppb => (0x7E)
132	84	NOT USED		1		FFFFFFFF
136	88	NOT USED		2		FFFFFFFF
140	8C	NOT USED		3		FFFFFFFF
144	90	NOT USED		4		FFFFFFFF
148	94	NOT USED		5		FFFFFFFF
152	98	NOT USED	PAGE#2	6		FFFFFFFF
156	9C	NOT USED		7		FFFFFFFF
160	A0	NOT USED		8		FFFFFFFF
164	A4	NOT USED		9		FFFFFFFF
168	A8	NOT USED		A		FFFFFFFF
172	AC	NOT USED		B		FFFFFFFF
176	B0	NOT USED		C		FFFFFFFF
180	B4	NOT USED		D		FFFFFFFF
184	B8	NOT USED		E		FFFFFFFF
188	BC	NOT USED		F		FFFFFFFF

Page 0 is used for the calibration settings.
Page 1 and 2 are used for the ozone offset recordings.

Ozone offset is used when the auto calibration procedure is activated.

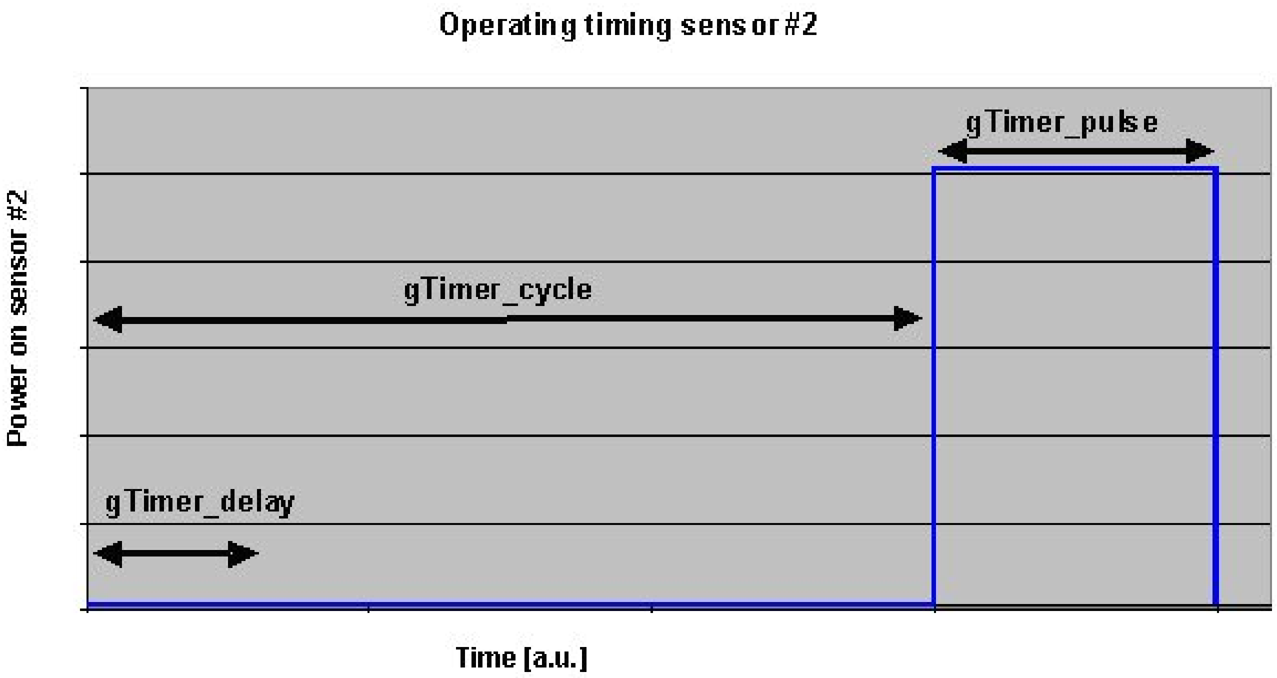
Page: 0
Register address: D
Name: gAuto_calib
“00”: autocalibration
“??”: no autocalibration

When autocalibration register is set, this means that the module is using the measurement of the second ozone sensor to adjust the measurement of the first ozone sensor. This principle is due to the fact that the second sensor is operated for only a few minutes per day and is then much less affected by time degradation than the first one that is continuously operated.

According with the timing settings programmed in the registers, the second sensor is then operated during ***gTimer_pulse*** every ***gTimer_cycle***. Measurements are made every ***gTimer_delay***.

This mode is not available when the module is in calibration mode ({K}).

Ozone concentration and resistance value for the second sensor are available only when the second sensor is operated. During ***gTimer_pulse***, the second sensor and the first one are initially overheated for 1 minute in order to allow the second sensor to converge faster to a relevant measurement by degassing. This periodic overheating is known to decrease the drift over time of the sensor and is by the way also applied to the first sensor.



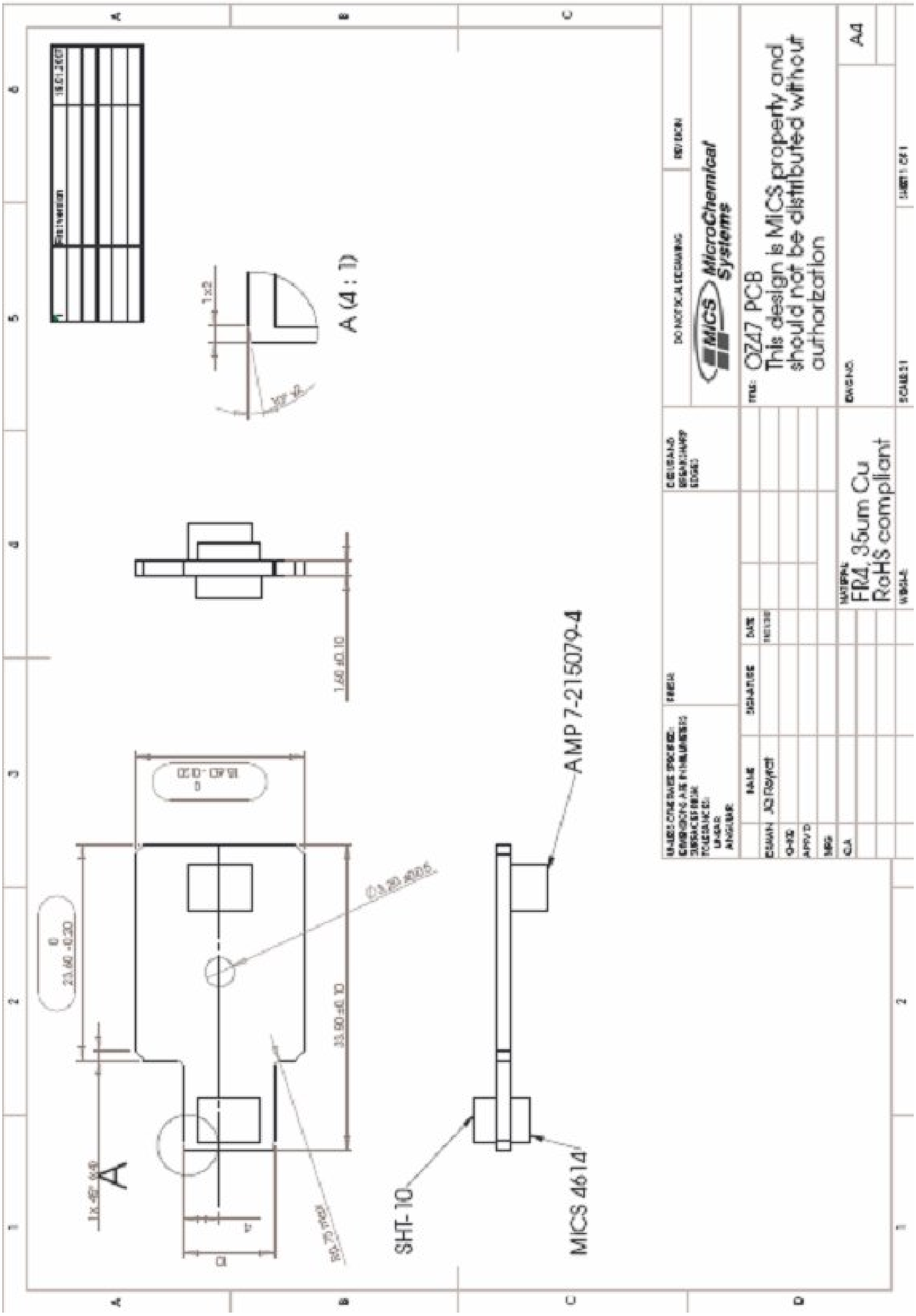
At the end of ***gTimer_pulse***, R_s measurement is done on both sensors and the ozone concentration is calculated. If the difference between the two values is less than 20 ppb, then the offset is actualised (recorded) and will be used during the next period by the first sensor. To avoid losing the offset value during the recording, the offset is then copied to page 1 and page 2 (redundancy principle) (register names: offset_mem, offset_verif, goffset). These three register values have to be the same in correct behaviour. The ozone offset can be -127 up to +128 ppb. Only the offset is compensated, as the sensitivity is not significantly affected but mainly the baseline.

Temperature offset can be applied to adjust the temperature read by the temperature sensor if the module is placed in a housing (self-heating compensation). RH is then calculated to adapt the relative humidity level to this new absolute temperature.

The calibration parameters are programmed after a conversion in IEEE 32 bits floating numbers.

Example
Decimal value: 0.2024
IEEE 32 floating value: 3E 4F 41 F2
MiCS-OZ-47 ASCII coding:3>4?41?2

APPENDIX – Dimensions



HANDLING AND PRECAUTIONS

It is recommended not to touch the area surrounding the sensor with bare hands.

- Avoid direct exposure of the sensor to grease or organic solvents (perfumes). These compounds can produce erroneous signals.
- Keep the sensor dry. Do not allow water or other liquids into the sensor
- Do not store in high levels of dust.
- Do not clean the module with cleaning chemicals or solvents.
- Do not operate near heavy aerosols (e.g. cleaning sprays) or where oxygen is being administered.
- Keep at least one metre above fruit in food storage applications to avoid possible negative responses resulting from ethylene ripening agent emitted from the fruit.
- The presence of the following compounds can affect the output from the sensor:
    - Chlorine or other halogen compounds
    - Sulfur compounds
    - Strong VOCs such as solvent vapours
    - Silicone compounds
    - Urine residues and ammonia compounds
    - Acid gases such as sulfuric acid or nitric acid fumes