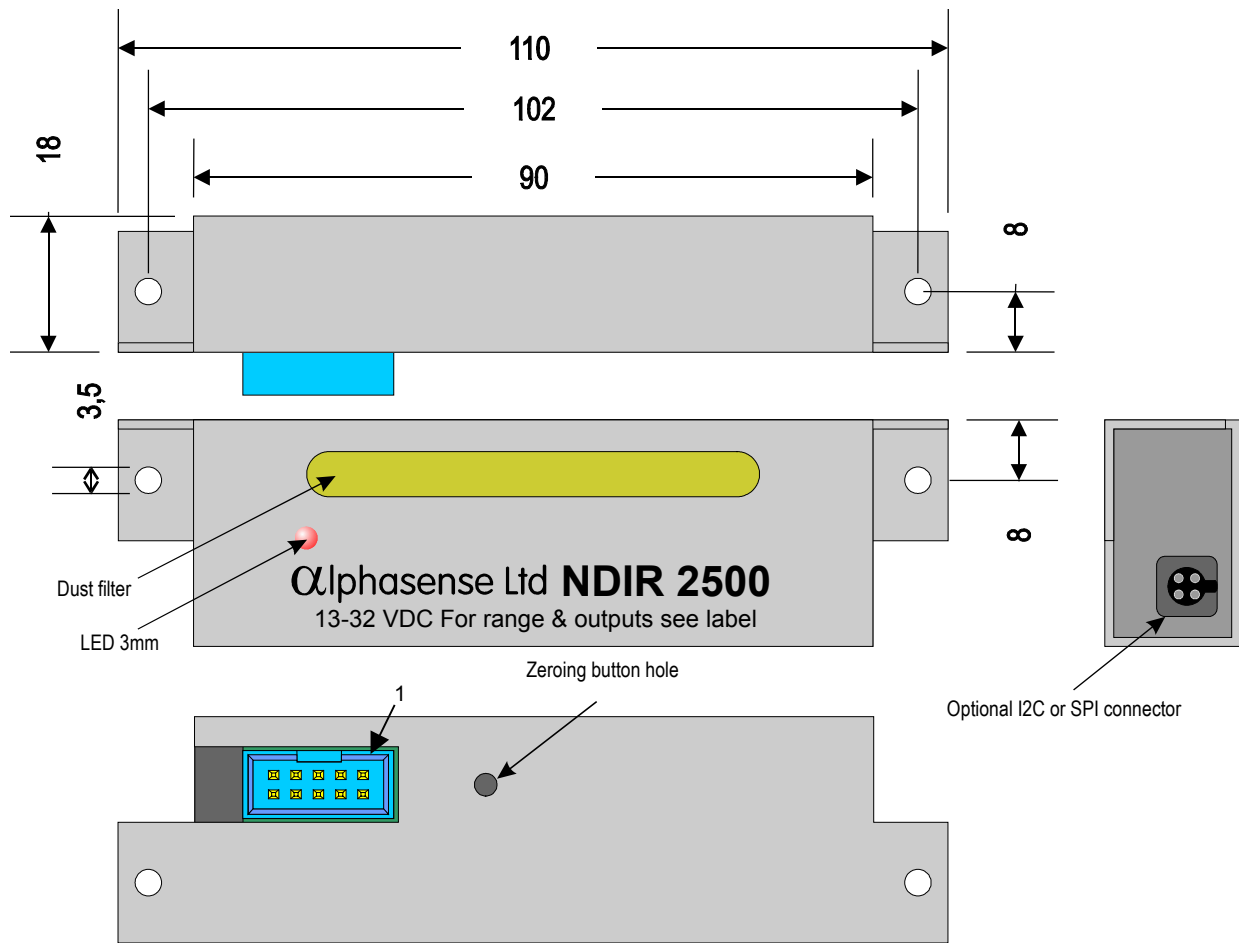


# mdir 90 (A01) technical description

## External View & Dimensions



All sizes in [mm]

## Operation

mdir 90 (A01) sensor is a NDIR, single beam, single wavelength, CO<sub>2</sub> sensor. The sensor is equipped with both digital and analogue outputs.

### **Averaging of results**

mdir 90 calculates a new result every second and keeps the last 60 results in the memory buffer for calculating a rolling average. So it is possible to ask the sensor at any moment for a result averaged for the last 1, 2, 3...60 seconds. The analogue outputs and external LCD display are updated every second. The result for the analogue outputs is calculated as a rolling average of the last 1..60 seconds. The averaging time for the analogue outputs and LCD display can be changed by the user using **mdir 90** PC software (15 seconds by default).

### **Calibration and settings memory**

Calibration data and all sensor settings are kept in the non-volatile EEPROM memory. Using the RS232C interface, **mdir 90** PC software and standard 3-wire cable the user can change all sensor settings.

### **Programme memory**

Sensor programme is written to Flash memory. It can be reprogrammed by the user via RS232C but (to improve security) it is disabled unless the DLOAD pin is kept Hi. In other words, reprogramming the Flash programme memory needs a special (non-standard) cable for communication. For reprogramming, special software from Atmel (freeware) is also necessary.

## Zeroing button

There is a zeroing button (optional) on the sensor. The button is accessible through a 3mm hole on the rear side of the sensor (the side with the 10-pin connector). Pressing the key for at least 2 seconds will zero the sensor.

This process is called “manual zeroing” and has to be unlocked by **madir 90** PC software to be active.

## LED

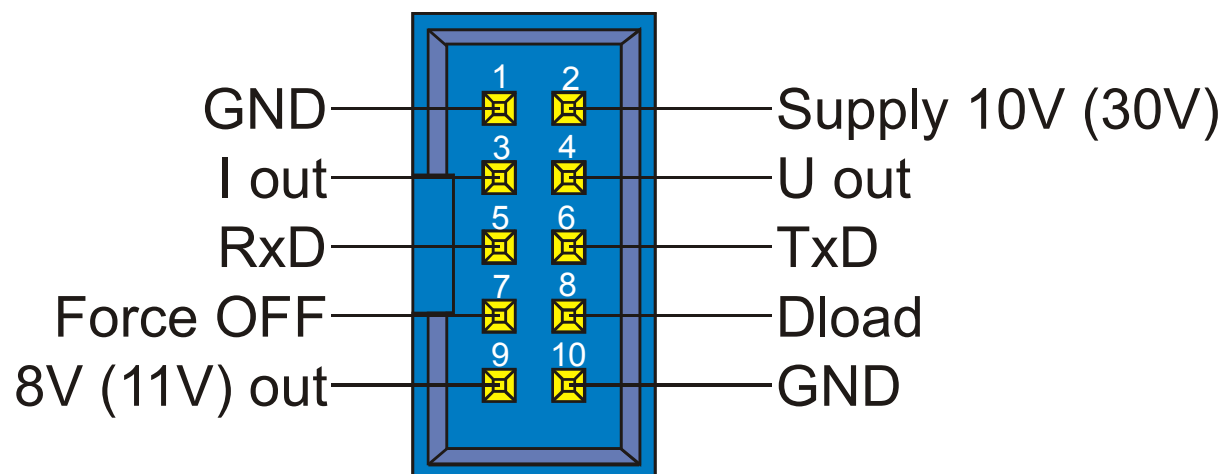
There is a 3mm red LED in the sensor. The LED signalises the status of the sensor.

Meaning of different LED signals:

LED activity			Meaning
	ON time	OFF Time	
continuous blinking	0.1s	14.9s	normal sensor operation
continuous blinking	0.3s	0.7s	warm-up time after power on (results not stable)
on whilst zeroing key depressed			zeroing key pressed
triple blink after zeroing key released	0.2s	0.2s	confirmation of zeroing
continuously on			error (results incorrect)
continuously off			sensor off

## Connector pinning

### *madIR-A01 socket*



madir 90 (A01) has a 10-pin male connector for standard 1.27mm flat cable.

1. GND - ground (common for Vsupply, VDD, Iout, Uout, and RS232C, also frame ground)
2. Supply - supply voltage input (DC or AC/DC – see power supply versions)
3. Iout - current analogue output (0..25mA)
4. Uout - voltage analogue output (0..5V or 0..10V – see power supply versions)
5. RxD - sensor RS232C input
6. TxD - sensor RS232C output
7. Force Off - for multipoint communication (turns sensor RS232 driver off when Lo), leave unconnected for communication with single sensor
8. DLOAD - for Flash reprogramming purposes (has to be connected to +5V for changing program memory) – leave unconnected for normal operation
9. OUT - supply voltage output (12V for standard or 6V for low voltage versions)
10. GND - same as 1

## Power supply

There are several supply versions possible in madir 90.

1. Standard
2. Low Voltage

- 3. Extended Supply, Standard
- 4. Extended Supply, Low Voltage

Version	DC supply range	AC supply range	Vout range [max]	average supply current / power [max] <sup>1</sup>	IC type
Standard	13.5..18V	N/A	0..10V	30mA	7812+78L05
Low Voltage	7.5..18V	N/A	0..5V	27mA	7806+ LM2931Z
Extended Supply, Standard	13..32V	9..24VAC	0..10V	0.6W	ADP3050+78L05
Extended Supply, Low Voltage	7..32V	6..24VAC	0..5V	0.5W	ADP3050+LM2931Z

<sup>1</sup> no load on analogue outputs

## Analogue outputs

Madir 90 (A01) has two separate analogue outputs:

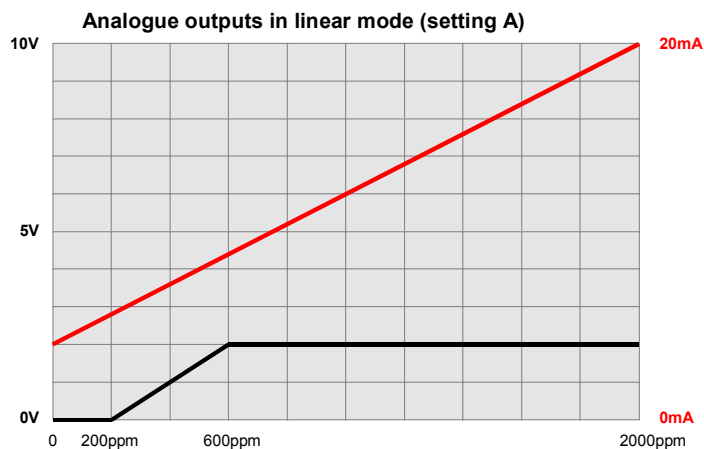
1. Current output  $I_{out}$ , maximum range 0..25mA
2. Voltage output  $U_{out}$ , maximum range (depending on power supply version): 0..5V or 0..10V

Both outputs are fully independent. User can set the minimum/maximum voltage/current using RS232 and **madir 90** PC software as well as corresponding minimum/maximum of gas concentration separately for each analogue output.

For example following settings are possible:

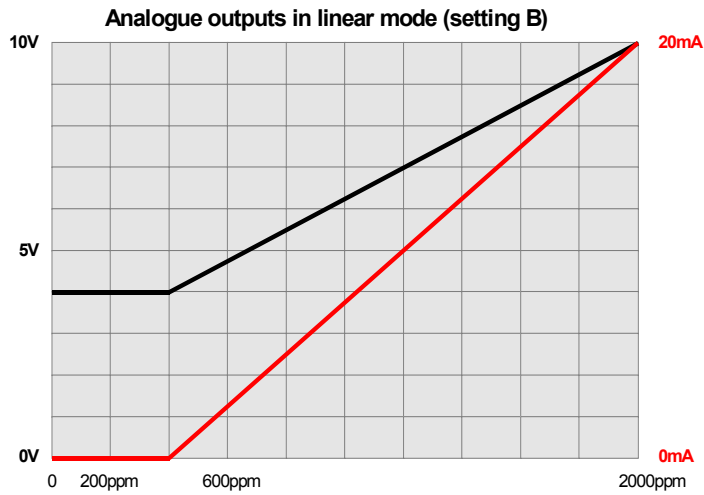
Setting A:

	Electric signal		Gas concentration	
	minimum	maximum	minimum	maximum
Voltage output	0V	2V	200ppm	600ppm
Current output	4mA	20mA	0ppm	2000ppm



Setting B:

	Electric signal		Gas concentration	
	minimum	maximum	minimum	maximum
Voltage output	4V	10V	400ppm	1000ppm
Current output	0mA	20mA	400ppm	2000ppm



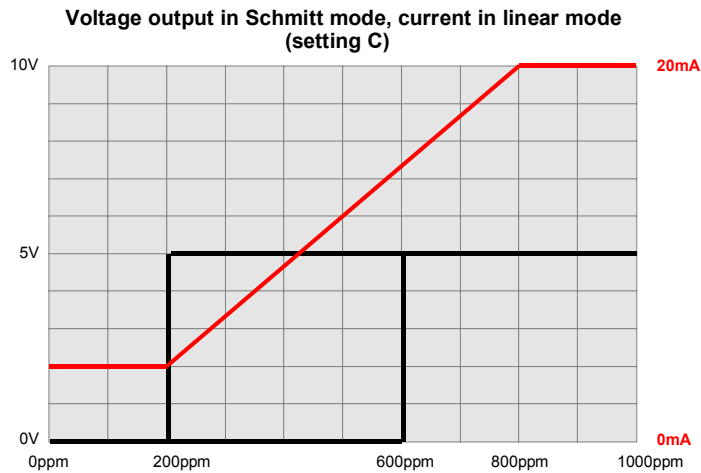
### Voltage output in Schmitt mode

The voltage output can also be configured as a Schmitt output (instead of the normal linear mode). The Lo and Hi voltage as well as Lo-to-Hi and Hi-to-Lo trip points are definable by user via RS232. For example following settings are possible for the voltage output working in Schmitt mode:

Setting C:

	Electric signal		Gas concentration	
	Lo voltage	Hi voltage	Lo-to-Hi trip point	Hi-to-Lo trip point
Voltage output	0V	5V	600ppm	200ppm

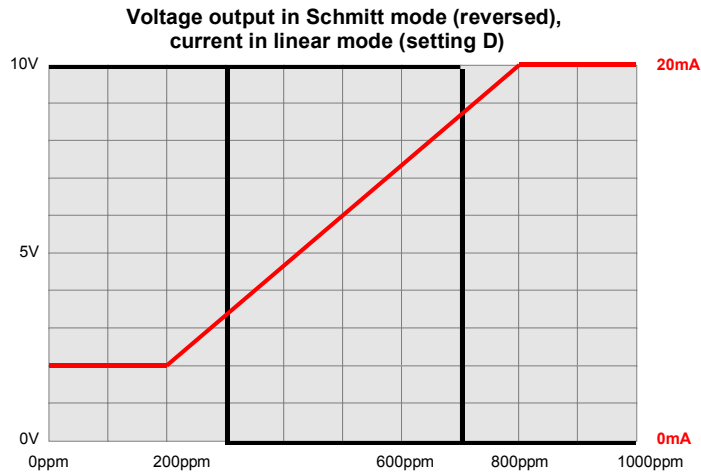
	Electric signal		Gas concentration	
	minimum	maximum	minimum	maximum
Current output	4mA	20mA	200ppm	800ppm



Setting D (for reversed logic of Schmitt output):

	Electric signal		Gas concentration	
	Lo voltage	Hi voltage	Lo-to-Hi trip point	Hi-to-Lo trip point
Voltage output	10V	0V	700ppm	300ppm

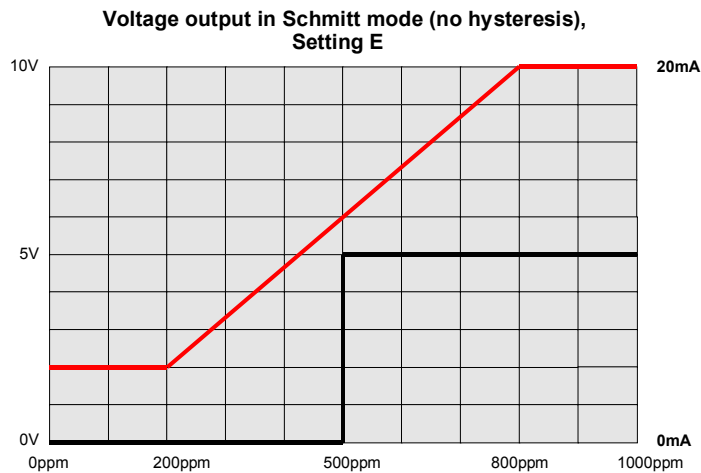
	Electric signal		Gas concentration	
	minimum	maximum	minimum	maximum
Current output	4mA	20mA	200ppm	800ppm



**Settings E (for no-hysteresis Schmitt output):**

	Electric signal		Gas concentration	
	Lo voltage	Hi voltage	Lo-to-Hi trip point	Hi-to-Lo trip point
<b>Voltage output</b>	0V	5V	500ppm	500ppm

	Electric signal		Gas concentration	
	minimum	maximum	minimum	maximum
<b>Current output</b>	4mA	20mA	200ppm	800ppm



The analogue outputs are driven by a 12-bit DAC. The full DAC range (4096) corresponds to 0..12V range for voltage output and 0..25mA for current output. Limiting the voltage output range to 0..2V one still has 2/12<sup>th</sup> of DAC range (i.e. 682), which is better than 9-bit resolution (512).

## **Digital communication interface**

Madir 90 (A01) is equipped with three types of serial digital interface: RS232C, SPI and I<sup>2</sup>C.

### **RS232C**

The RS232C interface is standard in each sensor and attached to the 10pin connector. RS232C operates with settings **4800, N, 8, 1**. This interface serves for programming the processor's flash memory, calibration, changing sensor settings and reading results.

### **SPI (optional)**

The SPI interface is built into each sensor but not attached to any connector in the standard version. The interface can operate in Slave or Master mode (selectable using *madir 90* PC software) and serves exclusively for reading gas measurement results. There is no possibility of sensor programming via SPI. To use the SPI interface an optional 5-pin female connector has to be added. The connector pinning is shown below:



External view

#### Connector pinning for SPI interface:

1. MOSI - output in master mode, input in slave mode
2. MISO - input in master mode, output in slave mode
3. SS - Slave Select, enable input in slave mode (active Lo)
4. SCLK - serial Clock (input in slave mode, output in master mode)
5. GND - common ground

**Note:** only one interface from the optional SPI & I<sup>2</sup>C is possible in a single sensor

#### I<sup>2</sup>C (optional)

The I<sup>2</sup>C interface is built into each sensor but not attached to any connector in the standard version. The interface can operate in master mode only and serves exclusively for controlling the external 4.5 digit LCD display. There is no possibility of sensor programming via I<sup>2</sup>C.

To use the I<sup>2</sup>C interface an optional 4pin female connector has to be added.



External view

#### Connector pinning for I<sup>2</sup>C interface (external LCD display)

1. SDA - serial data
2. SCL - serial clock
3. VDD - supply output for display (12V in standard- 6V in low voltage versions)
4. GND - common ground

**Note:** only one interface from the optional SPI & I<sup>2</sup>C is possible in single sensor

### Digital communication orders and data formats

The range of binary results produced by the sensor depends on the gas range of the sensor as follows:

0..500	for ranges: 500ppm, 5000ppm, 5.00%, 50.0%
0..1000	for ranges: 1000ppm, 10000ppm, 10.00%, 100.0%
0..2500	for ranges: 2500ppm, 25000ppm, 25.00%

The maximum result value fits in 12 bits.

#### RS232C

There are several orders in RS232C communication. Most of them serve for changing settings and are used by the **madir 90** PC software. Only two orders are designed to be used by the end-user. These are the following:

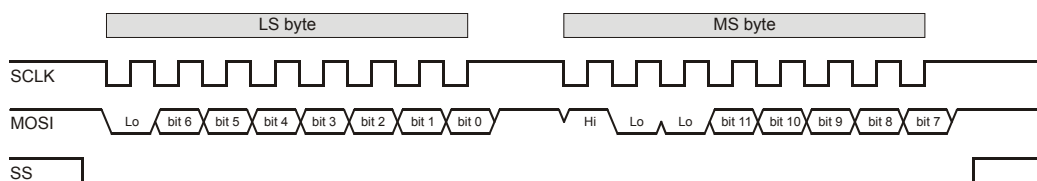
1. Order #2: "Send results"  
Question: 02H, aa, tt, xx, xx, xx  
Answer: 02H, aa LSB1, MSB1, LSB2, MSB2  
  
Where:  
aa - sensor address (1..255) or 00H  
tt - averaging time (1..60)  
xx - no meaning  
  
LSB1 - LSB of the fast (1 second) result  
MSB1 - MSB "

- LSB2 - LSB of the averaged (for tt time) result  
 MSB2 - MSB “
2. Order #30: “Execute zeroing for a given value”  
 Order: 30H, aa, tt, LSBz, MSBz, xx  
 Answer: 30H, aa, 00H, 00H, 00H, 00H
- Where: LSBz - LSB of the gas concentration for zeroing  
 MSBz - MSB “

### SPI in master mode

When in master mode the sensor sends two bytes of result (LSB first) every second via SPI lines. To distinguish the MS from LS bytes the result format is as follows:

**LS Byte:** 0 b6 b5 b4 b3 b2 b1 b0  
**MS Byte:** 1 0 0 b11 b10 b9 b8 b7



**SPI transmission in master mode (all signals generated from sensor)**

Clock frequency in master mode is 1MHz.

### SPI in slave mode

When in slave mode the sensor waits for orders from SPI master device. Two orders are possible:

- Order #1: “Calculate new result for a given averaging time and prepare LS byte of the result for next transmission”

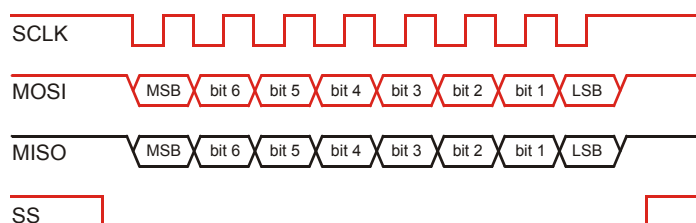
Order: 1xtttttt where: x – no meaning, tttttt – averaging time 1..60  
 Answer: previously asked result byte (LSB after order #1 or MSB after order #0)

Operation: After receiving this order sensor calculates new result with a given averaging time and pushes the result LS byte into the transmission buffer.

- Order #0: “Prepare the MS byte of previously calculated result for next transmission”

Order: 0xxxxxxx where: x – no meaning  
 Answer: previously asked result byte (LSB after order #1 or MSB after order #0)

Operation: After receiving this order sensor pushes the MS byte of the previously calculated result into the transmission buffer.



**SPI transmission in slave mode (black signal generated from sensor, red from master device)**

## **madir 90 PC software**

The software is prepared in two versions: the end-user version and the service version. The software will be described in a separate document.