

Output configuration in CO2 Engine K30

1. Revision information

Revision	Date	Author	Status
1.00	Feb 22, 2007	JE	New document
1.01	March 13, 2007	JE	Added note about current firmware
1.02	June 22, 2015	ML	Removed note about current firmware

2. Description

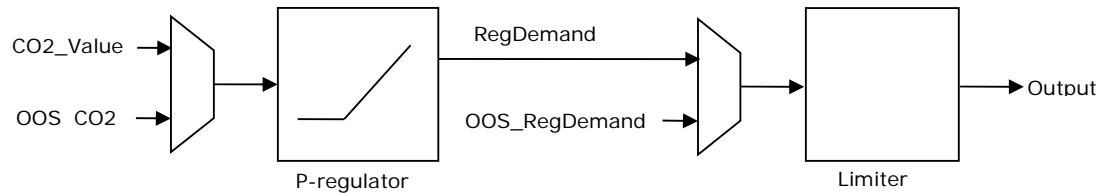
The CO2 Engine K30 has 4 different outputs, 2 analog and 2 digital. The behaviour of the outputs can be configured by a set of parameters stored in the sensor's EEPROM.

This document describes the parameters and how to change them to configure the sensors outputs.

The CO2 Engine Development tool can be used to change the settings.

3. Output regulator function

The output is designed as a P-regulator function in series with a shaping function:

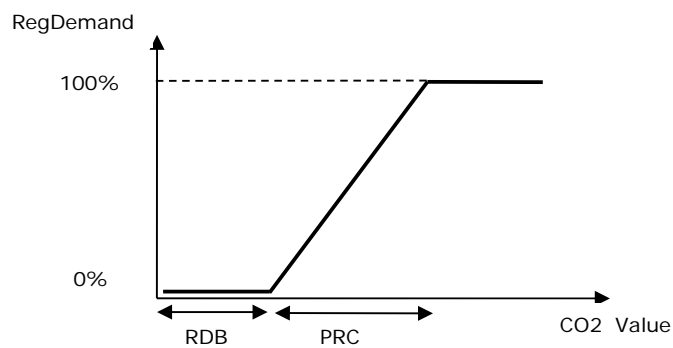


All outputs are configured by 6 parameters:

P-regulator parameters:

RDB – Regulator Dead Band

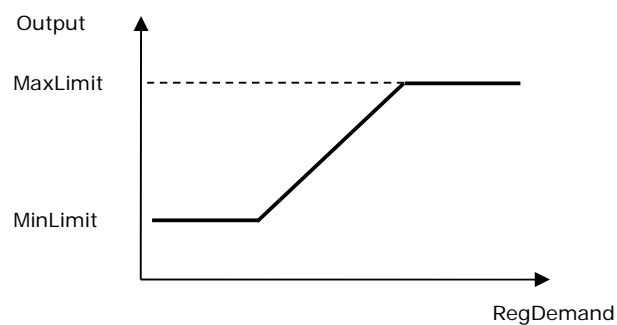
PRC – Proportional Regulator Constant



Limiter parameters:

Max Limit – The highest allowed output voltage

Min Limit – The lowest allowed output voltage



Override parameters:

OOS_CO2 – CO2 value override, can be used for test of P-regulator function

OOS_RegDemand – RegDemand override, can be used for test of Limiter function

The output from the P-regulator, RegDemand is fed into the output limiter. In this way we can define the size of the P-regulator dead band, RDB, and the slope of the regulation, PRC.

The limiter function limits the output value in range between MinLimit and MaxLimit.

The effect of the parameters on the output behaviour is dependent on if the actual output is defined as analog or digital. Analog or digital output function for an output is selected by a bit in the OutputControl register (one byte in sensor EEPROM).

Note: If the value of the OutputControl register has been changed, the sensor needs to be restarted by switching power off and then back again.

3.1. Analog outputs

Only outputs OUT1 and OUT2 can be configured as analog outputs. OUT3 and OUT4 are restricted to digital outputs by sensor hardware.

Note that the available output range of OUT1 is 0..10V while OUT2 is 0..5V.

The analog output function is configured by the P-regulator and the Limiter parameters. When the CO₂ value is below RDB, the output will stay at the value defined by MinLimit. If the CO₂ value rises above RDB, output voltage will increase at a rate defined by PRC, until output voltage reaches MaxLimit (or saturates at a level limited by power supply voltage).

The OUT1 and OUT2 can be alternatively be configured to act as a digital outputs. If this mode is selected (by setting the proper bit low in the OutputControl register), the output will act as a digital output with hysteresis. If MaxLimit=100% and MinLimit=0%, it will go high when CO₂ value increases above RDB+PRC, and go low when CO₂ value decreases below RDB.

The output voltage can be limited in voltage range by setting MaxLimit and MinLimit; in this case the output will go high when RegDemand (P-regulator output) increases above MaxLimit and go low when RegDemand decreases below MinLimit.

3.2. Digital outputs

Only outputs OUT1 and OUT2 can be configured as analog outputs. OUT3 and OUT4 are restricted to digital outputs by sensor hardware.

The output function with P-regulator and limiter is the same for all outputs. For digital outputs the output switches to high level if RegDemand (output from P-regulator) increases to MaxLimit, and switches to low level if RegDemand decreases to MinLevel. By setting RDB, PRC, MaxLimit and MinLimit the hysteresis range and output voltage range can be modified.

3.3. Parameter values

RDB and PRC are expressed in units of ppm CO₂, the range is 0..10000 (0..1000.0ppm CO₂) for sensor type CO₂ Engine K30 LN.

MaxLimit and MinLimit are expressed in %, where 1024 equals 100%. For Out1 100% will give 10V on output, and for OUT2 100% will give 5V on output. The range for MaxLimit and MinLimit is 0..1024. MinLimit is assumed to be less than MaxLimit.

3.4. Examples

Here are some examples of parameter settings for different output configurations:

Out1 configured as analog output, 0..1000ppm 0..5V.

Parameter	Value	Comment
OutputControl	b'xxxxxxx1	Bit0 set to 1
Out1_RDB	0	0ppm
Out1_PRC	10000	1000.0 ppm
Out1_MaxLimit	512	5V = 50% of 10V = $1024/2 = 512$
Out1_MinLimit	0	0V = 0%

x = don't care

Out1 configured as analog output, 0..1000ppm 1..4V

Parameter	Value	Comment
OutputControl	b'xxxxxxx1	Bit0 set to 1
Out1_RDB	0	0ppm
Out1_PRC	10000	1000.0 ppm
Out1_MaxLimit	410	4V = 40% of 10V = $1024 * 0.40 = 409.6$
Out1_MinLimit	102	1V = 10% of 10V = $1024 * 0.10 = 102$

Out1 configured as digital output with hysteresis

On at 700ppm and off at 500ppm. Voltage levels: low 0,0V high 3,3V

Parameter	Value	Comment
OutputControl	b'xxxxxxx0	Bit0 set to 0
Out1_RDB	5000	
Out1_PRC	6077	
Out1_MaxLimit	337	3.3V = 33% of 10V = $1024 * 0.33 = 337.92$
Out1_MinLimit	0	0V

To find the right value for PRC a little computation is needed; the output will go high when RegDemand increases to MaxLimit.

RegDemand is calculated as:

$$\text{RegDemand} = 1024 * (\text{CO}_2 - \text{RDB}) / \text{PRC}$$

hence PRC can be expressed as:

$$\text{PRC} = 1024 * (\text{CO}_2 - \text{RDB}) / \text{RegDemand}$$

The output will go high when RegDemand = MaxLimit, so replacing gives:

$$\text{PRC} = 1024 * (\text{CO}_2 - \text{RDB}) / \text{MaxLimit}$$

We want this to happen when CO₂ level is at 700.0 ppm, inserting values gives:

$$\text{PRC} = 1024 * (7000 - 5000) / 337 = 6077.15$$

So we select PRC = 6077

Out3 configured as digital output with hysteresis
On at 800ppm and off at 600ppm:

Parameter	Value	Comment
OutputControl	b'xxxxx0xx	Bit3 set to 0
Out3_RDB	6000	Off at 600.0ppm
Out3_PRC	2000	On at 600.0+200.0ppm = 800.0ppm
Out3_MaxLimit	1024	OUT3 has digital hardware so set 100% = 1024
Out3_MinLimit	0	OUT3 has digital hardware so set 0% = 0