Smart IR Datasheet

Ver. 2.0/Rev. 0.3/Issue 01

SMART IR FEATURES

- **Provides a linear and temperature compensated output when connected to the SGX Sensortech's Infrared Gas Sensors.**
- **Intrinsically safe (IS) Certified design.**
- **Low power consumption < 35mA with the Sensor**
- **Factory configurable for Methane 0-5% volume or 0-2% volume Carbon Dioxide.**
- **Can be Factory calibrated for Methane 0-5% volume or 0-2% volume Carbon Dioxide (if required) when purchased with the gas sensor.**
- **24-bit Analog to Digital Converter (ADC) for high active and reference detector channel resolution.**
- **Digital output of calculated concentration with maximum 50 ppm resolution.**
- **14-bit Digital to Analog (DAC) output of calculated concentration.**
- **Full Fault Diagnostics and Error generation.**
- **User configurable up to 38400 baud rate for digital communications.**
- **Evaluation Kit available with Configuration Unit and PC software for easy control and sensor production calibration functions.**
- **Digital Monitoring of the gas sensor temperature.**
- **Easy implementation into Gas Sensors Network.**
- **Optional flameproof Housing, made out of Noryl SEO material.**

RECOMMENDED APPLICATIONS

- **Mining**
- **Industrial Factories**
- **Automation**
- **Network of Sensors**

GENERAL DESCRIPTION

The Smart IR module has been designed with the latest technology, using a microcontroller unit with an ARM7TDMI core and via software design the necessary techniques have been implemented to increase the reliability of the device therefore minimize the probability of faults.

The Smart IR is a user friendly electronic module, which is designed to fit directly on to SGX Sensortech's existing Series 2 gas sensor product types like IR12GM_1 or IR11GM_1. The electronic module is designed to decrease the implementation time therefore increase productivity. The Smart IR module incorporates the necessary electronics and embedded software to operate the infrared sensors from a low voltage DC power supply. The module will process the raw signals to output a linear, temperature compensated signal proportional to the gas concentration applied. The output signal is available in digital and analogue forms.

The SGX Sensortech Smart IR module provides users with a simple method of incorporating an SGX Sensortech infrared sensor into their gas detection instrument which will significantly reduce the development time and expertise required during the design and implementation phase. The Smart IR can also be factory calibrated with the gas sensor to allow installation without the need for recalibration.

The Smart IR has been designed to fit directly to SGX Sensortech's 7-pin single gas IR11GM_1 (Carbon Dioxide) and IR12GM_1 (Methane), which both contain a supported lamp for additional shock protection. Containing the necessary electronics and embedded software to send the linearized and temperature compensated concentration via Digital (32-bit) and Analog (14-bits) outputs, the Smart IR Configuration Unit can be used to configure, calibrate and evaluate the Smart IR via the USB interface with an easy-to-use PC software interface.

Alternatively, control of the Smart IR via UART is available for communicating with an external microprocessor as well. The device itself contains full fault diagnostics, which are sent via the digital string along with the temperature output of the sensor and the linearized concentration.

TABLE OF CONTENTS

DOCUMENT REVISION RECORD

Version	Issue Date	Change
1.0	04/01/2013	Original Version Released.
1.1	17/01/2013	Correct Drawings of the Smart IR, Recommended Footprint added, Wiring Diagram changed
2.0	28/02/2013	Images changed, drawings changed, wiring diagram changed, compatibility sensor list added
2.0/ 0.1	19/06/2013	1.The error produced by the Temperature Sensor has a double meaning now, page 16. 2.Temperature Cycle Rate Limits added, page 3.
2.0/ 0.2	05/07/2013	1.Warning in page 3 added, layout in page 3 corrected. 2.Coefficient Table changed.
2.0/ 0.3/01	07/10/2013	1.Minor changes to the comparison table.

TECHNICAL SPECIFICATIONS

Table 1.0 - Technical Specifications

Power Supply DC Input (from Customer's Equipment)			
	Min	*Typical*	*Max*
Input Voltage	3.2 VDC	3.3 VDC	5.0 VDC
Input Current	30mA with gas sensor	35mA with gas sensor	50mA with gas sensor
Humidity			
Operating Humidity	0%	50%	90%
Storage Humidity	0%	50%	90%
Temperature			
Operating Temperature	-20 °C	+20 °C	+55 °C
Storage Temperature	-20 °C	+20 °C	+55 °C
Temp. Cycle Rate Limits	0.25 °C per minute	0.75 °C per min.	1.25 °C per minute
Pressure			
Operating Pressure	80kPa	-	120kPa
Storage Pressure	80kPa	-	120kPa
Performance			
ADC Resolution	-	24-Bit	-
DAC Resolution	-	14-Bit	I_{max}= 0.5 mA on 5K Load
Lamp Frequency	-	5 Hz	-
Dimensions			
Diameter (D)	19.9mm	20mm	20.1mm
Height (H)	8.9mm	9mm	9.1mm
Pins Height (pH)	3.8mm	4.6mm	5.4mm
Body Material	ABS	ABS	Noryl SEO
Weight (gr)	-	<7 gr	-
Gas Sensor Sockets			
S1	7-Pin Series 2; Single Gas Detection Infrared Gas Sensors		

Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. SGX Sensortech (IS) maintains the right to modify those specifications at any time without warning.

Table 2.0 - Sensor List Compatible with the Smart IR

Sensors compatible with the Smart IR Module		
Sensor Type	**Gas type**	**Range(v/v)**
IR11GJ/GM_1	CO_2	0.5%/2.0%/5.0%
IR12GJ/GM_1	CH_4	5.0%/100%

ESD CAUTION

ESD (Electrostatic Discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary subjected circuicity, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degration or loss of functionality.

***Warning!* Plugging or Unplugging the Sensor on the Smart IR while is in operation may damage the device beyond repair. Always power down the device to change a damaged sensor or perform maintenance.**

ROHS

Under the EU Directives, compliance testing is necessary for Pb, Cd, Hg, Cr (VI) and Br. The WEEE directive is effective August 13, 2005 and the RoHS directive July 1, 2006. End of Life Vehicle, or ELV, prohibits the use of these hazardous substances in vehicles sold after July 2003.

RoHS compliant 2002/95/EC

WEEE

WEEE (Waste from Electrical and Electronic Equipment) is a directive that controls how electric and electronic equipment is handled and recycled. Most businesses that must ensure RoHS compliance must also ensure WEEE compliance as well.

ATEX

The ATEX directive consists of two EU directives describing what equipment and work environment is allowed in an environment with an explosive atmosphere.

The Smart IR Module is certified for ATEX.

SIL

Safety Integrity Level (SIL) is defined as a relative level of risk-reduction provided by a safety function, or to specify a target level of risk reduction

The Smart IR doesn't need to be SIL certified, but is designed to meet SIL 1 rating.

PIN CONFIGURATIONS AND FUNCTIONALITY

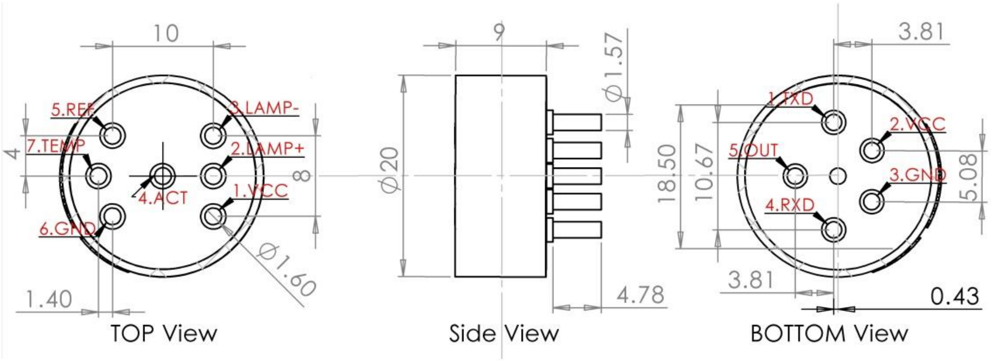


Figure 1.0 - Smart IR Pin Configuration

Pin	Name	Description
1	TXD	Transmitted data via UART from the Smart IR. Connect this to your RXD pin.
2	+VCC	3.2 Volts – 5.0 Volts DC input to Smart IR
3	GND	GND Plane, 0 Volts reference for Smart IR
4	RXD	Received data via UART for the Smart IR. Connect this to your TXD pin on your MCU.
5	OUT	Analog Output. Read this with an ADC or a Voltmeter.
P1	P1	Bootloader Pad. Not used.

PIN CONFIGURATION OF A TYPICAL IR1XXX Series2

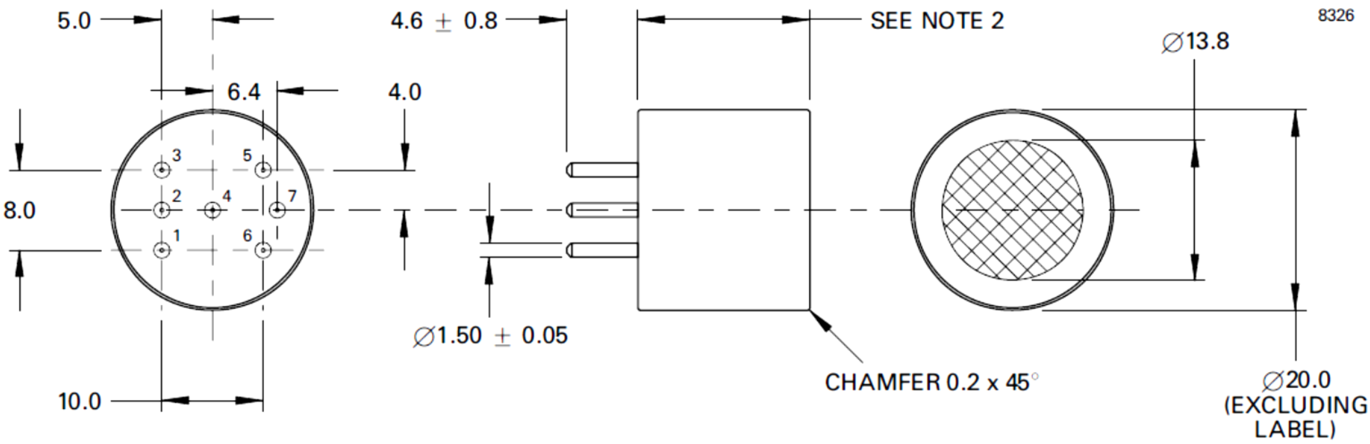


Figure 2.0 - IR Gas Sensor Typical Pin Configuration

Pin	Connection
1	+ VDC detector input
2	Lamp
3	Lamp return
4	Active detector output
5	Reference detector output
6	0 V input
7	Temperature sensor Thermistor (code E); IC (code G)

Notes:

1. Body dimensional tolerances +0.1 mm. Pin dimensional tolerances as indicated.
2. For code J devices, this length is 19.0 mm; for code M devices it is 16.6 mm.
3. Gas sensors are designed to press-fit into PCB sockets. Choose a socket to accommodate the full sensor pin length, ensuring a stable mechanical location as well as good electrical contact.

TYPICAL PERFORMANCE CHARACTERISTICS

Table 3.0 – Typical Performance Data of Smart IR (with sensor)
(Relating to EN 60079-29-1 & AQ 6211)

Test	IR12GM_1 (Methane)	IR11GM_1 (Carbon Dioxide)
Stabilisation Time / Warm-up Time (EN)	0%v/v ±0.1%Vol in 1 minute	0%v/v ±0.01%Vol in 1 minute
Calibration Curve (EN) / Basic Error (AQ)	0 to 5%v/v = ±0.15%v/v Methane 0 to 100%v/v = ±3%v/v Methane *(Calibration at Full-Scale)*	0 to 0.5%v/v = ±0.02%v/v 0 to 2%v/v = ±0.10%v/v 0 to 5%v/v = ±0.20%v/v *(Calibration at Full-Scale)*
Short Term Stability (EN) / Minimum Resolution (AQ) / Stability of Displayed Value (AQ)	0%v/v = ±0.01%v/v 5%v/v = ±0.05%v/v 20%v/v = ±0.2%v/v 100%v/v = ±1%v/v	0%v/v = ±0.001%v/v 0.5%v/v = ±0.01%v/v 2%v/v = ±0.04%v/v 5%v/v = ±0.10%v/v
Long Term Stability (EN) / Working Stability (AQ)	0%v/v = ±0.02%v/v / Month 5%v/v = ±0.1%v/v / Month 20%v/v = ±0.6%v/v / Month 100%v/v = ±3%v/v / Month	0%v/v = ±0.05%v/v / Month 0.5%v/v = ±0.02%v/v / Month 2%v/v = ±0.10%v/v / Month 5%v/v = ±0.3%v/v / Month
Temperature *(with Compensation)* *(-20°C to +55°C, relative to 20°C)*	0%v/v = ±0.10%v/v 5%v/v = ±0.5%v/v 20%v/v = ±2.5%v/v 100%v/v = ±5%v/v	0%v/v = ±0.05%v/v 0.5%v/v = ±0.10%v/v 2%v/v = ±0.20%v/v 5%v/v = ±0.25%v/v
Pressure *(without Compensation)* *(80kPa-120kPa, relative to 100kPa)*	±0.2%Vol or ±30% of actual gas concentration	±0.2%Vol or ±30% of actual gas concentration
Humidity *(20%RH to 90%RH, relative to 50%RH)*	0%v/v = ±0.1%v/v 5%v/v = ±0.2%v/v 20%v/v = ±0.8%v/v 100%v/v = ±3%v/v	0%v/v = ±0.01%v/v 5%v/v = ±0.05%v/v
Response Time *1	Min T_{90} ≈ 15 sec ,Average 2 Typ. T_{90} ≈ 18 sec, Average 5 Max T_{90} ≈ 27 sec, Average 6 (without dust filter)	Min T_{90} ≈ 18 sec, Average 2 Typ. T_{90} ≈ 20 sec, Average 5 Max T_{90} ≈ 27 sec, Average 6 (without dust filter)
Power Supply Variations	0%v/v = ±0.01%v/v 5%v/v = ±0.02%v/v 20%v/v = ±0.2%v/v 100%v/v = ±1%v/v *(at ±5% of Nominal Voltage)*	0%v/v = ±0.005%v/v 0.5%v/v = ±0.01%v/v 2%v/v = ±0.02%v/v 5%v/v = ±0.03%v/v *(at ±5% of Nominal Voltage)*
Temperature Cycling	0%v/v = ±0.02%v/v 5%v/v = ±0.1%v/v 20%v/v = ±0.5%v/v 100%v/v = ±2%v/v	0%v/v = ±0.005%v/v 0.5%v/v = ±0.01%v/v 2%v/v = ±0.01%v/v 5%v/v = ±0.20%v/v
Thermal Shock	0%v/v = ±0.05%v/v (max)	No Requirement

NOTE:*1. All the results regarding the response time (T_{90}) of the Smart IR are depending on the final Averaging value that we are going to choose for our application.

OUTLINE DIMENSIONS

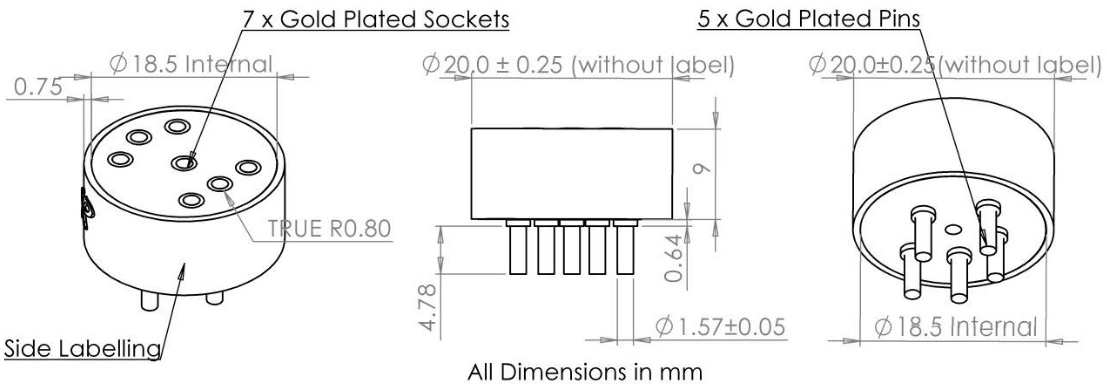


Figure 3.0 - Smart IR Outline Dimensions & Enclosure

Table 4.0 – Housing Specifications

	MIN.	TYP.	MAX.
Dimensions (OD)	19.85mm	20mm	20.15
Dimensions (ID)	18.45mm	18.5mm	18.65
Wall Thickness	0.60mm	0.75mm	0.90mm
Material*1	ABS	ABS	NORYL SEO
Color	-	BLACK	-
Certifications	-	UL 94	-
*1 – Typical NORYL but SGX Sensortech (IS) Ltd can downgrade it into NYLON or ABS depending on the application.			

ORDERING INFORMATION

For details in the ordering information about the Smart IR Module or the Evaluation Kit please see the Appendix B – Ordering Information in page 22, the last page of this datasheet.

WIRING DIAGRAM

Please use the recommended wiring diagram seen in Figure 4.0 to power the Smart IR and to communicate with the module.

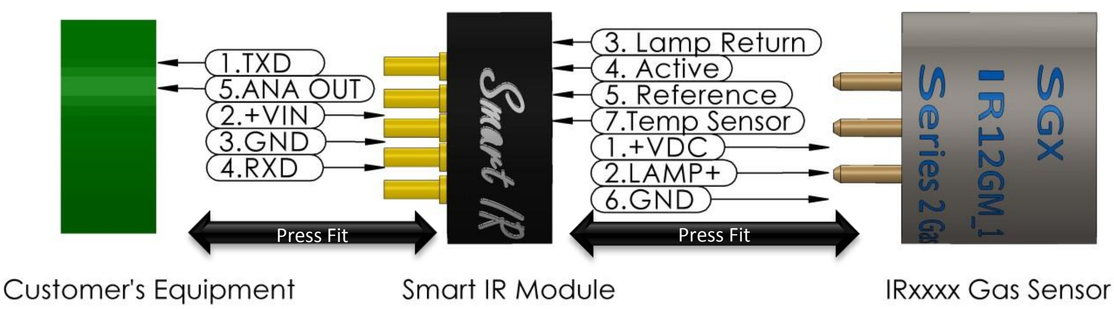


Figure 4.0 - Wiring Diagram of the Smart IR Module with IR1XXX Series2 Sensor

HARDWARE DESIGN CONSIDERATIONS

The following recommendations are here as hardware design guidelines to ensure the correct implementation of the Smart IR onto your Device to avoid damaging the Smart IR or the custom made device. SGX Sensortech (IS) Ltd has no responsibility all so ever if you wrongly or not at all implement the recommended techniques below and as a result you damage your equipment.

1. It is advisable to limit current with a 125mA Intrinsic Safety (I.S.) FUSE 1 (e.g. Littelfuse 0259.125). This will allow 125mA x 1.7 Ohms= 212.5mA max (see Figure 5.1). The FUSE1 meets the Barrier Network Standards EN50020 and the EN60079-11 for hazardous applications. Using the fuse may result into a voltage drop, therefore please ensure that the voltage used to power the Smart IR is 3.2 – 5.0 Volts DC.
2. It is recommended to limit the voltage with duplicate (ib) or triplicate (ia) zener diodes. Assume typical 5v1, 5% triple zeners (see Figure 5.1, D1, D2, D3), the power is limited to 1.138W max.
   I. This meets the Pi rating for the detector circuit of Series 2 Gas Sensor.
   II. This satisfies the 60 degree ambient requirement for >200mm^2 components (BS EN60079-11:2012).
3. The Smart IR has no ‘safety’ components implemented internally into the circuits therefore is essential to make sure all the values are according to specifications and the appropriate safety features are implemented according to the standards specified.
4. Keep the tracks protected with double printed solder mask. Keep any exposed cables as shielded as possible firmly attached onto terminal blocks, even if you are not using them. Loose cables can create unwanted sparks or short-circuits that will damage the equipment or ignite a gas.

Below in the Figure 5.1 we can see a schematic diagram of the recommended circuit that SGX Sensortech (IS) Ltd is proposing for powering up the Smart IR. Accordingly in the next Figure 5.2 we can see the Schematic Diagram for reading correct and accurately the Analog output (ANA_OUT) and the Digital output string of data transmitted by the Smart IR.

In terms of the Software implementation we will need a way to read the Digital Output or the Analog Output by using a Microcontroller (MCU) or a Personal Computer (PC). Because the Smart IR is doing all the calculations mainly we need to read the data string coming from the module. In the Evaluation Kit the software that we are using is compatible with Windows Operating System only and at the moment is not possible to read the Analog output by using the Evaluation Software.

Using the Smart IR in a network of sensors is possible but we will need an expansion board attached to the Smart IR to extend distance and guarantee the errorless connection between the Smart IR Module and the customer device. The Universal Asynchronous Receive/Transmit (UART) protocol cannot be transmitted into long distances without converting it into a Network Communication Protocol. Therefore to increase the reliability of the communication between the Smart IR and the Customer’s Device please keep the length of the connection short away from strong magnetic fields.

Using the Smart IR in extreme conditions of high humidity or low temperature may affect the performance due to the actual physical materials used. Typically the module has a very high corrosion resistance protected by a flameproof housing and a temperature compensated linear output.

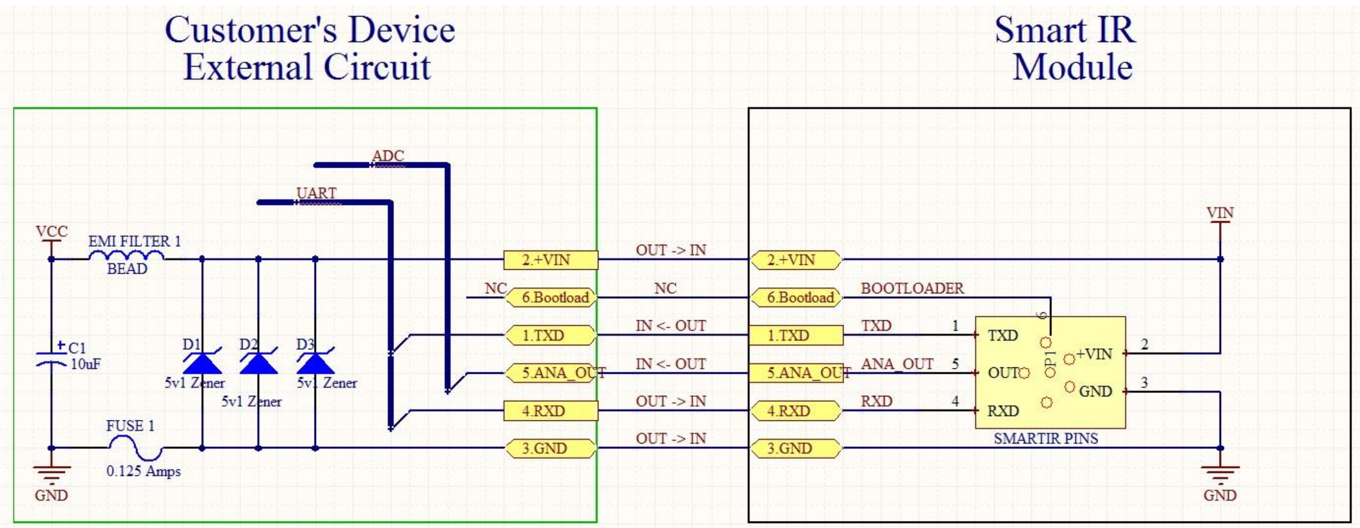


Figure 5.1 – Recommended Schematic Diagram for Powering the Smart IR

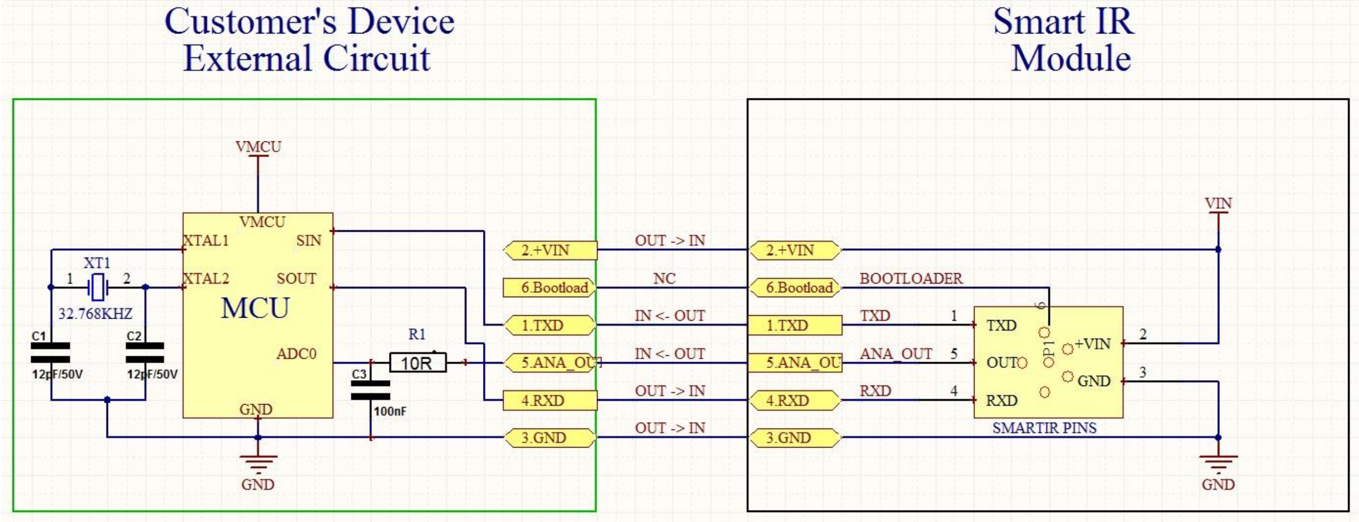


Figure 5.2 – Schematic Diagram for Reading the Digital and Analog Outputs

IMPORTANT!

If your device is intended to be used in a hazardous environment please seek guidance from a professional certification body and also look into the appropriate standards like EN 60079-11:2012 or others that may apply accordingly.

Below in Figure 5.3 we can see an example Block Diagram of an application using the Smart IR Module to simplify the design and the software implementation of the instrument. By using the Smart IR we can easily read the digital output that contains vital information for the Gas Concentration and the status of the Gas Sensor, therefore we got a bi-directional communication between the customer's device and the Smart IR Module.

Please keep the connections between the Smart IR Module and the Customer's Device as short as possible away from strong electromagnetic fields that can affect the performance of the Gas Sensor to maximize the reliability, precision and extend the lifecycle of the device itself.

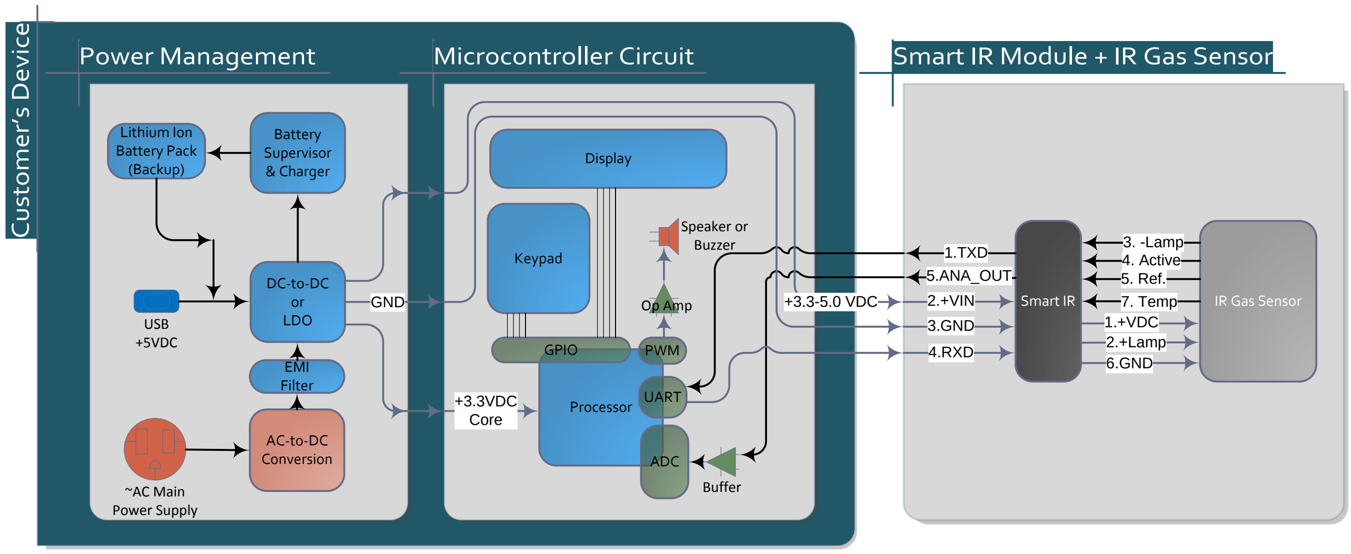


Figure 5.3 – Example Block Diagram for Gas Sensing Instrument Application

The above block diagram is here to illustrate the possible use of the Smart IR, more parts or other techniques can be implemented in order to produce a fully certified gas sensing instrument. The realization of a complicated embedded electronic instrument for gas sensing requires knowledge of the Intrinsic Safety (IS) (ATEX), Safety Integrity Level (SIL) or potential other Standards main apply as well.

APPLICATIONS INFORMATION

COMMUNICATE WITH THE SMART IR

There are two ways to communicate with the Smart IR. The first way is by reading the Analogue Output of the Smart IR which can be connected to an input of an Analog to Digital Converter (ADC). The Analogue Output is giving a linearized value of the concentration, please see "Calculating the %vol or ppm from the Analogue Output" for more details. This method of communication is one-way and we can only read the value coming from the Smart IR, but we cannot send data back. For best results and precision of the concentration we must be able to read the Analogue Output with up to 3 floating points precision.

The second way to communicate with the Smart IR is by using the Universal Asynchronous Receive /Transmit (UART) communication protocol. The Digital Output String is containing the information we need for the calculated concentration, faults, etc. We can read the UART output either by wiring the Smart IR to the Configuration Unit and using the Smart IR Evaluation Software or by connecting the UART directly to another microcontroller. This specific way of communication is bidirectional, meaning that we do have the opportunity to send some commands to the Smart IR via UART as well.

If you are using the second method it is possible to send some commands to the Smart IR and get some answers back from the device accordingly, please see "Universal Asynchronous Receive/Transmit (UART)" for more details.

The software for the device has been designed to reduce waiting times and increase response times making the whole module faster than most custom made equipment although fully customizable. During the data transition precautions has been taken to decrease the change of software failure by using common coding techniques, fuzzy logic algorithms and hardware supervision functions. Last but not least the fast data processing algorithm used in the module is making the device suitable for real time applications inside tight industrial standards.

UNIVERSAL ASYNCHRONOUS RECEIVE/TRANSMIT (UART)

The Universal Asynchronous Receive/Transmit (UART) is a protocol that many devices especially microcontrollers are using often to communicate with each other or with a computer. The Smart IR device has been designed to produce a string with all the data that we need to use to implement the sensor into any application. Please see the next paragraphs below for settings and more details on how to communicate with the Smart IR via the UART and in what format the digital output is transmitted.

Whether we want to communicate with another microprocessor or a computer via the serial communication protocol we must have the same settings in both devices otherwise the communication might be impossible or sometimes faulty.

When we are calculating the response times in the concentration of gases for the Smart IR, it is advisable to take into consideration the delay, which we are going to have from the transmission and from the period of the data processing. In case of the Smart IR Evaluation Software that delay is around 1 second, therefore the data that we can see in the Graph are effectively the data transmitted a second ago, overall 2 seconds delay from Real Time environment. If averaging of more than 2 values is chosen see the specifications page or is better if you calculate the overall delay by experiments.

UART COMMUNICATION SETTINGS

At the moment it is advisable to communicate with the UART of the Smart IR module by using the recommended setting in the Table 6.0 - UART Settings seen below. Obviously the same settings will be valid if you try to communicate with the Smart IR module by using a PC or another microcontroller.

In the near future the intention of the Smart IR is to implement the UART communication protocol with different Baud Rates up to 38400. Until then the evaluation version and the first release of the product will be fixed to Baud Rate equal to 38400 only.

Table 6.0 - UART Settings

Baud Rate	38400
Data Bits	8
Parity	None
Stop Bits	2
Handshaking	None

NOTE: The UART Communication settings can vary but the Smart IR can only reach at a maximum of 38400 Baud Rate. The probability of an error in communication protocol of the specific Baud Rate is around 0.015% given by the manufacturer assuming ambient temperature of 25°C, without strong electromagnetic field.

DIGITAL OUTPUT STRING VIA UART

Every second the Smart IR uses the UART to send a string to the digital output. Therefore the TXD pin of the UART is transmitting all the information from the Smart IR to the PC or another custom made device. There are two different states in the transmission, depending on the "Mode" that the Smart IR is running. There are generally three modes that the microprocessor can run and all of them can be configured via the UART by sending the appropriate command. Please see the Table 8.0 - UART Commands for more information on the commands that are available to the Smart IR and how we can send them. In the same way the Smart IR can send us an answer back so it is possible to have a two-way communication with the Smart IR device. See the Table 9.0 - Read Back the Settings from the Smart IR to understand how the data are being stored to the Microcontroller. We can also see the Table 10.0 - Answers from the Smart IR UART, for the possible answers that we can get when sending a command.

Please see the Table 7.0 below for more information about the digital output string.

Table 7.0 - Digital Output, UART String

Mode	String	
"NORMAL" MODE	[	// Start Character 0x000005Bu (HEX)
	0xAAAAAAAA	// Gas concentration in PPM (HEX)
	0xAAAAAAAA	// Faults (HEX)
	0xAAAAAAAA	// Sensor Temperature (HEX)
	0xAAAAAAAA	// CRC*1
	0xAAAAAAAA	// 1's Compliment of CRC*1
	]	// End Character 0x000005Du (HEX)
"ENGINEERING" MODE	[	// Start Character 0x000005Bu (HEX)
	0xAAAAAAAA	// Gas concentration in PPM (HEX)
	0xAAAAAAAA	// Faults (HEX)
	0xAAAAAAAA	// Sensor Temperature (HEX)
	0xAAAAAAAA	// Reference 1 sec Average value
	0xAAAAAAAA	// Active 1 sec Average value
	0xAAAAAAAA	// CRC*1
	0xAAAAAAAA	// 1's Compliment of CRC*1
	]	// End Character 0x000005Du (HEX)
"CONFIGURATION" MODE	The UART (Digital Output) and the DAC (Analogue Output) are disabled.	

NOTE:
***1.** The CRC and the first compliment of the CRC are not at the moment implemented in terms of calculation so you do not have to check them. In the future CRC will be used to make sure that the data are not being corrupted inside the communication network in case something goes wrong.
2. Obviously the 0xAAAAAAAA hex number is an example representing the 32-bit numbers that are being transmitted via the UART and is different in every case depending on the actual value that is representing, for example a concentration of 500 PPM will be 0x000001F4 in hex.

The basic difference between the NORMAL and ENGINEERING MODES, is the digital output representation of the signal processing. Therefore in the ENGINEERING MODE we are sending to the digital output two more variable that are representing the Active and Reference Peak-to-Peak voltages of the signals accordingly. The Faults in both cases are extracted and most of the times can help as identify critical errors of the Gas Sensor itself and of the Smart IR module. With the help of the CRC implementation in the final release of the device we will be able to expand the capabilities of the Smart IR into a sensing network system able to interrupt with the environment throw sophisticated PC software.

COMMANDS TO THE UART

The commands that we can send to the UART by using any kind of serial terminal or the Smart IR Evaluation Software are specified in the Table 8.0 – Smart IR UART Commands. All the commands that we can send to the actual COM port must be initialized with the character "["and ending with the character "]".

The implementation of the commands of the following table can be used to communicate and perform tasks, in a microcontroller-to-microcontroller low level programming. That condition and flexibility of the Smart IR module to communicate both with high-end and low-end applications is making the specific device easy to use in terms of connectivity. By using a microcontroller inside the Smart IR effectively we are making the Gas Sensor a standalone device that can also be implemented in a wired or wireless gas sensors network or any other hybrid network.

Table 8.0 – UART Commands

UART Command	HEX Code	Meaning of the Command	Detailed Description
[A]	0x41	**Enter Normal Mode**	By setting the Normal Mode to the Smart IR the configuration setting cannot be written to the Smart IR or read, the Active and Reference signal values are not being send to the output of the UART.
[B]	0x42	**Enter Engineering Mode**	By setting the Engineering Mode the Smart IR is calculating everything, the Active and Reference signal values are exported via UART and it is possible to perform commands: [D], [E], [H], [I]
[C]	0x43	**Enter Configuration Mode**	By setting the Configuration Mode the Smart IR is not calculating anything, the UART and DAC are disabled. Perform commands: [F], [G], [J]
[D]	0x44	**Calculate New Span**	A calibration routine that can be used to calculate new SPAN value. The value will be stored in the Flash/EE memory of the sensor automatically, This command can only be performed in NORMAL / ENGINEERING modes
[E]	0x45	**Calculate New Zero**	This command is a calibrating routine that can be used to calibrate the new ZERO value. The value will be stored in the Flash/EE memory of the sensor automatically. This command can only be performed under NORMAL or ENGINEERING modes.
[F]	0x46	**Read Back the Settings**	We can send this command to the Smart IR if we want to read the settings back. All the settings are in a hex form representing integer values only.*3 This Command can only be performed under CONFIGURATION mode.
[G]	0x47	**Load new settings on the SMART_IR**	We can send this command to the Smart IR if we want to write the new setting, all the settings are in a hex form representing integer values only. This Command can only be performed under CONFIGURATION mode.
[H]	0x48	**Select LOW Concentration**	By sending this command we are selecting the LOW range of concentration (eg. 5%) for the sensor to work. Can only be performed under NORMAL or ENGINEERING modes.
[I]	0x49	**Select HIGH Concentration**	By sending this command we are selecting the HIGH range of concentration (eg. 100%) for the sensor to work. This command can only be performed under NORMAL or ENGINEERING modes.
[J]	0x50	**Load the Dummy Data**	Inside the code there are some initial data stored like concentration ranges, coefficients etc. If you want to load those values back to the sensor send the command to the SMART_IR sensor via UART. This command can only be performed under CONFIGURATION mode.

NOTE:
1. All the command must have a starting ("["= 0x000005B) and a finishing character ("]"= 0x000005D), for the UART to work.
2. The Error in the communication protocol UART and any device running at maximum 38400 Baud rate is 0.015%.
*3. see Table 2.4 – Read Back the Settings from the Smart IR

ANSWERS FROM THE UART

Below we can see the set of Readings coming as an answer from the Smart IR when we perform the command [F] -> Read Back Readings, under CONFIGURATION mode. Every variable is being stored as an integer and it is advisable whenever we need to change the settings to keep them in the same format as well, otherwise the Smart IR will not function correctly.

Please see the Table 9.0 – Read Back the Settings from the Smart IR to see examples on how to convert from the readings to the actual normal values of the data.

Table 9.0 – Read Back the Settings from the Smart IR

Variable Type	Variable Name	Default Value Stored as Integer	Detailed Description
uint32_t	serial_number	= 0901130001	Serial number of the part
uint32_t	sensor_ID	= 1271	ID of the Sensor to be used
uint32_t	gas_type	= 2	Type of the gas sensor, TWIN_GAS_SENSOR = 0 SERIES2_IRxxEx = 1 SERIES2_IRxxGx =2
uint32_t	dac_config	= 1	
uint32_t	low_conc_range	= 50000	Concentration in PPM (5% v/v)
uint32_t	high_conc_range	= 1000000	Concentration in PPM (100% v/v)
float32_t	low_span_gas_conc	= 5 *10000	Initialize the coefficient for span calculations, low concentration
float32_t	high_span_gas_conc	= 100 *10000	Initialize the coefficient for span calculations, high concentration
float32_t	a_coeff_low_range	= 0.267 *1000000	"a" coefficient for low range of the gas sensor depends on the sensor
float32_t	a_coeff_high_range	= 0.0563 *1000000	"a" coefficient for the high range of the gas sensor, depends on the sensor
float32_t	n_coeff_low_conc	= 0.725 *1000000	"n" coefficient for the low concentration, depends on the sensor
float32_t	n_coeff_high_conc	= 0.497 *1000000	"n" coefficient for the high concentration, depends on the sensor
float32_t	betaneg_coeff_low_range	= -0.137 *1000000	"beta" negative coefficient for low range of the gas sensor, depends on the sensor
float32_t	betaneg_coeff_high_range	= -0.137 *1000000	"beta" negative coefficient for high range of the gas sensor, depends on the sensor
float32_t	betapos_coeff_low_range	= -0.106 *1000000	"beta" positive coefficient for low range of the gas sensor, depends on the sensor
float32_t	betapos_coeff_high_range	= -0.106 *1000000	"beta" positive coefficient for high range of the gas sensor, depends on the sensor
float32_t	alphaneg_coeff	= 0.000235 *1000000	"alpha" negative coefficient
float32_t	alphapos_coeff	= 0.000363 *1000000	"alpha" positive coefficient
uint32_t	time_delay_ms	= 12 ;	
float32_t	averaging	= 5 ;	Not used at the moment
uint32_t	concentration_range	= 0	LOW_CONC = 0 and HIGH_CONC = 1
float32_t	zero	= 2.7696 *10000000	Zero initialized to 3, means the Active x3 in Peak to Peak voltage than Reference
float32_t	span_low	= 0.2108 *1000000	Span initialized to 0.2108 for low range of the concentration

Variable Type	Variable Name	Default Value Stored as Integer	Detailed Description
float32_t	span_high	= 0.4980 *1000000	Span initialized to 0.4980 for high range of the concentration
uint32_t	calibration_temperature	= 293.1 *10	Calibration temperature stored in Kelvin * 10 to create an integer
uint32_t	sampling_frequency	= 125	Sampling Frequency fixed to 125, do not use other value at the moment
uint32_t	baud_rate	= 38400	The baud rate to run the UART communication
uint32_t	firmware	= 101	
uint32_t	first_time	= 1	Set this variable to 1 if you are writing the Flash for the first time or calibrating the sensor
float32_t	Act_1s_Average_Calibrate	= 0.008200	The default value of the Active Signal during calibration routine (Zero or Span Calibration)
float32_t	Ref_1s_Average_Calibrate	= 0.002960	The default value of the Reference Signal during calibration routines (Zero or Span Calibration)

NOTE:
1. All Readings are transmitted as integer numbers, in order to convert the integer into the normal value just divide by the multiplier.
eg. span_low = 0.2108 *1000000 = 210800
Therefore span_low = 210800 / 1000000 = 0.2108 32-bit floating number
2. That table is for information only and can be used if we are implementing the Smart IR with a custom device. The Smart IR Evaluation Software is using all the variables and doing all the calculations automatically.

WARNING!
Under no circumstances do not change the values on the readings that are highlighted with red colour. Doing so could prevent the Smart IR from working correctly and in some cases can produce faulty readings making the Smart IR malfunctioning.

Below in the Table 10.0 we can find attached the possible answers from the Smart IR via the UART communication port after we have performed a command.

Table 10.0 - Answers from the Smart IR UART

UART Answer	HEX Code	Meaning of the Answer	Detailed Description
[AK]	0x00414B00	**ACKNOWLEDGEMENT**	This answer means that we have an acknowledgement from the Smart IR that everything went OK and possible if we have sent a command that the command executed correctly.
[NA]	0x004E4100	**NO ACKNOWLEDGEMENT**	This answer means that we have not an acknowledgement from the Smart IR, something went wrong and if we have sent a command that the command has not been executed.

NOTE: All the commands have a starting character a starting (“[“= 0x5B00000) and a finishing character (“]“= 0x000005D).
So for example [AK] => 0x5B414B5D in HEX.

CALCULATE CONC.% FROM THE ANALOGUE OUTPUT

The DAC output can vary from 0 to 2.5 Volts. In order to calculate the concentration from the Volts that we are reading we can use the following equation:

$$\%vol = \left(\frac{DACvolts}{1.25} - 1\right) * Range$$

where $Range = 2, 5, 100$ or whatever is the range in concentration of the sensor (see Appendix A – Table of Coefficients).

In the same way we can convert the %vol to the HEX number that the DAC in using to give as the output by using the following equation:

$$HEX = \left(\frac{\%vol * 2048}{Range}\right) + 2047$$

In the same way we can convert the Volts from the HEX number that the DAC in using to give as the output by using the following equation:

$$DACvolts = \left(\frac{HEX * 1.25}{2048}\right)$$

The maximum current that the DAC can source is 0.5 mA, based on a 5K resistive Load at 2.5Volts.

There are some limitations in the concentration, if we are reading DACvolts = 0 then the DAC is stopped or not functioning. The DACvolts = 0.5 means that the Smart IR has a fault. Anything between the 0.5 and 2.5 can represent the 100% Full Scale with 1.25 being the zero of the scale. The scale representing the DAC output can be found in Figure below.

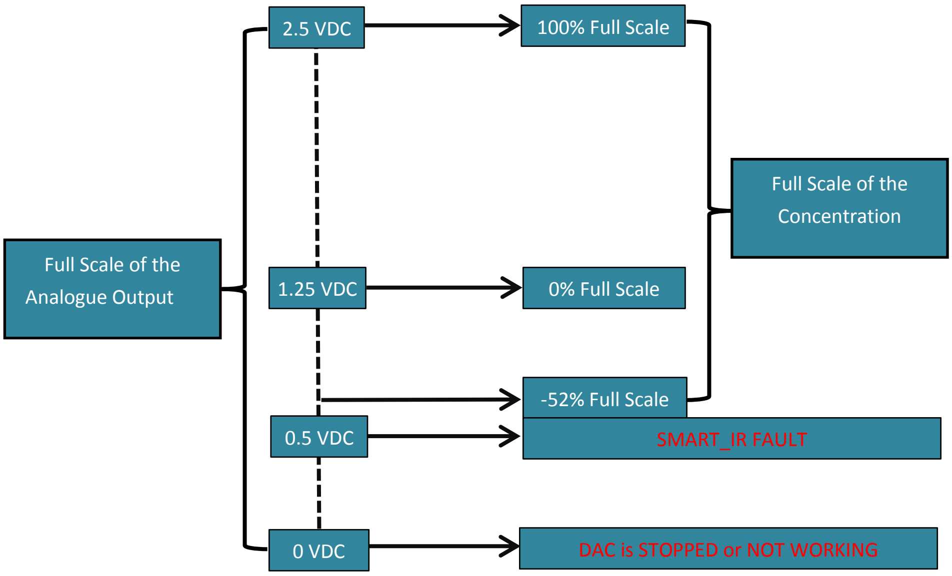


Figure 6.0 – Full Scale Representing the DAC Output

IMPORTANT!

The precision in the Analogue Output is not as high as the Digital output, therefore is recommended to use at least a 12-bit ADC to read it.

Example 1 : If Range = 5 : 3 Floating points precision => 0.0048%vol/mV of DACvolts

If Range = 5 : 4 Floating points precision => 0.0024%vol/mV of DACvolts

Example 2 : If Range = 100 : 3 Floating points precision => 0.08%vol/mV of DACvolts

If Range = 100 : 4 Floating points precision => 0.048%vol/mV of DACvolts

NOTE: If we are using the Analogue DAC Output for the concentration and we have a fault in the Smart IR therefore around 0.5 Volts DC in the output, there is no way to know what is the source of the problem that is causing the error.

In case the DAC is exactly 0 Volts DC then please make sure the connections are correct and you are reading the Smart IR the right way. If everything seems alright then we have to check if we are accidentally set the Smart IR into configuration mode.

ZERO CALIBRATION

As we can see in the Table 8.0 – UART Commands we can perform the "Zero" calibration routine by sending the command [E] while the Smart IR is in NORMAL or ENGINEERING mode.

Please make sure that the value we have set in the configuration Tab matches the percentage of concentration of the gas used. Performing the Zero calibration with different percentage of concentration as default value comparing with the Gas Sensor type will result unstable readings and may cause false alarms as well.

IMPORTANT!

It is advisable to do the Zero Calibration after we have left the sensor for 25-30 minutes to warm up and reach the ambient temperature. (If extreme precision is required perform the calibration twice and use the interactive method of Alpha and Beta compensation digitally.)

The Smart IR is not at the moment using the interactive method for Alpha and Beta compensation, this method is going to be implemented in later revision of the firmware.

SPAN CALIBRATION

As we can see in the Table 8.0 – UART Commands we can perform the "Span" calibration routine by sending the command [D] while the Smart IR is in NORMAL or ENGINEERING mode.

Please make sure that the value we have set in the configuration Tab matches the percentage of concentration of the gas used. Performing the Span calibration with different percentage of concentration as default value comparing with the Gas Sensor type will result unstable readings and may cause false alarms as well.

The routine is optimized for speed, therefore will not take anytime from the processing algorithms and can be performed real time and during NORMAL and ENGINEERING modes as well.

IMPORTANT!

It is advisable to do the Span Calibration after we have left the sensor for 25-30 minutes to warm up and reach the ambient temperature. If extreme precision is required perform the calibration twice and use the interactive method of Alpha and Beta compensation digitally.

The Smart IR is not at the moment using the interactive method for Alpha and Beta compensation, this method is going to be implemented in later revision of the software.

It is important to perform both zero and span calibration routines in the same controlled environmental conditions of ambient temperature, humidity and pressure without strengthening the components above the maximum ratings presented into the technical specifications table.

Last but not least will be also advisable to perform first the zero calibration in nitrogen gas solution and then the span calibration exposing the sensor in the gas that you want to detect.

In both cases the Active and Reference counts representing the Peak-to-Peak voltage of the signals accordingly along with the temperature the moment of the calibration, are stored inside the Flash/EE memory of the Smart IR and can be read back by performing the appropriate command.

IMPORTANT!

Beware that selecting different concentration ranges via the Evaluation Software or with the low level microcontroller implementation, the steps of the calibration routine should be performed again. By changing the concentration ranges we only changing the coefficients for that range and not the stored data of the calibration. Obviously most of the times by changing the concentration ranges, means that we also have to change the Gas Sensor therefore we have to perform a recalibration process anyway.

TRANSLATING THE "FAULTS" CODE

The Fault is a 32-bit unsigned integer number that is representing all the errors either code or hardware related. The Fault is transmitted via the UART second in place after the Concentration in ppm. Each 4-bits of the Fault variable can represent different levels of errors, so we can simultaneously monitor 8 different errors from 8 different parts in terms of hardware or software. The association between the Fault variable and the different states of errors can be found below in the Table 11.0 – Faults/Errors Interpretation.

To interpret the Fault variable, first identify the Assigned Digit that we want to translate then the function/error that is representing from the column Associated Part and finally the Meaning of the error depending on the value of the digit.

Table 11.0 – Faults/Errors Interpretation

Variable	Associated Part	Assigned DIGIT	Error Meaning	Value UART
Fault	ALL Parts	**7 to 0**	NO ERROR IN ALL PARTS (EVERYTHING OK)[*1]	0xAAAAAAAA
ENABLED	Gas Sensor	**0**	NO ERROR	0x0000000A
			01-Sensor not Present	0x00000001
			02-Temperature sensor not working **OR** Device Temperature Out of the Operating Range	0x00000002
			03-Active or Reference are weak	0x00000003
			04-First Time Configuration Mode, no settings present	0x00000004
ENABLED	Power Related	**1**	NO ERROR	0x000000A0
			01-Last Reset was because of a Power on Reset	0x00000010
			02-Last Reset was because of a Watchdog Timer	0x00000020
			03-Last Reset was because of a Software Reset	0x00000030
			04-Last Reset was because of an External Pin Interrupt	0x00000040
			05-Not assigned yet	0x00000050
DISABLED	ADC Related	**2**	NO ERROR	0x00000A00
			01-ADC is switched off	0x00000100
			02-Weak Signals Received	0x00000200
			03-Not assigned yet	0x00000300
ENABLED	DAC Related	**3**	NO ERROR	0x0000A000
			01-DAC is switched off	0x00001000
			02-DAC output disable in Configuration mode	0x00002000
ENABLED	UART Related*[2]	**4**	NO ERROR	0x000A0000
			01-Break Indicator P1.0 set LOW for more than the maximum word length	0x00010000
			02-Framing Error, stop bit was invalid	0x00020000
			03-Parity Error, stop bit was invalid	0x00030000
			04-Overrun Error, data overwrite before being read	0x00040000
DISABLED	TIMERS Related	**5**	NO ERROR	0x00A00000
			01-Timer1 Error	0x00100000
			02-Timer2/Watchdog Error	0x00200000
			03-Not assigned yet	0x00300000
DISABLED	General Error	**6**	NO ERROR	0x0A000000
			01-Main loop is not executed	0x01000000
			02-Not assigned yet	0x02000000
ENABLED	MEMORY Related*[3]	**7**	NO ERROR	0xA0000000
			01-Unable to store Data, to the SMART_IR	0x10000000
			02-Unable to read Data from the SMART_IR	0x20000000
			03-Not assigned yet	0x30000000

*1: It normal to get a Fault = 0xAAAAAA1A because the "1" in the second digit representing the Power on Reset process of the MCU which is a normal operation when we turn on the SMART_IR.
*2: This is the function that will check the UART Status (COMSTA0) register, to produce a fault depending on the previous experience. Obviously if the error is serious we will not be able to receive the message via UART, but we can check it later to find out what caused it.
*3: The Memory will work correctly as long as the MCU is working but it will not be able to store the data in the flash upon reset, if the Error 01 is present. If we cannot read the Memory then check the Mode you are working, the memory cannot be read other than CONFIGUATION MODE.

EXPERIMENTAL RESULTS

MEASUREMENTS (0%VOL - 5%VOL METHANE)

The following experiment has the intention to present a guide to what we should expect from the Smart IR Module. Obviously the Smart IR is a module that will help us implement the Gas Sensing Process easily in different applications without complicated designs but the accuracy and precision is depending also on the Gas Sensor.

The measurements of the Smart IR for the following graphical representation of the concentration against Time (in seconds) where made after the Smart IR was "ZERO" and "SPAN" calibrated.

At the first start up both the "Active" and "Reference" signals need 1 minute to fully stabilize. In order to calibrate the sensor the following settings where made, after we left the sensor for 25-30 minutes to warm up and reach the ambient temperature.

Table 12.0 - Calibration Settings for Smart IR + IR12GM_1 Gas Sensor

Variable	Value
Concentration Range (ppm)	50000
Span Gas Concentration (%vol)	5%
Coefficient "a"	0.267
Coefficient "n"	0.725
Coefficient "Beta Negative"	-0.137
Coefficient "Beta Positive"	-0.106
Coefficient "Alpha Negative"	0.000235
Coefficient "Alpha Positive"	0.000363
Time Delay*1	12
Averaging*2 (Samples/second)	5
Temperature	26 °C

NOTE:
***1** - Keep that value 12, using something else may affect the measurements accuracy and stability.
***2** - Recommended Averaging value is between 4 to 6, more than 6 will affect the response times of the sensor and less than 4 will affect the stability, precision of the signal.

Please apply averaging value accordingly to your technical specifications taking in account precision vs stability vs response times, depending on the application.

In the Figure 7.0 we can see the graphical representation of the measurements taken place in a controlled environment of pressure and temperature. In the graph we can see a typical implementation of the SMART_IR Gas sensor in a 5%vol Methane application.

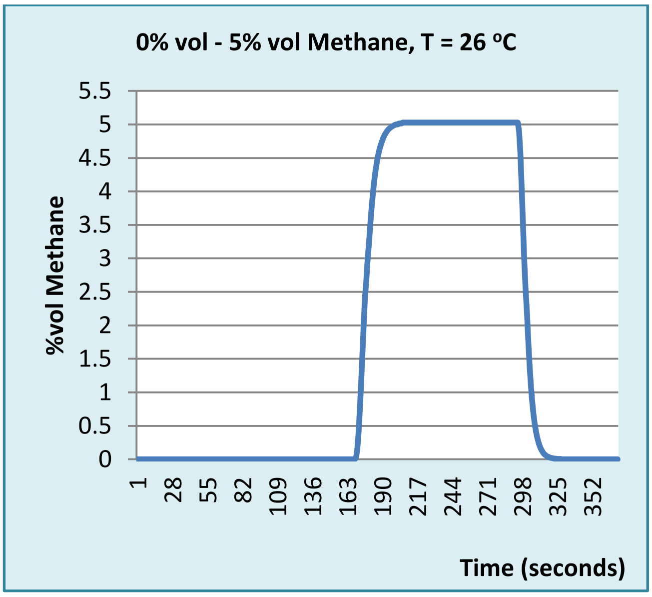


Figure 7.0 - Graph of 0%vol to 5%vol Methane Against Time (secs)

The first few seconds we can see the SMART_IR Sensor under 0%vol Methane environment and then the concentration suddenly increases to 5%vol Methane. From 0% vol until 4.5% vol Methane, to reach 90% of the full scale of the concentration, takes 13 seconds.

From 5%vol Methane to 0.5% vol Methane, to reach 10% of the full scale of the concentration, takes 15 seconds. Both of the response times in terms of gas detection are below 2 seconds, so almost instant detection.

The Smart IR Module has integrated Temperature Compensated function that will help the signal to be stable and precise even with the temperature changes. Extremely fast changing temperature and humidity conditions like high or low temperature winds can introduce oscillations to the signal and decrease the stability and precision of the data.

MEASUREMENTS (0%VOL - 2%VOL CARBON DIOXIDE)

The following experiment has the intention to present a guide to what we should expect from the Smart IR Module. Obviously the Smart IR is a module that will help us implement the Gas Sensing Process easily in different applications without complicated designs but the accuracy and precision is depending also on the Gas Sensor.

The measurements of the Smart IR for the following graphical representation of the concentration against Time (seconds) where made after the Smart IR was "ZERO" and "SPAN" calibrated.

In order to calibrate the sensor the following settings where made, after we left the sensor for 25-30 minutes to warm up.

Table 13.0 - Calibration Settings for Smart IR + IR11GM_1 Gas Sensor

Variable	Value
Concentration Range (ppm)	20000
Span Gas Concentration (%vol)	2%
Coefficient "a"	1.020
Coefficient "n"	0.678
Coefficient "Beta Negative"	0.208
Coefficient "Beta Positive"	0.211
Coefficient "Alpha Negative"	0.000242
Coefficient "Alpha Positive"	0.000275
Time Delay *1	12
Averaging *2 (Samples/second)	5
Temperature	29.5 °C

NOTE:*1 - Keep that value 12, using something else may affect the measurements accuracy and stability.
***2** - Recommended Averaging value is between 4 to 6, more than 6 will affect the response times of the sensor and less than 4 will affect the stability, precision of the signal. Please apply averaging value accordingly to your technical specifications taking in account precision vs stability vs response times, depending on the application.

In the Figure 8.0 we can see the graphical representation of the measurements taken place in a controlled environment of pressure and temperature. In the graph we can see a typical implementation of the SMART_IR Gas sensor in a 2% vol Carbon Dioxide application, with internal temperature 29.5 °C.

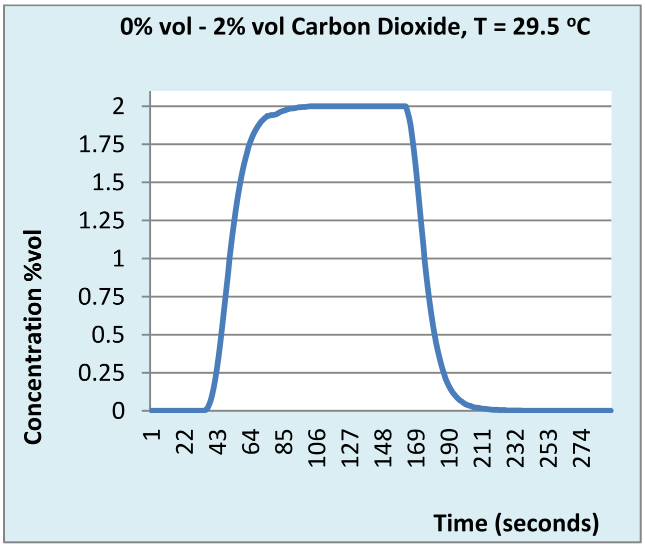


Figure 8.0 - Graph of 0%vol to 2%vol Carbon Dioxide Against Time (secs)

The first few seconds we can see the SMART_IR Sensor under 0%vol Carbon Dioxide environment and then the concentration suddenly increases to 2%vol Carbon Dioxide. From 0% vol until 4.5% vol Carbon Dioxide, to reach 90% of the full scale of the concentration, is taking 13 seconds.

From 5%vol Carbon Dioxide to 0.5% vol Carbon Dioxide, to reach 10% of the full scale of the concentration, is taking 15 seconds. Both of the response times in terms of gas detection are below 2 seconds, so almost instant detection.

The Smart IR Module has integrated Temperature Compensated function that will help the signal to be stable and precise even with the temperature changes. Extremely fast changing temperature and humidity conditions like high or low temperature winds can introduce oscillations to the signal and decrease the stability and precision of the data.

IMPORTANT!
Please be aware that the response times can be affected if we change the Averaging value.

The following table contains the actual readings we got from the Smart IR sensor on the Smart IR Evaluation Software while the program was running in stable low and high concentrations of the gases.

Those values that we can see below in the Table 14.0 are just an average result of the different Active and Reference counts that were measured from different sensors.

Table 14.0 – Active & Reference Readings from Smart IR

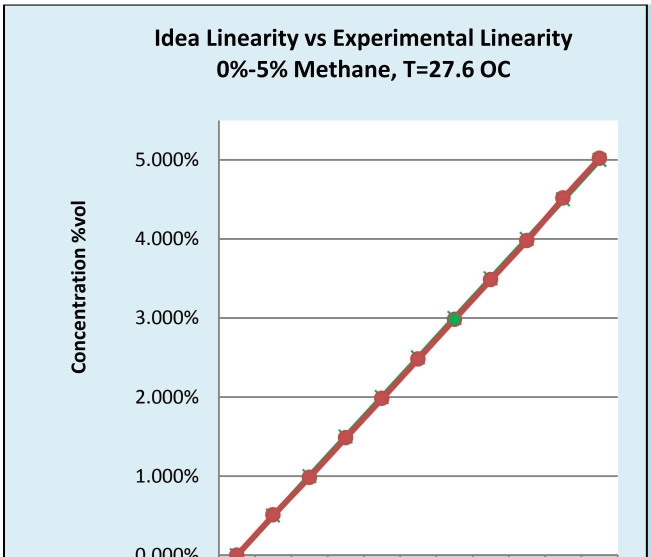
Methane Gas Sensor IR12GM_1				
	Active Counts	Reference Counts	Ratio	Temp. (°C)
0%vol Methane	8200	2960	2.7763	26
5%vol Methane	7228	2950	2.4502	26
Carbon Dioxide Gas Sensor IR11GM_1				
	Active Counts	Reference Counts	Ratio	Temp. (°C)
0%vol Carbon Dioxide	4039	2660	1.5184	29.5
2%vol Carbon Dioxide	2979	2670	1.1161	29.5

NOTE: It is normal to expect a variation in Counts especially in the Active Signal Counts from sensor to sensor. Therefore it is essential to perform the calibration routines again, if the sensor is changed.

TYPICAL CALCULATED LINEARITY

In the specific example we are using a gas blender to check the linearity of an IR12GM_1 Gas Sensor in 5% Methane by using the Smart IR expansion module attached to it.

The Figure 9.0 shows a graphical representation of the readings that were obtained with the Smart IR Evaluation Software.



	1	2	3	4	5	6	7	8	9	10	11
Idea Linearity Curve	0.000%	0.500%	1.000%	1.500%	2.000%	2.500%	3.000%	3.500%	4.000%	4.500%	5.000%
Experimental Linearity	0.000%	0.510%	0.984%	1.484%	1.982%	2.482%	2.986%	3.484%	3.980%	4.520%	5.020%

Figure 9.0 - Linearity in an IR12GM_1 5% Methane Gas Sensor plus Smart IR

The Linearity that we can see on the Figure 9.0 is an typical response of the IR12GM_1 sensor. In specific applications if extremely high precision linearity is required we recommend to produce and implement digitally the linearity equation depending on the measurements that we are getting from the specific sensor. That action will produce the new coefficients that will highly improve and smoothen the linearity response of the particular gas sensor. In the near future, we intent to implement the solution above in the firmware of the Smart IR Module.

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Ordering Information:

For more information and technical support for the product please contact SGX Sensortech (IS) Ltd in United Kingdom using the following lines:

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Fax. +44(0) 1245-809112

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Appendix A
Table of Coefficients

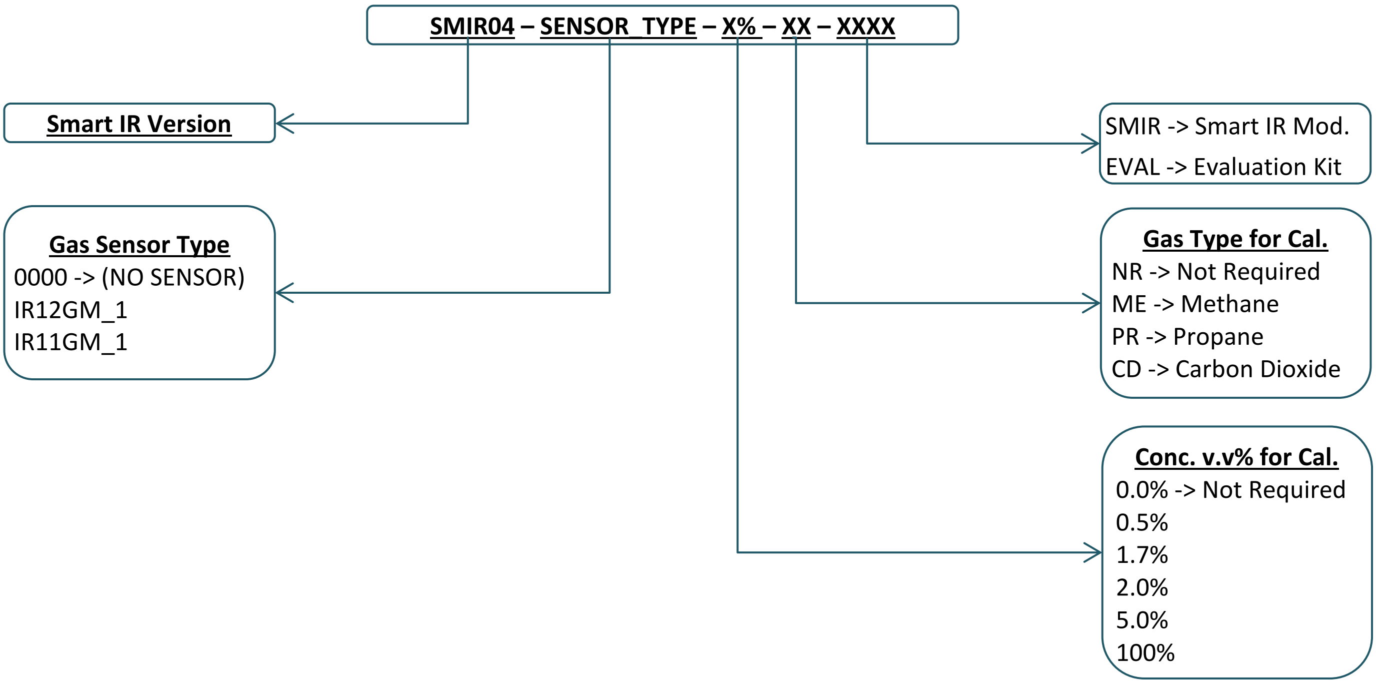
Sensor Type	Gas Type	Range (v/v)	a	n	alphapos	alphaneg	betapos	Betaneg
IR11GJ/GM_1	CO_2	**0.5%**	1.75	0.789	0.000275	0.000242	0.100	0.113
		2.0%	1.02	0.678			0.211	0.208
		5.0%	0.832	0.588			0.352	0.358
IR12GJ/GM_1	CH_4	**5.0%**	0.267	0.725	0.000363	0.000235	-0.106	-0.137
		100%	0.0563	0.497			Contact SGX Sensortech	
	C_3H_8	**1.7%**	0.664	0.949	-0.000070	0.000195	0.166	0.162

NOTE:

1. These coefficients are based upon results measured at SGX Sensortech (IS) Ltd using standard test equipment. These coefficients may vary slightly when using different circuits. It may be required to recalculate some of these coefficients if small inaccuracies are observed during testing (refer to Infrared Sensor Application Note 5 for determination of coefficients).

2. For sensor variants with a "_1" suffix (supported lamp versions), use the equivalent non-supported lamp version. For example for an IR11GM_1, use coefficients for the IR11GM.

Appendix B
Ordering Information



Note: Not all concentrations are available with all gases; please refer to the Table 2.0 – Sensor List Compatible with the Smart IR in page 3 for more details.

Example of ordering code:

1. If we want to order the only the Smart IR Module along with one sensor calibrated with a IR12GM_1 in 5% Methane then all we have to do is to order the part number: ***SMIR04 – IR12GM_1 – 5.0% – ME – SMIR***

2. If we want to order the Smart IR Evaluation Kit along with one sensor calibrated with a IR11GM_1 in 2.0% Carbon Dioxide then all we have to do is to order the part number: ***SMIR04 – IR11GM_1 – 2.0% – CD – EVAL***

3. If we want to order the Smart IR Module only without any sensor, not calibrated then all we have to do is to order the part number: ***SMIR04 – 0000 – 0.0% – NR – SMIR***

Note: When ordering a Smart IR Evaluation Kit please order the Type of Sensor that you want to evaluate; the Evaluation Kits do not include a Gas Sensor of your choice unless you ask for it.