UM2247
User manual

Getting started with the P-NUCLEO-IKA02A1 STM32 Nucleo pack for electrochemical toxic gas sensor expansion board with CO sensor

Introduction

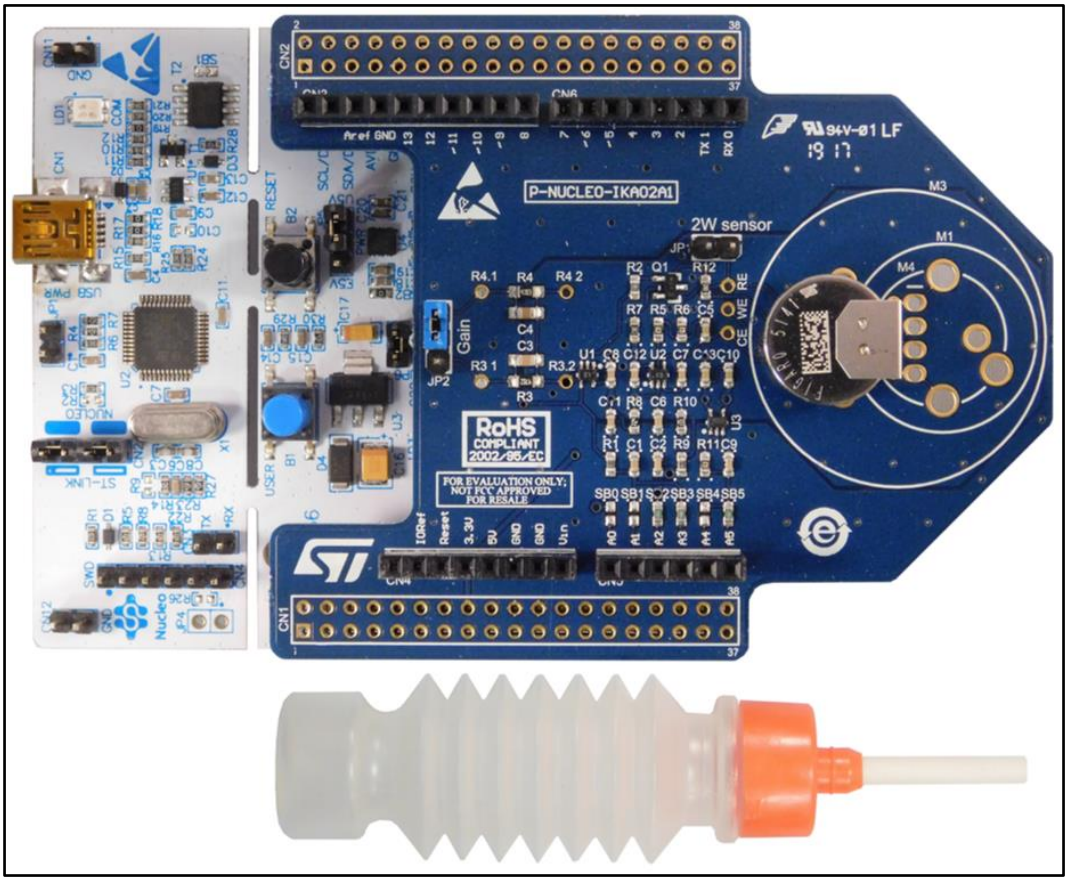
The P-NUCLEO-IKA02A1 evaluation pack provides a reference design for various electrochemical sensors.

The STM32 Nucleo gas expansion board interfaces electrochemical sensors with the MCU on the STM32 Nucleo development board. Two TSU111 operational amplifiers provide signal conditioning; they are ideal for electrochemical sensing thanks to their high precision and low power consumption. The expansion board includes an ultra-low current precision analog temperature sensor STLM20 used for compensation of gas readings.

STM32 Nucleo boards provide an affordable and flexible way for users to experiment with new ideas and build prototypes with any STM32 microcontroller line. The NUCLEO-L053R8 is designed for low power applications.

The design and componentry are optimised for battery operation and maximum battery life time.

Figure 1: P-NUCLEO-IKA02A1 evaluation pack



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1 Getting started

1.1 Evaluation pack overview

The P-NUCLEO-IKA02A1 evaluation pack targets a segment of CO detectors for home alarm systems. It is designed to be easily customized and meets EN50291 requirements.

It features:

- STM32 Nucleo gas expansion board
  - compatible with most electrochemical sensors
  - four different footprints for sensors (PCD13,5, PCD17, Mini and TGS5141)
  - two-, three- and four-electrode sensors
  - signal conditioning with TSU111
  - STLM20 temperature sensor
  - changeable gain
- NUCLEO-L053R8
  - Ultra-low-power ARM® Cortex®-M0+ MCU (32 MHz max.) with 64 Kbytes Flash and 8 Kbytes of SRAM
- Carbon monoxide sensor
  - Figaro TGS5141
  - coin-cell sensor
  - expected life time > 10 yrs
  - can pass 5000 ppm EN50291
- Low power design for long battery life
- RoHS compliant

1.2 Electrochemical gas sensors

The P-NUCLEO-IKA02A1 expansion board interfaces electrochemical sensors with the MCU on the STM32 Nucleo development board.

Electrochemical gas sensors help detect toxic gases like CO, SO_2, NO and CL_2.

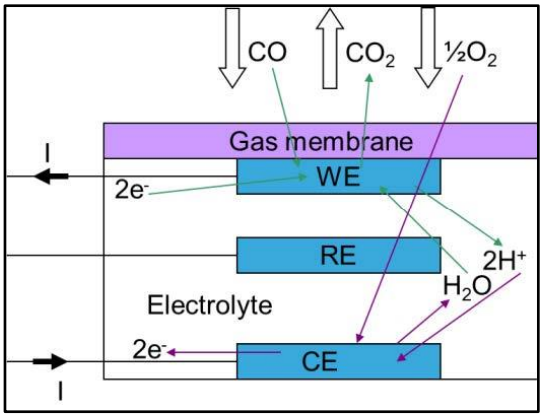
Specifically, the P-NUCLEO-IKA02A1 evaluation pack features the carbon monoxide sensor (Figaro TGS5141), which acts as a fuel cell.

It contains two or three electrodes, electrolyte and gas membrane: the detected gas is oxidized or reduced on the working electrode and a small amount of current is generated (from a few nA to hundreds of nA per ppm of gas concentration).

Depending on the process of oxidization or reduction, the generated current can be positive or negative. The sensors also require some bias voltage to be applied between the working electrode (WE) and the reference electrode (RE) (see *Section 2: "Gas signal conditioning"*)[a].

[a] For further details on sensors and signal conditioning refer to AN4348: "Signal conditioning for electrochemical sensors" on www.st.com.

Figure 2: Carbon monoxide electrochemical sensor



1.3 P-NUCLEO-IKA02A1 expansion board

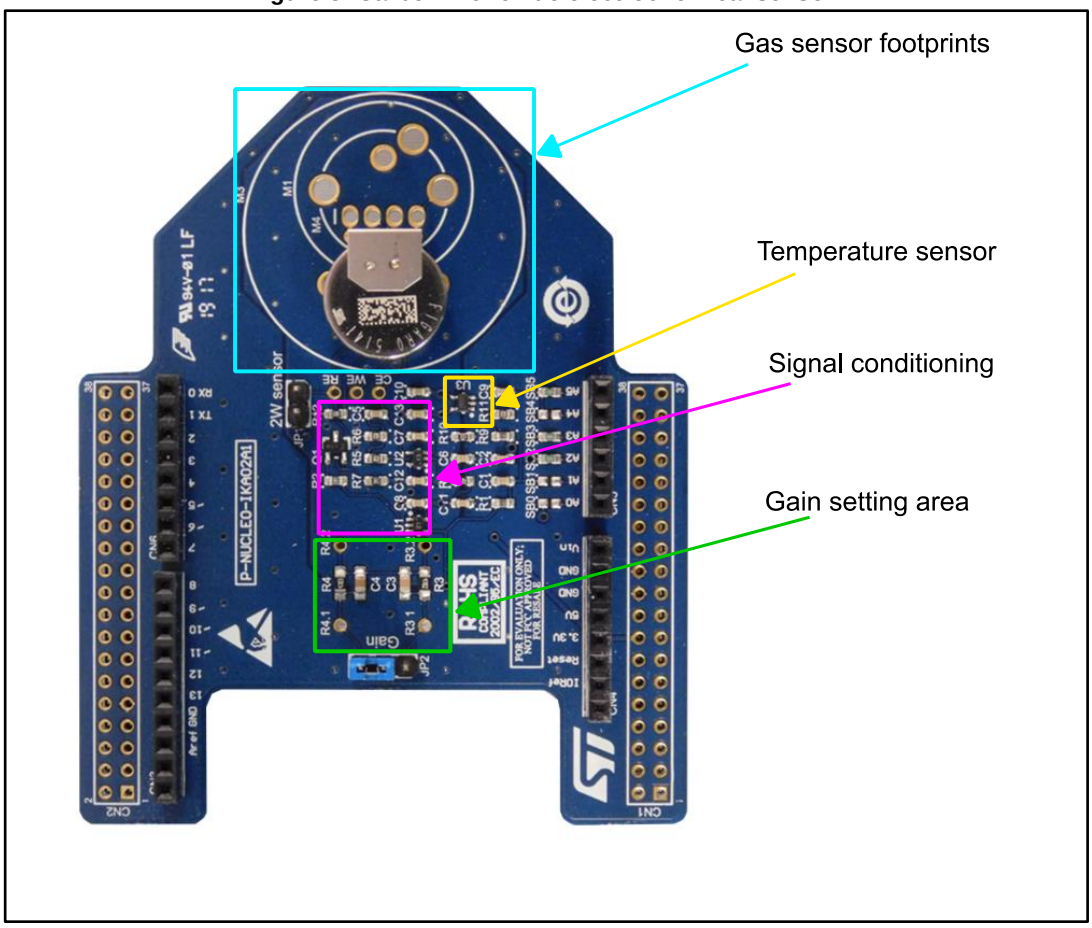
The P-NUCLEO-IKA02A1 expansion board is compatible with the STM32 Nucleo board family thanks to the Arduino™ UNO R3 connectors. It is recommended to stack it on NUCLEO-L053R8 or NUCLEO-F401RE boards.[a]

The expansion board is composed of three main blocks:

- Carbon monoxide sensor: Figaro TGS5141
- TSU111 operational amplifiers for signal conditioning
- STLM20 analog temperature precision sensor for temperature compensation

[a] More information can be found at http://www.st.com/stm32nucleo.

Figure 3: Carbon monoxide electrochemical sensor



1.3.1 Jumper settings

The P-NUCLEO-IKA02A1 expansion board can use electrochemical sensors with 2, 3 or 4 wires.

To provide the right reference and bias value, set jumper JP1 as shown in the table below.

Table 1: JP1 jumper settings

Sensor type	JP1 jumper
2 wires	Shorted
3 or 4 wires	Open
TGS5141	Doesn't matter

Every electrochemical sensor produces a different amount of current. Therefore the expansion board embeds a gain setting area to change the gain through JP2 jumper.

The following table shows the default configuration.

Table 2: JP2 jumper description

Position	Gain	Capacitor value	Max. sensor current
Pins 1 and 2 shorted	47 k	100 n	60 µA
Pins 2 and 3 shorted	470 k	1 µ	6 µA

1.3.2 Solder bridges

The P-NUCLEO-IKA02A1 expansion board is compatible with most X-NUCLEO expansion boards. See the following figure and table for configuration and compatibility information, respectively.

Figure 4: Configuration of solder bridges

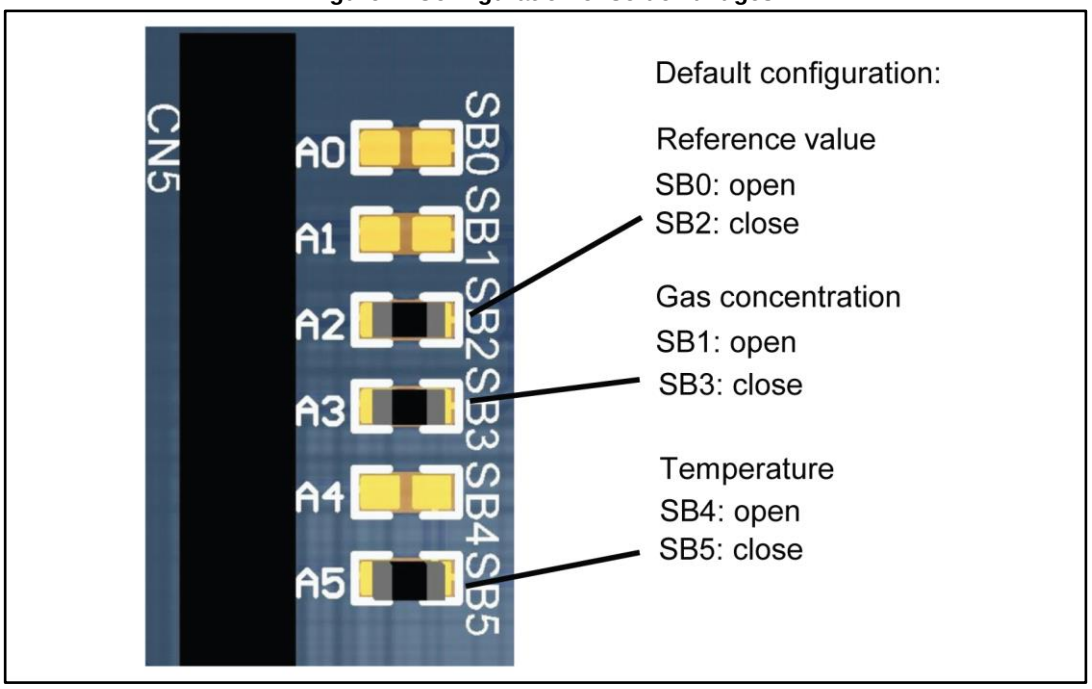


Table 3: Compatibility table

Expansion board	Reference	Gas reading	Temperature
X-NUCLEO-IDB0xA1	Default	Default	Default
X-NUCLEO-IDW01M1	Default (1)	Default	Default
X-NUCLEO-IDS01Ax	Default (2)	Default (2)	Default (2)
X-NUCLEO-IKS01Ax	Default (3)	Default (3)	Default (3)
X-NUCLEO-IKA01A1	Alternative	Default	Default

Notes:

(1)Alternative connection of GPIO13 of Wi-Fi module cannot be used

(2)Optional SPI connection and GPIO pins of SPSGRF module cannot be used

(3)Limited usage of INT on DIL24 and DRDY – see schematic pack and used alternative configuration. It is possible to use humidity sensor on board to provide temperature and humidity compensation

2 Gas signal conditioning

The current generated by electrochemical sensors is transferred to the voltage by the U1 operational amplifier connected as a transimpedance amplifier. The gain of the amplifier is set by R4 and R3.

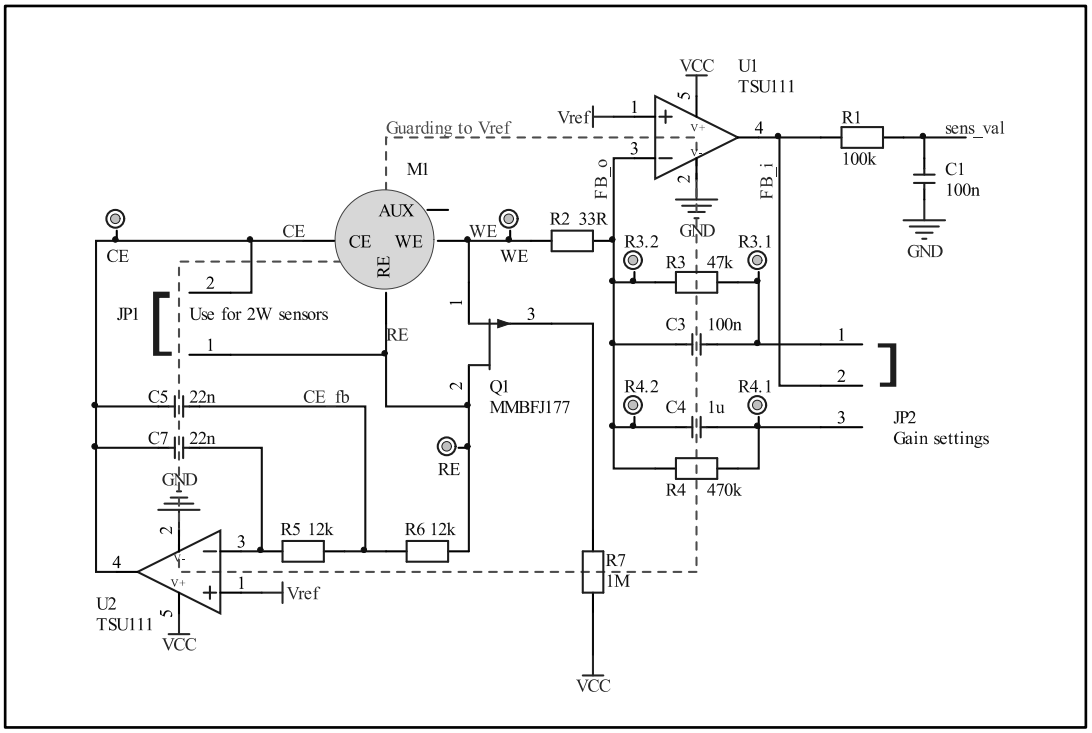
To prevent the operational amplifier U1 from being in low saturation (no presence of gas) the reference voltage is used: V_{REF} is 430 mV but can be altered by changing R8 and R10 resistors.

If V_{REF} is shifted close to V_{CC}, the electrochemical sensors with negative sensitivity (i.e. CL_2 and NO_2 sensors) can be used.

The sensors produce current in the order of nano amps and every leakage affects measurement. Therefore, the guarding ring connected to V_{REF} is made around the reference (RE) and working (WE) electrode; there is no current leakage as the potential difference among WE, RE and V_{REF} is 0 V.

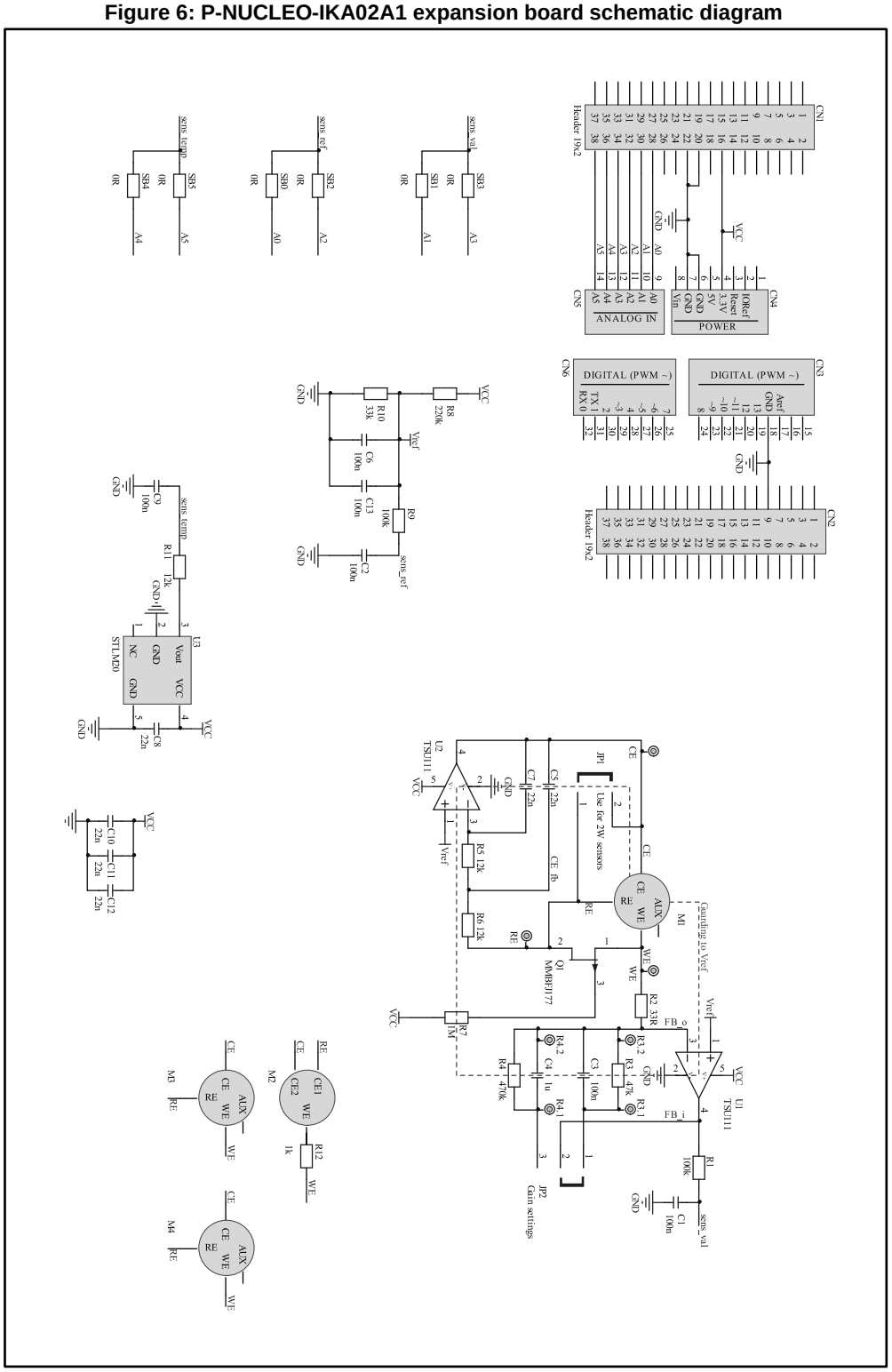
The transimpedance amplifier is not able to keep sensors biased during power-off. Therefore, the Q1 transistor, which shorts the sensor during power-off, is added to protect the sensor against polarization.

Figure 5: P-NUCLEO-IKA02A1 expansion board: gas signal conditioning schematic diagram



3 Schematic diagrams

Figure 6: P-NUCLEO-IKA02A1 expansion board schematic diagram



4 Bill of materials

Table 4: P-NUCLEO-IKA02A1 expansion board bill of materials

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
1	2	U1, U2	AOP-5PINS, SC-70-5, SMD	Operational amplifier	ST	TSU111ICT
2	1	U3	SC-70-5, SMD	Temperature sensor	ST	STLM20W87F
3	1	CN3	Socket 1x10, THT	Arduino Uno Digi 2	Samtec	SSQ-110-03-F-S
4	1	CN4	Socket 1x8, THT	Arduino Uno Power	Samtec	SSQ-108-03-F-S
5	1	CN6	Socket 1x8, THT	Arduino Uno Digi 1	Samtec	SSQ-108-03-F-S
6	1	CN5	Socket 1x6, THT	Arduino UNO Analog	Samtec	SSQ-106-03-G-S
						SQ-106-03-F-S
7	1	Q1	SOT-23, SMD	P-channel silicon junction field-effect transistor	Fairchild	MMBFJ177
8	1	JP1	Header 1x2, THT	Jumper	TE Connectivity	77311-401-36LF
9	1	JP2	Header 1x3, THT	Jumper	TE Connectivity	77311-401-36LF
10	3	SB2, SB3, SB5	0 R, 50 V, 100 mW, 0603_SB, SMD	Resistors		
11	2	R1, R9	50 V, 100 mW, 100 k, ±1%, ±100 ppm/K, 0603_R, SMD	Resistors		
12	5	C1, C2, C6, C9, C13	100 n, 50 V, X7R, ±10%, 0603_C, SMD	Capacitors		
13	1	C3	100 n, 50 V, X7R, ±10%, 0805_C, SMD	Capacitor		
14	3	R5, R6, R11	12 k, 50 V, 100 mW, ±1%, ±100 ppm/K, 0603_R, SMD	Resistors		
15	1	R12	1 k, 50 V, 100 mW, ±1%, ±100 ppm/K, 0603_R, SMD	Resistor		
16	1	R7	1 M, 50 V, 100 mW, ±1%, ±100 ppm/K, 0603_R, SMD	Resistor		
17	1	C4	1 µ, 50 V, X7R, ±10%, 0805_C, SMD	Capacitor		

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
18	1	R8	220 k, 50 V, 100 mW, ±1%, ±100 ppm/K, 0603_R, SMD	Resistor		
19	6	C5, C7, C8, C10, C11, C12	22 n, 50 V, X7R, ±10%, 0603_C, SMD	Capacitors		
20	1	R10	33 k, 50 V, 100 mW, ±1%, ±100 ppm/K, 0603_R, SMD	Resistor		
21	1	R2	33 R, 50 V, 100 mW, ±1%, ±100 ppm/K, 0603_R, SMD	Resistor		
22	1	R4	470 k, 50 V, 100 mW, ±1%, ±100 ppm/K, 0805_R, SMD	Resistor		
23	1	R3	47 k, 50 V, 100 mW, ±1%, ±100 ppm/K, 0805_R, SMD	Resistor		
24	1	M2	THT	CO sensor	Figaro	TGS541
25	1			Gas collection tool	New Cosmos Electric	CZ-163 CO
26	1			STM32 Nucleo board	ST	NUCLEO-L053R8

5 Revision history

Table 5: Document revision history

Date	Version	Changes
26-Jun-2017	1	Initial release.

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