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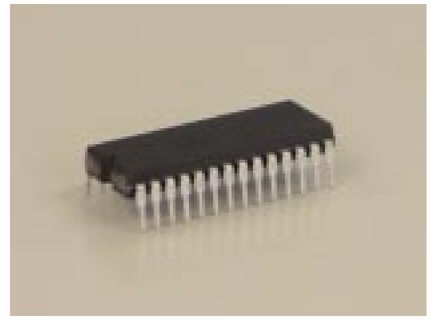
Technical Information for FIC03272--microprocessor for use with TGS4161 in automatic CO_2 monitors

The FIC03272 is a microprocessor for handling signals from the TGS4161 carbon dioxide sensor. This microprocessor enables maintenance-free automation of the air quality control in buildings when connected with appliances such as ventilation fans, air cleaning systems, etc.



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IMPORTANT NOTE: OPERATING CONDITIONS IN WHICH FIGARO SENSORS ARE USED WILL VARY WITH EACH CUSTOMER'S SPECIFIC APPLICATIONS. FIGARO STRONGLY RECOMMENDS CONSULTING OUR TECHNICAL STAFF BEFORE DEPLOYING FIGARO SENSORS IN YOUR APPLICATION AND, IN PARTICULAR, WHEN CUSTOMER'S TARGET GASES ARE NOT LISTED HEREIN. FIGARO CANNOT ASSUME ANY RESPONSIBILITY FOR ANY USE OF ITS SENSORS IN A PRODUCT OR APPLICATION FOR WHICH SENSOR HAS NOT BEEN SPECIFICALLY TESTED BY FIGARO.

Introduction

The FIC03272 is a microprocessor for handling signals from the TGS4161 carbon dioxide sensor, enabling maintenance-free automation of air quality control in buildings when connected with appliances such as ventilation fans, air cleaning systems, etc.

The microprocessor takes in the output voltage, or electromotive force (EMF), from the TGS4161 sensor and outputs a signal which corresponds to a concentration of CO_2 in the environment. CO_2 concentrations are calculated in the microprocessor based on ΔEMF, which is the change in the value of EMF from the value in a normal clean environment. The microprocessor also contains software to compensate the sensor's signal for changes in temperature and basic environmental factors.

1. Features

1-1 *Automatic calibration*

The FIC03272 uses the concept of a benchmark value of EMF in order to provide automatic calibration. The benchmark value is assumed to be equal to the level of CO_2 which exists in ambient air (approx. 400ppm). CO_2 concentrations are calculated periodically by determining the change of EMF from the benchmark level (ΔEMF). In order to offset the effects of sensor signal drift which are caused by environmental temperature and air contaminants, the microprocessor automatically renews the benchmark level to the current EMF value whenever a lower CO_2 concentration than the current benchmark is calculated. Using this method of automatic calibration, very stable characteristics can be expected for the sensor, allowing for reliable monitoring of CO_2 levels and long term maintenance-free ventilation control.

1-2 *High CO_2 sensitivity and wide detectable range of 400~3000ppm*

By programming the microprocessor to take into consideration the unique performance characteristics of the TGS4161, reliable readings of CO_2 concentrations within a wide range (400~3000ppm) can be achieved, satisfying the requirements of building ventilation control applications.

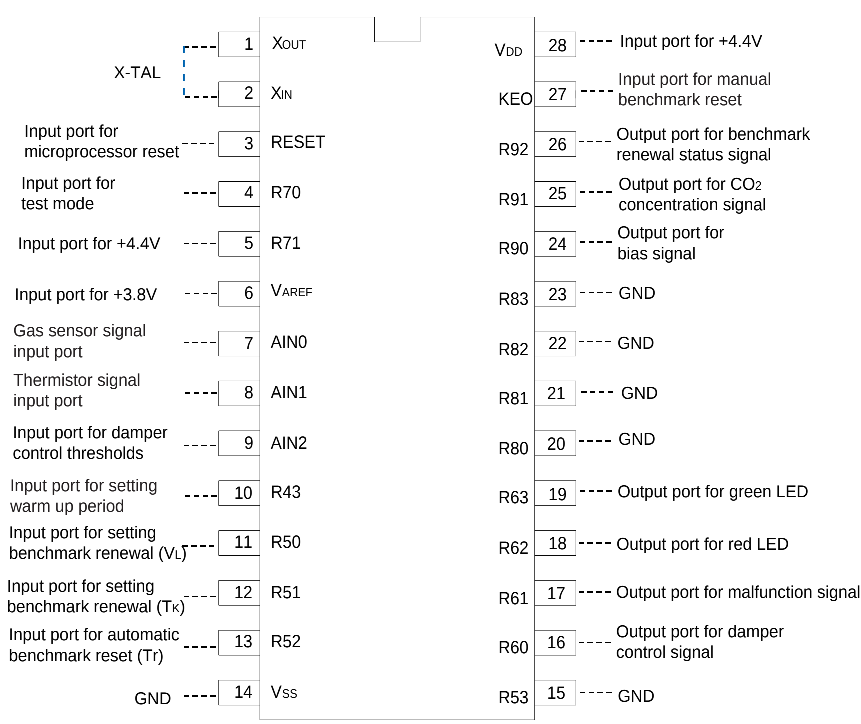

Figure 1 - Pin arrangement for FIC03272

1-3 *Two output signals*
FIC03272 generates two separate output signals:
a) For calculating CO_2 concentrations, a pulse width modulated (PWM) signal is output.
b) An On/Off signal is generated as a control signal for devices such as ventilation fans, dampers, etc.

Notes:
1) The microprocessor is designed to assume the highest value of EMF reading is representative of 400ppm of CO_2 (ambient air levels). As a result, an accurate reading cannot be expected if the sensor is used in an environment where CO_2 constantly exists at higher concentrations than can be found in a normal clean environment.
2) This device is not suitable for usage in life saving equipment.

2. Basic Functions

2-1 *Initial setting of operational conditions*
In order to achieve optimal performance of the sensor, manual preset of operational conditions is provided.

2-2 *Automatic operation*
Once power is supplied, an initial warm-up timer is activated. When the initial warm-up time is finished, the microprocessor will automatically begin operation and commence generating the two output signals mentioned above.

2-3 *Line test*
The microprocessor has the ability to perform a line test for checking the functionality of the microprocessor and the surrounding circuits. This allows users to eliminate tool testing which is normally done on the production line after assembly.

3. Pin Arrangement

Pin arrangement of FIC03272 is shown in Figure 1.

4. Pin Functions

The basic pin functions of FIC03272 are shown in Table 1 (*shown on Page 4*).

4-1 *Pins for the initial setting of operational conditions*
To optimize sensor performance, the following pins are provided for setting operational conditions at the time of power-on. No change can be made to operational conditions after the initial setting without powering off and then repowering the device.

4-1-1 *Input signal for setting the sensor's initial warm-up time (Pin No. 10)*
Initial warm-up time, which is necessary to stabilize the sensor's output signal after an unpowered period, is set by input of a signal to port R43 (see Table 2). No signal can be taken from the microprocessor's output ports during initial warm-up time.

Setting	Signal Input	
	"H"	"L"
Initial warm-up time (T1)	30 minutes	120 minutes

Table 2 - Initial warm-up time setting (AM-4-4161 default = "L")

4-1-2 *Input signals V_L and T_K for benchmark adjustment (Pins No. 11 and 12)*
The benchmark level is normally set at the lowest value of the sensor's signal (Vg), which is considered as 400ppm of CO_2 (ambient levels). The benchmark level Vg is renewed whenever a lower signal voltage than the present benchmark level is read from the sensor (as described in *Sec. 1-Automatic calibration*). If the benchmark level Vg is not renewed for a pre-set period of time (T_K), it is automatically adjusted upward by a pre-set voltage (V_L) which corresponds to an equivalent concentration of CO_2. Table 3 shows the user-determined settings for V_L and T_K which can be selected by applying a signal to Ports R50 and R51 respectively.

Setting	Terminal		Signal input	
	Symbol	Pin No.	"H"	"L"
Benchmark adjustment level (V_L)	R50	11	5ppm equivalent	20ppm equivalent
Benchmark adjustment time (T_K)	R51	12	1 day	7 days

Table 3 - Benchmark adjustment level and timer setting
(AM-4-4161 default = 20ppm equiv. and 1 day)

Category	Terminal			Functions
	Name	Symbol	Pin No.	
Power	Power supply	V_{DD}	28	Connect to +4.4V power supply
	Ground	V_{SS}	14	Connect to ground
	Reference voltage	V_{AREF}	6	Connect to 3.8V power supply (Reference voltage for A/D converter)
Microprocessor control	Reset	RESET	3	Microprocessor reset when "L" is input for one machine cycle or longer
	Clock in	X_{IN}	2	Connect to ceramic oscillator of 4.19MHz (ports to internal clock circuit)
	Clock out	X_{OUT}	1	
Settings	Initial warm-up time	R43	10	Input optional "H" or "L" signal See *Sec. 4-1 - Pins for initial setting of operation conditions*
	Benchmark adjustment level (V_L)	R50	11	
	Benchmark adjustment time (T_K)	R51	12	
	Auto reset time	R52	13	
Analog signal input	Gas sensor signal (Vg)	AIN0	7	Input gas sensor signal (Vg) See *Sec. 4-2 - Gas sensor signal Vg input*
	Thermistor signal (V_T)	AIN1	8	Thermistor signal (V_T) for temperature compensation circuit See *Sec. 4-3 - Internal thermistor signal V_T input*
	Control signal threshold	AIN2	9	Calibration of CO_2 levels for damper control See *Sec. 4-1-4 - Input signal for damper control*
Switch input	Manual benchmark reset	KEO	27	See *Sec. 4-5 - Manual benchmark reset signal input*
Signal output	Bias signal	R90	24	See *Sec. 4-4 - Bias signal output*
	Damper control signal	R60	16	See *Sec. 4-6-2 - Damper control signal output*
	CO_2 concentration signal	R91	25	See *Sec. 4-6-1 - PWM signal output for CO_2 concentration*
	Green LED	R63	19	See *Sec. 4-7 - LED display signal output*
	Red LED	R62	18	See *Sec. 4-7 - LED display signal output*
Other	Test mode (Input)	R70	4	See *Sec. 4-10 - Line test mode*
	Malfunction (Output)	R61	17	See *Sec. 4-8 - Malfunction signal output*
	Benchmark renewal status (Output)	R92	26	See *Sec. 4-9 - Benchmark renewal status signal output*

Table 1 - Pin functions of FIC03272

4-1-3 *Input signal Tr for automatic benchmark reset (Pin No. 13)*

Whenever the benchmark level Vg has only been adjusted (*Sec. 4-1-2*) and has not been renewed (*Sec. 1-1*) for a pre-set period of time (Tr), it should be automatically reset at the current output signal in ambient air. Table 4 shows the time intervals (Tr) which can be pre-set by applying a signal to Port R52.

Setting	Signal Input	
	"H"	"L"
Auto reset time (Tr)	7 days	30 days

Table 4 - Auto reset timer setting (AM-4-4161 default = 7 days)

4-1-4 *Input signal for damper control (Pin No. 9)*

Concentration levels of CO_2 at which the damper control signals are activated are selected by inputting a voltage signal to port AIN2. Sensor output voltage is first AD converted within the microprocessor. The relationship between these AD converted values and CO_2 concentrations is shown in Table 5. Whenever a CO_2 concentration exceeds the threshold level for opening the damper (Cd1), a low signal (L) is output from port R60. A high signal (H) is output for closing the damper when the CO_2 concentration drops beneath the Cd2 level. Figure 11 shows the circuit for damper control signal threshold. Please note that a high signal (H) is designed to be output during the sensor's initial warm-up period and also whenever the malfunction signal is activated.

Signal input (AD converted: 0-255*)	Cd1 (ppm)	Cd2 (ppm)
0 - 48	800	720
49 - 96	1000	800
97 - 144	1500	1300
145 - 192	2000	1800
193 - 255	3000	2700

Cd1: Threshold for OPEN signal
Cd2: Threshold for CLOSE signal
* 8-bit - Least significant byte=3.8V/256

Table 5 - Thresholds for damper OPEN/CLOSE signal

4-2 *Gas sensor signal Vg input (Pin No. 7)*

Since the raw sensor output voltage (EMF) actually decreases as CO_2 concentration increases, the sensor's output voltage is reversed, amplified and adjusted (please refer to Figure 3, *Sec. 4-4*, and *Sec. 5-1* for details). The result of this process is a gas sensor signal Vg with good resolution and which increases/ decreases as CO_2 concentration increases/decreases. This gas sensor signal Vg is input to port AIN0.

4-3 *Internal thermistor signal V_T input (Pin No. 8)*

To compensate for the temperature dependency of CO_2 sensor, a signal from the sensor's internal thermistor (V_T) is input to port AIN1. This thermistor also monitors the sensor's built-in heater from 30 minutes after powering and after. By detecting a sharp drop in the sensor's internal temperature indicative of a broken heater, the thermistor can cause a malfunction signal to be generated by the microprocessor.

4-4 *Bias signal output (Pin No. 24)*

A PWM signal, of which the pulse width is variable, is output from port R90. To optimize the resolution of Vg readings, this signal is introduced to the differential circuit after being converted to an analog voltage, and adjusts the benchmark level Vg to fall between 25 and 51 counts at AD converted value, or 0.38 ~ 0.75V at 3.8V full scale. The bias signal starts from 128 counts (1.9V at 3.8V full scale) when the power is switched on, and reduces the count stepwise along with the sensor's initial action until Vg falls and then stabilizes at the above stated level.

4-5 *Manual benchmark reset signal input (Pin No. 27)*

The benchmark level can be reset manually at any time by inputting an "L" pulse to port KEO. This manual benchmark reset should be done in a clean atmosphere where the CO_2 concentration is about 400ppm (please refer to *Sec. 5-6 - Benchmark reset circuit*).

Note: If the benchmark level is manually reset under a high CO_2 concentration environment, the device's sensitivity would be decreased and calculated CO_2 concentration values would be less than the actual concentration.

4-6 *Sensor signal output*

4-6-1 *PWM signal output for CO_2 concentration (Pin No. 25)*

A PWM signal is output from port R91 to show CO_2

concentration readings. The pulse width against a cycle corresponds to the CO_2 concentration as shown in Figure 2. This pulse width is then converted to an analog output voltage between 0 ~ 3V by the circuit (please refer to *Sec. 5-4 - CO_2 concentration circuit*).

4-6-2 *Damper control signal output (Pin No. 16)*

The output from port R60 is set to "H" under normal conditions in a clean environment, indicating that the damper should be closed. When a CO_2 reading exceeds the preset level of the Open Damper Threshold (Cd1) as shown in Table 2, an "L" signal is output from port R60 as a signal for opening the damper. When CO_2 drops below the preset level of the Close Damper Threshold (Cd2), the output from port R60 returns to an "H" signal for closing a damper. "H" is also output from port R60 during initial warm-up time and whenever a malfunction signal is output.

4-7 *LED display signal output (Pin Nos. 18 & 19)*

The following LED display signals are output from port R62 (red LED) and port R63 (green LED):

4-7-1 *Initial warm-up time*

During the initial warm-up period (see *Sec. 4-1-1*), an alternating H/L signal is output from port R63 every 0.5 seconds, causing the green LED to alternate between on and off every 0.5 seconds. "L" is output continuously from R62 during this period.

4-7-2 *Normal operation mode*

When the CO_2 concentration is lower than the preset threshold level for the damper control (Cd1), "L" is output from port R62 and "H" is output from the R63, causing the green LED to be lit continuously. Conversely, if the CO_2 concentration is higher than the preset threshold level for the damper control (Cd1), "H" is output from port R62 and "L" is output from port R63, causing the red LED to be lit continuously.

4-7-3 *Malfunction mode*

When a malfunction has been detected (see *Sec. 4-8*), an alternating H/L signal is output from port R62 every 0.5 seconds, causing the red LED to alternate between on and off every 0.5 seconds. "L" is output

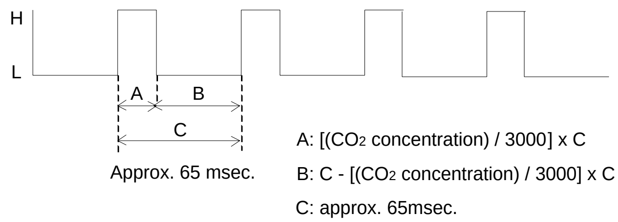

Figure 2 - PWM signal for CO_2 concentration

continuously from R63 during this period.

4-8 *Malfunction signal output (Pin No. 17)*

An "H" signal is output from port R61 under normal operation conditions. When a malfunction is detected on the benchmark level Vg, an "L" signal is output from port R61. The following condition would generate a malfunction signal:

> *Benchmark level Vg malfunction*—when the benchmark level Vg (gas sensor's signal) cannot be adjusted in the range between 25 and 51 counts at AD converted value within 10 minutes after the adjustment is started, a malfunction is considered to have occurred.

The relationship between signal output ports and their output signals under malfunction mode can be seen in Table 6.

Because a thermistor is not built into the TGS4161, a heater breakage detection circuit cannot be used in conunction with TGS4161.

Terminal	Signal	Indication
CO_2 concentration signal (R91)	"L" signal	0ppm
Damper control signal (R60)	"H" signal	Close
Red LED (R62)	Alternate H/L signal (0.5 sec./0.5 sec.)	On/Off
Green LED (R63)	"L" signal	Off
Bias signal (R90)	Hold the level	Off

Table 6 - Malfunction signal

4-9 *Benchmark renewal status signal output (Pin No. 26)*

When the benchmark level has been renewed, an "L" signal is output from port R92 for one second to indicate the status. An "H" signal is normally output from this port.

4-10 *Line test mode (Pin No. 4)*
A line test mode can be activated by the input of an "L" signal to port R70 at the moment of power supply. Operation of the microprocessor and the surrounding circuits will be tested according to the schedule shown in Table 7. After powering on, signal outputs change from Step 1 to Step 4 according to the table, with Steps 1-3 lasting 5 seconds each. Afterwards, Step 4 outputs will be maintained continuously until the power is shut off.

Terminal			Signal Output			
Name	**Symbol**	**Pin No.**	**Step 1**	**Step 2**	**Step 3**	**Step 4**
CO_2 concentration signal	R91	25	Cd1 (ppm) *Note *1*	Cd1 (ppm)	Cd1 (ppm)	Cd1 (ppm)
Bias signal *Note *2*	R90	24	0	255	128	128
Green LED	R63	19	L	H	(*Note 3*)	H
Red LED	R62	18	H	L	(*Note 4*)	H
Damper control signal	R60	16	H	L	(*Note 5*)	H
Malfunction	R61	17	H	L	(*Note 6*)	H
Benchmark renewal status	R92	26	H	L	H	H

Notes:
(1) Please refer to *Sec. 4-1-4 - Input signal for damper control*
(2) Please refer to *Sec. 4-4 - Bias signal output*
(3) H or L, as input to Pin #10 for initial warmup setting - refer to *Sec. 4-1-1*
(4) H or L, as input to Pin #11 for benchmark adjustment - refer to *Sec. 4-1-2*
(5) H or L, as input to Pin #12 for benchmark adjustment - refer to *Sec. 4-1-2*
(6) H or L, as input to Pin #13 for benchmark reset - refer to *Sec. 4-1-3*
(7) Outputs shown are held until power is shut off

Table 7 - Line test mode

5. Electrical Circuit for FIC03272

The following peripheral circuits are suggested when using the FIC03272 with the TGS4161 sensor.

5-1 *Circuit for driving sensor and for processing sensor signals*
The block/circuit diagrams for driving the sensor and processing its signals are shown in Figure 3 (below) and Figure 4 (Page 8) respectively. Please note the following items:

a) +5.0V should be applied to Pin No. 6 for the heater of TGS4161.
b) +3.8V is the specified voltage to sensor pin No. 5 for the built-in thermistor which is connected in series with an 8.2kΩ resistor. Output voltage across the 8.2kΩ resistor is designed to be input to port

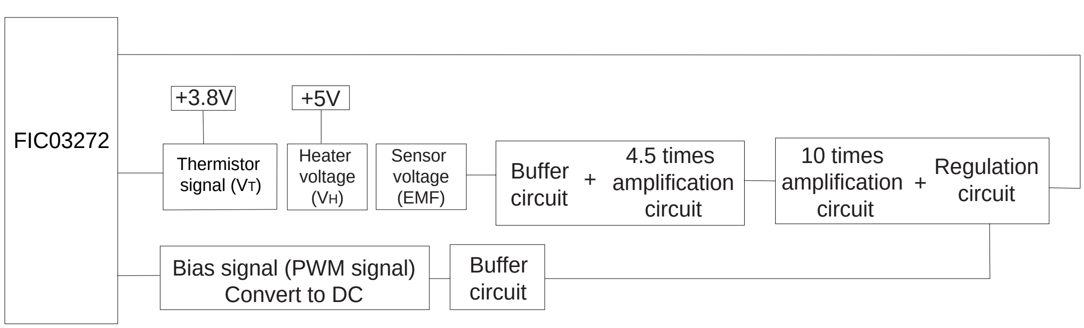

Figure 3 - Block diagram for driving sensor and processing sensor signal

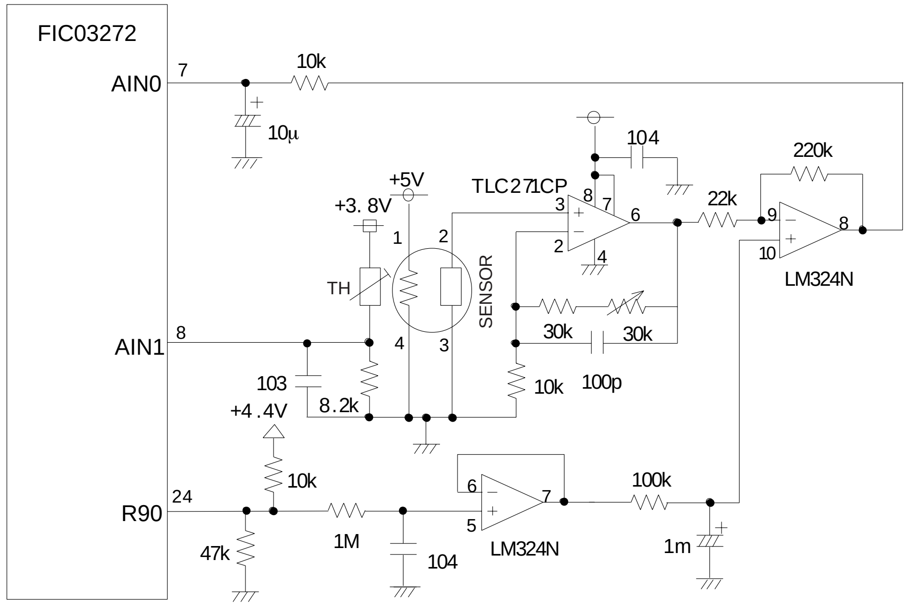

Figure 4 - Circuit for driving sensor and processing sensor signal

AIN1 (Pin No. 8) as a thermistor signal for the temperature compensation circuit.

c) As a first stage, the sensor's output (pin No. 3), which is of very high impedance, should be amplified by 4.5 times with a high impedance (100MΩ or higher) operational amplifier, such as Texas Instrument's Model No. TLC271. This amplified signal is designed to be further amplified by ten times in the second stage. The output from the amplifier is input into port AIN0 (Pin No. 7) after being adjusted by a regulator (differential circuit) with a bias signal.

5-2 *Power supply circuit*

As illustrated in Figure 5, the circuit is designed to be operated by +5V. The sensor's heater, which requires a large current, is powered directly by +5V. The microprocessor is powered by +4.4V (downstream from a diode). A diode is connected between the power supply and the microprocessor to protect the microprocessor from a surge current. Taking the saturation voltage of the operational amplifiers into consideration, the analog reference voltage (VAREF) is set at +3.8V. Voltage is provided downstream from another diode.

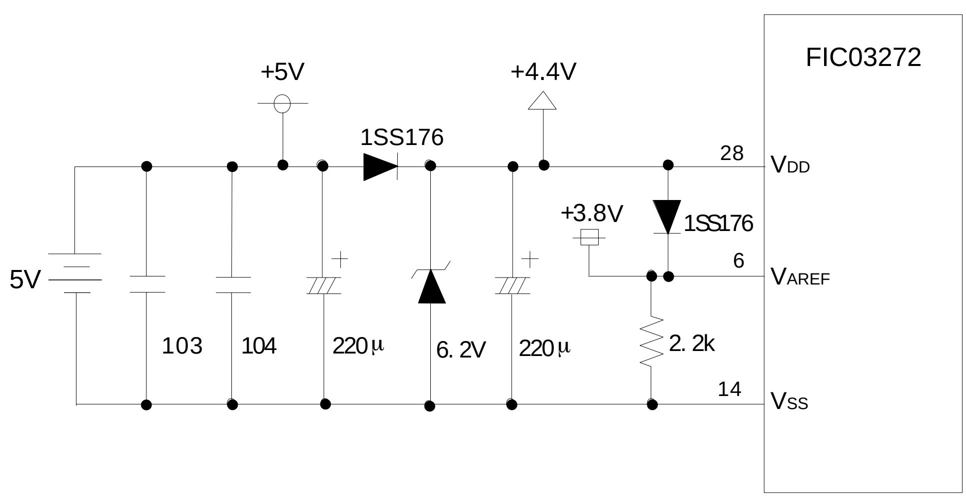

Figure 5 - Power supply circuit

5-3 *System reset circuit*

Under normal operating conditions, an "H" signal is continuously applied to the RESET port (Pin #3). When an "L" signal is applied to the RESET port for a period of one machine cycle or longer, the internal logic circuit of FIC03272 and the micro-processor's program return to the same condition which exists just after powering on the unit, effectively resetting the system.

To perform the above described system reset function automatically, a circuit such as that shown in Figure 6 is suggested. This kind of automatic system reset circuit is useful in circumstances such as just after powering on, after a momentary power interruption, at the moment of recovery after a sudden drop of voltage, etc. The microprocessor's program sometimes does not run correctly in these cases due to a malfunction of the internal logic circuit in the processor. Manual resets help to assure normal operation of the microprocessor's program.

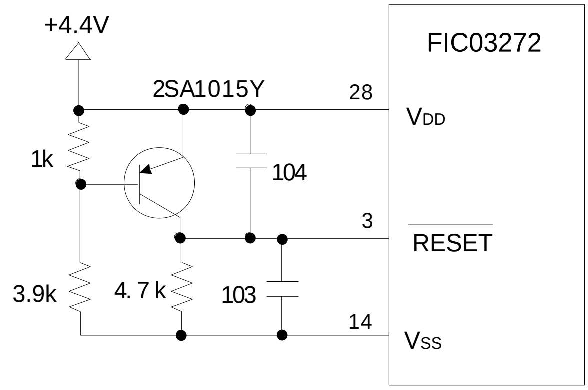

Figure 6 - Reset circuit

5-4 *CO_2 concentration signal circuit*

Port 91 (Pin No. 25) outputs a PWM signal which represents a CO_2 concentration in the range between 400 and 3000ppm. Figure 7 illustrates a sample circuit for converting a PWM signal to a linear output of 0~3V DC. A delay of several seconds is anticipated in the DC voltage concentration signal because a C-R combination is used in the circuit. A 100Ω resistor is connected in series to protect the external circuit from excessive current.

5-5 *Circuit for damper control signal*

Figure 8 shows an example circuit in which an H/L signal which is output from port R60 (Pin No. 16) and converted to an On/Off signal for controlling the opening/closing of a damper. A 100Ω resistor is connected in series to protect the external circuit from excessive current.

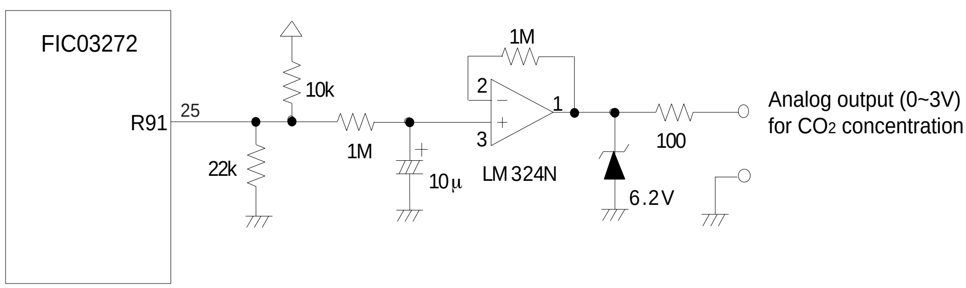

Figure 7 - CO_2 concentration signal circuit

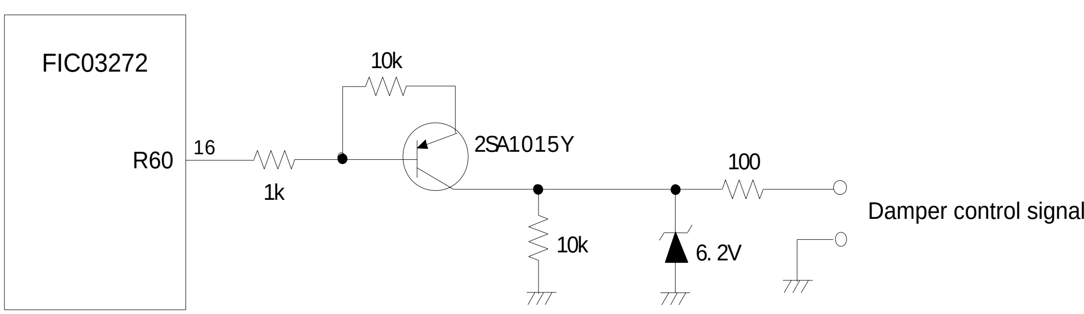

Figure 8 - Damper control circuit

5-6 *Circuit for manual benchmark reset*

A circuit designed to allow for manual benchmark reset is shown in Figure 9.

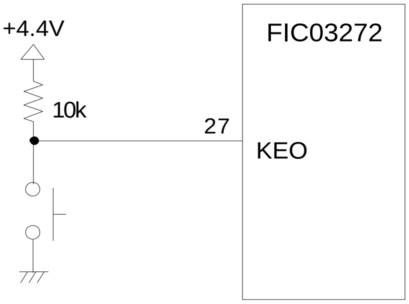

Figure 9 - Manual benchmark reset circuit

5-7 *Circuit for clock signal generator*

When a ceramic oscillator is connected with the clock in and out ports, Xin and Xout (Pins No. 2 and 1 respectively), a clock signal is activated in FIC03272 by a built-in clock signal generator. A sample circuit for connecting such an oscillator is shown in Figure 10. Murata Electronics model CST4.19MGW is a well-matched ceramic oscillator for FIC03272. Before using a different oscillator, please consult with Figaro or the oscillator manufacturer.

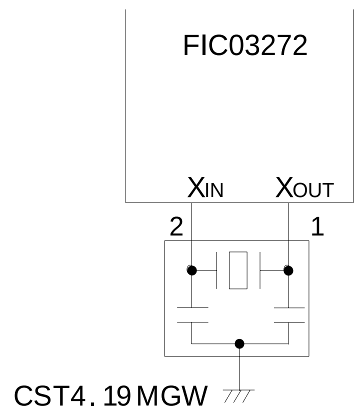

Figure 10 - Clock signal generator circuit

5-8 *Circuit for damper control signal threshold*

A recommended circuit design for setting the damper control signal threshold can be seen in Figure 11.

5-9 *Sample circuit of damper control with TGS4161 and FIC03272*

A sample application circuit for damper control when using a TGS4161 CO_2 sensor and a FIC03272 microprocessor is shown in Figure 12. Please refer to T*echnical Information for AM-4-4161* for details.

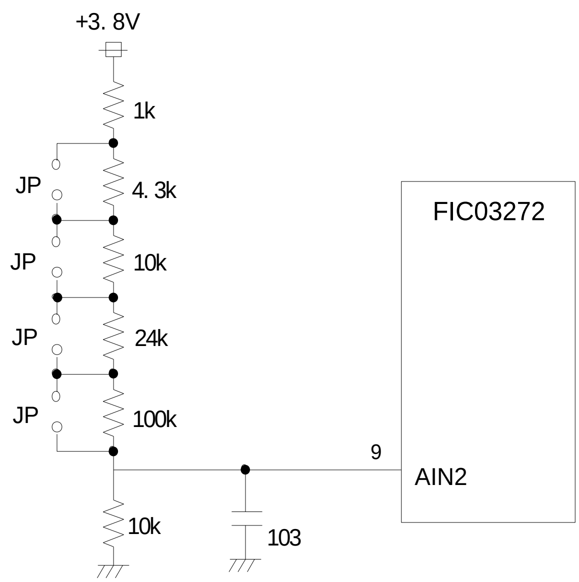

Figure 11 - Damper control signal threshold circuit

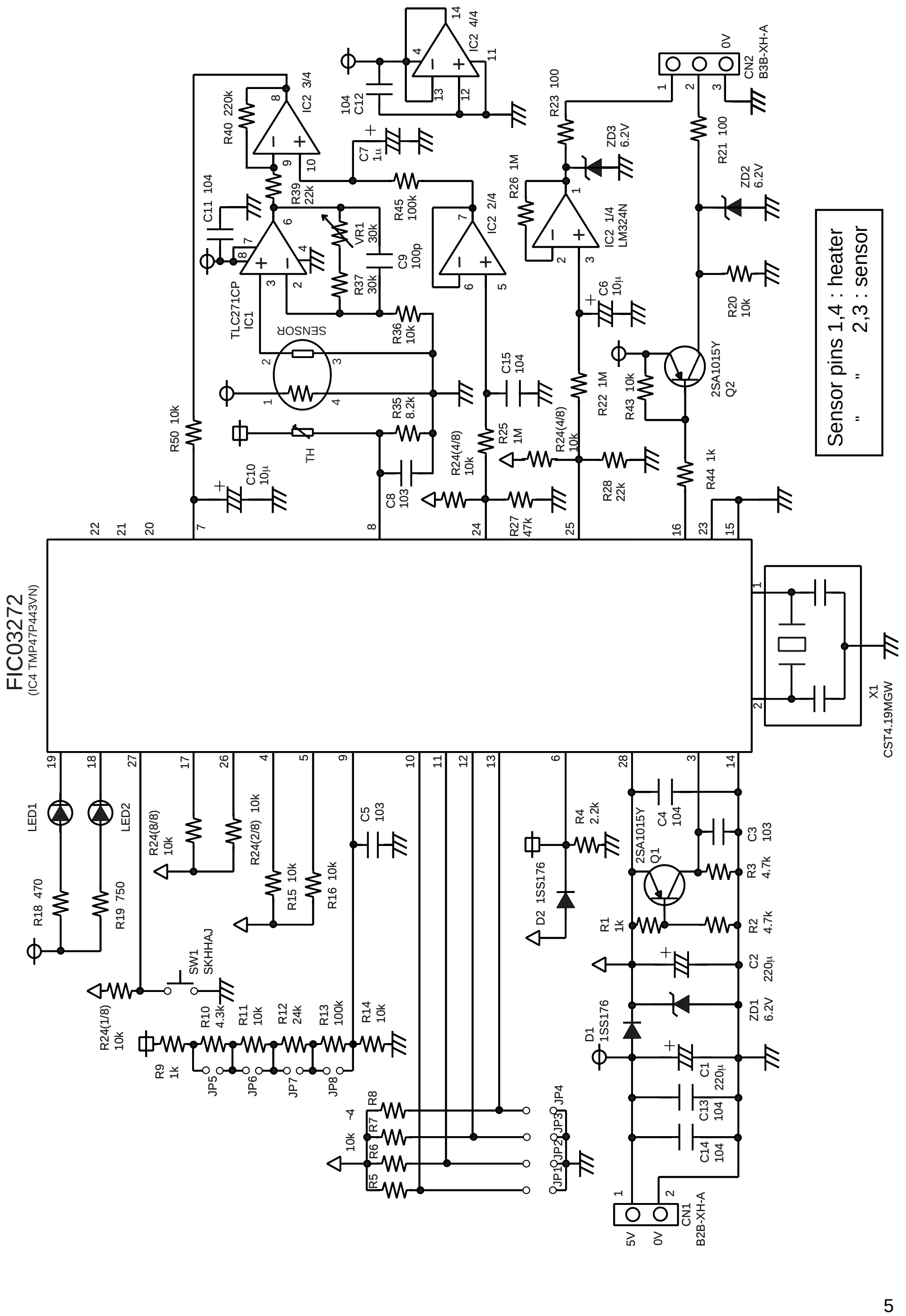

Figure 12 - Application circuit

6. Hardware Specifications

6-1 *Features*

*4-bit single chip microcomputer
*Instruction execution time: 1.0µs (at 8MHz)
*Low voltage operation: 2.2V (at 4.2MHz)
*Basic instructions: 92
- ROM table look-up instructions
- 5-bit to 8-bit data conversion instruction

*Subroutine nesting: 15 levels maximum
*6 interrupt sources (External: 2, Internal: 4)
- All sources each have independent latches, and multiple interrupt control is available

*I/O port (23 pins)
*Two 12-bit Timer/Counters
- Timer, event counter, and pulse width measurement mode

*Interval Timer
*Emulation pod: BM47C443
*8-bit successive approximate type A/D converter with sample and hold
- 8 analog inputs
- Conversion time: 24µs (at 8MHz)

*Serial Interface with 8-bit buffer
- Simultaneous transmission and reception capability
- 8/4-bit transfer, external/internal clock, and leading/trailing edge shift mode

*Zero-cross detector (and external interrupt handler)
*Pulse output
- Buzzer drive/Remocon carrier

*High current outputs
- LED direct drive capacity: typ. 20mA x 8 bits (Ports R5, R6)

*Reset function
- Watchdog timer reset

*Hold function
- Battery/Capacitor back-up

6-2 *DC characteristics (see Table 8)*

Parameter	Symbol	Pins	Conditions	Min.	Typ.	Max.	Unit
Hysteresis voltage	V_{HS}	Hysteresis input	-	-	0.7	-	V
Input current	I_{IN1}	RESET, HOLD	V_{DD} = 5.5V, V_{IN} = 5.5V/0V	-	-	±2	µA
	I_{IN2}	Open drain ports					
Input resistance	R_{IN}	RESET	-	100	220	450	kΩ
Output leakage current	I_{LO}	Open drain output ports	V_{DD} = 5.5 V, V_{OUT} = 5.5 V	-	-	2	µA
Output low voltage	V_{OL}	Ports R4, R7, R8, R9	V_{DD} = 4.5V, I_{OL} = 1.6mA	-	-	0.4	V
			V_{DD} = 2.2V, I_{OL} = 20µA	-	-	0.1	
Output low current	I_{OL}	Ports R5, R6	V_{DD} = 4.5V, V_{OL} = 1.0V	7	20	-	mA
Supply current (NORMAL operating mode)	I_{DD}	-	V_{DD} = 5.5V, fc = 4MHz	-	2	4	mA
			V_{DD} = 3.0V, fc = 4MHz	-	1	2	
			V_{DD} = 3.0V, fc = 400kHz	-	0.5	1	
Supply current (HOLD operating mode)	I_{DDH}	-	V_{DD} = 5.5V	-	0.5	10	µA

Table 8 - DC characteristics
(V_{ss} = 0, Topr = -30~+70˚C)

6-3 *A/D conversion characteristics (Table 9)*

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Analog reference voltage	V_{AREF}	(Mask option)	V_{DD} - 1.5	-	V_{DD}	V
Analog reference voltage range	ΔV_{AREF}	V_{AREF} - V_{ss}	2.7	-	-	V
Analog input voltage	V_{AIN}	-	V_{ss}	-	V_{DD}	V
Analog supply current	I_{REF}	-	-	0.5	1.0	mA
Nonlinearity error	-	V_{DD} = 2.7 ~5.5V V_{AREF} = V_{DD} ± 0.001V V_{ss} = 0.000V	-	-	±1	LSB
Zero point error			-	-	±1	
Full scale error			-	-	±1	
Total error			-	-	±2	

Table 9 - A/D conversion characteristics
(Topr = -30~+70˚C)

6-4 *AC characteristics (Table 10)*

Parameter	Symbol	Condition		Min.	Typ.	Max.	Unit
Instruction Cycle Time	t_{cy}	V_{DD} = 2.7~5.5V		1.0	-	20	µs
		V_{DD} = 2.2~5.5V		1.9			
		in RC oscillation		3.2			
High level clock pulse width	t_{WCH}	For external clock (X_{IN} input)	V_{DD}≥2.7V	60	-	-	ns
			V_{DD}<2.7V	120			
Low level clock pulse width	t_{WCL}		V_{DD}≥2.7V	60			
			V_{DD}<2.7V	120			
A/D Conversion Time	t_{ADC}	-		-	24t_{cy}	-	µs
A/D Sampling Time	t_{AIN}	-		-	2t_{cy}	-	
Shift data Hold Time	t_{SDH}	-		0.5t_{cy}-300	-	-	ns

Table 9 - A/D conversion characteristics
(Vss = 0, Topr = -30~+70˚C)

6-5 *Dimensions*

Dimensions of FIC03272 are shown in Figure 13.

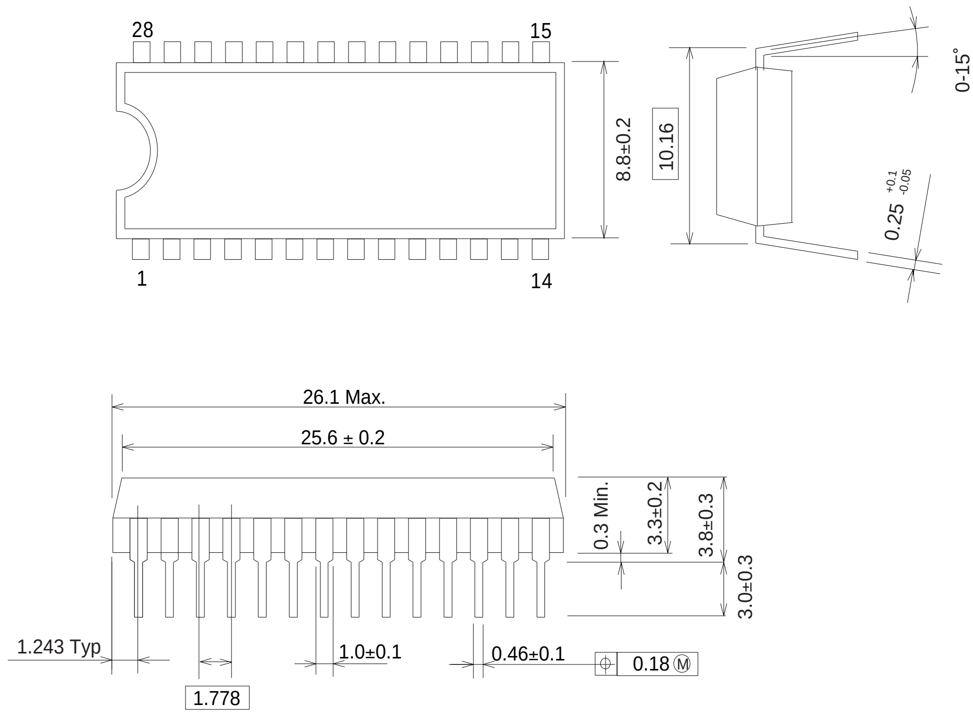

Figure 13 - Dimensions of FIC03272

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FIGARO GROUP

HEAD OFFICE

Figaro Engineering Inc.
1-5-11 Senba-nishi
Mino, Osaka 562 JAPAN
Tel.: (81) 72-728-2561
Fax: (81) 72-728-0467
email: figaro@figaro.co.jp

OVERSEAS

Figaro USA Inc.
3703 West Lake Ave. Suite 203
Glenview, IL 60025 USA
Tel.: (1) 847-832-1701
Fax.: (1) 847-832-1705
email: figarousa@figarosensor.com