USER'S GUIDE

for

ETCO2 MODULE

Model C002, C002A

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ATTENTION

Any one who use, service, resale this module should read this guide carefully. Any operation not according to this guide may cause severe aftermath, such as damaging patient and module or getting wrong data. The operator who make mistake should take the responsibility upon oneself.

I. INTRODUCTION

The OEM ETCO2 module MODEL C002 or C002A is a complete data collection and analysis system for monitoring respiratory carbon dioxide concentration. The MODEL C002 or C002A module includes a miniature CO2 sensor, barometric pressure transducer, sampling flow control and a miniature low-power vacuum pump. A microprocessor collects the sensor data and calculates various real-time parameters: instantaneous CO2 concentration, respiration rate, end-tidal CO2, inspired CO2, inspiration and expiration times.

The module is highly configurable to meet most OEM implementation requirements. System specifications such as sampling flow rate and floating point data format can be changed by customer.

The host sends commands and receives waveform, breath parameters and command responses on two +5.0V asynchronous serial data lines (TTL or RS232).

II. HIGH LIGHTS

✧ Best performance-price ratio and cost effective CO2 solution. The price is much lower while the performance is better than other ETCO2 modules in the market.

✧ Better stability. Better design can wipe off the excursion from temperature, pressure and inconsistent component.

✧ Better self- protected ability. It allows wrong power supply, humidity in the pipeline.

✧ Better communication interface. Either TTL or RS232, chosen by customer.

✧ Better before or after sale service. Our engineers work closely with our sales to provide prompt response to customers' inquiries and technical questions; we can also provide suggestions to customers' product design; One year warranty for replacement or repair (see warranty information in the manual)

✧ Longer life. Using long-life IR source (100 thousand hours life).

III. SAFETY GUIDE

For your safety, please read the content below and comply the indication request of medical instrument.

WARNING, ATTENTION & NOTICE

Key Word	Descriptions
WARNING	Point out the operations which may damage patient or operator
ATTENTION	Point out operations which may damage the module
NOTICE	Point out other important things

A. WARNING (Please read the following notices before any operations)

A) Our module can only supply value of ETCO2, INCO2, respiration rate etc. It is only an assistant to a clinical doctor. The doctor must do the clinical diagnosis according to more information, such as the symptom of the patient, the sickness of the patient etc.

B) The gas sample line can be used just once. If you use it repeatedly, it may cause cross infection.

B. ATTENTION

✧ **The water trap can be used only once. If you use if repeatedly, it may cause wrong data or damage to the module.**

✧ In order to ensure the accuracy of the module, you must replace the water trap when it is close to water full.

✧ Please ensure the sampling line is expedited. If the sampling line is blocked or jammed, the sampling pump will work harder, causing its lifespan much shorter.

✧ **It is strongly recommended that you run the gas pump intermittently, running for 8-10 hours then stop it for a while before running again.** You can stop the pump running by powering off the pump or shut down the module. Because the pump motor is a brush motor, there is friction between the brush and the commutation device, continuous running for long hours will cause the temperature rise and aggravate the degree of friction, which is not good for the life of motor.

✧ Please don't keep the pump running continuous while evaluating the module.

✧ Services can only be done by authorized or well-trained individual. Please send it back to the manufacture or your distributor/reseller for repair or maintenance if necessary.

✧ The manufacturer will not be responsible for any wrong operation.

✧ The module should be operated and stored in the environment according to the requirement of the specification.

✧ Do not use the module without connecting with the water trap. Otherwise, it will cause measurement error or damage the module.

✧ The measurement will error out or malfunction when the module is not warm up.

C. **NOTICE**

✧ Working in strong disturbing of electromagnetism (such as ESU, MRI, CT etc.) environment, the module will be inaccurate.

✧ Just use the gas sampling line supplied by the manufacturer of MODEL C002 or C002A , otherwise, the reading may not be accurate.

✧ The reading will be not accurate when using in hard wavy-temperature environment.

✧ The reading will vary a little when the gas sampling line is mightily occluded or the water trap is occluded. At the same time, this occlusion will damage the module.

✧ Gas leakage by any reason will cause the reading fall down and influence the configuration of CO_2 wave.

IV. ELECTRICAL SPECIFICATIONS

Sensor Operating Principle	Infrared Spectroscopy

Energy Emitting Device	Proprietary High Efficiency IR Source
Energy Detecting Device	Frequency Stable Thermopile
CO2 Range	0% to 20%
CO2 Accuracy	± 2 mmHg @ < 5.0% CO2 *(at BTPS)* < 10% of reading @ >5.0% CO2 *(at BTPS)*
Breath Rate	2-150 BPM
Dimensions	77mm*52mm*28mm
Weight	< 3.0 ounces *(< 76 grams)*
Operating Temperature Range	5°C to 55°C
Shipping / Storage Temperature Range	-40°C to 70°C
Automatic Offset Calibration	Time and temperature based, as well as on-demand
Input Voltage	5.00 Volts *(± 5%)*
Interface	Highly configurable serial digital interface(TTL/RS232), CO2 and barometric waveform data, Breath Detect Algorithm data
Pneumatics	On-board aspiration pump and flow controller Configurable aspiration flows to 250 ml/min *(± 10%)*
Power Consumption	480mW (*typical with pump on*) 1200mW (*extreme status[1]*)
Warm-up Time	10 seconds
Response Time Detector System	38 mSec *(typical)* 200mSec *(typical) (Dependent Upon Implementation, Pneumatics and Water Separation Technique)*

V. HARDWARE INTERFACE

Power and serial communications (TTL) to the MODEL C002 or C002A module is provided

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[1] Extreme status: Extreme status means when both scenarios below happen at the same time, this is called an extreme situation and will consume the most power, but this rarely happens actually.

1) When the inhale pipe jams (that happens when the air dust gets into the pipe while being used in a dusty environment, the module has to work harder to get air, so it consumes more power.

2) Another situation is, about every 20-30 minutes the magnetic valve will run to take air from outside just to collect the CO2 data in the environment.

through connector JP2. Below are pin descriptions for this connector.

| JP2-PIN	NAME	DESCRIPTION
1	NC	
2	NC	
3	GND	GND
4	POWER	5VDC
5	EN	PWROFF, System shutdown=0V, Power enable=5V
6	NC	
7	DIGTX	Asynchronous 8-bit serial transmit from MODEL C002 or C002A , +5.0V TTL logic levels
8	NC	
9	DIGRX	Asynchronous 8-bit serial receive to MODEL C002 or C002A , +5.0V CMOS logic levels
10	NC	
11	NC	
12	POWER	5VDC
13	GND	GND
14	NC	
15	NC	
16	NC	

If you want to use RS232 directly, you can get data from the white socket (the one has 3 pin, and named RS232), it defines as below:

PIN 1: TX, PIN 2: RX, PIN 3: GND.   **PNEUMATIC SYSTEM**
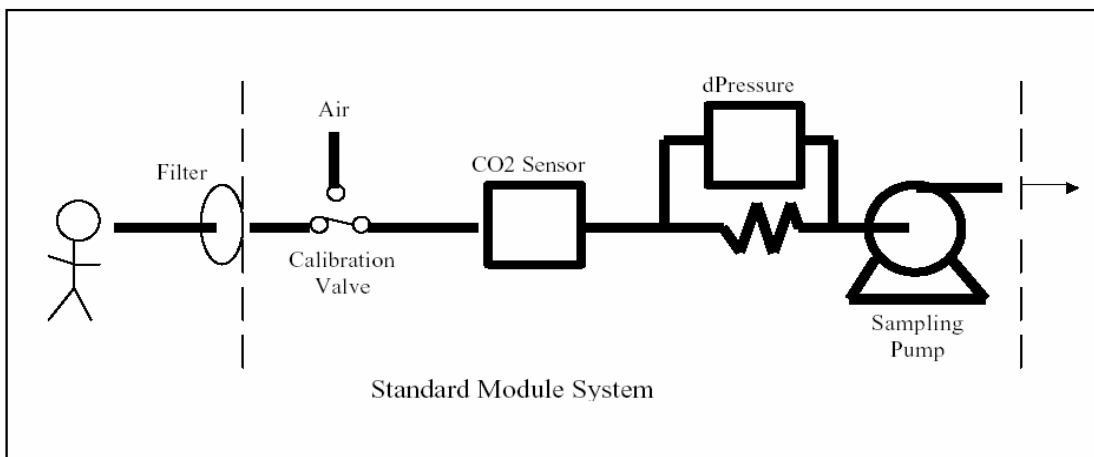
FIGURE 1

The pump provided with the MODEL C002 or C002A module is capable of sampling patient gas at 50-250cc/min. In some applications, it may be necessary to connect a gas reservoir (pump "capacitor") to the inlet port of the pump to reduce the effects of pressure pulses on the CO2 waveform. A flow regulation system controls the gas flow rate, and attempts to clear the sample line if it gets occluded. The MODEL C002 or C002A notifies the host system of the occlusion via the status packet of the communication protocol. The exhaust port of the pump is typically connected to an exhaust port on the exterior of the host device to allow connection to a hospital scavenging system. Another gas reservoir on the exhaust port of the pump may help to reduce the audible noise level of the system.

Inhale line

Zero collection line
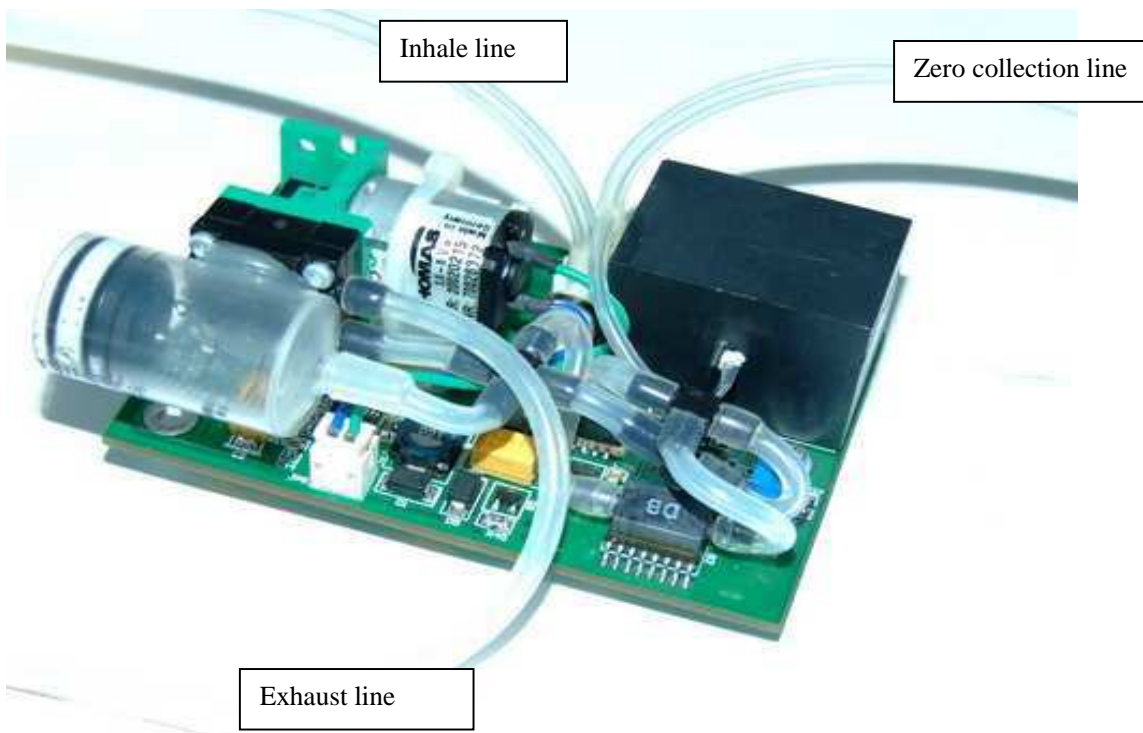
Exhaust line

FIGURE 2

There are 3 gas lines on the board. The first one is inhale line which should be connected to the water trap bench. The second one is exhaust line which should be connected to an exhaust port on the exterior of the host device. The third one is zero collecting line which should be connected to a port being open to the air around the host device.

VI. COMMUNICATION INTERFACE

Module is working at automatic mode. It sends data packet with changeless velocity (100Hz).
Data packet includes two categories, the first one is W/w data packet, it contains wave form
data, W means expiratory period and w means aspiratory period. The second one is P data
packet, which contains CO2 parameters, such as ETCO2, RR, and InCO2.

There is a P data packet after every breath wave (or every W/w packet).

User can send some dictate to the module, include Offset Calibration, Sampling pump on/off,
Gain gas concentration, Sample flow rate, etc.

Default settings:

Parameter	Factory Setting
Comm. Baud rate	38400 baud
Comm. Parity	Even
Auto. Waveform Data rate	100Hz
Waveform Packet Configuration	CO2 and Baro
Breath Parameters	ON ALL
Floating Point Format	Motorola Fast FP
Gas Sample Flow rate	100 ml/min
Baseline Bashing (insCO2)	1 mmHg
Automatic Calibration Configuration	All Settings Enabled
Maximum Reported CO2 Concentration	100mmHg
Maximum RR interval	25S

Protocol:

DESCRIPTION	HOST	C002A (C002)
Hardware/Software revision	<Ax>	<Axyyz>
Barometric/Chamber pressure	<Bx>	<Bxyyyy>
Gain gas concentration	<Cxyyy>	<Cxxyy>
Waveform data rate / pkt cfg.	<Dxxy>	<Dxxy>
A/D Raw voltages	<Ex>	<Exyyyyz>
Sample flowrate	<Fxx>	<Fxx>

Read running time byte	<G8002>	<G8002xxxx>
Sampling pump on/off	<Jx>	<Jx>
Sensor lamp on/off	<Lx>	<Lx>
Serial Number	<Nx>	<Nxyyyy>
Offset Calibration	<O1>	<O1>
CO2 parameter packet	<Pxx>	<Pxxyyyyz>
CO2 configuration	<Qxx>	<Qxx>
System reset	<RESET>	<RESET>
System status	<S1>	<Sabcdz>
System temperature	<Tx>	<Txyyyy>
Offset valve enable/disable	<Vy>	<Vy>
CO2 & Baro waveform (insp)	<Wx>	<wxxxxyyyyz> or <wxxxxz>
CO2 & Baro waveform (exp)	<Wx>	<Wxxxxyyyyz> or <Wxxxxz>
Balance Gas Compensation	<Zxxxx>	<Zxxxx>
Floating Point format	<#X>	<#X>
Module State		<Uxx>

Host Communication Packet Structure

1. Hardware/Software revision

. Transmit <Ax>

      x = ascii 1 Software Revision

      x = ascii 2 Hardware Revision

      x = ascii 3 Manufacture date

. Receive <Axyyz>

      x = ascii 1 Software Revision

      yy = ascii-hex 00-FF Major revision number

      z = ascii-hex 0-F Minor revision number

      x = ascii 2 Hardware Revision

      yy = ascii-hex 00-FF Major revision number

z = ascii-hex 0-F Minor revision number

x = ascii 3 Manufacture date

yy is 1 byte unsigned integer format

z=0

2. Barometric/Sample chamber pressure

Transmit <Bx>

x = ascii 1 Barometric pressure

x = ascii 2 Sample chamber pressure

Receive <Bxyyyy>

x = ascii 1 Barometric pressure

x = ascii 2 Sample chamber pressure

yyyy = ascii-hex 0000-FFFF Pressure in mmHg

example: <B102F8> = 760 mmHg baro pressure

3. Gain Calibration gas concentration

Transmit <Cxxyy>

xx = ascii 00 - 20 CO_2 gas concentration in percent

yy = ascii 00 - 99 CO_2 gas concentration in hundredth of percent

example: <C0518> = 5.18% CO_2

Receive <Cxxyy>

xx = ascii 00 - 20 CO_2 gas concentration in percent

yy = ascii 00 - 99 CO_2 gas concentration in hundredth of percent

4. Waveform data rate and packet configuration

Transmit <Dxxy>

xx = ascii-hex **(00,19,32,64)**waveform rate (**0，25，50，100**100Hz)

y = ascii-hex 1 send CO_2 and Baro in waveform packet (Default)

y = ascii-hex 2 send only CO_2 in waveform packet

Receive <Dxxy>

xx = ascii-hex **(00,19,32,64)**waveform rate (**0，25，50，100**100Hz)

y = ascii-hex 1 CO_2 and Baro in waveform packet

y = ascii-hex 2 only CO2 in waveform packet

5. A/D Voltage data (Factory and service use only!)

Transmit <Ex>

x = ascii 1 System Vflow

x = ascii 2 System Vtherm

x = ascii 3 Sensor Vbaro

x = ascii 4 Sensor Vsig

x = ascii 5 System Vpres

x = ascii 6 Sensor Vtemp

x = ascii 7 Sensor Vsrc

Receive <Exyyz>

x = ascii 1 System Vflow

x = ascii 2 System Vtherm

x = ascii 3 Sensor Vbaro

x = ascii 4 Sensor Vsig

x = ascii 5 System Vpres

x = ascii 6 Sensor Vtemp

x = ascii 7 Sensor Vsrc

yy = unsigned integer format

z = Unsigned char modified checksum

6. Gas Sample Flow rate

Transmit <Fxx>

xx = ascii-hex 00-FF flow rate in ml/min (100ml/min Default)

Receive <Fxx>

xx = ascii-hex 00-FF flow rate in ml/min

7. Read running time (Factory and service use only!)

Transmit **<G8002>**

Receive **<G8002xxxx>**

xxxx = unsigned integer format (unit: 30min)

8. Sampling pump on/off

Transmit <Jx>

>x = ascii 1 pump on (Default)

>x = ascii 0 pump off

Receive <Jx>

>x = ascii 1 pump on

>x = ascii 0 pump off

9. Sensor Lamp on/off (Factory and service use only!)

Transmit <Lx>

>x = ascii 1 Lamp on (Default)

>x = ascii 0 Lamp off

Receive <Lx>

>x = ascii 1 Lamp on

>x = ascii 0 Lamp off

10. System/Sensor serial number

Transmit <Nx>

>x = ascii 1 System

>x = ascii 2 Sensor

Receive <Nxyyyy>

>x = ascii 1 System

>x = ascii 2 Sensor

>yyyy = ascii-hex 0000-FFFF Serial number

11. Offset Calibration

Transmit <Ox>

>x = ascii 1 perform offset calibration immediately

Receive <Ox>

>x = ascii 1 perform offset calibration immediately

12. CO2 **parameter packet**

. Transmit <Pxx>

xx = ascii-hex 00 RR identifier (breaths/min)

xx = ascii-hex 01 insCO2 identifier (mmHg)

xx = ascii-hex 02 etCO2 identifier (mmHg)

xx = ascii-hex 03 Ti identifier (seconds)

xx = ascii-hex 04 Te identifier (seconds)

. Receive <Pxxyyyyz>

xx = ascii-hex 00-FF Parameter identifier

yyyy = Single precision Floating-Point format

z = Unsigned char modified checksum

13. CO2 **configuration**

Transmit <Qxx>

xx = ascii-hex 00 no numerics parameters to be sent

xx = ascii-hex 01 three numerics parameters (RR, insCO2, etCO2)

xx = ascii-hex 02 five numerics parameters

(RR, insCO2, etCO2, Ti, Te) (Default)

xx = ascii-hex FF All numeric parameters

. Receive <Qxx>

xx = ascii-hex 00 no numerics parameters

xx = ascii-hex 01 three numerics parameters

xx = ascii-hex 02 five numerics parameters   (Default)

xx = ascii-hex FF All numeric parameters

14. System reset

. Transmit <RESET>

. Receive <RESET>

15. System status

. Transmit <S1>

. Receive <Sabcdz>

a = Unsigned char Status Byte 1

> bit 7 valve_enable
>
> bit 6 valve_on
>
> bit 5 TBD
>
> bit 4 TBD
>
> bit 3 paramcomms_on
>
> bit 2 src_on
>
> bit 1 pump_on
>
> bit 0 TBD

b = Unsigned char Status Byte 2

> bit 7 over flow
>
> bit 6 TBD
>
> bit 5 TBD
>
> bit 4 TBD
>
> bit 3 TBD
>
> bit 2 cal_mode
>
> bit 1 run_mode
>
> bit 0 TBD

c = Unsigned char Status Byte 3

> bit 7 TBD
>
> bit 6 no_breath
>
> bit 5 temp_low
>
> bit 4 temp_high
>
> bit 3 TBD
>
> bit 2 cal_err
>
> bit 1 a2din_err
>
> bit 0 TBD

d = Unsigned char Status Byte 4

> bit 7 bench_err

bit 6 occlusion

bit 5 TBD

bit 4 eeprom_err

bit 3 TBD

bit 2 TBD

bit 1 TBD

bit 0 invalid_cmd

z = Unsigned char modified checksum

16. System temperature (Factory and service use only!)

. Transmit <Tx>

. Receive <Txyyyy>

> x = ascii 1 System temperature
>
> x = ascii 2 Sensor temperature
>
> yyyy = ascii-hex 0000-FFFF Temperature in degrees 0.5℃

17. Offset valve enable/disable

. Transmit <Vx>

> x = ascii-hex 0 Offset valve disable
>
> x = ascii-hex 1 Offset valve enable

. Receive <Vx>

> x = ascii-hex 0 Offset valve disable
>
> x = ascii-hex 1 Offset valve enable

18. Waveform Packet

. Transmit <Wx>

> x = ascii-hex 1 Send CO_2 in mmHg, Baro in mmHg (Default)
>
> x = ascii-hex 2 Send CO_2 in mmHg, Sensor Pressure in mmHg
>
> x = ascii-hex 3 Send Vsig in volts, Sensor temperature in Celsius
>
> x = ascii-hex 4 Send Example CO2 and Baro waveforms
>
> x = ascii-hex 5 Send Vflow in volts
>
> x = ascii-hex 6 Send Vtherm in volts, Vpres in volts

x = ascii-hex 7 Send Vsig in volts, Vbaro in volts

x = ascii-hex 8 Send Vtemp in volts, Vsrc in volts

. Receive (<Dxx1> configuration)

<wxxxxyyyyz> inspiration

<Wxxxxyyyyz> expiration

. Receive (<Dxx2> configuration)

<wxxxxz> inspiration

<Wxxxxz> expiration

xxxx = Single precision Floating Point format

yyyy = Single precision Floating Point format

z = Unsigned char modified checksum

Example:

< W … l é F ¦ z J ó >

0x3C 0x57 0x85 0x6C 0x82 0x46 0xB9 0x1C 0x7A 0x4A 0xA2 0x3E

Notice there are 12 bytes per waveform packet. The first byte is the packet header <. The second byte is the packet type W. The third, fourth, fifth and sixth bytes are the CO2 information. The seventh, eighth, ninth and tenth bytes are the BARO information. The eleventh byte is the checksum calculation. The twelfth byte is the packet ending >.

19. Balance Gas Compensation

. Transmit <Zabcd>

. Receive <Zabcd>

a = ascii-hex Byte 1

a=00

b = ascii-hex Byte 2

b=00

c = ascii-hex Byte 3

bit 7 BTPS compensation

bit 6 H2O = fully saturated

bit 5 N2O = 60%

bit 4 N2O = 40%

bit3=bit2=bit1=bit0=0

d = ascii-hex Byte 0

bit7=bit6=bit5=bit4=0

bit 3 N2O = 20%

bit 2 O2 = 80%

bit 1 O2 = 60%

bit 0 O2 = 40%

example: <Z0012> enables N2O=40%, O2=60%

20. Floating Point Format

. Transmit <#x>

x = ascii-hex 1 Motorola Fast Floating Point Format

x = ascii-hex 2 IEEE Floating Point Format

. Receive <#x>

x = ascii-hex 1 Motorola Fast Floating Point Format

x = ascii-hex 2 IEEE Floating Point Format

21. Module State

. Receive **<U01>**

System is running an **offset Calibration**

Motorola Fast Floating Point Format

MANTISSA   SIGN   EXPONENT

24-bit   1-bits   7-bits

$FP = [(-1)^{SIGN}] * [2^{(EXP - 0x40)}] * [MANTISSA/0x1000000]$

Example:

0x856C8246 = 1000,0101,0110,1100,1000,0010,0100,0110 (binary)

MANTISSA = 1000,0101,0110,1100,1000,0010 = 0x856C82

SIGN = 0

EXP = 100,0110 = 0x46

FP = [(-1)^SIGN] * [2^(EXP - 0x40)] * [MANTISSA / 0x1000000]

    = 1 * [2^(6)] * [0.5211869478226]

    = 33.35596466065

(IEEE Floating Point Format also available via Factory Setup or Host Command)

SIGN   EXPONENT   MANTISSA

1-bit   8-bits   23-bits

FP = [(-1)^SIGN] * [2^(EXP - 0x7F)] * [1.MANTISSA / 0x800000]

Example:

   0x42056C82 = 0100,0010,0000,0101,0110,1100,1000,0010 (binary)

      SIGN = 0

      EXP = 1000,0100 = 0x84

      MANTISSA = [1]000,0101,0110,1100,1000,0010 = 0x856C82

      FP = [(-1)^SIGN] * [2^(EXP - 0x7F)] * [MANTISSA / 0x800000]

        = 1 * [2^(5)] * [1.04237389564514]

        = 33.35596466065

Checksum Calculation

CHKSUM = (SUM(binary bytes) AND 0xFF) XOR 0xF0

VII.   CALIBRATION AND SERVICE

Gain Calibration

The MODEL C002 or C002A may be recalibrated in the field to correct gain errors if necessary. Following is a recommended procedure for performing the calibration with best results:

1. Allow the MODEL C002 or C002A to power up and run for 30 minutes.
2. From a service screen in the host display, prompt the user to provide clean CO2-free room air to the sample line of the MODEL C002 or C002A.
3. When clean air is passing through the MODEL C002 or C002A sensor, prompt the user to initiate an offset calibration. This will result in the host sending the <O1> command to

the MODEL C002 or C002A. The MODEL C002 or C002A will immediately perform an offset calibration.

4. Prompt the user to provide the concentration value of the gain gas if it may vary from calibration to calibration. This input may be in the form of a pull down menu, up/down arrows, or a text box that the user types the value into. The valid range for gain calibration gas is 4.5% to 5.5% CO_2. When the value has been entered, the host will send the <Cxxxx> command, For example, if the gain gas concentration is 5.08% CO_2, the host will send the <C0508> command to the MODEL C002 or C002A.

5. Prompt the user to provide CO_2 calibration gas to the sample line of the MODEL C002 or C002A . This gas is commonly available in hospitals, and is sold through a variety of suppliers. The gas from the CO_2 tank must be regulated in such a way as to prevent over-pressurizing the MODEL C002 or C002A pneumatics. The following implementation (FIGURE 19) works well, provided that adequate CO_2 flow is drawn by the MODEL C002 or C002A   module and excess CO_2 is observed blowing out of the T-fitting:
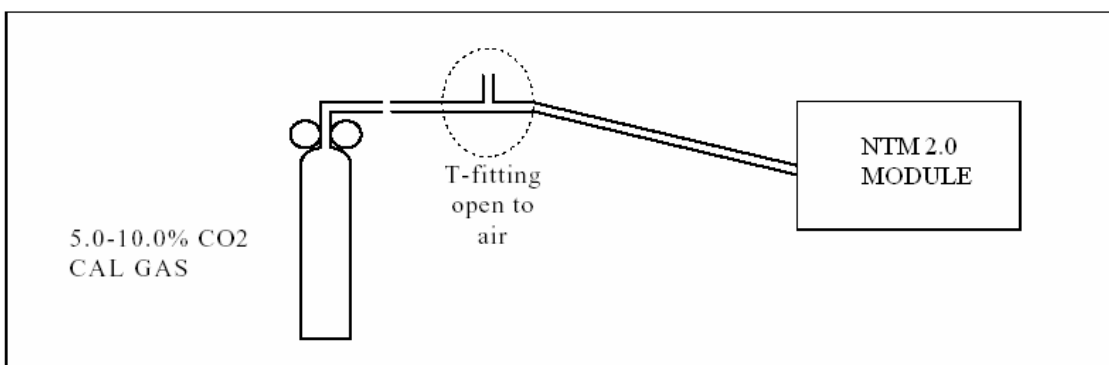
FIGURE 3

6. When the calibration gas is passing through the MODEL C002 or C002A sensor, prompt the user to initiate a gain calibration. This will result in the host sending the <Cxxxx> command to the MODEL C002 or C002A. The MODEL C002 or C002A will immediately perform a gain calibration. The data collected during the gain calibration is used by the MODEL C002 or C002A to calculate new CO_2 equation coefficients, and these coefficients are used until the next gain calibration cycle.

Note: it is recommended by the Manufacturer that gain calibration be performed

whenever:

- ✧ six months to one year of operation have elapsed
- ✧ the accuracy of readings is suspected by the clinician
- ✧ a new CO2 sensor has been installed into the MODEL C002 module
- ✧ a dramatic change in barometric pressure or altitude has occurred since the last gain calibration

SERVICE

All service should be done by The Manufacturer

VIII.   ORDER INFOMATION

The whole set of MODEL C002 or C002A ETCO2 module includes the items below:

- ✧ One water trap; (extra water trap can be ordered with the distributor at extra cost)
- ✧ One gas sample line;
- ✧ One T-fitting;
- ✧ One water trap bench;
- ✧ One ETCO2 module board.

IX.   Warranty

We offer 24 months warranty from the date of delivery for all defects arising from manufacturing or material faults. The warranty is for the Module board itself and doesn't include the consuming materials or supplies, such as the gas pump, T-fitting, sampling line, water trap, etc.

The lifespan of the module is five years, but qualified service personnel should perform periodic inspections on the module every year.

Particularly not covered by the warranty conditions are any defects or faults of the instruments function arising from disobedience of the operating instruction, improper maintenance, misuse or strange interference. In this case the product liability is changed

to the customer. Defects caused by the gas pump due to disobedience of the operating instructions or exhaust of the pump lifespan can be fixed/replaced by the manufacturer at customer's cost.

IMPORTANT:

The purchase invoice must be presented when making a claim under the warranty.

Please send devices to be repaired together with all accessories to:

GoldWEI Corporation

2595 James Madison Circle, Herndon VA 20171 USA

Phone:	**+1-703-713-0198**
Fax:	**+1-320-514-0198**
Email:	**sales@goldwei.com**

Or,

Asian Operations, GoldWEI

124, Huang Pu Da Dao Zhong

Suite 1103, Jin Hui Ge

Tian He Dist., Guangzhou, China 510655