SPECIFICATION

Product Name: Mainstream ETCO2 Sensor

Module Item No.: CM2200

Version: V0.2

Date: July 02, 2020

Revision

No.	Version	Content	Reviser	Date
1	V0.1	First Edition	Mei Yang	2018-11-01
2	V0.2	1. Company Name Amendment	Fei Ruan	2020-7-02

Mainstream ETCO2 Module CM2200

Applications

- ✧ Non-Invasive Medical Ventilator
- ✧ Clinical Anesthetic Machine
- ✧ PACU, ICU, OR, EMS, Pre-hospital Rescue

Description

Mainstream ETCO2 module CM2200 is designed by the principle of infrared absorption spectroscopy for the determination of the concentration of CO2 at the end of exhaled breath. It provides measurement of End-tidal Carbon Dioxide（ETCO2）, respiration rate, and a clear, accurate capnogram at all respiratory rate up to 150 breaths per minute.

CM2200 is easy to be integrated to patient monitors, medical ventilator and anesthesia machines. Also, it is very compact, flexible, reliable and cost-effective.

CM2200 is one of the OEM solutions we have developed for our customers, we have also other solutions for our customers and would like to support your new OEM requirement with core technology and great service.

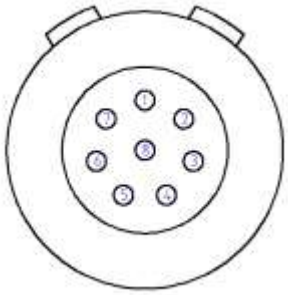
Features

- ✧ Based on principle of NDIR, infrared absorption spectroscopy, widely used to monitor the respiratory end tidal CO2 concentration and respiration rate.
- ✧ Fast response, reliable
- ✧ Compact, easy to be integrated to patient monitors, medical ventilator and anesthesia machines.
- ✧ Compensation technology used for high accuracy of temperature
- ✧ Low maintenance costs, long lifespan.
- ✧ With EMI system, avoid interference of electromagnetic.
- ✧ OEM solution available.

Specifications

Mainstream ETCO2 Module Specification	
Transducer Type	Mainstream ETCO2 sensor CM2200
Principle of Operation	Non-dispersive Infrared (NDIR)
Energy Emitting Device	Proprietary High Efficiency IR Source
Data Output	CO2 Gas Concentration (mmHg), End-tidal CO2, Inspired CO2, Respiratory Rate.
EtCO2 Measurement Range	0 to 150mm Hg; 0 to 20kPa (at 760mm Hg); 0 to 19.7%
EtCO2 Resolution	0.1mmHg
EtCO2 Accuracy	0-40mmHg: ±2mmHg; 41-70mmHg: ±5% of reading 71-100mmHg: ±8% of reading 100-150mmHg: ±10% of reading
Respiration Rate Range	0 to 150 Breaths Per Minute (BPM)
Respiration Rate Accuracy	±1 breath
Calibration	No routine user calibration required. An airway adapter zero is required when changing airway adapter.
CO2 Stability	Short term drift: Drift over four hours shall not exceed 0.8mmHg max. Long term drift: Accuracy specification will be maintained over a 120-hour period.
Input Voltage	5.00 Volts (± 5%)
Power Consumption	500mW
Peak Current	≤240mA
Sample Frequency	16Hz
Initialization Time	Displayed in less than 15s, full specifications within 2 minutes（25℃）
Response Time	Detector: 28ms System: 200ms
Compensation	Barometric pressure:400 mmHg to 850 mmHg
Airway Adapters	Single patient uses or reusable, < 5 cc deadspace (Adult), < 1 cc deadspace (Infant) Adapter taper meets ISO 5356-1
Temperature & humidity	Operating: 0℃ to 45℃, 10 to 90%RH, non-condensing Storage: -40 to 70℃, < 90% RH, non-condensing
Data Interface	Highly configurable serial digital interface (TTL/RS232 Level)
Interconnection	Compatible Lemo Redel 8-pin plastic
Baud Rate	19200-N-8-1
Dimensions	52 mm *23 mm *36mm
Weight	< 40g

Pin Definition



Drawing 1 ETCO2 Module CM2200

O/I Definition List

Pin	Item	Description
1	Power Supply	VA 5.0V
2	Shield	Shield
3	DGND	Digital Ground
4	Power Supply	VA 5.0V
5	TXD	Serial Data from the Module
6	RXD	Serial Data from Host
7	AGND	Analog Ground
8	NC	No Connection
Notes: Pin 5, 6 is serial signal.		
Be careful of connection with external communication.		

Communication Protocol

1. Protocol Overview

1) The communication interface follows RS232 standard. Baud Rate: 19200bps, Start Bits: 1, Data Bits: 8, Stop Bits: 1, Parity: No.
2) The protocol data are hexadecimal data. For example, 46h in hexadecimal is 70d in decimal;

2. Protocol Format Description

2.1 Protocol Format

The data is transmitted and received in the form of data package, and the format is as below:

CMD - NBF - [BYTE0, BYTE1 ⋯ BYTEn] - CKS

Description:

CMD: Command, single byte, range 80h-FFH

NBF: The number of bytes after the current byte, including the length of the check sum [BYTE0, BYTE1 ⋯ BYTEn]

BYTEn: Data transmitted

CKS: Checksums

2.2 Checksum Calculation

Checksum calculation formula CKS= (not (CMD+NBF+[BYTE0]+ [BYTE1]+⋯[BYTEn]) +1) &7Fh

The sample program (C language) is as follows:

```
unsigned char ChecksumCal(unsigned char *buf,unsigned char Len)
{
  unsigned char checksum=0,i=0;
  for (i = 0; i < Len; i++)
  {
      checksum +=  buf[i];
  }
  checksum = (-checksum) & 0x7F;
  return checksum;
}
```

2.3 Function List

No.	Function	Command	Description	Remark
1	CO2 Waveform/Data Model	0x80	Transmission of CO2 waveform /data mode	Continuous Response Command
2	Zero Command	0x82	Zero	Single Response Command
3	Signal Setting	0x84	Get and set parameters for different signal in the sensor module	Single Response Command
4	NACK Error	0xC8	Check error command	/
5	Stopping Continuous Mode	0xC9	Stop data transmission of continuous response command	Single Response Command
6	Getting Software Version	0xCA	Get current software version	Single Response Command
7	Resetting no Breath Detection Flag	0xCC	Require system clear no breath detection flag compulsorily	Single Response Command
8	Sensor Resetting	0xF8	A reset system monitor is generated in the sensor	Single Response Command

3. Communication Protocol

3.1 CO2 Waveform/Data Model (Command 80h)

Command: 80h - NBF - 0 - CKS

Command Type: Continuous Response Command

Response: 80h - NBF – SYNC - CO2WB1 - CO2WB2 - [DPI – DPB1 - DPBn] - CKSUM

Definitions:

80h - Command byte

NBF - Number of bytes to follow (including CKS)

SYNC - Synchronization counter which increments with each packet sent. Counter starts at 0 and rolls over to zero when it reaches 127. This byte can be used to detect missed packets.

CO2WB1, CO2WB2 - CO2 Waveform x100. (Note: 1. CO2 value is the unit of current CO2 transmission, which can be set and restored by using the corresponding instructions in parameter setting)

DPI - Data Parameter Index. The DPI is sent only when necessary. (Standard resolution)

DPB1, DPBn - These bytes are sent only when necessary. These bytes contain the DPI data and the number of bytes can vary from zero to five bytes.

CKSUM - Checksum byte

The CO2 waveform can be decoded as follows:

Units	Range	Resolution	Conversion
mmHg	-9.99 to150.00 mmHg	0.01 mmHg	(((128 * CO2WB1) + CO2WB2) – 1000)/100
kPa	-9.99 to 20.00 kPa	0.01 kPa	(((128 * CO2WB1) + CO2WB2) – 1000)/100
Percent %	-9.99 to 19.70 %	0.01 %	(((128 * CO2WB1) + CO2WB2) – 1000)/100

The DPI byte contains patient parameter data. The types of DPI are summarized in the table below and described in detail in Appendix B.

Command 80h DPI Parameter Table

DPI	Number Bytes	Description	Calculation
1	5	Reserved	
2	2	$ETCO_2$ x10	ETCO2 = (DPB1 * 2^7) + DPB2
3	2	Respiration Rate	RespRate= (DPB1 * 2^7) + DPB2
4	2	Insp CO_2 x10	Insp CO2 = (DPB1 * 2^7) + DPB2
5	0	Breath Detected Flag	Breath has been detected when this DPI is sent.
7	2	Reserved	

3.2 Zero Command (Command 82h)

Command: 82h -NBF - CKS

Command Type: Single Response Command

Response: 82h - NBF - ZSB - CKS

Definitions:

82h - Command byte

NBF - Number of bytes to follow (including CKS)

ZSB - Zero status byte (see table below)

CKS - Checksum

Description: This command is used to initiate a zero. A zero is used to correct for differences in airway adapter types. The zero must be performed free of any CO2.

ZSB	Description
0	Zero started.
1	Zero errors. It may be caused by the following reasons: • In sleep mode • Module temperature not stable • Sensor signal error
2	Zero in already progress (started).
3	Zero adjustment unsuccessful and breaths have been detected in the last 20 seconds.

3.3 Signal Setting (Command 84h)

Command: 84h - NBF - ISB - [DB1 - … - DBN] - CKS

Command Type: Single Response Command

Response: 84h - NBF - ISB - DB1 - … - DBN - CKS

Definitions:

84h - Command byte

NBF - Number of bytes to follow (including CKS)

ISB – Identifier of setting byte (see table below)

DB1 … DBN - Data bytes used to set and return the parameter of a particular sensor setting

CKS - Checksum

Description: This command is used to get and set the various sensor parameter in the module. When the command has no selectable data bytes in DB1... DBN transmitted to the sensor, the command string displays the current value set by the sensor. The setting for host recognizing a valid byte identifier - ISB. If an invalid byte identifier is given, the response of the command string will not return the data bytes, only ISB=0

Communication Protocol

The table below lists the ISB byte identifiers and the corresponding sensor settings.

ISB	Number of Bytes	Sensor Setting Description
0	0	Invalid Instrument or Parameter Setting Number of Data Bytes = 0
1	2	Pressure **Default:** 760 mmHg. **Resolution:** 1 mmHg (400-850 mmHg) Conversion: Barometric Pressure = (128 * DB1) + DB2 DB1 = (Barometric Pressure / 128) & 7Fh DB2 = (Barometric Pressure) & 7Fh **Notes**: This setting is used to set current Barometric Pressure.
4	2	Gas Temperature **Default:** 35.0 ℃. **Resolution:** 0.1 ℃ (0.0 – 50.0 ℃) **Conversion:** Gas Temperature ℃ = (128 * DB1 + DB2) / 10 **Notes:** This setting is used to set temperature of the gas mixture.
7	1	Current CO2 Units **Default:** mmHg **Conversion:** CO2 units = DB1 = 0 CO2 units are mmHg = 1 CO2 units are kPa = 2 CO2 units are percent (%)
9	1	Zero Gas Type **Default:** zero on room air **Conversion:** zero gas = DB1 = 0 zero on N2 = 1 zero on room air **Notes:** When performing a zero on room air, this setting should be set to room air (the default). Only change to nitrogen (N2) when performing a zero on 100% N2 gas; this is provided for use in a laboratory environment.
11	4	Get/Set Gas Compensations DB1 = O2 Compensation **Default:** 16 % **Conversion:** O2 compensation = DB1 **Resolution:** 1 % (0 – 100 %) DB2 = Balance gas **Default:** 0 (room air) **Conversion:** balance gas = DB2 = 0, room air = 1, N2O = 2, Helium DB3, DB4 = Anesthetic agent x10 **Default:** 0.0 % **Conversion:** Anesthetic agent = [(DB3 * 27) + DB4] / 10 **Resolution:** 0.1 % (0.0 – 20.0 %) **Notes:** This setting is used to adjust the compensation of the sensor when the mixed gas acts on the patient. Anesthetic agent is ignored when the balance gas is set to helium. **Example:** An oxygen value is 40%, N2O was balanced with 3.5% anesthetic, comply with the following data bytes, DB1 = 40, DB2 = 1, DB3 = 0, and DB4 = 35

Attachment: Main parameter setting and reading protocol.

Communication Protocol

(1) Barometric Pressure Default 760mmHg Resolution 1 mmHg (400-850 mmHg)

Type	Host sending(hex)	Sensor Respond(hex)
Setting Barometric Pressure=760mmHg	84 04 01 05 78 6A	84 04 01 05 78 6A
Getting Current Barometric Pressure	84 02 01 79	84 04 01 05 78 6A

(2) Temperature Default 35.0℃ Resolution 0.1℃ (0.0-50.0 ℃)

Type	Host sending(hex)	Sensor Respond(hex)
Setting Temperature =35.0℃	84 04 04 02 5E 14	84 04 04 02 5E 14
Getting Current Temperature	84 02 04 76	84 04 04 02 5E 14

(3) Unit Default mmHg

Type	Host sending(hex)	Sensor Respond(hex)
Setting Unit =mmHg	84 03 07 00 72	84 03 07 00 72
Getting Current Unit	84 02 07 73	84 03 07 00 72

(4) Gas Compensation

O2 Compensation Default 16% Resolution 1%（0-100%）

Balance gas

Balance Gas	Definition
0	room air (Default)
1	N2O
2	He

Anesthetic agent Default 0.0% Resolution 0.1%（0.0-20.0%）

Type	Host sending(hex)	Sensor Respond(hex)
Setting O2 concentration =40%, balanced gas is N2O, anesthetic agent concentration =3.5%	84 06 0B 28 01 00 23 1F	84 06 0B 28 01 00 23 1F
Getting Current Information of Gas Compensation	84 02 0B 6F	84 06 0B 28 01 00 23 1F

3.4 NACK Error (Command C8h)

Response: C8h - NBF - CEB - CKS

Definitions: C8h - command identifier

NBF - Number of bytes to follow (including CKS)

CEB - Command error byte (see Table below)

CKS - Checksum byte

Description: The communications protocol has built-in command error checking. The following command errors are detected:

CEB	**NACK Error**	**Description**
0	Boot code	Waiting for bootloader – Startup only
1	Invalid Command	This occurs whenever a command other than the defined commands is received. It can also occur when a command byte (byte > 80h) is expected but the actual byte is < 80h.
2	Checksum Error	This occurs whenever an improper checksum is received.
3	Time-out Error	This occurs whenever more than 500 ms elapses between the first and last bytes of a command.
4	Invalid Byte count	This occurs whenever the byte count is less than the number of bytes expected for a particular command.
5	Invalid Data Byt	This occurs whenever a non-command byte expected and a command byte (byte with MSB=1) is encountered.
6	System Faulty	This occurs when the system is in a non-functional state due to a system fault. All commands will be ignored. Contact Service.
7		
8		
9		
10		
11-19	Not used	Reserved for future use.
20	System Faulty	This occurs when the system is in a non-functional state due to a system fault. All commands will be ignored. Contact Service provider.
21		
22		
23		
24		

During normal operation, command errors should not occur. In cases where one of these errors is encountered, the CO2 module will respond by sending the appropriate NACK response.

If system faulty errors are encountered, the module is in a non-functional state and all commands will be rejected. Check that the sensor is properly plugged in. Reinsert or reset the sensor if necessary. If the error persists, return the sensor to the factory for servicing.

3.5 Stopping Continuous Mode (Command C9h)

Command: C9h - NBF - CKS

Command Type: Single Response Command

Response: C9h - NBF - CKS

Definitions:

C9h - Command

NBF - Number of bytes to follow (including CKS)

CKS - Checksum

Description: This command is used to stop the data transmission of a continuous response command. The response is sent as soon as the current process is halted. Any data packet currently being sent will be sent in its entirety before the current continuous response is halted. If the waveform mode command is not active, the Stop Continuous Mode command will send the appropriate response but the command has no effect.

3.6 Getting Software Revision (Command CAh)

Command: CAh - NBF - RF - CKS

Command Type: Single Response Command

Response: CAh - NBF - RF - DA0 - DA1 - … - DAn - CKS

Definitions:

CAh - Command

NBF - Number of bytes to follow (including CKS)

RF - Revision, 0 by default; all software versions are displayed

CKS - Checksum

Description: This command returns the software version of the current sensor. The length of the software version does not exceed the character length of 32 bytes, and the transmission format is ASCII.

3.7 Resetting no Breath Detection Flag (Command CCh)

Command: CCh - NBF - CKS

Command Type: Single Response Command

Response: CCh - NBF - CKS

Definitions:

CCh - Command

NBF - Number of bytes to follow (including CKS)

CKS - Checksum

Description: this command is used to force the system to clear the "breath not detected" flag. After sending this command, clear the detected no breath flag bit, the system enters a similar initialization state, and all DPI parameters will be reset. In addition, this command can be sent even if the undetected breathing flag is not set.

3.8 Sensor Resetting (Command F8h）

Command: F8h - NBF - CKS

Command Type: Single Response Command

Response: No

Definitions:

F8h - Command

NBF - Single Response Command

CKS - Checksum

Description: This command is used to reset the sensor. After sending this command, the sensor will be reset.

Suitable Types of Patient Monitor

Suitable Types of Patient Monitor

OEM Manufacturer & Models	Installation method	Mainstream ETCO2 Sensor
Respironics:		CM2200
MEK: MTV1000 Pneuma2 /MP800C/MP1300		
Bionet: BM3/BM5		
Edan:Elite V8/M80/M50		
General Meditech: G3C/G3D/ G3F/G3G/G3H/G3L /G9L		
Biocare:PM-2000/Im12/iM15		
Contecmed: CMS8000/CMS7000 /CMS6000B/CMS6000A		

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