IMI FAS®

CHIPREG MFC

IMI FAS CHIPREG miniature MFC

Engineering
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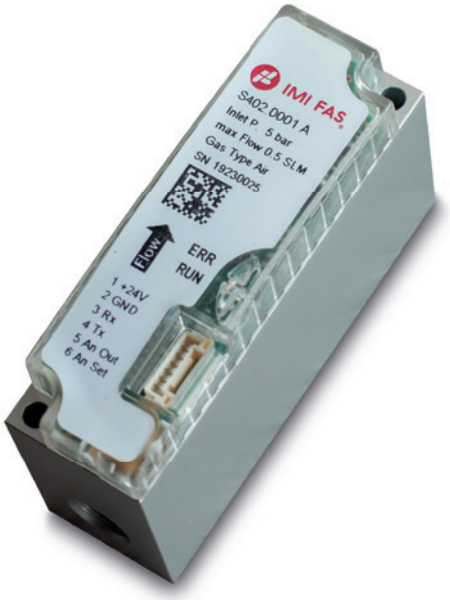

Communication Protocol & Structure

IMI Precision Engineering

Before starting work read these instructions.

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Record of Revisions

Name & Rev	Date	Who	Localization	Nature of Modif
V1	15.11.2018	DAZ		Add gas temp cmd
V2	07.01.2019	DAZ		Add NVM commands and IO data
V2.1	11.02.2019	DAZ		Change Title
V2.2	19.02.2019	DAZ		Add script
V2.3	20.02.2019	DAZ		Add Sensor Information Table
V2.4	01.03.2019	DAZ		Add Identification Data
V3	05.03.2019	DAZ		Add factory password

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1. Abbreviations and Acronyms

0d Number:	decimal format
0x Number:	hexadecimal format
0b Number:	binary format
Uint8: unsigned integer of 8 bit	(0d0..0d255)
Uint16: unsigned integer of 16 bit	(0d0..0d65535)
Uint32: unsigned integer of 32 bit	(0d0..0d4294967295)
Int8: signed integer of 8 bit	(0d-128..0d127)
Int16: signed integer of 16 bit	(0d-32768..0d32767)
Int32: signed integer of 32 bit	(0d-2147483648..0d2147483647)
Float32: single precision floating point	(IEEE754)
NVM: Non-volatile memory	

2. Purpose

The aim of this document is the specification of all commands which can be performed through the serial line RS232 of the controller module.

3. General Description

3.1. RS232 Peripheral settings

The settings are the following:

- Baud rate 115200
- Data 8 bits
- Parity none
- Data bits 8
- Stop bits 1
- Handshaking none
- Level EIA232 (PC serial port type)

3.2. Command Structure

The serial line uses characters to send / receive 8 bits (1 octet or 1 byte) packets. For numbers, all values must be specified in hex format. Thus, each octet needs 2 characters. A command operation integrates two phases: send and receive, always with the same structure.

- Device Address: 2 char (always '01')
- Command Code: 4 char (combination of 4 letters)
- Data: n char (series of 0 to 255 octets max)
- CRC16 Code: 4 char (16bit value)

After sending a command (master) the CHIPREG MFC (slave) must reply in accordance with the following format:

Command Send (from Master)

Device		Command				Data				CRC16			
'0'	'1'	C0	C1	C2	C3	D0	D1	D2	Dn-1	R0	R1	R2	R3

Command Receive (from Slave)

Device		Command				Data				CRC16			
'0'	'1'	C0	C1	C2	C3	D0	D1	D2	Dn-1	R0	R1	R2	R3

NOTICE:
For numbers (always in hex format) the letters For numbers (always in hex format), the letters a, b, c, d, e and f can be written either in uppercase or lowercase. However, for text, the system is case-sensitive.

Example:
The user requests a mass flow read with the command ‘SMFR’

Command Send (from Master)

Device		Command				CRC16			
‘0’	‘1’	‘S’	‘M’	‘F’	‘R’	‘e’	‘1’	‘4’	‘a’

- The device number is always 0x01 ⟶ char ‘01’
- The command is composed of 4 letters ⟶ char ‘SFMR’
- No Data to send ⟶ void
- The CRC16 code of the whole character string ‘01SFMR’ is 0xe14a ⟶ char ‘e14a’

Command Receive (from Slave)

Device		Command				Data				CRC16			
‘0’	‘1’	‘S’	‘M’	‘F’	‘R’	‘0’	‘0’	‘0’	‘1’	‘f’	‘5’	‘9’	‘c’

- The device number is always 0x01 ⟶ char ‘01’
- The command is composed of 4 letters ⟶ char ‘SFMR’
- The returned data from the CHIPREG MFC is a 16 bits number of 0x0001 ⟶ char ‘0001’
- The CRC16 code of the whole character string ‘01SFMR0001’ is 0xf59c ⟶ char ‘f59c’

In the case where a number is bigger than 8 bits (16 or 32 bits), we must split that number in several octets. An example where the 16 bits number 0d15893 must be written on the serial line:

0d15893 = 0x3e15 = 0b00111110 00010101
MSByte = 0x3e
LSByte = 0x15

Thus, we need 4 chars:

char0 = ‘3’
char1 = ‘e’
char2 = ‘1’
char3 = ‘5’

For reading operation, MSByte and LSByte must be merged together to find the original number. The MSByte must be multiplied by 2^8 (shifted to the left 8 times) and added to LSByte.

We receive through the serial line 4 chars:

char0 = ‘3’
char1 = ‘e’
char2 = ‘1’
char3 = ‘5’

We convert it in 2 bytes:

MSByte = 0x3e
LSByte = 0x15

Number = (MSBytes << 8) + LSByte = 0x3E00 + 0x15 = 0x3E15 = 0d15893

3.3. CRC16 Computation

The CRC16 computation (checksum) is performed in accordance with the following algorithm:

```
//     Crc16 Modbus Checksum computation.
// Note             -
// *charData Array of characters.
// uint8Nbr         Numbers of characters to receive.
// uint16Crc16      Output value.
uint16_t Crc16ModBusComputation (char* charData, uint8_t uint8Nbr)
{
       uint16_t                  uint16Crc16 = 0xFFFF;
       uint8_t                   uint8Position;
       uint8_t                   uint8Shift;

       for (uint8Position = 0; uint8Position < uint8Nbr;uint8Position++)
       {
              uint16Crc16 ^= (uint16_t)charData[uint8Position];

              for (uint8Shift = 8; uint8Shift != 0; uint8Shift--)
              {
                     if ((uint16Crc16 & 0x0001) != 0)
                     {
                            uint16Crc16 >>= 1;
                            uint16Crc16 ^= 0xA001;
                     }
                     else uint16Crc16 >>= 1;
              }
       }
       return uint16Crc16;
}
```

The Master can avoid the CRC16 computation replacing it by the character string ‘XXXX’.

Example:
The user requests a mass flow read with the command ‘SMFR’ avoiding the CRC16 computation.

Command Send (from Master)

Device		Command				CRC16			
‘0’	‘1’	‘S’	‘M’	‘F’	‘R’	‘X’	‘X’	‘X’	‘X’

- The device number is always 0x01 ⟶ char ‘01’
- The command is composed of 4 letters ⟶ char ‘SFMR’
- No Data to send ⟶ void
- Instead of CRC16 code, the user can use ‘XXXX’ (capital letters) ⟶ char ‘XXXX’

3.4. Special Commands

Command	Type	Command	Type
MFSR	U	CALR	F
MFSW	U	CALW	FPW
VCSR	U	CONR	F
VCSW	U	CONW	FPW
CTRR	U	IDER	U
CTRW	U	IDEW	FPW
CTLR	U	FPWW	F
CTLW	U	SITR	F
RMFR	F		
CRSN	U		
SMFR	U		
RVCR	F		
SVCR	U		
AOSR	U		
AOSW	U		
DPSR	U		
DPSW	U		
SISR	U		
SISW	U		
SYRN	U		
RASR	F		
SASR	U		
RDUR	F		
RDUW	F		
SDUR	U		
SDUW	U		
EFSR	U		
HWSR	U		
RDPR	U		
RAOR	F		
SAOR	U		
RDVR	F		
SDVR	U		
RGTR	F		
SGTR	U		
NMSR	F		
NMSW	FPW		
NMWM	FPW		

U: User-oriented command
F: Factory oriented command (but available for user)
FPW: Need factory password (no access for user)

4. Commands Description

4.1. Mass Flow Setpoint Read: MFSR

Name
MFSR

Purpose
Read the last mass flow setpoint written
Data Send (char): 0
Data Receive (char): 4

Data Send
void

Data Receive

Parameter	Type	Min	Max	Char	Notice
Mass Flow Setpoint	Unit16	0x0000 (0d0)	0x0FFF (0d4095)	0..3	1)

1) See section 'Computation of the digital I/O data'

Example
Command Send

Device		Command				CRC16			
'0'	'1'	'M'	'F'	'S'	'R'	'9'	'b'	'3'	'3'

Command Receive

Device		Command				Data				CRC16			
'0'	'1'	'M'	'F'	'S'	'R'	'0'	'b'	'b'	'8'	'c'	'7'	'f'	'8'

4.2. Mass Flow Setpoint Write: MFSW

Name
MFSW

Purpose
Write the mass flow setpoint.
Data Send (char): 4
Data Receive (char): 0

Data Send

Parameter	Type	Min	Max	Char	Notice
Mass Flow Setpoint	Unit16	0x0000 (0d0000)	0x0FFF (0d4095)	0..3	1)

1) See section 'Computation of the digital I/O data'

Data Receive
void

Example
Command Send

Device		Command				Data				CRC16			
'0'	'1'	'M'	'F'	'S'	'W'	'0'	'b'	'b'	'8'	'c'	'7'	'3'	'4'

Command Receive

Device		Command				CRC16			
'0'	'1'	'M'	'F'	'S'	'W'	'9'	'8'	'f'	'3'

- The mass flow setpoint written is 0x0bb8 (0d3000)

4.3. Valve Current Setpoint Read: VCSR

Name
VCSR

Purpose
Read the last mass flow setpoint written
Data Send (char): 0
Data Receive (char): 4

Data Send
void

Data Receive

Parameter	Type	Min	Max	Char	Notice
Mass Flow Setpoint	Unit16	0x0000 (0d0)	0x0FFF (0d4095)	0..3	1)

1) See section 'Computation of the digital I/O data'

Example
Command Send

Device		Command				CRC16			
'0'	'1'	'V'	'C'	'S'	'R'	'7'	'e'	'2'	'5'

Command Receive

Device		Command				Data				CRC16			
'0'	'1'	'V'	'C'	'S'	'R'	'0'	'7'	'd'	'0'	'0'	'e'	'f'	'f'

- The valve current read is 0x07d0 (0d2000).

4.4. Valve Current Setpoint Write: VCSW

Name
VCSW

Purpose
Write the mass flow setpoint.
Data Send (char): 4
Data Receive (char): 0

Data Send

Parameter	Type	Min	Max	Char	Notice
Valve Current Setpoint	Unit16	0x0000 (0d0000)	0x0FFF (0d4095)	0..3	1)

1) See section 'Computation of the digital I/O data'

Data Receive
void

Example
Command Send

Device		Command				Data				CRC16			
'0'	'1'	'V'	'C'	'S'	'W'	'0'	'7'	'd'	'0'	'0'	'e'	'3'	'3'

Command Receive

Device		Command				CRC16			
'0'	'1'	'V'	'C'	'S'	'W'	'7'	'd'	'e'	'5'

- The valve current setpoint written is 0x07d0 (0d2000)

4.5. Control Read : CTRR

Name
CTRR

Purpose
Read the control configuration.
Data Send (char): 0
Data Receive (char): 2

Data Send
void

Data Receive

Parameter	Type	Min	Max	Char	Notice
Control	Uint8	0x0000 (0d0)	0x03 (0d3)	0..1	1)

1) 0x00: No Control
0x01: Valve Current
0x02: Mass Flow
0x03: Drive Pwm

Example
Command Send

Device		Command				CRC16			
'0'	'1'	'C'	'T'	'R'	'R'	'e'	'6'	'9'	'0'

Command Receive

Device		Command				Data				CRC16			
'0'	'1'	'C'	'T'	'R'	'R'	'0'	'2'	'5'	'f'	'7'	'8'	'f'	'f'

- The control configuration read is 0x02 (0d2).

4.6. Control Write : CTRW

Name
VCSW

Purpose
Write the control configuration. After a 'CTRW', the CTLW must rewrite.
Data Send (char): 2
Data Receive (char): 0

Data Send

Parameter	Type	Min	Max	Char	Notice
Control	Uint8	0x00 (0d0)	0x03 (0d3)	0..1	1)

1) 0x00: No Control
0x01: Valve Current
0x02: Mass Flow
0x03: Drive Pwm

Data Receive
void

Example
Command Send

Device		Command				Data		CRC16			
'0'	'1'	'C'	'T'	'R'	'W'	'0'	'2'	'5'	'e'	'6'	'8'

Command Receive

Device		Command				CRC16			
'0'	'1'	'C'	'T'	'R'	'W'	'e'	'5'	'5'	'0'

- The control configuration written is 0x02 (0d2)

4.7. Controller Read : CTLR

Name
CTLR

Purpose
Read the controller configuration.
Data Send (char): 0
Data Receive (char): 2

Data Send
void

Data Receive

Parameter	Type	Min	Max	Char	Notice
Controller	Uint8	0x00 (0d0)	0x05 (0d5)	0..1	1)

1) 0x00: No Controller
0x01: Basic
0x02: Slow PID
0x03: Medium PID
0x04: Fast PID
0x05: User PID
0x06: Drive Pwm

Example
Command Send

Device		Command				CRC16			
'0'	'1'	'C'	'T'	'L'	'R'	'4'	'6'	'9'	'9'

Command Receive

Device		Command				Data		CRC16			
'0'	'1'	'C'	'T'	'R'	'R'	'0'	'2'	'7'	'7'	'7'	'e'

- The controller configuration read is 0x02 (0d2).

4.8. Controller Write : CTLW

Name
CTLW

Purpose
Write the controller configuration
Data Send (char): 2
Data Receive (char): 0

Data Send

Parameter	Type	Min	Max	Char	Notice
Controller	Uint8	0x00 (0d0)	0x05 (0d5)	0..1	1)

1) 0x00: No Controller
0x01: Basic
0x02: Slow PID
0x03: Medium PID
0x04: Fast PID
0x05: User PID
0x06: Drive Pwm

Data Receive
void

Example
Command Send

Device		Command				Data		CRC16			
'0'	'1'	'C'	'T'	'L'	'W'	'0'	'2'	'7'	'6'	'6'	'e'

Command Receive

Device		Command				CRC16			
'0'	'1'	'C'	'T'	'L'	'W'	'4'	'5'	'5'	'9'

- The controller configuration written is 0x02 (0d2)

4.9. Raw Mass Flow Read: RMFR

Name
RMFR

Purpose
Data from the mass flow sensor
Data Send (char): 0
Data Receive (char): 4

Data Send
void

Data Receive

Parameter	Type	Min	Max	Char	Notice
Raw Mass Flow	Int16	0x0000 (0d)	0xFFFF (0d±32767)	0..3	1)

1) See section 'Computation of the digital I/O data'

Example
Command Send

Device		Command				CRC16			
'0'	'1'	'R'	'M'	'F'	'R'	'1'	'd'	'4'	'b'

Command Receive

Device		Command				Data				CRC16			
'0'	'1'	'R'	'M'	'F'	'R'	'1'	'd'	'9'	'5'	'8'	'6'	'1'	'a'

- The raw data read is 0x1d95 (0d7573).

4.10. Scaled Mass Flow Read: SMFR

Name
SMFR

Purpose
Read the mass flow
Data Send (char): 0
Data Receive (char): 4

Data Send
void

Data Receive

Parameter	Type	Min	Max	Char	Notice
Scaled Mass Flow	Uint16	0x0000 (0d0)	0x0FFF (0d4095)	0..3	1)

1) See section 'Computation of the digital I/O data'

Example
Command Send

Device		Command				CRC16			
'0'	'1'	'S'	'M'	'F'	'R'	'e'	'1'	'4'	'a'

Command Receive

Device		Command				Data				CRC16			
'0'	'1'	'S'	'M'	'F'	'R'	'0'	'0'	'6'	'd'	'6'	'a'	'5'	'f'

- The mass flow read is 0x006d (0d109).

4.11. Raw Valve Current Read: RVCR

Name
RVCR

Purpose
Data from the valve current ADC
Data Send (char): 0
Data Receive (char): 4

Data Send
void

Data Receive

Parameter	Type	Min	Max	Char	Notice
Raw Valve Current	Uint16	0x0000 (0d0)	0x0FFF (0d4095)	0..3	1)

1) See section 'Computation of the digital I/O data'

Example
Command Send

Device		Command				CRC16			
'0'	'1'	'R'	'V'	'C'	'R'	'4'	'a'	'3'	'8'

Command Receive

Device		Command				Data				CRC16			
'0'	'1'	'R'	'V'	'C'	'R'	'0'	'8'	'4'	'8'	'6'	'9'	'b'	'5'

- The raw data read is 0x0848 (0d2122).

4.12. Scaled Valve Current Read: SVCR

Name
SVCR

Purpose
Read the valve current
Data Send (char): 0
Data Receive (char): 4

Data Send
void

Data Receive

Parameter	Type	Min	Max	Char	Notice
Scaled Valve Current	Uint16	0x0000 (0d0)	0x0FFF (0d4095)	0..3	1)

1) See section 'Computation of the digital I/O data'

Example
Command Send

Device		Command				CRC16			
'0'	'1'	'S'	'M'	'F'	'R'	'e'	'1'	'4'	'a'

Command Receive

Device		Command				Data				CRC16			
'0'	'1'	'S'	'M'	'F'	'R'	'0'	'0'	'6'	'd'	'6'	'a'	'5'	'f'

- The valve current read is 0x006d (0d109).

4.13. Analog Output Selection Read: AOSR

Name
AOSR

Purpose
Read the analog output selection.
Data Send (char): 0
Data Receive (char): 2

Data Send
void

Data Receive

Parameter	Type	Min	Max	Char	Notice
Analog Output Selection	Uint8	0x00 (0d0)	0x03 (0d3)	0..1	1)

1) 0x00: No Analog Out
0x01: Valve Current
0x02: Mass Flow
0x03: Scaled User
0x04: Raw User

Example
Command Send

Device		Command				CRC16			
'0'	'1'	'A'	'0'	'S'	'R'	'c'	'9'	'e'	'0'

Command Receive

Device		Command				Data		CRC16			
'0'	'1'	'A'	'0'	'S'	'R'	'0'	'2'	'4'	'3'	'1'	'c'

- The analog output selection read is 0x02 (0d2).

4.14. Analog Output Selection Write: AOSW

Name
AOSW

Purpose
Write the analog output selection.
Data Send (char): 2
Data Receive (char): 0

Data Send

Parameter	Type	Min	Max	Char	Notice
Analog Output Selection	Uint8	0x00 (0d0)	0x03 (0d3)	0..1	1) 2)

1) 0x00: No Analog Out
0x01: Valve Current
0x02: Mass Flow
0x03: Scaled User
0x04: Raw User

2) For 'User' mode see command 'SDUW' and 'RDUW'

Data Receive
void

Example
Command Send

Device		Command				Data		CRC16			
'0'	'1'	'A'	'0'	'S'	'W'	'0'	'2'	'4'	'2'	'0'	'c'

Command Receive

Device		Command				CRC16			
'0'	'1'	'A'	'0'	'S'	'W'	'c'	'a'	'2'	'0'

- The analog output selection written is 0x02 (0d2)

4.15. Drive PWM Setpoint Read: DPSR

Name
DPSR

Purpose
Read the last drive PWM setpoint written
Data Send (char): 0
Data Receive (char): 4

Data Send
void

Data Receive

Parameter	Type	Min	Max	Char	Notice
Drive PWM Setpoint	Uint16	0x0000 (0d0)	0x0F9F (0d3999)	0..3	1)

1) See section 'Computation of the digital I/O data'

Example
Command Send

Device		Command				CRC16			
'0'	'1'	'D'	'P'	'S'	'R'	'c'	'3'	'd'	'1'

Command Receive

Device		Command				Data				CRC16			
'0'	'1'	'D'	'P'	'S'	'R'	'0'	'9'	'c'	'4'	'2'	'a'	'3'	'f'

- The drive pwm setpoint read is 0x09c4 (0d2500).

4.16. Drive PWM Setpoint Write: DPSW

Name
DPSW

Purpose
Write the drive PWM setpoint.
Data Send (char): 4
Data Receive (char): 0

Data Send

Parameter	Type	Min	Max	Char	Notice
Drive PWM Setpoint	Uint16	0x0000 (0d0000)	0x0F9F (0d3999)	0..3	1)

1) See section 'Computation of the digital I/O data'

Data Receive
void

Example
Command Send

Device		Command				Data				CRC16			
'0'	'1'	'D'	'P'	'S'	'W'	'0'	'9'	'c'	'4'	'2'	'a'	'f'	'3'

Command Receive

Device		Command				CRC16			
'0'	'1'	'D'	'P'	'S'	'W'	'c'	'0'	'1'	'1'

- The drive pwm setpoint written is 0x09c4 (0d2500).

4.17. Setpoint Input Selection Read: SISR

Name
SISR

Purpose
Read the setpoint input selection.
Data Send (char): 0
Data Receive (char): 2

Data Send
void

Data Receive

Parameter	Type	Min	Max	Char	Notice
Setpoint Input Selection	Uint8	0x00 (0d0)	0x02 (0d3)	0..1	1) 2)

1) 0x00: No Setpoint Input
0x01: Adc (analog)
0x02: RS232 (digital)

2) Analog Input option only for the mass flow control.
(valve current and drive pwm setpoint through RS232 only)

Example
Command Send

Device		Command				CRC16			
'0'	'1'	'S'	'I'	'S'	'R'	'b'	'0'	'0'	'5'

Command Receive

Device		Command				Data		CRC16			
'0'	'1'	'S'	'I'	'S'	'R'	'0'	'1'	'3'	'0'	'd'	'7'

- The setpoint input selection read is 0x01 (0d1).

4.18. Setpoint Input Selection Write: SISW

Name
SISW

Purpose
Write the setpoint input selection.
Data Send (char): 2
Data Receive (char): 0

Data Send

Parameter	Type	Min	Max	Char	Notice
Setpoint Input Selection	Uint8	0x00 (0d0)	0x02 (0d2)	0..1	1) 2)

1) 0x00: No Setpoint Input
0x01: Adc (analog)
0x02: RS232 (digital)

2) Analog Input option only for the mass flow control.
(valve current and drive pwm must be set through RS232 only)

Data Receive
void

Example
Command Send

Device		Command				Data		CRC16			
'0'	'1'	'S'	'I'	'S'	'W'	'0'	'1'	'3'	'1'	'c'	'7'

Command Receive

Device		Command				CRC16			
'0'	'1'	'S'	'I'	'S'	'W'	'b'	'3'	'c'	'5'

- The setpoint input selection written is 0x01 (0d1)

4.19. System Reset : SYRN

Name
SYRN

Purpose
Perform a soft reset of device.
Data Send (char): 0
Data Receive (char): 0

Data Send
void

Data Receive
void

Example
Command Send

Device		Command				CRC16			
'0'	'1'	'S'	'Y'	'R'	'N'	'2'	'c'	'0'	'4'

Command Receive

Device		Command				CRC16			
'0'	'1'	'S'	'Y'	'R'	'N'	'2'	'c'	'0'	'4'

4.20. Raw Adc Setpoint Read: RASR

Name
RASR

Purpose
Data from the setpoint ADC
Data Send (char): 0
Data Receive (char): 4

Data Send
void

Data Receive

Parameter	Type	Min	Max	Char	Notice
Raw Adc Setpoint	Uint16	0x0000 (0d0)	0x0FFF (0d4095)	0..3	1)

1) See section 'Computation of the digital I/O data'

Example
Command Send

Device		Command				CRC16			
'0'	'1'	'R'	'A'	'S'	'R'	'8'	'e'	'8'	'5'

Command Receive

Device		Command				Data				CRC16			
'0'	'1'	'R'	'A'	'S'	'R'	'0'	'7'	'7'	'f'	'f'	'3'	'6'	'1'

- The raw data read is 0x077f (0d1919).

4.21. Scaled Adc Setpoint Read: SASR

Name
SASR

Purpose
Read the analog input setpoint
Data Send (char): 0
Data Receive (char): 4

Data Send
void

Data Receive

Parameter	Type	Min	Max	Char	Notice
Scaled Adc Setpoint	Uint16	0x0000 (0d0)	0x0FFF (0d4095)	0..3	1)

1) See section 'Computation of the digital I/O data'

Example
Command Send

Device		Command				CRC16			
'0'	'1'	'S'	'A'	'S'	'R'	'7'	'2'	'8'	'4'

Command Receive

Device		Command				Data				CRC16			
'0'	'1'	'S'	'M'	'F'	'R'	'0'	'6'	'4'	'6'	'3'	'3'	'f'	'1'

- The analog input setpoint read is 0x0646 (0d1606).

4.22. Effective Setpoint Read: EFSR

Name
EFSR

Purpose
Read the last effective setpoint written
Data Send (char): 0
Data Receive (char): 4

Data Send
void

Data Receive

Parameter	Type	Min	Max	Char	Notice
Effective Setpoint	Uint16	0x0000 (0d0)	0x0FFF (0d4095)	0..3	1) 2)

1) See section 'Computation of the digital I/O data'
2) Depends on command 'CTRW' and 'SISW'

Example
Command Send

Device		Command				CRC16			
'0'	'1'	'E'	'F'	'S'	'R'	'f'	'b'	'3'	'1'

Command Receive

Device		Command				Data				CRC16			
'0'	'1'	'E'	'F'	'S'	'R'	'0'	'b'	'b'	'8'	'6'	'1'	'f'	'9'

- The effective setpoint read is 0x0bb8 (0d3000).

4.23. Raw DAC User Read: RDUR

Name
RDUR

Purpose
Data from the DAC user
Data Send (char): 0
Data Receive (char): 4

Data Send
void

Data Receive

Parameter	Type	Min	Max	Char	Notice
Raw DAC User	Uint16	0x0000 (0d0)	0x0FFF (0d4095)	0..3	1)

1) See section 'Computation of the digital I/O data'

Example
Command Send

Device		Command				CRC16			
'0'	'1'	'R'	'D'	'U'	'R'	'2'	'f'	'9'	'6'

Command Receive

Device		Command				Data				CRC16			
'0'	'1'	'R'	'D'	'U'	'R'	'0'	'a'	'2'	'8'	'2'	'd'	'5'	'6'

- The raw data read is 0x0a28 (0d2600).

4.24. Raw DAC User Write: RDUW

Name
RDUW

Purpose
Data to the DAC user
Data Send (char): 4
Data Receive (char): 0

Data Send

Parameter	Type	Min	Max	Char	Notice
Raw DAC User	Uint16	0x0000 (0d0000)	0x0FFF (0d4095)	0..3	1) 2)

1) See section 'Computation of the digital I/O data'
2) To use this command, the user must select the 'User' option in command 'AOSW'

Data Receive
void

Example
Command Send

Device		Command				Data				CRC16			
'0'	'1'	'R'	'D'	'U'	'W'	'0'	'7'	'd'	'0'	'5'	'b'	'4'	'4'

Command Receive

Device		Command				CRC16			
'0'	'1'	'R'	'D'	'U'	'W'	'2'	'c'	'5'	'6'

- The dac user written is 0x07d0 (0d2000)

4.25. Scaled DAC User Read: SDUR

Name
SDUR

Purpose
Data from the DAC user
Data Send (char): 0
Data Receive (char): 4

Data Send
void

Data Receive

Parameter	Type	Min	Max	Char	Notice
Scaled DAC User	Uint16	0x0000 (0d0)	0x0FFF (0d4095)	0..3	1)

1) See section 'Computation of the digital I/O data'

Example
Command Send

Device		Command				CRC16			
'0'	'1'	'S'	'D'	'U'	'R'	'd'	'3'	'9'	'7'

Command Receive

Device		Command				Data				CRC16			
'0'	'1'	'S'	'D'	'U'	'R'	'0'	'7'	'd'	'0'	'9'	'7'	'4'	'9'

- The scaled data read is 0x07d0 (0d2000).

4.26. Scaled DAC User Write: SDUW

Name
SDUW

Purpose
Data to the DAC user
Data Send (char): 4
Data Receive (char): 0

Data Send

Parameter	Type	Min	Max	Char	Notice
Scaled DAC User	Uint16	0x0000 (0d0000)	0x0FFF (0d4095)	0..3	1) 2)

1) See section 'Computation of the digital I/O data'
2) To use this command, the user must select the 'User' option in command 'AOSW'

Data Receive
void

Example
Command Send

Device		Command				Data				CRC16			
'0'	'1'	'S'	'D'	'U'	'W'	'0'	'9'	'6'	'0'	'3'	'4'	'd'	'9'

Command Receive

Device		Command				CRC16			
'0'	'1'	'S'	'D'	'U'	'W'	'd'	'0'	'5'	'7'

- The scaled data written is 0x0960 (0d2400)

4.27. Hardware Status Read : HWSR

Name
HWSR

Purpose
Read the status of the critical parts of the device.
Data Send (char): 0
Data Receive (char): 2

Data Send
void

Data Receive

Parameter	Type	Min	Max	Char	Notice
Hardware Status	Uint8	0x00 (0d0)	0xFF (0d255)	0..1	1)

1) bx00000000: No trouble
bx00000001: Control Saturation
bx00000010: Control Overload
bx00000100: Drive Voltage High
bx00001000: Drive Voltage Low
bx00010000: Reserved1
bx00100000: Reserved2
bx01000000: Reserved3
bx10000000: Reserved4

Example
Command Send

Device		Command				CRC16			
'0'	'1'	'H'	'W'	'S'	'R'	'5'	'2'	'6'	'3'

Command Receive

Device		Command				Data		CRC16			
'0'	'1'	'H'	'W'	'S'	'R'	'0'	'5'	'1'	'a'	'7'	'd'

- The hardware status read is 0x05 (0d5), 0b00000101
- That means: 'Control Saturation' and 'Drive Voltage High'

4.28. Raw Drive PWM Read : RDPR

Name
RDPR

Purpose
Read the raw drive PWM.
Data Send (char): 0
Data Receive (char): 4

Data Send
void

Data Receive

Parameter	Type	Min	Max	Char	Notice
Raw Drive PWM	Uint16	0x0000 (0d0)	0x0F9F (0d3999)	0..3	1)

1) See section 'Computation of the digital I/O data'

Example
Command Send

Device		Command				CRC16			
'0'	'1'	'R'	'D'	'P'	'R'	'7'	'f'	'9'	'5'

Command Receive

Device		Command				Data				CRC16			
'0'	'1'	'R'	'D'	'P'	'R'	'0'	'5'	'd'	'c'	'f'	'3'	'6'	'9'

- The raw data read is 0x05dc (0d1500).

4.29. Raw Analog Output Read: RAOR

Name
RAOR

Purpose
Data from the analog output ADC
Data Send (char): 0
Data Receive (char): 4

Data Send
void

Data Receive

Parameter	Type	Min	Max	Char	Notice
Raw Analog Output	Uint16	0x0000 (0d0)	0x0FFF (0d4095)	0..3	1)

1) See section 'Computation of the digital I/O data'

Example
Command Send

Device		Command				CRC16			
'0'	'1'	'R'	'A'	'O'	'R'	'4'	'e'	'8'	'd'

Command Receive

Device		Command				Data				CRC16			
'0'	'1'	'R'	'V'	'C'	'R'	'0'	'0'	'3'	'2'	'5'	'1'	'd'	'1'

- The raw data read is 0x0032 (0d50).

4.30. Scaled Analog Output Read: SAOR

Name
SAOR

Purpose
Read the analog output
Data Send (char): 0
Data Receive (char): 4

Data Send
void

Data Receive

Parameter	Type	Min	Max	Char	Notice
Scaled Analog Output	Uint16	0x0000 (0d0)	0x0FFF (0d4095)	0..3	1)

1) See section 'Computation of the digital I/O data'

Example
Command Send

Device		Command				CRC16			
'0'	'1'	'S'	'A'	'0'	'R'	'b'	'2'	'8'	'c'

Command Receive

Device		Command				Data				CRC16			
'0'	'1'	'S'	'A'	'0'	'R'	'0'	'0'	'3'	'0'	'5'	'c'	'9'	'1'

- The analog output read is 0x0030 (0d48).

4.31. Raw Drive Voltage Read: RDVR

Name
RDVR

Purpose
Data from the drive voltage ADC
Data Send (char): 0
Data Receive (char): 4

Data Send
void

Data Receive

Parameter	Type	Min	Max	Char	Notice
Raw Drive Voltage	Uint16	0x0000 (0d0)	0x0FFF (0d4095)	0..3	1)

1) See section 'Computation of the digital I/O data'

Example
Command Send

Device		Command				CRC16			
'0'	'1'	'R'	'D'	'V'	'R'	'd'	'f'	'9'	'6'

Command Receive

Device		Command				Data				CRC16			
'0'	'1'	'R'	'D'	'V'	'R'	'0'	'6'	'c'	'a'	'6'	'4'	'1'	'a'

- The raw data read is 0x06ca (01738).

4.32. Scaled Drive Voltage Read: SDVR

Name
SDVR

Purpose
Read the drive voltage
Data Send (char): 0
Data Receive (char): 4

Data Send
void

Data Receive

Parameter	Type	Min	Max	Char	Notice
Scaled Drive Voltage	Uint16	0x0000 (0d0)	0x0FFF (0d4095)	0..3	1)

1) See section 'Computation of the digital I/O data'

Example
Command Send

Device		Command				CRC16			
'0'	'1'	'S'	'D'	'V'	'R'	'2'	'3'	'9'	'7'

Command Receive

Device		Command				Data				CRC16			
'0'	'1'	'S'	'D'	'V'	'R'	'0'	'6'	'c'	'5'	'5'	'7'	'd'	'a'

- The analog output read is 0x06c5 (0d1733).

4.33. Raw Gas Temperature Read : RGTR

Name
RGTR

Purpose
Read raw data from the gas temperature sensor
Data Send (char): 0
Data Receive (char): 4

Data Send
void

Data Receive

Parameter	Type	Min	Max	Char	Notice
Raw GasTemperature	Uint16	0x0000 (0d0)	0xFFFF (0d±32767)	0..3	1)

1) See section 'Computation of the digital I/O data'

Example
Command Send

Device		Command				CRC16			
'0'	'1'	'R'	'G'	'T'	'R'	'b'	'b'	'6'	'7'

Command Receive

Device		Command				Data				CRC16			
'0'	'1'	'R'	'G'	'T'	'R'	'0'	'0'	'5'	'e'	'e'	'4'	'f'	'6'

- The raw gas temperature read is 0x005e (0d94).

4.34. Scaled Gas Temperature Read: SGTR

Name
SGTR

Purpose
Read scaled data from the gas temperature sensor
Data Send (char): 0
Data Receive (char): 4

Data Send
void

Data Receive

Parameter	Type	Min	Max	Char	Notice
Scaled Gas Temperature	Uint16	0x0000 (0d0)	0x0FFF (0d4095)	0..3	1)

1) See section 'Computation of the digital I/O data'

Example
Command Send

Device		Command				CRC16			
'0'	'1'	'S'	'G'	'T'	'R'	'4'	'3'	'6'	'6'

Command Receive

Device		Command				Data				CRC16			
'0'	'1'	'S'	'G'	'T'	'R'	'0'	'4'	'7'	'd'	'4'	'9'	'b'	'6'

- The scaled gas temperature read is 0x047d (0d1149).

4.35. Non-Volatile Memory Status Read: NMSR

Name
NMSR

Purpose
Read the status of the non-volatile memory.
Data Send (char): 0
Data Receive (char): 2

Data Send
void

Data Receive

Parameter	Type	Min	Max	Char	Notice
Non-Volatile Memory Status	Uint8	0x00 (0d0)	0x01 (0d1)	0..1	1)

1) 0x00: Nvm Incomplete
0x01: Nvm Complete

Example
Command Send

Device		Command				CRC16			
'0'	'1'	'N'	'M'	'S'	'R'	'1'	'd'	'4'	'2'

Command Receive

Device		Command				Data		CRC16			
'0'	'1'	'N'	'M'	'S'	'R'	'0'	'0'	'b'	'd'	'e'	'4'

- The non-volatile memory status read is 0x00 (0d0).

4.36. Non-Volatile Memory Status Write : NMSW

Name
NMSW

Purpose
Write the status of the non-volatile memory.
Data Send (char): 2
Data Receive (char): 0

Data Send

Parameter	Type	Min	Max	Char	Notice
Non-Volatile Memory Status	Uint8	0x00 (0d0)	0x01 (0d2)	0..1	1)

1) 0x00: Nvm Incomplete
0x01: Nvm Complete

Data Receive
void

Example
Command Send

Device		Command				Data		CRC16			
'0'	'1'	'N'	'M'	'S'	'W'	'0'	'1'	'7'	'c'	'3'	'5'

Command Receive

Device		Command				CRC16			
'0'	'1'	'N'	'M'	'S'	'W'	'1'	'e'	'8'	'2'

- The non-volatile memory status written is 0x01 (0d1).

4.37. Non-Volatile Memory Write Memory: NMWM

Name
NMWM

Purpose
Perform a non-volatile memory write (the control CTR must be disabled)
Data Send (char): 0
Data Receive (char): 0

Data Send
void

Data Receive
void

Example
Command Send

Device		Command				CRC16			
'0'	'1'	'N'	'M'	'W'	'M'	'1'	'5'	'0'	'1'

Command Receive

Device		Command				CRC16			
'0'	'1'	'N'	'M'	'W'	'M'	'1'	'5'	'0'	'1'

4.38. Calibration Read : CALR

Name
CALR

Purpose
Read calibration data
Data Send (char): 0
Data Receive (char): 184

Data Send
void

Data Receive

Parameter	Type	Min	Max	Char	Notice
Calibration Data				0..183	1)

1) See Annex for details.

4.39. Calibration Write: CALW

Name
CALW

Purpose
Write calibration data
Data Send (char): 184
Data Receive (char): 0

Data Send

Parameter	Type	Min	Max	Char	Notice
Calibration Data				0..183	1)

1) See Annex for details.

Data Receive
void

4.40. Configuration Read: CONR

Name
CONR

Purpose
Read configuration data
Data Send (char): 0
Data Receive (char): 200

Data Send
void

Data Receive

Parameter	Type	Min	Max	Char	Notice
Configuration Data				0..199	1)

1) See Annex for details.

4.41. Configuration Write: CONW

Name
CONW

Purpose
Write configuration data
Data Send (char): 200
Data Receive (char): 0

Data Send

Parameter	Type	Min	Max	Char	Notice
Configuration Data				0..199	1)

1) See Annex for details.

Data Receive
void

4.42. Identification Read: IDER

Name
IDER

Purpose
Read identification data
Data Send (char): 0
Data Receive (char): 114

Data Send
void

Data Receive

Parameter	Type	Min	Max	Char	Notice
Part Number	Char			0..12	
Suffix	Char			13..20	
Description	Char			21..52	
Serial Number	Char			53..74	
Device Address	Uint8	0x00 (0d0)	0xFF (0d255)	75..76	0x01 by default
SW Version	Char			77..85	
HW Version	Char			86..94	
Calibration Date	Char			95..108	1)
Device Gas	Uint8			109..110	1)
Device Full Scale	Uint16	0x0000 (0d0)	0xFFFF (0d65535)	111..114	
Device Unit	Unit8	0x00 (0d0)	0xFF (0d255)	115..116	1)
Pressure Reference	Unit16	0x0000 (0d0)	0xFFFF (0d65535)	117..120	mbar
Temperature Reference	Uint16	0x0000 (0d0)	0xFFFF (0d65535)	121..124	m°C
Calibration Gas	Uint8	0x00 (0d0)	0xFF (0d255)	125..126	1)
Calibration Pressure	Unit16	0x0000 (0d0)	0xFFFF (0d65535)	127..130	mbar
Calibration Temperature	Unit16	0x0000 (0d0)	0xFFFF (0d65535)	131..134	m°C
Full Scale Accuracy	Unit16	0x0000 (0d0)	0xFFFF (0d65535)	135..138	m%
Reading Accuracy	Unit16	0x0000 (0d0)	0xFFFF (0d65535)	139..142	m%

1) See Annex for details.

4.43. Identification Write: IDEW

Name
IDEW

Purpose
Write identification data
Data Send (char): 114
Data Receive (char): 0

Data Send

Parameter	Type	Min	Max	Char	Notice
Part Number	Char			0..12	
Suffix	Char			13..20	
Description	Char			21..52	
Serial Number	Char			53..74	
Device Address	Uint8	0x00 (0d0)	0xFF (0d255)	75..76	0x01
SW Version	Char			77..85	
HW Version	Char			86..94	
Calibration Date	Char			95..108	1)
Device Gas	Uint8			109..110	1)
Device Full Scale	Uint16	0x0000 (0d0)	0xFFFF (0d65535)	111..114	
Device Unit	Unit8	0x00 (0d0)	0xFF (0d255)	115..116	1)
Pressure Reference	Unit16	0x0000 (0d0)	0xFFFF (0d65535)	117..120	mbar
Temperature Reference	Uint16	0x0000 (0d0)	0xFFFF (0d65535)	121..124	m°C
Calibration Gas	Uint8	0x00 (0d0)	0xFF (0d255)	125..126	1)
Calibration Pressure	Unit16	0x0000 (0d0)	0xFFFF (0d65535)	127..130	mbar
Calibration Temperature	Unit16	0x0000 (0d0)	0xFFFF (0d65535)	131..134	m°C
Full Scale Accuracy	Unit16	0x0000 (0d0)	0xFFFF (0d65535)	135..138	m%
Reading Accuracy	Unit16	0x0000 (0d0)	0xFFFF (0d65535)	139..142	m%

1) See Annex for details.

Data Receive
void

4.44. Factory Password Write: FPWW

Name
FPWW

Purpose
Enter factory mode
Data Send (char): 8
Data Receive (char): 0

Data Send

Parameter	Type	Min	Max	Char	Notice
Factory Password	Uint32	0x00000000 (0d0)	0xFFFFFFFF (0d 4294967296)	0..7	1)

1) Only for factory calibration

Data Receive
void

Example
Command Send

Device		Command				Data				CRC16			
'0'	'1'	'S'	'D'	'U'	'W'	'0'	'9'	'6'	'0'	'3'	'4'	'd'	'9'

Command Receive

Device		Command				CRC16			
'0'	'1'	'S'	'D'	'U'	'W'	'd'	'0'	'5'	'7'

- The scaled data written is 0x0960 (0d2400)

4.45. Sensor Information Table Read: SITR

Name
SITR

Purpose
Read information about main sensor
Data Send (char): 0
Data Receive (char): 21

Data Send
void

Data Receive

Parameter	Type	Min	Max	Char	Notice
Sensor Type	Char			0..10	
Sensor ID	Char			11..12	
Sensor Week	Uint8	0x00 (0d0)	0xFF (0d0)	13..14	
Sensor Year	Uint8	0x00 (0d0)	0xFF (0d0)	15..16	
Sensor Sequence	Uint16	0x0000 (0d0)	0xFFFF (0d65535)	17..20	

1) The serial number includes Sensor ID, Week, Year and Sequence

Example
Command Send

Device		Command				CRC16			
'0'	'1'	'S'	'I'	'T'	'R'	'8'	'0'	'0'	'7'

Command Receive

Device		Command				Data	CRC16			
'0'	'1'	'S'	'I'	'T'	'R'	See below	'8'	'e'	'5'	'0'

- Data: 'LMIS500BB3SAD12120095'

4.46. Communication Reset: CRSN ('\n')

Name
CRSN

Purpose
Perform a communication reset.
Data Send (char): 0
Data Receive (char): 0

Data Send
void

Data Receive
void

Example
Command Send

Command
'\n'

Command Receive

Device		Command				CRC16			
'0'	'1'	'C'	'R'	'S'	'N'	'b'	'e'	'7'	'0'

5. Computation of the Digital I/O data

5.1. Mass Flow

There are two types of mass flow data: raw and scaled. The raw data are the raw values coming out from the embedded sensor used during the calibration process in production. The scaled data are the raw values after conversion, it represents **the mass flow rate.**

Command	Type of Data
MFSR	Scaled
MFSW	Scaled
RMFR	Raw (only use for production mode)
SMFR	Scaled

$$\text{Mass Flow} = \frac{(\text{Mass Flow FS} \cdot \text{Scaled Data})}{(\text{Digital FS})}$$

- Mass Flow: ls/min standard conditions 20°C, 1.013 bar, calibrated for Air
- Mass Flow Full Scale: ls/min standard conditions 20°C, 1.013 bar, calibrated for Air
- Scaled Data: command digital value
- Digital Full Scale: 4095

Example

The device is a 10 ls/min MFC. After sending the SMFR command (Scaled Mass Flow Read) the returned value is 2000. Thus, the mass flow is:

$$\text{Mass Flow} = \frac{10 \cdot 2000}{4095} = 4.884 \text{ ls/min}$$

5.2. Valve current

There are two types of valve current data: raw and scaled. The raw data are the raw values coming out from the embedded ADC used during the calibration process in production. The scaled data are the raw values after conversion, it represents **the current supplying the valve.**

Command	Type of Data
VCSR	Scaled
VCSW	Scaled
RVCR	Raw (only use for production mode)
SVCR	Scaled

$$\text{Valve Current} = \frac{\text{Valve Current FS} \cdot \text{Scaled Data}}{\text{(Digital FS)}}$$

- Valve Current: mA
- Valve Current Full Scale: 110 mA
- Scaled Data: command digital value
- Digital Full Scale: 4095

Example
After sending the SVCR command (Scaled Valve Current Read) the returned value is 1000. Thus, the valve current is:

$$\text{Valve Current} = \frac{110 \cdot 1000}{4095} = 26.9 \text{ mA}$$

5.3. Drive PWM

The raw data represents the **register value of the PWM duty cycle of the power drive supplying the valve.**

Command	Type of Data
DPSR	Raw
DPSW	Raw
RDPR	Raw

$$\text{Duty Cycle} = \frac{\text{Raw Data}}{\text{(Digital FS)}} \cdot 100$$

- Duty Cycle: %
- Raw Data: command digital value
- Digital Full Scale: 4000

Example
After sending the RDPR command (Raw Drive PWM Read) the returned value is 2500. Thus, the duty cycle is:

$$\text{Duty Cycle} = \frac{2500}{4000} \cdot 100 = 62.5\%$$

5.4. ADC Setpoint

There are two types of ADC setpoint data: raw and scaled. The raw data are the raw values coming out from the embedded ADC used during the calibration process in production. The scaled data are the raw values after conversion, it represents **the mass flow setpoint of the analog input.**

Command	Type of Data
RASR	Raw (only use for production mode)
SASR	Scaled

$$\text{Mass Flow Setpoint} = \frac{\text{Mass Flow FS} \cdot \text{Scaled Data}}{\text{(Digital FS)}}$$

- Mass Flow Setpoint: ls/min standard conditions 20°C, 1.013 bar, calibrated for Air
- Mass Flow Full Scale: ls/min standard conditions 20°C, 1.013 bar, calibrated for Air
- Scaled Data: command digital value
- Digital Full Scale: 4095

Example

The device is a 10 ls/min MFC. After sending the SASR command (Scaled ADC Setpoint Read) the returned value is 2000. Thus, the mass flow setpoint is:

$$\text{Mass Flow Setpoint} = \frac{10 \cdot 2000}{4095} = 4.884 \text{ ls/min}$$

5.5. Effective Setpoint

The read data gives the last setpoint sent by the user regardless of the command ‘CTRW’ and ‘SISW’. Thus, the nature of the setpoint can be:

- Mass Flow
- Valve Current
- Drive PWM
- Mass Flow Analog Input (ADC Setpoint)

To interpret the read data, see the information of the same chapter.

5.6. DAC User

There are two types of DAC user data: raw and scaled. The raw data are the raw values written to the embedded DAC used during the calibration process in production. The scaled data are the raw values after conversion, it represents **the voltage that the user wants to set at the analog output.**

Command	Type of Data
RDUR	Raw (only use for production mode)
RDUW	Raw (only use for production mode)
SDUR	Scaled
SDUW	Scaled

$$\text{Set Analog Output} = \frac{\text{Set Analog Output FS} \cdot \text{Scaled Data}}{\text{(Digital FS)}}$$

- Set Analog Output: V
- Set Analog Output Full Scale: 5 V
- Scaled Data: command digital value
- Digital Full Scale: 4095

Example
After sending the SDUW command (Scaled DAC User Write) with the value of 2000, the set output voltage is:

$$\text{Set Analog Output} = \frac{5 \cdot 2000}{4095} = 2.442 \text{ V}$$

5.7. Analog Output

There are two types of analog output data: raw and scaled. The raw data are the raw values coming out from the embedded ADC used during the calibration process in production. The scaled data are the raw values after conversion, it represents **the approximate voltage at the analog output.**

Command	**Type of Data**
RAOR	Raw (only use for production mode)
SAOR	Scaled

$$\text{Analog Output} = \frac{\text{Analog Output FS} \cdot \text{Scaled Data}}{\text{(Digital FS)}}$$

- Analog Output: V
- Analog Output Full Scale: 5.1 V
- Scaled Data: command digital value
- Digital Full Scale: 4095

Example
After sending the SAOR command (Scaled Analog Output Read) the returned value is 1500. Thus, the approximate output voltage is:

$$\text{Analog Output} = \frac{5.1 \cdot 1500}{4095} = 1.868 \text{ V}$$

5.8. Drive Voltage

There are two types of drive voltage data: raw and scaled. The raw data are the raw values coming out from the embedded ADC used during the calibration process in production. The scaled data are the raw values after conversion, it represents **the approximate voltage of the power drive.**

Command	Type of Data
RDVR	Raw (only use for production mode)
SDVR	Scaled

$$\text{Drive Voltage} = \frac{\text{Drive Voltage FS} \cdot \text{Scaled Data}}{\text{(Digital FS)}}$$

- Drive Voltage: V
- Drive Voltage Full Scale: 39.6 V
- Scaled Data: command digital value
- Digital Full Scale: 4095

Example
After sending the SDVR command (Scaled Drive Voltage Read) the returned value is 1768. Thus, the approximate output voltage is:

$$\text{Drive Voltage} = \frac{39.6 \cdot 1768}{4095} = 17.097 \text{ V}$$

5.9. Gas Temperature

There are two types of gas temperature data: raw and scaled. The raw data are the raw values coming out from the embedded sensor used during the calibration process in production. The scaled data are the raw values after conversion, it represents **the gas temperature.**

Command	Type of Data
RGTR	Raw (only use for production mode)
SGTR	Scaled

$$\text{Gas Temperature} = \frac{\text{Gas Temperature FS} \cdot \text{Scaled Data}}{\text{(Digital FS)}}$$

- Drive Voltage: °C
- Drive Voltage Full Scale: 81.9 °C
- Scaled Data: command digital value
- Digital Full Scale: 4095

Example
After sending the SGTR command (Scaled Gas Temperature Read) the returned value is 1800. Thus, the gas temperature is:

$$\text{Gas Temperature} = \frac{81.9 \cdot 1800}{4095} = 30\ °C$$

6. Troubleshooting

Following a master command, if an error occurs during communication, the device sends back an error code, designed by 'ERRN' describing the type of error with the following structure:

Error Receive

Device						Data		CRC16			
'0'	'1'	'E'	'R'	'R'	'N'	D0	D1	R0	R1	R2	R3

Data Receive

Parameter	Type	Min	Max	Char	Notice
Communication Error	Uint8	0x00 (0d0)	0x08 (0d8)	0..1	1)

1) 0x01: Error Device (wrong device number used, must be '01')
0x02: Error Command (command doesn't exist, wrong name)
0x03: Error CRC16 (the computation of the CRC16 is incorrect)
0x04: Error Integrity (number in hex format has an incorrect character: g, h, i…)
0x05: Error Range (the range of a number is out of bounds)
0x06: Error Rx Timeout (the master command takes too much time, max 1 sec)
0x07: Error Pass Word (wrong factory password)
0x08: Error Control Disable (operation not possible, because control disabled)
0x09: Error Control Enable (operation not possible, because control enabled)

Examples

Command Send

Device		Command				CRC16			
'0'	'2'	'S'	'I'	'S'	'R'	'b'	'0'	'4'	'1'

Error Receive

Device		Command				Data				CRC16			
'0'	'1'	'E'	'R'	'R'	'N'	'0'	'1'	'f'	'e'	'1'	'7'	'f'	'6'

- Error Device

Command Send

Device		Command				Data				CRC16			
'0'	'1'	'S'	'D'	'U'	'W'	'0'	'9'	**'z'**	'a'	'0'	'8'	'2'	'c'

Error Receive

Device		Command				Data		CRC16			
'0'	'1'	'E'	'R'	'R'	'N'	'0'	'4'	'f'	'd'	'b'	'1'

- Error Integrity

7. Scripts

7.1 Default State

The CHIPREG MFC can be used either through the analog setpoint (ADC) or the digital setpoint (RS232). After production calibration (or System Reset) the device default state is the following:

- CTRR: Mass Flow (Control in Mass Flow)
- CTLR: Slow PID (Controller in Slow PID)
- SISR: ADC (Analog Setpoint)
- AOSR: Mass Flow (Mass Flow on Analog Output)

7.2 Examples

7.2.1 Scenario1: Check the default state

The following examples starts from the default state.

Command Send	Command Receive
'01CTRRe690'	'01CTRR**02**5f78'
'01CTLR4699'	'01CTLR**02**777e'
'01SISRb005'	'01SISR**01**30d7'
'01AOSRc9e0'	'01AOSR**02**431c'

- Confirmed indicated in the previous section 'Default State'

7.2.2 Scenario2: Enter in digital mode for mass flow control

Command Send	Command Receive
'01SISW**02**3087'	'01SISWb3c5'
'01CTRW**02**5e68'	'01CTRWe550'
'01CTLW**02**766e'	'01CTLW4559'

- Enter in RS232 (digital) mode.
- Enter in mass flow control (if default state, already done)
- Enter in slow PID (if default state, already done)

7.2.3 Scenario3: Setpoint and mass flow reading

The following example starts from 7.2.2 example.
The range of the MFC is 10 l/min.

Command Send	Command Receive
'01MFSW**09c4**8144'	'01MFSW98f3'
'01SMFRe14a'	'01SMFR**09a6**a530'

- Setpoint at 0x09c4 (0d2500) 6.105 l/min
- Read value: 09a6 (0d2470) 6.032 l/min

8. Annex

8.1 Calibration Data Description

Parameter	Type	Char	Notice
floatNvmScaledAdcSetpointSlope	Uint32	0..7	Float32 Encoded
floatNvmScaledAdcSetpointOffset	Uint32	8..15	Float32 Encoded
floatNvmRawDac1Slope	Uint32	16..23	Float32 Encoded
floatNvmRawDac1Offset	Uint32	24..31	Float32 Encoded
int16NvmMflsBound[0]	Int16	32..35	
int16NvmMflsBound[1]	Int16	36..39	
int16NvmMflsBound[2]	Int16	40..43	
int16NvmMflsBound[3]	Int16	44..47	
int16NvmMflsBound[4]	Int16	48..51	
int16NvmMflsBound[5]	Int16	52..55	
floatNvmMflsMathFuncCoeff[0][0]	Uint32	56..63	Float32 Encoded
floatNvmMflsMathFuncCoeff[0][1]	Uint32	64..71	Float32 Encoded
floatNvmMflsMathFuncCoeff[0][2]	Uint32	72..79	Float32 Encoded
floatNvmMflsMathFuncCoeff[1][0]	Uint32	80..87	Float32 Encoded
floatNvmMflsMathFuncCoeff[1][1]	Uint32	88..95	Float32 Encoded
floatNvmMflsMathFuncCoeff[1][2]	Uint32	96..103	Float32 Encoded
floatNvmMflsMathFuncCoeff[2][0]	Uint32	104..111	Float32 Encoded
floatNvmMflsMathFuncCoeff[2][1]	Uint32	112..119	Float32 Encoded
floatNvmMflsMathFuncCoeff[2][2]	Uint32	120..127	Float32 Encoded
floatNvmMflsMathFuncCoeff[3][0]	Uint32	128..135	Float32 Encoded
floatNvmMflsMathFuncCoeff[3][1]	Uint32	136..143	Float32 Encoded
floatNvmMflsMathFuncCoeff[3][2]	Uint32	144..151	Float32 Encoded
floatNvmMflsMathFuncCoeff[4][0]	Uint32	152..159	Float32 Encoded
floatNvmMflsMathFuncCoeff[4][1]	Uint32	160..167	Float32 Encoded
floatNvmMflsMathFuncCoeff[4][2]	Uint32	168..175	Float32 Encoded
int16NvmMflsRawTemperatureReference	Int16	176..179	
int16NvmMflsScaledTemperatureReference	Int16	180..183	

8.2 Configuration Data Description

Parameter	Type	Char	Notice
floatNvmCtrlValveCurrentSlowPid[0]	Uint32	0..7	Float32 Encoded
floatNvmCtrlValveCurrentSlowPid[1]	Uint32	8..15	Float32 Encoded
floatNvmCtrlValveCurrentSlowPid[2]	Uint32	16..23	Float32 Encoded
floatNvmCtrlValveCurrentMediumPid[0]	Uint32	24..31	Float32 Encoded
floatNvmCtrlValveCurrentMediumPid[1]	Uint32	32..39	Float32 Encoded
floatNvmCtrlValveCurrentMediumPid[2]	Uint32	40..47	Float32 Encoded
floatNvmCtrlValveCurrentFastPid[0]	Uint32	48..55	Float32 Encoded
floatNvmCtrlValveCurrentFastPid[1]	Uint32	56..63	Float32 Encoded
floatNvmCtrlValveCurrentFastPid[2]	Uint32	64..71	Float32 Encoded
floatNvmCtrlMassFlowSlowPid[0]	Uint32	72..79	Float32 Encoded
floatNvmCtrlMassFlowSlowPid[1]	Uint32	80..87	Float32 Encoded
floatNvmCtrlMassFlowSlowPid[2]	Uint32	88..95	Float32 Encoded
floatNvmCtrlMassFlowMediumPid[0]	Uint32	96..103	Float32 Encoded
floatNvmCtrlMassFlowMediumPid[1]	Uint32	104..111	Float32 Encoded
floatNvmCtrlMassFlowMediumPid[2]	Uint32	112..119	Float32 Encoded
floatNvmCtrlMassFlowFastPid[0]	Uint32	120..127	Float32 Encoded
floatNvmCtrlMassFlowFastPid[1]	Uint32	128..135	Float32 Encoded
floatNvmCtrlMassFlowFastPid[2]	Uint32	136..143	Float32 Encoded
floatNvmCtrlValveCurrentUserPid[0]	Uint32	144..151	Float32 Encoded
floatNvmCtrlValveCurrentUserPid[1]	Uint32	152..159	Float32 Encoded
floatNvmCtrlValveCurrentUserPid[2]	Uint32	160..167	Float32 Encoded
floatNvmCtrlMassFlowUserPid[0]	Uint32	168..175	Float32 Encoded
floatNvmCtrlMassFlowUserPid[1]	Uint32	176..183	Float32 Encoded
floatNvmCtrlMassFlowUserPid[2]	Uint32	184..191	Float32 Encoded
uint8NvmSetpointInputSelection	Uint8	192..193	
uint8NvmControlType	Uint8	194..195	
uint8NvmControllerType	Uint8	196..197	
uint8NvmAnalogOutputDac1Selection	Uint8	198..199	
floatNvmMflsGasCoefficient	Uint32	200..207	Float32 Encoded

8.3 Identification Data Description

8.3.1 Date

		Example
Format:	YYYYMMDDHHMMSS	20190221153623
Year:	YYYY	2019
Month:	MM	02
Day:	DD	21
Hour:	HH	15
Minute:	MM	36
Second:	SS	23

8.3.2 Gas

Format: Uint8

Argon (Ar):	4
Air:	8
Nitrogen (N2):	13
Oxygen (O2):	15
Carbon Dioxide (CO2):	25

8.3.3 Unit

Format: Uint8

Standard litre per minute (ls/min): 1	(1013 mbar, 20°C)
Standard millilitre per minute (mls/min): 2	(1013 mbar, 20°C)
Normal litre per minute (ln/min): 3	(1013 mbar, 0°C)
Normal millilitre per minute (mln/min): 4	(1013 mbar, 0°C)

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