AFRecorder 2000A Serial Port Programming Interface Description for Versions 2.1 to 2.6

Background

The AFRecorder 2000 may be operated under remote control using a standard RS232 serial port. Available remote operating modes include two types of real-time data upload. For examples of remote control operation, try using the AFRemote (MS-DOS PC) software included with the AFRecorder.

The AFRecorder may not be operated both under remote control and "local" control at the same time. If AFRecorder operation is attempted using the front panel keypad while under remote control, the remote control operation will be terminated. Remote control commands are available to enable and disable the front panel keypad in order to avoid accidental termination of remote operation. To initiate remote control of the AFRecorder, a command is issued over the serial port. No operations using the front panel are necessary. The external computer may take control of the AFRecorder at any time except during initialization. The serial port parameters are 4800 baud, no parity, 8 data bits, 1 stop bit.

The AFRecorder stores setup and calibration data in an Electrically Erasable Programmable Read Only Memory (EEPROM). EEPROM values may be altered by the external computer, one at a time, using simple command strings along with the new value. New EEPROM values downloaded from the external computer do not affect the operation of the AFRecorder until an initialization is performed. An initialization is performed during power-on, if real-time data upload is requested, or if a recording session is started.

Data in the EEPROM is stored either as one byte "selections" or as four byte floating point "constants". An example of a "selection" is the choice of AFR units (1 = AFR, 2 = Phi, 3 = Lambda, 4 = %O2). The "constants" are values such as the sensor calibration constants. Changing these parameters using the external computer is equivalent to changing them using the front panel keypad.

The serial port remote control code in the AFRecorder was designed to be used with a PC as the external computer. A PC (Intel) stores multi-byte data types with the low byte first. The AFRecorder (Motorola) stores multi-byte data types with the high byte first. In order to make interfacing to a PC easier, the AFRecorder accepts multi-byte data included in download commands in Intel format. However, data uploaded from the AFRecorder to an external computer is in Motorola format. Therefore, a two byte checksum or a floating point number sent by the AFRecorder to a PC must undergo a byte reversal before use as shown in the code fragment below. In most applications, a serial port interrupt routine will be used to create a buffer of received characters. The data bytes may then be taken from the buffer and placed in the union variable in reversed order directly, so as to avoid the need for a "reversing" operation.

```
/* Code showing translation of an AFRecorder floating point data value to PC format */

typedef union {
    float fl;
    unsigned char uc[4];
} FloatData;
```

```
FloatData afrfloat;

unsigned char uchar;
          .
          .
          .
/* Assume that a floating point data value from the AFRecorder is contained in "afrfloat" */

uchar = afrfloat.uc[0];
afrfloat.uc[0] = afrfloat.uc[3];
afrfloat.uc[3] = uchar;
uchar = afrfloat.uc[1];
afrfloat.uc[1] = afrfloat.uc[2];
afrfloat.uc[2] = uchar;
          .
          .
          .
/* Use the data */
```

Serial Port Commands

When the AFRecorder is being operated under remote control, it is said to be "connected". When "connected", the AFRecorder LCD display will either show the AFR data (while in measure mode) or serial link information. Some commands, such as the status command, do not require "connection".

Many of the commands are acknowledged by the AFRecorder with a two byte code indicating that the command was correctly received. Some commands are not acknowledged since performance of the requested function may be used as an acknowledgement. For example, the command to start the uploading of real-time data is "acknowledged" by the presence or absence of the real-time data.

There are three serial port command formats: "Control", "Change Selection", and "Change Value".

Control Commands

A "Control" command to the AFRecorder consists of a header and the command number sent twice. A total of 7 bytes must be sent. There is no checksum sent with this type of command. Some Control commands require prior "connection" to the PC while others do not. The Control command format is:

<C8> <C8> <C8> <C8> <D9> <command> <command>

For example, command number 2, the "connect" command (initiate remote control of the AFRecorder), would be sent as:

<C8> <C8> <C8> <C8> <D9> <2> <2>.

The valid Control command numbers and their functions are as follows:

1: Upload status byte. Returns <status byte> <status byte>:

<A0> <A0> - Initializing
<A1> <A1> - Sensor warm-up period
<A2> <A2> - Measure mode
<A5> <A5> - Remote mode
<A6> <A6> - Recording

2: Start remote operation ("connect" command). This command is acknowledged by the AFRecorder sending <D0> <D0> (two bytes). This command should be issued first, before any other commands are used.

3: Disable keyboard operation. The keyboard will remain disabled until either Control command 4 or Control command 6 is received or the AFRecorder is switched off then on. This command is not acknowledged.

4: Enable keyboard operation. This command is not acknowledged.

6: Hard reset of AFRecorder (watchdog reset). This command is not acknowledged.

The following commands require prior "connection" (Control command 2):

7: Terminate remote operation and return to local mode ("disconnect" command). This command is acknowledged by the AFRecorder sending <D0> <D0> (two bytes).

8: Upload all current AFRecorder EEPROM selections. There are a total of 14 individual one byte selection values in the EEPROM. The 14 bytes of data are uploaded followed by a two byte (16 bit) checksum, for a total of 16 bytes. A listing of the function of the relevant EEPROM values is given below in the "Change Selection Command" section. Remember that the checksum value may have to be reversed before use.

9: Upload all current AFRecorder EEPROM constants. There are a total of 64 individual four byte floating point constant values in the EEPROM. The 256 bytes of data are uploaded followed by a two byte (16 bit) checksum, for a total of 258 bytes. A listing of the function of the relevant EEPROM values is given below in the "Change Value Command" section. Remember that the floating point data and checksum values may have to be reversed before use.

12: Start a recording session. This command is equivalent to placing the unit in measure mode and then pressing the "REC" button on the front panel. This command is acknowledged by the AFRecorder sending <D0> <D0> (two bytes) to the PC.

13: Upload all AFRecorder EEPROM selections corresponding to the last recording session. The response to this command is similar to command number 8.

14: Upload all AFRecorder EEPROM constants corresponding to the last recording session. The response to this command is similar to command number 9.

15: Upload number of recorded data points. The value is a single floating point number followed by a two byte checksum. If there is no recorded data, the AFRecorder will return a value of zero.

16: Upload translated recorded data. The data is sent in floating point format as:

<all AFR data> <checksum byte 1> <checksum byte 2>.

Be sure to upload the **recorded EEPROM selections and constants** before using this command, since the current EEPROM data and the data used for recording may be different. The total number of points recorded is available using command 15.

17: Set real-time data upload mode. This command prepares the AFRecorder for real-time mode. The data is sent as <C8> <C8> <C8> <C8> <AFR value> <checksum byte 1> <checksum byte 2>. The AFR data is uploaded in four byte floating point number format. Remember that the data and checksum values may have to be reversed before use. If the AFR data is invalid, one of the limit values is uploaded (see the instruction manual for limit values). This command prepares the AFRecorder for real-time data upload but does not start the data transfer. **Use Control command 19 to start the data transfer**.

There are two types of real-time data upload modes: "standard" and "fast". In standard mode, the data is averaged in the same way as the front panel display. In fast mode, the data is not averaged. The range of allowed data upload rates is from 0.24 to 60.0 seconds in standard mode, and 0.10 to 60.0 seconds in fast mode. Fast mode is selected by setting the "fast real-time" flag (Control command 21). The data rate is set using the "Change Value" command described below.

18: Halt real-time upload and return to idle state. This command is acknowledged by the AFRecorder sending <D0> <D0> (two bytes) to the PC.

19: Set real-time allowed flag (start/restart real-time data upload). Commands 19 and 20 may be used to temporarily suspend and restart real-time data upload without affecting other AFRecorder functions. These functions may be used to avoid buffer overflow problems in data acquisition or display programs. This command is not acknowledged.

20: Clear real-time allowed flag. This command temporarily suspends real-time data upload. This command is not acknowledged.

21: Set fast real-time flag. This command allows variable data upload rates from 0.10 seconds to 60.0 seconds.. The data uploaded in this mode is not averaged, but is a "snapshot" of the values at the time of data upload. For use, see Control command 17. This command is not acknowledged.

22: Clear fast real-time flag. This command is not acknowledged.

23: Reset AFRecorder. Equivalent to pressing the "SYS" key on the front panel during stand-alone operation. Will terminate a recording session. This command is not acknowledged.

Change Selection Command

A "Change Selection" command to the AFRecorder consists of a header, an index, and the one byte value sent twice. A total of 8 bytes must be sent. There is no checksum sent with this type of command. The index is an array index in the 14 byte selection list in the EEPROM. Any indices not listed below should **never** be changed by the external computer. The Change Selection command requires prior "connection" to the PC. Values successfully received by the AFRecorder are acknowledged by <D0> <D0>. A checksum failure is reported by <D1> <D1>.

The "Change Selection" command format is:

<C8> <C8> <C8> <C8> <DA> <index> <selection> <selection>

The valid index values and selections are:

Index	Function	Valid Values
4	Display units	1=AFR, 2=Phi, 3=Lambda, 4=%O2
5	Analog output units	1=AFR, 2=Phi, 3=Lambda, 4=%O2
6	Simulated EGO output units	1=AFR, 2=Phi, 3=Lambda
7	Display size for recording	1=Small, 2=Large
8	Display update rate	1=Slow, 2=Med, 3=Fast
9	LED alarm enable	0=Disabled, 1=Enabled
10	Buzzer alarm enable	0=Disabled, 1=Enabled
11	Buzzer/LED Alarm source	1=AFR, 2=Phi, 3=Lambda, 4=%O2
12	ICC (Incomplete combustion)	0=Disabled, 1=Enabled
13	Hydrogen fuel enable	0=Disabled, 1=Enabled
14	Key beeping enable	0=Disabled, 1=Enabled

Change Value Command

A "Change Value" command to the AFRecorder consists of a header, an index, the four byte floating point value and a two byte checksum. A total of 12 bytes must be sent. **Remember to present the floating point and checksum values to the AFRecorder in Intel format**. The index is considered an array index (float) in the 64 item selection list in the EEPROM. Any indices not listed below should **never** be changed by the external computer. The Change Value command requires prior "connection" to the PC. Values successfully received by the AFRecorder are acknowledged by <D0> <D0>. A checksum failure is reported by <D1> <D1>.

The "Change Value" command format is:

<C8> <C8> <C8> <C8> <DB> <index> <value 1> <value 2> <value 3> <value 4> <checksum 1> <checksum 2>.

The valid index values and allowed ranges for the data are:

Index	Function	Valid Values
	Real-time Data Rate	
43	Real-time data upload rate	0.10 to 60.0 sec.
	Fuel Constants	
28	Fuel H:C	1.0 to 10.0
29	Fuel O:C	0.0 to 1.0
30	Fuel N:C	0.0 to 1.0
	AFR Sensor Calibration Constants	
14	Sensor I_{O2}	0.01 to 1.0
15	Sensor I_{CO}	0.01 to 1.0
16	Sensor I_{H2}	0.01 to 1.0
17	Sensor I_1	0.10 to 5.0

18	Sensor I_2	-10.0 to 10.0
19	Sensor I_3	1.0 to 10.0
20	Sensor I_4	-2.0 to 5.0
21	Sensor I_5	-2.0 to 5.0
22	Sensor I_6	-2.0 to 5.0
23	Sensor I_7	-2.0 to 5.0
24	Sensor I_8	-2.0 to 5.0
25	Sensor I_9	-2.0 to 5.0
26	Sensor I_{10}	-2.0 to 5.0
27	Sensor I_{11}	-2.0 to 5.0
	Engine (User input) Calibration Constants	
36	ICC lean	0.0 to 10.0
37	ICC stoic	0.0 to 10.0
38	ICC rich	0.0 to 10.0
	Analog Output Constants	
55	AFR at 0.0V	0.0 to 100.0
56	AFR at 5.0V	0.0 to 100.0
57	Phi at 0.0V	0.0 to 4.0
58	Phi at 5.0V	0.0 to 4.0
59	Lambda at 0.0V	0.0 to 10.0
60	Lambda at 5.0V	0.0 to 10.0
61	%O2 at 0.0V	0.0 to 100.0
62	%O2 at 5.0V	0.0 to 100.0
63	%O2 for cal in air	18.0 to 25.0
	Simulated EGO Output Function	
39	Simulated EGO threshold (AFR)	0.0 to 90.0
40	Simulated EGO threshold (Phi)	0.0 to 10.0
41	Simulated EGO threshold (Lam.)	0.0 to 10.0
	Recording Functions	
44	Recording period (interval)	0.01 to 60 sec
45	Recording duration (minutes)	0 to 5000
46	Recording duration (seconds)	0 to 1000
	Alarm Functions	
47	AFR Alarm upper limit	0 to 100
48	AFR Alarm lower limit	0 to 100
49	Phi Alarm upper limit	0 to 100
50	Phi Alarm lower limit	0 to 100
51	Lambda Alarm upper limit	0 to 100
52	Lambda Alarm lower limit	0 to 100
53	%O2 Alarm upper limit	0 to 100
54	%O2 Alarm lower limit	0 to 100
	AFR Offset Value	
42	AFR offset	-2.0 to 2.0, AFR units