API Hessen Network Protocol
Revision C
June 24, 1998

Table of Contents

Introduction *1*

Hardware Configuration *2*
    Manual Mode Switch 2

Software Configuration..*3*
    Setting the Gas and Instrument ID Numbers 3
    Selecting the Concentration Units..3

Protocol Implementation *5*
  Message Overview *5*
    Binary Message Format...5
    Text Message Format...5
    Broadcast Mode..6
  Status Request and Response Messages...............................*6*
    Operational and Failure Status Bits 7
    Indicating Invalid Concentrations..7
    Status Response Concentration Field Format 7
    Status Response Message Format..7
    Old Status Response Message Format 9
    Additional Status Response Message Details 10
  Command Request Messages.. *10*
    Ignoring Command Requests 11
    Repeated Command Requests...11

Appendix A — Status Bit Assignments................................. *12*

Appendix B — Test Program.. *19*
  Configuring the Equipment *19*
  Running the Program.. *19*
  Sample Program Output *21*

List of Tables

Introduction

This document describes the Hessen network protocol revision C, as implemented in API's air pollution analyzers. This document is intended for use by end-users, although it may also help factory personnel to configure and test instruments containing the Hessen protocol. The Hessen protocol is not well defined, so API's implementation is likely to be different from other implementations.

A Hessen network typically consists of a *host computer* that monitors the status and controls the calibration of remote instruments, and one or more *remote instruments*. The terms host computer and remote instrument will be used throughout this document. Also, the remote instruments are regarded as slaves of the host computer, and only respond to commands from the host computer; remote instruments never initiate Hessen protocol messages.

The Hessen protocol is a multidrop protocol, in which several instruments are connected to a common communications channel. However, the implementation details of this multidrop bus are handled outside of the instruments. The instruments are unaware that they are connected to a multidrop bus, except that they respond only to commands containing their own unique ID number.

The Hessen protocol is designed to accomplish two things: to obtain the status of remote instruments, including the concentrations of all the gases measured; and to place remote instruments into zero or span calibration or measure mode. API's implementation supports both of these principal features.

Hardware Configuration

From the user's point of view, the RS-232 hardware on API's instruments supporting the Hessen protocol is no different from that on API's standard instruments. The RS-232 communication parameters are different, however, as shown in the table below.

RS-232 Communication Parameters for API Instruments		
Parameter	**Standard**	**Hessen**
Baud Rate	300-19200	1200
Data Bits	8	7
Stop Bits	1	2
Parity	None	Even
Duplex	Full	Half

There is currently no provision for modifying the RS-232 communications parameters used by the Hessen protocol software, so you must make sure that your equipment is compatible with the parameters in the table above.

Although the communication speed of the Hessen protocol is 1200 baud, the instrument software has a 200 ms. latency before it responds to commands issued by the host computer. This latency should present no problems, but you should be aware of it and not issue commands to the instrument too frequently.

Manual Mode Switch

Some of API's instruments that support the Hessen protocol are equipped with an extra switch on the front panel for disabling the execution of Hessen commands. In the Hessen protocol design documentation this switch is referred to as the *manual mode* switch. It is intended to be used by service personnel working on a remote instrument to inhibit the initiation of zero or span calibration by the host computer.

When this switch is on, calibration commands from the Hessen network are ignored, and a status bit (PSTAT_MANUAL) is set in the Hessen protocol status messages sent by the instrument to indicate that the instrument is in manual mode.

Not all of API's instruments that support the Hessen protocol have this switch, however. Even if the manual mode switch is not present, manual mode can still be invoked simply by placing the instrument in setup mode.

If the manual mode switch is installed in an AMX-based instrument, it must also be enabled by setting the appropriate bit in the *FACTORY_OPT* setup variable. Refer to the instrument's release notes for details on enabling the manual mode switch.

Software Configuration

There is little software configuration required in an API instrument supporting the Hessen protocol. Typically, all you have to do is assign each remote instrument a unique ID number, which is used by the host computer to identify the instrument and/or gas. Each remote instrument will only respond to commands that contain its own ID number; commands containing a different ID number are assumed to be for other instruments and are ignored.

Setting the Gas and Instrument ID Numbers

In instruments containing the Hessen protocol option, the instrument and the gases have separate ID numbers. To set the gas and instrument ID numbers, press **SETUP-MORE-COMM-ID** and enter a unique ID number for the instrument. Then, the analyzer will prompt you to enter a separate ID number for each gas.

The Hessen protocol supports only three digit ID numbers (i.e. 000-999), while some of API's instruments allow you to enter four digit ID numbers. Do not enter ID numbers larger than 999 or the Hessen protocol software may behave unpredictably.

The ID numbers within a single instrument need not be different since the instrument will respond to *any* of the ID numbers. But at least make sure that the ID numbers are different from those in any other instrument.

Selecting the Concentration Units

The Hessen protocol documentation specifies that the concentration be reported in status messages in one of two possible units, using a single operational status bit. Typically, the concentration is reported in either PPB or $\mu g/m^3$.

In response to customer requests, however, API's implementation of the protocol defines *two* status bits that can indicate four possible units. Consequently, the concentration is reported to the Hessen network in the currently selected instrument units, and the status bits of the message are set to indicate what units the concentration is in, as shown in the table below.

Operational Status Bits Indicating Concentration Units		
Bit 6 (0x4000)	**Bit 5 (0x2000)**	**Units**
0	0	$\mu g/m^3$
0	1	mg/m^3
1	0	PPB
1	1	PPM

The status bits shown in the table above were carefully selected to retain maximum compatibility with previous versions of the Hessen protocol that used only one bit to indicate the units. When the units are $\mu g/m^3$ or PPB, bit 6 has the same meaning as before, and bit 5 is zero, as before.

To select the instrument's concentration units, you would typically press **SETUP-RNGE-UNIT** or **SETUP-MISC-MORE-UNIT** and select one of the available units.

> ***You cannot select the concentration units using the Hessen protocol, since there is no command defined in the protocol to do this.***

Protocol Implementation

This section describes the details of the Hessen protocol in API's instruments. It is subdivided into three sections: an overview, status request and response messages, and command request messages.

Message Overview

The protocol supports three basic types of messages: status requests, status responses, and command requests. In all messages, printable characters (i.e. 'D,' 'A,' etc.) must be in upper case.

Binary Message Format

To ensure the integrity of messages transmitted over the network, all messages sent to or received from the instrument are formed into data packets consisting of a header character, a terminator character, and a *block check code*, as shown below.

```
<STX><message><ETX><BCC>
```

In the message above, and throughout this document, *<STX>* is the ASCII start-of-text character (ASCII code 2); *<ETX>* is the ASCII end-of-text character (ASCII code 3); and *<BCC>* is the block check code, which is a one-byte value, represented by two hexadecimal characters. For example, a block check code of 0x43 would appear in a message as the characters "43." (For non-programmers, *0x43* is the C language convention for denoting hexadecimal numbers.) The *<message>* field varies and each variation will be discussed below. Note that the < and > characters merely delimit the message fields and do not appear in the messages.

The block check code, from now on referred to as *BCC* is simply the exclusive-OR (XOR) of all of the bytes in the message, including the STX and ETX characters, formatted as two hexadecimal characters. For example, a fully formed status request message would look like this.

```
<STX>DA123<ETX>34
```

In the example above, the "34" at the end of the message is the BCC; the "123" is the instrument or gas ID number. This message format, with STX, ETX, and BCC, is referred to as *binary* format throughout the remainder of this document.

Text Message Format

In order to facilitate testing the protocol using a terminal, the protocol supports a *text* format for messages, which omits the STX, ETX, and BCC from the messages and responses, accepts a carriage return (CR) as the message terminator, and appends a CR to the responses so that they appear neatly on the terminal. If you make a mistake while typing a message, you can use the backspace key to correct it. (The backspace capability exists only in recent instruments.)

Note that the RS-232 interface operates in half duplex mode, so your terminal must be so configured in order to see the commands you are sending to the instrument. Also, your terminal must be configured to translate CR to CR-LF because the protocol software sends only a CR.

For example, the status request message above would be sent in text format as shown below.

```
DA123<CR>
```

The Hessen protocol software in the instruments automatically recognizes which format (binary or text) is being used and responds in the same mode. If you send a message in binary format, the instrument will respond in binary format; if you send a message in text format, the instrument will respond in text format. This sensing of the format occurs automatically on a message-by-message basis.

Broadcast Mode

Although it's not clear whether this feature is intended to be part of the Hessen protocol, the protocol supports a *broadcast mode*, in which messages may be sent by the host computer without an ID number. For instance, the message below requests the status from all the instruments on the network.

```
<STX>DA<ETX>04
```

Any instrument receiving this message will respond, even though it contains no ID number. This feature is most handy when using a terminal to test the Hessen protocol. Assuming you have a single instrument hooked up to the terminal, you can simply type the following to obtain the instrument's status.

```
DA<CR>
```

Or type the following to put the instrument into span calibration mode (see the section below titled *Command Request Messages* for detailed information on the commands).

```
ST K<CR>
```

Status Request and Response Messages

There is only one kind of status request message supported, as shown below.

```
<STX>DA<nnn><ETX><BCC>
```

This message is issued by the host computer and requests the current status, including the concentration and operational and failure status bits for each gas being measured. <nnn> is the instrument or gas ID number — the instrument will respond to its instrument ID or *any* of its gas ID numbers. The instrument always responds to status requests, regardless of what mode it's in.

Operational and Failure Status Bits

The protocol documentation distinguishes between operational status and failure status, and separates the two groups of status bits in the response messages. Generally, in the API implementation the operational status indicates things like whether the instrument is in calibration and the concentration units. The failure status indicates warning conditions. Usually, each failure status bit is associated with a warning message that is displayed on the instrument's front panel.

There is a special operational status bit named PSTAT_MANUAL in all of the API instruments that is set under the following conditions.

- When the manual mode switch is on and enabled in the instrument software.

- When the instrument is in manual calibration mode (i.e. calibration was initiated through the instrument's front panel).

- When the instrument is in setup or diagnostic mode.

Indicating Invalid Concentrations

API's instruments sometimes display "XXXX" instead of a concentration. This occurs, for example, during startup because the instrument doesn't have enough data to compute the concentration, or during transitions between calibration and measure mode. Displaying the concentration as "XXXX" indicates that it is invalid and unreliable.

Unfortunately, the Hessen protocol has no provision for indicating an invalid concentration. So to indicate an invalid concentration to the Hessen network, the API implementation sets an operational status bit called PSTAT_INV_CONC and sets the concentration to zero. Host computers should examine this operational status bit and, if set, discard the concentration.

Status Response Concentration Field Format

The numeric format of the concentration field in status response messages is a floating point format consisting of an arithmetic sign for the mantissa, four mantissa digits with an implied decimal point after the first digit, an arithmetic sign for the exponent, and two exponent digits — a total of eight characters.

For example, "+1234-56" is read as plus 1.234 times ten to the -56th power. The implied decimal point is to the right of the first mantissa digit, the "1" in the example above. As a more realistic example, a concentration of 400 (in any units) would be formatted as "+4000+02."

Status Response Message Format

The status response message has the following format. The underlined portion is repeated for each gas.

```
<STX>MD<aa><SP><nnn><SP><smmmmsee><SP><oo><SP><ff><SP>
<iii><SP>000000<SP><ETX><BCC>
```

The message is broken down from left to right into individual fields in the table below.

Status Response Message Fields		
Message Field	**Length (bytes)**	**Description**
<STX>	1	Start-of-text character.
MD	2	"MD" is the message header; it's unknown what it stands for.
<aa>	2	This is the number of gases being reported in the message; in an M200A it would appear as "03."
<SP>	1	Space character.
<nnn>	3	Three-digit gas ID number. This number is usually different for each gas.
<SP>	1	Space character.
<smmmmsee>	8	Gas concentration. The operational status bits PSTAT_UNITS indicate the units. See the section above for a description of the concentration format.
<SP>	1	Space character.
<oo>	2	8 operational status bits, formatted as a two digit hexadecimal number. These are fairly uniform for all instruments. See Appendix A for a complete list.
<SP>	1	Space character.
<ff>	2	8 failure status bits, formatted as a two digit hexadecimal number. These vary from one instrument to another. See Appendix A for a complete list.
<SP>	1	Space character.
<iii>	3	Three-digit instrument ID number. This number is usually different from the gas ID numbers.
<SP>	1	Space character.
000000	6	Spare field. Set to all zeros.
<SP>	1	Space character.
<ETX>	1	End-of-text character.
<BCC>	2	Block check code, formatted as a two digit hexadecimal number.
Total	**9 + 30 ´ G**	**'G' is the number of gases being reported in the message.**

For example, in an instrument supporting three gases, if the concentrations are 400, 380, and 20 PPB and the instrument is in measure mode and there are no failures or warnings present, the instrument would respond with the following message.

```
<STX>MD03 200 +4000+02 40 00 123 000000 201 +3800+02 40 00 123
000000 202 +2000+01 40 00 123 000000 <ETX>XX
```

In the above example, the fields that are repeated for each gas are underlined. The "200" is the ID number for the first gas; "201" is the ID for the second gas; and "202" is the ID for the third gas. "123" is the instrument ID, and is the same for all three gases. Also, the status bits (i.e. "40 00") are the same for all the gases, because there is just one instrument. "XX" represents the block check code. In a real message it would consist of hexadecimal digits.

Old Status Response Message Format

In single-gas instruments containing older versions of the Hessen protocol, the status response message has the following format.

```
<STX>MD01<SP><nnn><SP><smmmmsee><SP><oo><SP><ff><SP>0000000000
<SP><ETX><BCC>
```

The message is broken down from left to right into individual fields in the table below.

Old Status Response Message Fields		
Message Field	**Length (bytes)**	**Description**
<STX>	1	Start-of-text character.
MD	2	"MD" is the message header; it's unknown what it stands for.
01	2	"01" is the number of gases being reported in the message; in this message it's one.
<SP>	1	Space character.
<nnn>	3	Three-digit instrument ID number.
<SP>	1	Space character.
<smmmmsee>	8	Gas concentration. The operational status bits PSTAT_UNITS indicate the units. See the section above for a description of the concentration format.
<SP>	1	Space character.
<oo>	2	8 operational status bits, formatted as a two digit hexadecimal number. These are fairly uniform for all instruments. See Appendix A for a complete list.
<SP>	1	Space character.
<ff>	2	8 failure status bits, formatted as a two digit hexadecimal number. These vary from one instrument to another. See Appendix A for a complete list.
<SP>	1	Space character.
0000000000	10	Spare field. Set to all zeros.
<SP>	1	Space character.
<ETX>	1	End-of-text character.
<BCC>	2	Block check code, formatted as a two digit hexadecimal number.
Total	**39**	

For example, if the concentration is 400 PPB and the instrument is in measure mode and there are no failures or warnings present, the instrument would respond with the following message.

```
<STX>MD01 123 +4000+02 40 00 0000000000 <ETX>XX
```

Notice in the above example that the operational status bit field is "40." This indicates that the concentration is in units of PPB.

Additional Status Response Message Details

The Hessen protocol documentation states that the maximum length allowed for messages is 130 bytes. Since the status response messages are $9 + 30 \times G$ bytes long, where G is the number of gases, a single status response can contain data for up to four gases (i.e. (130 - 9) / 30 = 4). It's unclear how to format the response message if an instrument supports more than four gases.

In status response messages all of the operational and failure status bits except PSTAT_INV_CONC are the same for every gas because all the gases are measured by the same instrument. The PSTAT_INV_CONC status bit may be different for each reported concentration.

Command Request Messages

Hessen protocol command request messages are sent from the host computer to the remote instruments and have the following format.

```
<STX>ST<nnn><SP><c><ETX><BCC>
```

The "<c>" field is a single character that specifies the command to execute. The Hessen protocol documentation defines six different commands, as summarized in the table below.

Hessen Protocol Commands	
Command Character	**Description**
M	Go to measure mode (i.e. exit calibration mode).
N	Go to zero calibration mode.
K	Go to span calibration mode.
A[1]	Shut off power.
R[1]	Reset.
I[1]	Change filter.
[1] These commands are not supported in API instruments.	

The functions of the last three commands (A, R, and I) in the table above are not clearly explained in the Hessen protocol documentation, so they are not supported in any API instrument. The functions of the other commands are fairly obvious. For example, to put the remote instrument into zero calibration mode, the host computer would send the following command request message.

```
<STX>ST123 N<ETX>XX
```

In the above example, the instrument ID number is "123" and the command is "N," which initiates zero calibration. Also note the space between the ID number and the command. "XX" represents the block check code. In a real message it would consist of hexadecimal digits.

Unlike status request messages, there is no response to a command request message. The instrument simply executes the command, if able, and sets one of its status bits to reflect its new mode. Presumably, the host computer will follow each command request with a status request to verify that the new mode was invoked. For instance, if the host computer sends the command request,

```
<STX>ST123 N<ETX>XX
```

to initiate zero calibration, and then sends the status request,

```
<STX>DA123<ETX>XX
```

to obtain the instrument's status, the instrument will probably return a status response message similar to the following (assuming it's a single-gas instrument).

```
<STX>MD01 123 +0000+00 44 00 0000000000 <ETX>XX
```

Notice in the above status response that the operational status bits are "44." This indicates that the concentration is in units of PPB and that the instrument is in zero calibration mode.

Ignoring Command Requests

Hessen protocol calibration commands are ignored (status requests are still processed) under the following conditions.

- When the manual mode switch is on and enabled in the instrument software.

- When the instrument is in setup or diagnostic mode.

Repeated Command Requests

Although it's not stated in any of the Hessen documentation, in some networks command requests are issued repeatedly, in some cases as frequently as every five seconds. So instead of sending a single command to put a remote instrument into zero calibration, for example, the host computer keeps sending the command. Therefore, API's implementation of the Hessen protocol ignores repeated calibration commands, because in API instruments each new command message would reinitiate the calibration mode.

Appendix A — Status Bit Assignments

This appendix lists the status bit assignments for all of API's instruments. The operational status bits are somewhat defined by the Hessen protocol, but the failure status bits are fairly arbitrary and differ from one instrument to another.

M100 Hessen Protocol Status Bit Assignments		
Status Name	**Hex Bit**	**Description**
Failure status bits		
PSTAT_FLOW	0x0001	1 = any flow warning
PSTAT_LAMP	0x0002	1 = UV lamp intensity warning
PSTAT_HVPS	0x0004	1 = HVPS warning
PSTAT_CHOP	0x0008	1 = chopper warning
PSTAT_RCELL	0x0010	1 = reaction cell temperature warning
PSTAT_IZS	0x0020	1 = IZS temperature warning
	0x0040	spare
PSTAT_PMT	0x0080	1 = PMT temperature warning
Operational status bits		
PSTAT_OFF	0x0100	1 = instrument off
PSTAT_MANUAL	0x0200	1 = manual operation
PSTAT_ZERO_CAL	0x0400	1 = in zero calibration
PSTAT_SPAN_CAL	0x0800	1 = in span calibration
PSTAT_DIAG	0x1000	1 = in diagnostic mode
PSTAT_HOLD_OFF	0x2000	1 = in hold off mode
PSTAT_UNITS_PPM	0x4000	1 = PPM, 0 = $\mu g/m^3$
PSTAT_SAMPLE	0x8000	1 = sampling normally (DAS)

M100A Hessen Protocol Status Bit Assignments		
Status Name	**Hex Bit**	**Description**
Failure status bits		
PSTAT_FLOW	0x0001	1 = any flow warning
PSTAT_LAMP	0x0002	1 = UV lamp intensity warning
PSTAT_HVPS	0x0004	1 = HVPS warning
PSTAT_SHUTTER	0x0008	1 = shutter warning
PSTAT_RCELL	0x0010	1 = reaction cell temperature warning
PSTAT_IZS	0x0020	1 = IZS temperature warning
PSTAT_PMT	0x0040	1 = PMT temperature warning
PSTAT_INV_CONC	0x0080	1 = invalid concentration (the instrument's front panel display will show the concentration as "XXXX")
Operational status bits		
PSTAT_OFF	0x0100	1 = instrument off

PSTAT_MANUAL	0x0200	1 = manual operation
PSTAT_ZERO_CAL	0x0400	1 = in zero calibration
PSTAT_SPAN_CAL	0x0800	1 = in span calibration
	0x1000	spare
PSTAT_UNITS	0x4000, 0x2000	0x0000 = $\mu g/m^3$, 0x2000 = mg/m^3, 0x4000 = PPB, 0x6000 = PPM
	0x8000	spare

M100A-AMX Hessen Protocol Status Bit Assignments		
Status Name	**Hex Bit**	**Description**
Failure status bits		
PSTAT_FLOW	0x0001	1 = any flow warning
PSTAT_LAMP	0x0002	1 = UV lamp intensity warning
PSTAT_HVPS	0x0004	1 = HVPS warning
PSTAT_SHUTTER	0x0008	1 = shutter warning
PSTAT_RCELL	0x0010	1 = reaction cell temperature warning
PSTAT_IZS	0x0020	1 = IZS temperature warning
PSTAT_PMT	0x0040	1 = PMT temperature warning
PSTAT_INV_CONC	0x0080	1 = invalid concentration (the instrument's front panel display will show the concentration as "XXXX")
Operational status bits		
PSTAT_OFF	0x0100	1 = instrument off
PSTAT_MANUAL	0x0200	1 = manual operation
PSTAT_ZERO_CAL	0x0400	1 = in zero calibration
PSTAT_SPAN_CAL	0x0800	1 = in span calibration
	0x1000	spare
PSTAT_UNITS	0x4000, 0x2000	0x0000 = $\mu g/m^3$, 0x2000 = mg/m^3, 0x4000 = PPB, 0x6000 = PPM
	0x8000	spare

M101A Hessen Protocol Status Bit Assignments		
Status Name	**Hex Bit**	**Description**
Failure status bits		
PSTAT_SAMP_FLOW	0x0001	1 = sample flow warning
PSTAT_UV_LAMP	0x0002	1 = UV lamp intensity warning
PSTAT_SHUTTER	0x0004	1 = dark shutter warning
PSTAT_BOX_TEMP	0x0008	1 = internal box temperature warning
PSTAT_RCELL_TEMP	0x0010	1 = reaction cell temperature warning
PSTAT_IZS_TEMP	0x0020	1 = IZS temperature warning
PSTAT_PMT_TEMP	0x0040	1 = PMT temperature warning
PSTAT_CONV_TEMP	0x0080	1 = converter temperature warning

Operational status bits		
PSTAT_OFF	0x0100	1 = instrument off
PSTAT_MANUAL	0x0200	1 = manual operation
PSTAT_ZERO_CAL	0x0400	1 = in zero calibration
PSTAT_SPAN_CAL	0x0800	1 = in span calibration
PSTAT_WARMUP	0x1000	1 = in warm up mode (for 15 minutes after powering up)
PSTAT_UNITS	0x4000, 0x2000	0x0000 = $\mu g/m^3$, 0x2000 = mg/m^3, 0x4000 = PPB, 0x6000 = PPM
PSTAT_INV_CONC	0x8000	1 = invalid concentration (the instrument's front panel display will show the concentration as "XXXX")

M101A-AMX Hessen Protocol Status Bit Assignments		
Status Name	**Hex Bit**	**Description**
Failure status bits		
PSTAT_FLOW	0x0001	1 = any flow warning
PSTAT_LAMP	0x0002	1 = UV lamp intensity warning
PSTAT_SHUTTER	0x0004	1 = dark shutter warning
PSTAT_BOX	0x0008	1 = internal box temperature warning
PSTAT_RCELL	0x0010	1 = reaction cell temperature warning
PSTAT_IZS	0x0020	1 = IZS temperature warning
PSTAT_PMT	0x0040	1 = PMT temperature warning
PSTAT_CONV	0x0080	1 = converter temperature warning
Operational status bits		
PSTAT_OFF	0x0100	1 = instrument off
PSTAT_MANUAL	0x0200	1 = manual operation
PSTAT_ZERO_CAL	0x0400	1 = in zero calibration
PSTAT_SPAN_CAL	0x0800	1 = in span calibration
PSTAT_WARMUP	0x1000	1 = in warm up mode (for 15 minutes after powering up)
PSTAT_UNITS	0x4000, 0x2000	0x0000 = $\mu g/m^3$, 0x2000 = mg/m^3, 0x4000 = PPB, 0x6000 = PPM
PSTAT_INV_CONC	0x8000	1 = invalid concentration (the instrument's front panel display will show the concentration as "XXXX")

M200A Hessen Protocol Status Bit Assignments		
Status Name	**Hex Bit**	**Description**
Failure status bits		
PSTAT_SAMP_FLOW	0x0001	1 = sample flow warning
PSTAT_OZONE_FLOW	0x0002	1 = ozone flow warning

PSTAT_RCELL_PRESS	0x0004	1 = reaction cell pressure warning
PSTAT_BOX_TEMP	0x0008	1 = internal box temperature warning
PSTAT_RCELL_TEMP	0x0010	1 = reaction cell temperature warning
PSTAT_IZS_TEMP	0x0020	1 = IZS temperature warning
PSTAT_PMT_TEMP	0x0040	1 = PMT temperature warning
PSTAT_CONV_TEMP	0x0080	1 = converter temperature warning
Operational status bits		
PSTAT_OFF	0x0100	1 = instrument off
PSTAT_MANUAL	0x0200	1 = manual operation
PSTAT_ZERO_CAL	0x0400	1 = in zero calibration
PSTAT_SPAN_CAL	0x0800	1 = in span calibration
PSTAT_WARMUP	0x1000	1 = in warm up mode (for 15 minutes after powering up)
PSTAT_UNITS	0x4000, 0x2000	$0x0000 = \mu g/m^3$, $0x2000 = mg/m^3$, 0x4000 = PPB, 0x6000 = PPM
PSTAT_INV_CONC	0x8000	1 = invalid concentration (the instrument's front panel display will show the concentration as "XXXX")

M200A-AMX Hessen Protocol Status Bit Assignments		
Status Name	**Hex Bit**	**Description**
Failure status bits		
PSTAT_SFLOW	0x0001	1 = sample flow warning
PSTAT_OFLOW	0x0002	1 = ozone flow warning
PSTAT_RCPRESS	0x0004	1 = reaction cell pressure warning
PSTAT_BOX	0x0008	1 = internal box temperature warning
PSTAT_RCTEMP	0x0010	1 = reaction cell temperature warning
PSTAT_IZS	0x0020	1 = IZS temperature warning
PSTAT_PMT	0x0040	1 = PMT temperature warning
PSTAT_CONV	0x0080	1 = converter temperature warning
Operational status bits		
PSTAT_OFF	0x0100	1 = instrument off
PSTAT_MANUAL	0x0200	1 = manual operation
PSTAT_ZERO_CAL	0x0400	1 = in zero calibration
PSTAT_SPAN_CAL	0x0800	1 = in span calibration
PSTAT_WARMUP	0x1000	1 = in warm up mode (for 15 minutes after powering up)
PSTAT_UNITS	0x4000, 0x2000	$0x0000 = \mu g/m^3$, $0x2000 = mg/m^3$, 0x4000 = PPB, 0x6000 = PPM
PSTAT_INV_CONC	0x8000	1 = invalid concentration (the instrument's front panel display will show the concentration as "XXXX")

M300 Hessen Protocol Status Bit Assignments		
Status Name	**Hex Bit**	**Description**
Failure status bits		
PSTAT_SOURCE	0x0001	1 = source warning
PSTAT_BOX	0x0002	1 = box temperature warning
PSTAT_BENCH	0x0004	1 = bench temperature warning
PSTAT_WHEEL	0x0008	1 = wheel temperature warning
PSTAT_STEMP	0x0010	1 = sample temperature warning
PSTAT_PRESS	0x0020	1 = any pressure warning
PSTAT_FLOW	0x0040	1 = any flow warning
PSTAT_INV_CONC	0x0080	1 = invalid concentration (the instrument's front panel display will show the concentration as "XXXX")
Operational status bits		
PSTAT_OFF	0x0100	1 = instrument off
PSTAT_MANUAL	0x0200	1 = manual operation
PSTAT_ZERO_CAL	0x0400	1 = in zero calibration
PSTAT_SPAN_CAL	0x0800	1 = in span calibration
	0x1000	spare
PSTAT_UNITS	0x4000, 0x2000	$0x0000 = \mu g/m^3$, $0x2000 = mg/m^3$, $0x4000 = PPB$, $0x6000 = PPM$
	0x8000	spare

M300-AMX Hessen Protocol Status Bit Assignments		
Status Name	**Hex Bit**	**Description**
Failure status bits		
PSTAT_SOURCE	0x0001	1 = source warning
PSTAT_BOX	0x0002	1 = box temperature warning
PSTAT_BENCH	0x0004	1 = bench temperature warning
PSTAT_WHEEL	0x0008	1 = wheel temperature warning
PSTAT_STEMP	0x0010	1 = sample temperature warning
PSTAT_PRESS	0x0020	1 = any pressure warning
PSTAT_FLOW	0x0040	1 = any flow warning
PSTAT_INV_CONC	0x0080	1 = invalid concentration (the instrument's front panel display will show the concentration as "XXXX")
Operational status bits		
PSTAT_OFF	0x0100	1 = instrument off
PSTAT_MANUAL	0x0200	1 = manual operation
PSTAT_ZERO_CAL	0x0400	1 = in zero calibration
PSTAT_SPAN_CAL	0x0800	1 = in span calibration
	0x1000	spare
PSTAT_UNITS	0x4000,	$0x0000 = \mu g/m^3$, $0x2000 = mg/m^3$,

	0x2000	0x4000 = PPB, 0x6000 = PPM
	0x8000	spare

M400 Hessen Protocol Status Bit Assignments		
Status Name	**Hex Bit**	**Description**
Failure status bits		
PSTAT_SFLOW	0x0001	1 = sample flow warning
PSTAT_ALAMP	0x0002	1 = analyzer lamp intensity warning
PSTAT_SPRESS	0x0004	1 = sample pressure warning
PSTAT_STEMP	0x0008	1 = sample temperature warning
PSTAT_O3REF	0x0010	1 = O_3 generator reference detector warning
PSTAT_OLAMP	0x0020	1 = O_3 generator lamp intensity warning
PSTAT_LTEMP	0x0040	1 = O_3 generator lamp or analyzer lamp temperature warning
	0x0080	spare
Operational status bits		
PSTAT_OFF	0x0100	1 = instrument off
PSTAT_MANUAL	0x0200	1 = manual operation
PSTAT_ZERO_CAL	0x0400	1 = in zero calibration
PSTAT_SPAN_CAL	0x0800	1 = in span calibration
	0x1000	spare
PSTAT_UNITS	0x4000, 0x2000	0x0000 = $\mu g/m^3$, 0x2000 = mg/m^3, 0x4000 = PPB, 0x6000 = PPM
PSTAT_INV_CONC	0x8000	1 = invalid concentration (the instrument's front panel display will show the concentration as "XXXX")

M400-AMX Hessen Protocol Status Bit Assignments		
Status Name	**Hex Bit**	**Description**
Failure status bits		
PSTAT_SFLOW	0x0001	1 = sample flow warning
PSTAT_ALAMP	0x0002	1 = analyzer lamp intensity warning
PSTAT_SPRESS	0x0004	1 = sample pressure warning
PSTAT_STEMP	0x0008	1 = sample temperature warning
PSTAT_O3REF	0x0010	1 = O_3 generator reference detector warning
PSTAT_OLAMP	0x0020	1 = O_3 generator lamp intensity warning
PSTAT_LTEMP	0x0040	1 = O_3 generator lamp or analyzer lamp temperature warning
	0x0080	spare

Operational status bits		
PSTAT_OFF	0x0100	1 = instrument off
PSTAT_MANUAL	0x0200	1 = manual operation
PSTAT_ZERO_CAL	0x0400	1 = in zero calibration
PSTAT_SPAN_CAL	0x0800	1 = in span calibration
	0x1000	spare
PSTAT_UNITS	0x4000, 0x2000	0x0000 = $\mu g/m^3$, 0x2000 = mg/m^3, 0x4000 = PPB, 0x6000 = PPM
PSTAT_INV_CONC	0x8000	1 = invalid concentration (the instrument's front panel display will show the concentration as "XXXX")

M400A-AMX Hessen Protocol Status Bit Assignments		
Status Name	**Hex Bit**	**Description**
Failure status bits		
PSTAT_SFLOW	0x0001	1 = sample flow warning
PSTAT_ALAMP	0x0002	1 = analyzer lamp intensity warning
PSTAT_SPRESS	0x0004	1 = sample pressure warning
PSTAT_STEMP	0x0008	1 = sample temperature warning
PSTAT_O3REF	0x0010	1 = O_3 generator reference detector warning
PSTAT_OLAMP	0x0020	1 = O_3 generator lamp intensity warning
PSTAT_LTEMP	0x0040	1 = O_3 generator lamp or analyzer lamp temperature warning
	0x0080	spare
Operational status bits		
PSTAT_OFF	0x0100	1 = instrument off
PSTAT_MANUAL	0x0200	1 = manual operation
PSTAT_ZERO_CAL	0x0400	1 = in zero calibration
PSTAT_SPAN_CAL	0x0800	1 = in span calibration
	0x1000	spare
PSTAT_UNITS	0x4000, 0x2000	0x0000 = $\mu g/m^3$, 0x2000 = mg/m^3, 0x4000 = PPB, 0x6000 = PPM
PSTAT_INV_CONC	0x8000	1 = invalid concentration (the instrument's front panel display will show the concentration as "XXXX")

Appendix B — Test Program

In order to test the operation of the Hessen protocol in an API instrument, an automated test program has been provided. This program is available for two operating system platforms, as summarized in the table below.

Test Program Supported Operating Systems	
Program Name	**Supported Operating Systems**
HTEST16.EXE	DOS, Windows 3.1, Windows 95/98
HessenTest32.exe	Windows 95/98, Windows NT

Configuring the Equipment

In order to use this test program you need an analyzer containing the Hessen protocol revision C, a PC with a 386 or higher CPU running DOS or Windows, and an RS-232 cable.

Connect one end of the serial cable to one of the PC's COM ports, and connect the other end of the cable to the Hessen port on the analyzer. This test program does *not* support multidrop configurations. This is because the program tests protocol commands that do not include the instrument ID number, and such commands cannot be used in a multidrop configuration.

On the analyzer front panel press **SETUP-MORE-COMM**. Press **BAUD** to set the analyzer's baud rate. Press **ID** to change the analyzer or gas ID number.

You should also make sure that the Hessen protocol is enabled. Press **SETUP-MORE-VARS-ENTR**. Repeatedly press **NEXT** to scroll to the *RS232_MODE* variable. It should be set to 19; if it's not, then press **EDIT** and change it to 19, and then power cycle the analyzer.

Running the Program

The program is a command line program, so it's best to execute it from a DOS window if you're running Windows. Sophisticated users can create an icon in Windows that executes the test program with the appropriate command line options.

Execute one of the two programs shown in the table above. If you don't specify any options, the program begins testing using the default options. To obtain a listing of the program options without executing the program, type the command "HessenTest32 -?" or "HTEST16 -?". This command will produce the following printout.

```
Description:
  This program tests the implementation of the Hessen Protocol,
Rev C
  in an API instrument that has the Hessen option installed.
Usage: HessenTest32 [options]
Options (* = default value):
  -?|-h          print this usage information
  -q             quiet; skip interactive tests and prompts
```

```
   -vn             verbose level (1*, 0 = no output, 9 = maximum
output)
   -ln             command delay (ms.) (500*)
   -tn             communications timeout (ms.) (2000*)
   -cn             comm. port (1 = COM1, 2* = COM2)
   -bnnnn          baud rate (300, 1200*, 2400, 4800, 9600, 19200)
   -pn             N = no parity, O = odd, E* = even
   -dn             7* or 8 data bits
   -sn             1* or 2 stop bits
   -o              old status message format (no instrument ID in
spare field)
Return codes:
   0 = all tests passed
   1 = command line argument error
   2 = one or more tests failed
```

The most important thing you must do in order to make the program work is connect the serial cable to the correct COM port on the PC, and specify the correct baud rate. The first time you run the test program, you should run it in *non-interactive* mode by including the "-q" option on the command line. If all the tests pass when this option is turned on, then you can re-run the test program with all the tests enabled by omitting the "-q" option. The table below describes all of the program options in more detail.

Test Program Options			
Option[1]	**Description**	Default Setting	Example
-? -H	Print usage information without executing the program.	—	-? -H
-Q	Skip interactive tests and prompts. Useful for executing program in a batch file. (See description of program return codes.)	interactive mode	-Q
-Vn	Specify amount of detail in test program printouts (0 = no output, 9 = maximum output). Settings above 1 are primarily for debugging purposes.	1	-V0
-Ln	Specify how much time (ms.) to allow the analyzer to execute commands such as initiating calibration. Time must be from 100–10000 ms.	500	-L1000
-Tn	Specify how much time (ms.) to wait for responses from analyzer. Time must be from 1000–10000 ms.	2000	-T5000
-Cn	Specify which communications port to use on the PC. (1 = COM1, 2 = COM2).	2	-C1
-Bn	Specify the communications baud rate	1200	-B19200

	(must match that of the analyzer). Only 300[3], 1200, 2400, 4800, 9600, and 19200 are allowed.		
-Pn[2]	Specify parity mode for communications channel. Only N, O, and E are allowed.	E	-PN
-Dn[2]	Specify number of data bits for communications channel. Only 7 and 8 are allowed.	7	-D8
-Sn[2]	Specify number of stop bits for communications channel. Only 1 and 2 are allowed.	1	-S2
-O	Analyzer uses the old status message format that doesn't include the instrument ID number in the spare field. This option is for compatibility with analyzers containing the old Hessen protocol (i.e. prior to revision C).	new message format	-O

[1] You may use '/' instead of '-' to specify a command line option.
[2] Currently the Hessen protocol in the analyzers is fixed at even parity, 7 data bits, and 1 stop bit. This option is for future use.
[3] At 300 baud, you may need to increase the communications timeout (-T).

The table below lists the codes that the program returns to the operating system when it executes. The codes may be checked in a batch file using the DOS *ERRORLEVEL* statement.

Test Program Return Codes	
Code	**Description**
0	All tests passed.
1	Command line argument error.
2	One or more tests failed.

Sample Program Output

If you run the program in non-interactive mode, it produces output similar to the following.

```
Testing ID 422 ...
  Uncoded status request without using ID number...passed.
  Uncoded status request using ID number...passed.
  Coded status request without using ID number...passed.
  Coded status request using ID number...passed.
  Zero calibration using ID number...passed.
  Span calibration using ID number...passed.
  Transitions between zero and span calibration...passed.
  Invalid commands...passed.
  Error detection on transmitted messages...passed.
```

```
   Error detection on received messages...passed.
   Using incorrect ID numbers...passed.

Test results for ID 422:
   All tests passed.
```

Notice that a series of tests are run and the result of each test is printed as "passed" or "failed." The instrument ID number (422 in the above example) is also displayed so you can verify that program is communicating with the correct instrument.