SmarTek Acoustic Sensor - Version 1 (SAS-1)

Installation and Setup Guide

Part-G
SAS-1 Detailed Communication Formats

04 April 2003

Note: In all cases, do not work or position equipment over an active traffic lane. Working over active lanes presents a hazard to the installer and to travelers using the highway. Follow local authorized procedures when installing the SAS-1 unit and any associated components or subsystems.

Sensing and System Integration Solutions

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Detailed SAS-1 Communication Message Formats

This document lists and describes in detail the entire set of SAS-1 messaging formats.
Every effort has been made to ensure the accuracy of the document relative to SAS-1 capability
and operation.

Command to SAS-1: Traffic Acoustic Image Reporting (SAS Monitor Mode=1)

    <ESC>{SASxxxx,BTR=Strt_LD,No_LDs,LD_Step}

All parameters are offset by +32 (20 Hex) and <ESC> is ASCii character 27.

SASxxxx	(ASCII)	SAS-1 Identification (xxxx=0000 to 9999)
Strt_LD	(Byte)	Starting look direction
No_LDs	(Byte)	Number of look direction to send out
LD_Step	(Byte)	LD step size relative to 181

SAS-1 Response:

    Chr(2)<Data Packet-No_LDs bytes long><5 bytes Avg Pk Val><5 bytes Veh Cnt>
        <5 bytes Veh Spd><5 bytes Op Sens>Chr(3)

    Each byte in packet is offset by +32 (20 Hex).

Command to SAS-1: Traffic Flow Measurement Reporting (SAS Monitor Mode=2, 4,6, 7)

    <ESC>{SASxxxx,FLOW=Comm_Mode,Mess_Format}

All parameters are offset by +32 (20 Hex) and <ESC> is ASCii character 27.

Comm_Mode (Byte) =1 for Polled, =2 for Periodic
Mess_Format (Byte) =0 or 1 for Simple Flow, 2 for Flow with Truck Count

SAS-1 Response (Mess_Format=0,1):

Chr(2)SASxxxx<sp>PPP<sp>LL<sp>VVV<sp>OOO<sp>SSSS<CR><LF>	(Lane 1 data)
LL<sp>VVV<sp>OOO<sp>SSSS<CR><LF>	(Lane 2 data)
LL<sp>VVV<sp>OOO<sp>SSSS<CR><LF>	(Lane 3 data)
LL<sp>VVV<sp>OOO<sp>SSSS<CR><LF>	(Lane 4 data)
LL<sp>VVV<sp>OOO<sp>SSSS<CR><LF>Chr(3)	(Lane 5 data)

or

SAS-1 Response (Mess_Format=2):

```
Chr(2)SASxxxx<sp>PPP<sp>LL<sp>VVV<sp>UUU<sp>WWW<sp>OOO<sp>SSSS<CR><LF>
LL<sp>VVV<sp>UUU<sp>WWW<sp>OOO<sp>SSSS<CR><LF>
LL<sp>VVV<sp>UUU<sp>WWW<sp>OOO<sp>SSSS<CR><LF>
LL<sp>VVV<sp>UUU<sp>WWW<sp>OOO<sp>SSSS<CR><LF>
LL<sp>VVV<sp>UUU<sp>WWW<sp>OOO<sp>SSSS<CR><LF>Chr(3)
```

where **PPP** is the message position in the SAS-1 FIFO buffer, **LL** is the lane number, **VVV** is the total vehicle volume or count, **UUU** is the commercial truck count, **WWW** is the tractor-trailer count, **OOO** is lane occupancy in percent, **SSSS** is average speed in mph. Spaces (ASCII Chr (32)) in the format are designated as **<sp>** while **<CR>** and **<LF>** represent carriage return and line feed respectively. **Chr (2)** and **Chr(3)** are the start of message and end of message characters. Note that this entire message is ASCII. When polling the SAS-1, **PPP** indicates whether the message is current (**PPP=1**), or old and should be dropped (**PPP=0**), or behind (**PPP>1**). If the "Poller" is behind, the SAS-1 should be immediately repolled (and the message kept) until PPP=1.

Depending on the SAS-1 setup, the above message will be output periodically every **Rpt_Intv** seconds (1 to 220 seconds), or when polled by a controller using the following command:

> **<ESC>{SASxxxx,FLOW=!,!}**   (Simple flow message)

or

> **<ESC>{SASxxxx,FLOW=!,"}**   (Message with truck counts).

If either of the above polling commands is sent with a SAS ID of SAS0000, each connected SAS-1 will respond with a 0.25 second delay according to its SAS ID. For example, if the broadcast flow command of

> **<ESC>{SAS0000,FLOW=!,!}**

is sent out to connected SAS-1 units, SAS0001 will respond after 0.25 seconds, SAS0002 will respond after 0.5 seconds, SAS0003 will respond after 0.75 seconds and so on. This facilitates the ordering of SAS-1 messages from a remote site without the need of a local controller and eliminates the need to poll individual SAS-1 units.

Command to SAS-1: Start Azimuth Detection Reporting (SAS Monitor Mode=3)

> **<ESC>{SASxxxx,AZDET=Comm_Mode}**

Comm_Mode is a byte (1-Polled, 2-Periodic) and is offset by +32 (20 Hex).

SAS-1 Response:

Byte #	Data Type	Description
1	Character	Ascii Character 2 (Start of Text)

2 to 8	7 Characters	Sensor ID (i.e. SAS0001, SAS0002, etc.)
9 to 11	3 Characters	Temperature (degrees F, 101, -12, +33, etc.)
12	Byte	No. of Current Detections + 32
13	Byte	First Detection Index + 32
14	Byte	First Detection Source Level + 32
15	Byte	First Detection LD Index + 32
16	Byte	Second Detection Index + 32
17	Byte	Second Detection Source Level + 32
18	Byte	Second Detection LD Index + 32
.......................Repeat Pattern for each detection..................		
12+N*3+1	Byte	Health Status Code + 32
12+N*3+2 to 9+N*3+5	4 Characters	Check Sum
12+N*3+6	Character	Ascii Character 3 (End of Text)

All byte data have been offset by 20H (32 Decimal) to keep their values away from ASCII control code values. Upon reception of these, subtract the offset before interpreting the data.

Depending on the SAS-1 setup, the above message will be output synchronously every **Rpt_Intv** seconds (1 to 220 seconds) or when polled by a controller using the following command:

> **<ESC>{SASxxxx,AZDET=Chr(33)}**

Command to SAS-1: Start Single Zone Relay Signals Reporting

> **<ESC>{SASxxxx,RELAY=Comm_Mode}**

> Comm_Mode ia a byte (1-Polled, 2-Periodic) and is offset by +32 (20 Hex).

SAS-1 Response:

> **Chr(2)SASxxxx<20 bytes>Chr(3)**

where **SASxxxx** is the sensor identification number (i.e. SAS0000, SAS0001, SAS0002, etc.), Chr (2) and Chr(3) are the start of message and end of message characters.   The SAS-1 formats the vehicle presence relays in a multi-time point, bit serial format. The 20 byte message packet represents 10 time points with an update time of 8 milli-seconds (one message covers 80 milli-seconds). The vehicle presence relays for five (5) zones are represented by the first **5** bits of each byte. Each time point is a pair of bytes with the first byte representing the "upstream relays" for each of up to 5 lanes and the second byte representing the "downstream relays" for each of up to 5 lanes. When using the above command to start periodic or polled operation (as opposed to using the default mode parameter, D_MODE), the 5 downstream relays (second byte) have no meaning. Note that each byte is offset by 32 (20 Hex) to shift the byte data away from the ASCII control codes. Hence, 32 (20 Hex) must be subtracted from each byte before interpreting each bit state. This message relative to "dual loop speed trap" emulation is only valid for default mode operation (D_MODE=96 to 110). The above message will be output periodically (every 80 milli-sec) or when polled by a controller using the following command:

<ESC>{SASxxxx,RELAY=Chr(33)}

Command to SAS-1: Start Dual Zone Relay Signals Reporting

<ESC>{SASxxxx,DRLY=Comm_Mode}

Comm_Mode ia a byte (1-Polled, 2-Periodic) and is offset by +32 (20 Hex).

SAS-1 Response:

Chr(2)SASxxxx<20 bytes>Chr(3)

where **SASxxxx** is the sensor identification number (i.e. SAS0000, SAS0001, SAS0002, etc.), Chr (2) and Chr(3) are the start of message and end of message characters.   The SAS-1 formats the vehicle presence relays in a multi-time point, bit serial format. The 20 byte message packet represents 10 time points with an update time of 8 milli-seconds (one message covers 80 milli-seconds). The vehicle presence relays for five (5) zones are represented by the first **5** bits of each byte. Each time point is a pair of bytes with the first byte representing the "upstream relays" for each of up to 5 lanes and the second byte representing the "downstream relays" for each of up to 5 lanes.   Note that each byte is offset by 32 (20 Hex) to shift the byte data away from the ASCII control codes. Hence, 32 (20 Hex) must be subtracted from each byte before interpreting each bit state. The "Loop" spacing for the "dual loop speed trap" emulation is specified by **D_MODE** (See the Get Parameter Command). If D_MODE is not set to a value between 96 and 110, the emulated "Dual Loop" spacing is assumed to be **18** feet. The above message will be output periodically (every 80 milli-sec) or when polled by a controller using the following command:

<ESC>{SASxxxx,DRLY=Chr(33)}

Command to SAS-1: STOP

<ESC>{SASxxxx,STOP}

SAS-1 Response:

SAS-1 Stops current communications.

Command to SAS-1: Get SAS-1 Parameters

<ESC>{SASxxxx,RPRM}

SAS-1 Response:

Chr(2)SASxxxx<T_Det><Alpha><Spare_2><Rpt_Intv><D_Mode><Monitor_Mode>
<InetSw><Comm_Mode><Network_Number><LC1><LC2><LC3><LC4><LC5>
<LS1><LS2><LS3><LS4><LS5><AVL1><AVL2><AVL3><AVL4><AVL5>
<OC1><OC2><OC3><OC4><OC5><SN1><SN2><SN3><SN4><SN5>
<T_Floor><Add_Noise>Chr(3)

All parameters are bytes and are offset by +32 (20 Hex).

T_Det is the max detection threshold byte (Max Det Threshold (db)=(T_Det - 120)/4.0).
Alpha is the smoothing time constant byte (Smoothing constant=Alpha/100).
Spare_2 is a spare parameter place holder byte.
Rpt_Intv is the measurement observation inerval and the periodic reporting interval in seconds.
D_Mode is default operating mode (**Note 0**).
Monitor_Mode is the monitoring mode (0-Intersection, 1-Freeway) (Set via the Default Op Mode Command).
InetSw is an Internet Connectivity Switch (0 if internet connection, 5 if hard wire or dedicated wireless). If InetSw = 0, SAS-1 response timeouts are increased to account for internet delays and latency.
Comm_Mode is the default communication mode (1-Polled, 2-Periodic).
Network_Number is the radio hopping pattern number (0 to 63).
LCx is each lane/zone center (pixels) and **LSx** is each lane/zone size (pixels).
AVLx is the average vehicle length for each lane/zone (feet).
OCx is the occupancy calibration factor (Calibration factor=OCx/100).
SNx is detection sensitivity for each lane relative to T_Det (Sensitivity (db)=(SNx - 120)/4.0).
T_Floor is the min detection threshold byte (Min Det Threshold (db)=(T_Floor - 120)/4.0).
Add_Noise is an added artificial noise floor byte to reduce SAS-1 sensitivity (Processing Noise Floor(db) = Actual Noise Floor + (Add_Noise-120)/4.0).

Note 0: D_Mode = 0   **Simple Flow**
            1   **AzDet**
            2   **Relay**..5 Upstream relays are vehicle presence, 5 Downstream relays are inactive
            3   Not Defined
            4   Not Defined
            5   **Flow with Truck Counts**
            6 to 95   Reserved for Future Enhancement
            96 to 110   **Dual Loop Relays**..5 Upstream and 5 Downstream vehicle presence relays with the equivalent loop separation (in feet) given by D_Mode-118+32

Command to SAS-1: Send Parameters to SAS-1

<ESC>{SASxxxx,SPRM=<T_Det>,<Alpha>,<Spare_2>,<Rpt_Intv>,<LC1>,<LC2>,<LC3>,<LC4>,
<LC5>,<LS1>,<LS2>,<LS3>,<LS4>,<LS5>,<AVL1>,<AVL2>,<AVL3>,<AVL4>,<AVL5>,

<OC1>,<OC2>,<OC3>,<OC4>,<OC5>,<SN1>,<SN2>,<SN3>,<SN4>,<SN5>,
<T_Floor>,<Add_Noiset>}

All parameters are bytes and are offset by +32 (20 Hex).

For SAS-1 software versions SAS_131 and above, the Send Parameters command not only sends parameters to the SAS-1, but causes the parameters to be written to non-volatile flash memory.

SAS-1 Response:

No Response.

Command to SAS-1: Set SAS Baud Rate

<ESC>{SASxxxx,BAUD=Baud_Rate}

Baud_Rate is a byte and is offset by +32 (20 Hex).

Baud_Rate =	0	"2400 bps"	This rate will not support TAI or RELAY operating modes.
	1	"4800 bps"	This rate will not support TAI or RELAY operating modes.
	2	"9600 bps"	This rate will not support support RELAY mode.
	3	"19200 bps"	This rate will not support RELAY mode.
	4	"38400 bps"	
	5	"57600 bps"	
	6	"115200 bps"	

SAS-1 Response:

Chr(2)OKChr(3)   "OK" is ASCII.

Command to SAS-1: Save Parameters to SAS-1 NonVolatile Memory

<ESC>{SASxxxx,WPRM}

SAS-1 Response:

Chr(2)OKChr(3)   "OK" is ASCII.

For SAS-1 Software Revision SAS_131 or higher, this command has no effect.

Command to SAS-1: Get SAS-1 ID

<ESC>{SAS0000,GETID}

SAS-1 Response:

Chr(2)SASyyyyChr(3)

SASyyyy is the SAS-1 ID (ASCii)

Each connected SAS-1 responds to the above command with a 0.5 second delay corresponding to its SAS ID. For example, SAS0001 responds after 0.5 second, SAS0002 responds after 1.0 seconds, SAS0003 responds after 1.5 seconds, and so on.

Command to SAS-1: Change SAS-1 ID

<ESC>{SASxxxx,CHGID=SASyyyy}

SASxxxx is current ID and SASyyyy is new ID.

SAS-1 Response:

Chr(2)OKChr(3)　　　　　"OK" is ASCii.

Command to SAS-1: Set SAS-1 Default Operating Mode

**<ESC>{SASxxxx,DMODE=<D_Mode>,<Monitor_Mode>,<InetSw>,<Comm_Mode>,
<Network_Number>,<Rpt_Intv>}**

All parameters are bytes and are offset by +32 (20 Hex). See Get SAS Parameters command for parameter definitions.

SAS-1 Response:

Chr(2)OKChr(3)　　　　　"OK" is ASCii.

Command to SAS-1: Continue Output from SAS-1

<ESC>{SASxxxx,CONT}

When SAS-1 is set to TAI data mode, this command must be sent to the SAS-1 every 374 scans (29.92 seconds) or SAS-1 output will stop and fall back (after 5 minutes) to default operation as specified by the D_MODE parameter.

When SAS-1 is set to FLOW mode, the AZDET mode, the RELAY mode, or the DRLY mode, this command must be sent to the SAS-1 after every other output message or SAS-1 will stop and fall back (after 5 minutes) to default operation as specified by the D_MODE parameter.

SAS-1 Response:

Continue the flow of data/messages from SAS-1

Command to SAS-1: RESET SAS-1

<ESC>{SASxxxx,RESET}

SAS-1 Response:

Chr(2)OKChr(3)   **(**"OK" is ASCII**)**

followed by:

Chr(2)<CR><LF>SmarTek<sp>Systems<sp>SAS-1<sp>Rev.<sp>xxx<sp>xMbit<sp>RTClk<sp>xxminChr(3)

where <CR> and <LF> represent a carriage return and line feed respectivly and <sp> is a space.

Command to SAS-1: Send SAS-1 New Executable Code

<ESC>{SASxxxx,WROM}

SAS-1 Response:

Chr(2)OKChr(3)   "OK" is ASCII

Sender Response:

Line 1 of the Code File (Supplied by SmarTek Systems) is sent to SAS-1.

SAS-1 Response:

Chr(2)OKChr(3)   If data is received with no errors,

Chr(2)NOT_OKChr(3)   If data is received with errors.

If SAS-1 Response is "**OK**" then:

Line 2 of Code File is sent to SAS-1,

Else If SAS-1 Response is "**NOT_OK**" Then

Repeat Sending Line 1 of Code File.

The above process is continued for each line of the Code File until the End of the File is reached or an unrecoverable error occurs during the transfer at which time,

SAS-1 Response:

> **Chr(2)DONEChr(3)**   Indicates SAS-1 received all data correctly.

SAS-1 Response:

> **Chr(2)ABORTChr(3)**   Indicates SAS-1 aborted the process.

SAS-1 Response:

> **Chr(2)WRFAILChr(3)**   Indicates the write to non-volatile memory failed.

Successful completion of this process results in the **New Executable Code** replacing the **Old Executable Code** in the SAS-1's non-volatile memory (flash memory). Use the "**RESET**" command to restart SAS-1 using the New Executable Code. At any time before last code line has been sent to the SAS-1 (EOF record), the process may be aborted by SAS-1 (unrecoverable error) or by sending the "**STOP**" command to SAS-1. After aborting the process, the Old Executable Code remains in the SAS-1's non-volatile memory and the New Executable Code is cleared and lost.   If a flash memory write failure occurs (indicated by the **WRFAIL** response from the SAS-1), the user may retry the upload process so long as the "**RESET**" command **has not** been sent to the SAS-1. A flash memory write failure will probably require the sensor be de-installed and returned to SmarTek Systems for memory replacement.

Command to SAS-1: Set SAS-1 Date and Time

> **<ESC>{SASxxxx,STIME=mm-dd-yyyy,hh:mm:ss}**

SAS-1 Response:

> **Chr(2)OKChr(3)**   "OK" is ASCII.

Command to SAS-1: Get SAS-1 Date and Time

> **<ESC>{SASxxxx,GTIME}**

SAS-1 Response:

Chr(2)mm-dd-yyyy,hh:mm:ssChr(3)

Command to SAS-1: Download Archive Data From the SAS-1

<ESC>{SASxxxx,GDATA}

SAS-1 Response:

Chr(2)[Data Archive Record]Chr(3)

Data Receiver Response:

	Chr(2)OKChr(3)	"OK" to send the next archive record
or	**Chr(2)NOT_OKChr(3)**	Resend the archive record
or	**Chr(2)DONEChr(3)**	All archive records received "OK"
or	**Chr(2)ABORTChr(3)**	Unrecoverable error, end the process.

The SAS-1 archive data is sent using multiple records of the following form:

Header Record 1
Header Record 2
Data Record 1
Data Record 2
.....
.....
Data Record k
.....
.....
Last Data Record
End of File Record

Command to SAS-1: Send (Upload) a New Header Record to SAS-1

<ESC>{SASxxxx,SHDR}

SAS-1 Response:

Chr(2)OKChr(3)   "OK" is ASCII

Sender Response:

Line 1 of Header Record File (Intel Format) is sent to SAS-1.

SAS-1 Response:

> **Chr(2)OKChr(3)**   If record is received with no errors,
>
> **Chr(2)NOT_OKChr(3)**   If record is received with errors.

If SAS-1 Response is "**OK**" then:

> **Line 2 of Header Record File is sent to SAS-1,**

Else If SAS-1 Response is "**NOT_OK**" Then

> **Repeat Sending Line 1 of Header Record File.**

The above process is continued for each line of the Header Record File until the End of the File is reached or an unrecoverable error occurs during the transfer at which time,

SAS-1 Response:

> **Chr(2)DONEChr(3)**   Indicates SAS-1 received all data correctly.

SAS-1 Response:

> **Chr(2)ABORTChr(3)**   Indicates SAS-1 aborted the process.

SAS-1 Response:

> **Chr(2)WRFAILChr(3)**   Indicates the write to non-volatile memory failed.

Successful completion of this process results in the **New Header Record** replacing the **Old Header Record** in the SAS-1's non-volatile memory (flash memory). If the process is aborted before successful completion, the stored Header Record in the SAS-1 may be corrupted. The Header Record upload process should be repeated. If a flash memory write failure occurs (indicated by the **WRFAIL** response from the SAS-1), the user may retry the upload process. A flash memory write failure may require the sensor be de-installed and returned to SmarTek Systems for memory replacement.

The SAS-1 Header Record may be edited and uploaded to the SAS-1 using the SAS Monitor and Setup Program supplied by SmarTek Systems.

Note that setting the SAS-1 Date and Time or sending an Archive Header to the SAS-1 will reset the SAS-1 archive pointer. This will result in the loss of any archive data that was previously logged. After either of these actions or upon SAS-1 power on or reset, data

archiving begins after the next full data write period. For example, let the archive period be set at 15 minutes and the SAS-1 Set Date and Time command be sent at 1:01:55 PM. The first archive record would be captured at 1:30:00 PM (data collected for interval 1:15 to 1:30) and the SAS-1 would write the archive records at 2:15:00 PM. The SAS-1 captures four (4) intervals of data before writing the data to non-volatile flash memory. The time stamp for each record corresponds to the end of the data interval.

Command to SAS-1: Randomly Change Own SAS-1 ID

<ESC>{SASxxxx,AUTOID=yy}

SASxxxx is the current ID and yy is the lowest permissable new ID ranging from 01 to 99.

SAS-1 Response:

Chr(2)SASzzzzChr(3)

Where SASzzzz is the new randomly generated SAS ID.

If multiple SAS-1 units are installed sharing the same hard wired home run cable or wireless link and they have the same SAS ID, it is not possible to communicate with individual SAS-1 units. This command provides the capability for each SAS-1 unit to change its own ID randomly independent from others connected on the same home run. For example:

<ESC>{SAS0001,AUTOID=05}

will cause all SAS-1 units with SAS ID of SAS0001 to generate new IDs randomly with the lowest permissable ID being SAS0005.