



TM

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SmarTek Acoustic Sensor - Version 1 (SAS-1)

Installation and Setup Guide

25 July 2000

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.

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1.0 Introduction

The SmarTek Systems Acoustic Sensor -Version 1 (SAS-1) is a non-contact, passive acoustic (listen only) sensor which provides monitoring for multi-lane highways. It is mounted on existing overhead or roadside structures such as light poles, sign bridges, and overpasses. It is completely non-intrusive to the highway or to the travelers using the highway. The SAS-1 is very compact and lightweight and designed to be quickly and easily installed on existing highway structures. The SAS-1 is designed to operate from a roadside position. No lane closures are needed for a typical installation on a roadside structure using a bucket truck. Reliability for the adverse highway environment is designed into the SAS-1 to minimize or eliminate any periodic maintenance requirements.

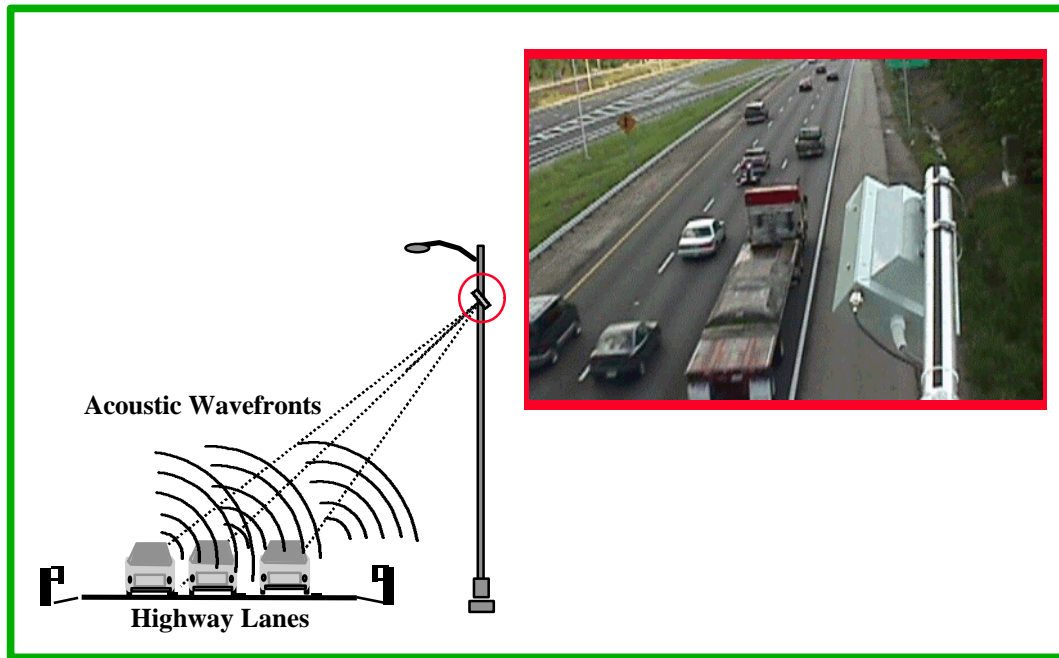


Figure 1 SmarTek Systems Acoustic Sensor (SAS-1)

The SAS-1 utilizes SmarTek Systems' advanced signal and spatial processing technology to provide a high resolution "acoustic image" of all vehicle traffic passing by the sensor (including shoulder activity). This advanced processing eliminates false vehicle detections caused by out of lane or off road noise. Because the SAS-1 "acoustically images" the highway traffic with a large number of high resolution cells (or look directions), the end user is provided with significant flexibility to electronically position each detection zone and set each detection zone's size. This capability eliminates the necessity of precise mechanical "pointing" of the sensor to a detection zone position during installation. After installation, electronic detection zone positioning and repositioning is accomplished using SmarTek Systems provided Windows 95/98 based software. SmarTek Systems' **SAS Monitor and Setup** software displays the position ("acoustic image") of every vehicle in real time as vehicles pass the sensor station. The SAS Monitor and Setup software also has "**Automatic Lane Finder**" processing which significantly simplifies the installer's task of setting detection zone positions. Using this display and associated controls, the end user sets each detection zone position and size in the cross-road direction. This easy process in effect electronically finds and sets each highway lane position relative to the mechanical sensor orientation after the sensor has been permanently "locked down".

1.0.1 How "Acoustic Imaging" Is Accomplished

Vehicle generated acoustic signals (engine noise, fans, belts, tire noise, etc.) leave their source (vehicle to be detected) and arrive at the SAS-1 (Figure 1) with an acoustic wave front which is essentially flat. Each acoustic signal from each vehicle will arrive at the SAS-1 with a different signal level and a different wave front angle (arrival angle).

The SAS-1 is comprised of an array of rugged microphones, analog signal conditioning, and sampling circuitry for converting impinging acoustic signal wave fronts to digital signals. These digital signals are processed using a programmable state of the art Digital Signal Processor (DSP) with associated memory and communication circuitry. The processing software implements SmarTek Systems' patented advanced signal processing, spatial processing, and vehicle detection algorithms. The SAS-1 "listens to" and processes every received acoustic signal generated by passing vehicles or stationary (idling) vehicles in real time. SAS-1 uses SmarTek Systems advanced signal and spatial processing to create multiple acoustic signal arrival direction channels (look directions) as shown in Figure 2. The SAS-1 implements 91 concurrent listening channels (look directions) along its short dimension and a single listening channel along its long dimension.

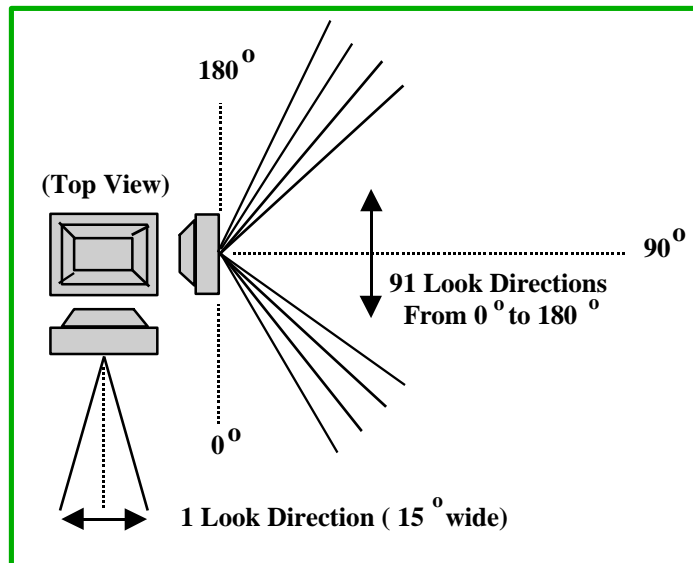


Figure 2 SAS-1 Look Directions

For **multi-lane highway monitoring**, the SAS-1 is mounted roadside and oriented so that the single listening channel is in the up/down road direction (SAS-1 mounting tube is approximately parallel to the traffic flow) and the 91 listening channels (look directions) are in the cross road direction as shown in Figure 3. In this configuration, the SAS-1 effectively divides the highway (cross road) into 91 look directions from which vehicle sounds may originate. The single up/down road look direction limits the SAS-1's ability to hear sound in the up/down road direction. It therefore, only considers vehicle sounds when the vehicle is passing by the sensor station. As vehicle traffic moves or flows by the sensor station, the SAS-1 processing forms acoustic "images" or "blobs" of high signal intensity. This acoustic "image" is displayed as the Traffic Acoustic Image (TAI) of the SAS Monitor and Setup software running on a laptop PC (Figure 3). Each "blob" represents the acoustic "image" of a vehicle as it passes the SAS-1.

Up to five(5) SAS-1 detection zones are formed by selecting the position and number of contiguous look directions which are combined for actual vehicle detection. This provides the end user with unparalleled flexibility in choosing detection zone sizes and locations. For the example shown in Figure 3, detection zone sizes and placement were selected to correspond to three active lanes and two shoulders. In the TAI display, each pair of Blue Lines represents the left and right edges of each detection zone. The detection zones for this example are chosen to leave little or no dead space. That is, where one zone stops, the next one begins. For this configuration, any lane switcher will be detected and placed in one zone (lane) or the other. In the TAI display, the blue detection zone indicator lines mimic real highway lane divider lines. The SAS Monitor and Setup display also provides the end user with SAS-1 detection indicator marks (magenta) which are placed in the center of each detection zone. These indicator marks provide the installer with instant real time feedback to show exactly how well the SAS-1 is detecting vehicles and what zone (or lane) the detections are assigned to. After setup is complete, the SAS-1 will operate in one of **two(2) default operating modes** as selected by the installer.

1.0.2 Monitoring Modes

In the **Multi-Lane Flow Mode**, the SAS-1 computes and reports vehicle count, lane occupancy, and average speed for each lane for a specified update period (i.e. 20 sec, 30 sec, 1 minute, etc.). SAS-1 can be set to output these measurements every period or wait to be polled.

In the **Multi-Detection Zone Relay Signal Mode**, the SAS-1 outputs a stream of bit serial relay signals for up to ten (10) relays (5 upstream relays and five down stream relays) for multi-lane monitoring and five (5) relays for single lane monitoring or intersection presence.

The SAS-1 is designed to operate and provide effective and accurate **true vehicle presence detection** and associated traffic flow measures on a lane by lane basis for vehicles passing the sensor station at any reasonable (and allowable) speed from stop and go to free flow. There is no inherent upper speed limitation relative to highway traffic. The SAS-1 will not “tune out” a vehicle that remains in the detection zone for a prolonged period of time. There is no loss of detection performance due to variation in weather, environmental conditions, or visibility conditions.

The maximum number of zones or lanes monitored by the current SAS-1 configuration is set at five (5). Figure 4 shows a typical side mount installation geometry for monitoring 3 lanes and 2 shoulders. The detection zone or lane limit of five (5) is driven by constraints for typical side mount geometry (resolution and occlusion of the far lanes). The ability of SAS-1 to separate or resolve lanes far from the sensor (lanes 4 and 5) is highly dependent on the installation geometry. If SAS-1 is installed high enough (30 to 35 ft) and close enough to the active lanes to be monitored, vehicle detection performance will be excellent for all lanes monitored. If SAS-1 is installed at a lower height or further from the active lanes to be monitored, vehicle detection performance for the lanes furthest from the sensor will be degraded.

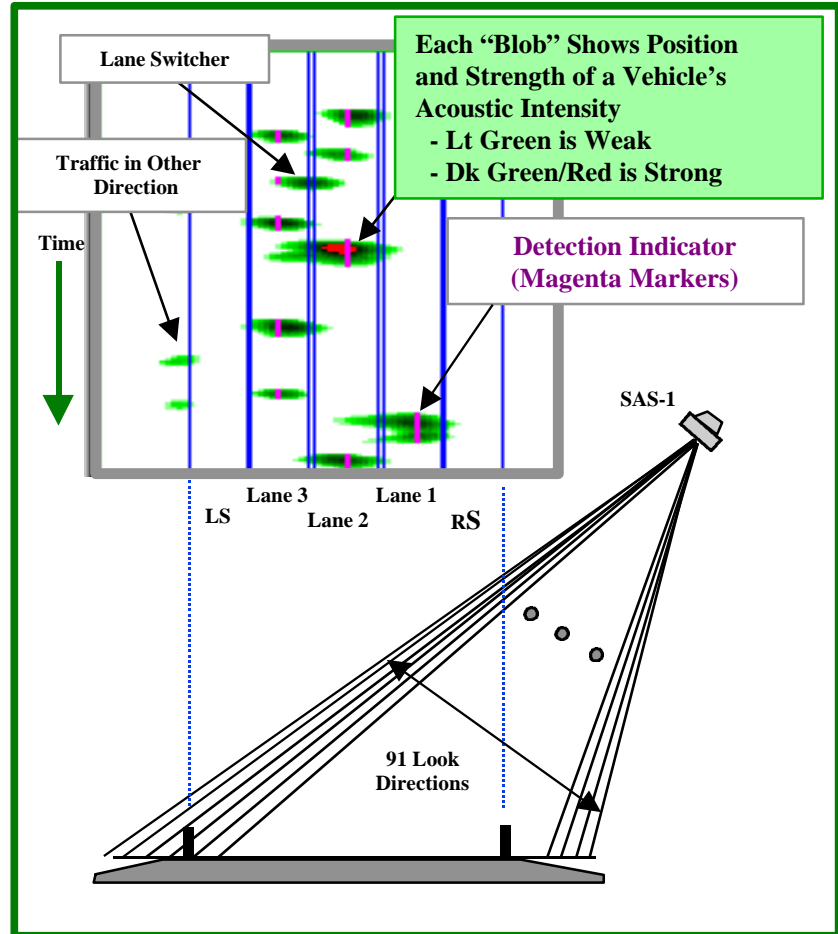


Figure 3 SAS-1 Acoustic “Image” Formation

Figure 5 shows a typical side mount installation geometry for monitoring vehicle speed and direction for a single lane. For **single lane highway speed and direction monitoring**, the SAS-1 is mounted roadside. It is oriented so that the single listening channel is in the crossroad direction (SAS-1’s long dimension is approximately perpendicular to the traffic flow). The 91 listening channels (look directions) are in the up/down road direction (SAS-1’s short dimension is approximately parallel to the traffic flow).

For single lane monitoring, mounting the SAS-1 at a lower height will increase the size of the SAS-1 detection zones in the crossroad direction. This may be desirable to cover approaches such as wide exit or entry ramps and the corresponding shoulders.

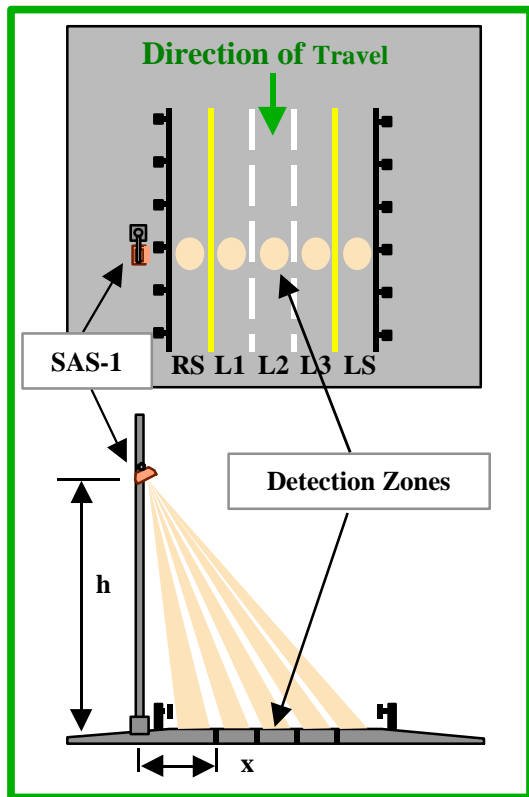


Figure 4 Side Mounting for Multilane Monitoring

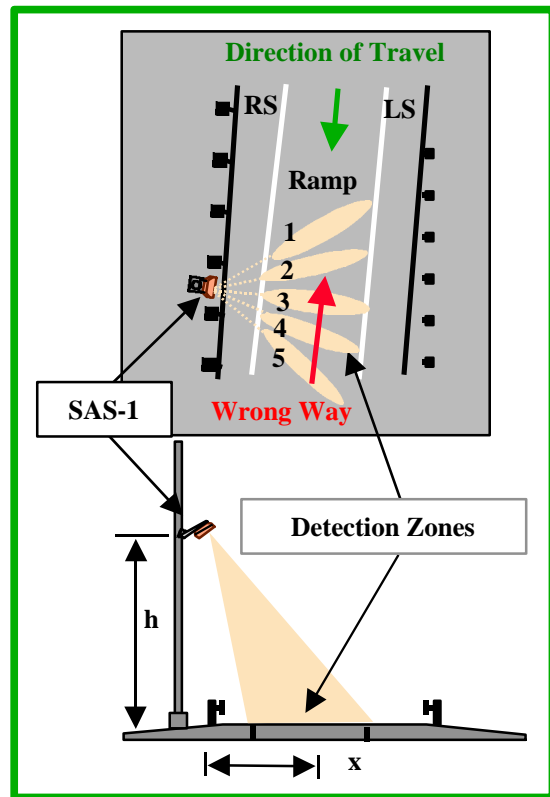


Figure 5 Single Lane, Multi-Zone Monitoring

2.0 Specifications

2.0.1 Message Formats

The SAS-1 provides for several different interfaces depending on the communication link and the cabinet controller interface desired. The standard SAS-1 output message provides traffic flow measurements of vehicle volume, lane occupancy, and average speed for each monitored zone (up to 5 zones or lanes) for a specified update period (1 Sec to 220 Sec). A bit serial vehicle presence relay message or actual dry contact vehicle presence relay signals can be provided. The dry contact relay signal option requires a SAS Relay Interface (SAS-RI) in the roadside cabinet.

The SAS-1 also provides autonomous measurement archiving for up to 60 days.

2.0.2 Signal Interfaces

The SAS-1 supports the following electrical communication interfaces:

- 1) **RS-422 (Standard)** **Hard Wired Home Run (up to 2000 feet)**
- 2) **RS-232 (Optional)** **Hard Wired Home Run (up to 100 feet)**
- 3) **Wireless (Optional)** **Wireless Link (2.4 GHz Spread Spectrum)**

2.0.3 Power

The SAS-1 re-regulates the supply voltage compensating for variation caused by long home run cables:

- 1) **Supply Voltage at the Sensor**..... **8 to 24 VDC**
- 2) **Required Power**..... **Less than 2 Watts**

2.0.4 Physical

- 1) **Dimensions**.....**12 inches long x 8 inches wide x 5 inches deep**
- 2) **Weight (with Mounting Bracket)**...**Less than 7 lb.**
- 3) **Material/Finish**.....**Aluminum/Enamel/Stainless Steel Fasteners**
- 4) **Mounting Approach**.....**2 inch Diameter Aluminum Tube/Stainless Steel Bands**
- 5) **Operating Temperature**.....**-20 Deg C to 75 Deg C**
- 6) **Humidity**.....**5% to 100%**
- 7) **Shock**.....**NEMA TS2-2.1.10**
- 8) **Vibration**.....**NEMA TS2-2.1.9**

2.0.5 Installation Procedure and Parameters

The SAS-1's compact size and modest weight make installation easy for a single installer using a bucket truck. Mounting brackets allow for coarse mechanical positioning so that the sensor face is pointing toward the center of the lanes to be monitored. Powering the sensor and using the SAS Monitor and Setup program on a PC Laptop makes the SAS-1 installation and pointing easy and quick. After the SAS-1 is mechanically oriented and locked down, the position and size of each detection zone (up to 5) are then electronically determined and set using the SAS Monitor and Setup program. All detection zones can be precisely matched to highway lanes and the specific traffic flow situation. All SAS-1 setup parameters are stored in non-volatile memory.

- 1) **Height Above Pavement** **20 to 35 feet**
- 2) **Horizontal Distance to First Detection Zone** **0 to 30 feet**
- 3) **Coarse SAS-1 Orientation** **Mechanical**
- 4) **Precise Detection Zone Position and Size** **Electronic using a Laptop PC.**

3.0 Service Information

3.0.1 Periodic Maintenance

No periodic maintenance is required. For verification, it is recommended that the user perform the Quick Checkout procedure upon receipt and unpacking of each SAS-1. Checkout of the SAS-1 after installation will also occur as a result of setting parameters (detection zone position and size) for each specific traffic monitoring site. After installation, verify that all nuts, bolts, and mounting straps are tight and secure.

Do not attempt to open, repair, or disassemble the SAS-1 unit or its interface modules. Such action will void the warranty on the SAS-1. Call SmarTek Systems if the SAS-1 or any of its interface modules need servicing.

3.0.2 Sensor Identification

Each SAS-1 is identified by two numbers on the Label located on the SAS-1 cover. The first number is the unit's Serial Number (S/N) and the second number is the unit's Software Revision Number (SW-Rev).

3.0.3 Factory Service

To avoid unnecessary shipments and delays, if you believe the SAS-1 unit is malfunctioning, call SmarTek Systems to discuss the problems and to determine if the SAS-1 should be returned for service.

If the SAS-1 is being returned to SmarTek Systems for service or repair, be sure to include the following information with the shipment:

- 1) Name, Address, and phone number of a Point of Contact,
- 2) Unit Serial Number and Software Revision Number,
- 3) A detailed description of the problem and the conditions under which the problem occurs,
- 4) Name and telephone number of staff familiar with the problem so that additional information may be obtained if necessary to localize and fix the problem,
- 5) Shipping address for return of the unit after service or repair.

3.0.4 Shipping Information

If the original shipping container and packing material is unavailable, wrap the unit with bubble wrap and place in a strong carton. Fill the carton with enough packing material to prevent movement inside the carton. Seal the carton with strong shipping tape on all seams. SmarTek Systems will provide appropriate shipping address information at the time it is determined that return for service is necessary.

3.0.5 Warranty

SmarTek Systems, Inc. warrants this product to be free from defects in material and workmanship for a period of one year from the date of delivery. Damage due to accident, abuse, or improper installation by the buyer or unauthorized modification or operation outside the specifications is not covered by this warranty. SmarTek Systems, Inc. will repair or replace at its option, any components of this product which prove defective during the warranty period.

Removing the SAS-1 cover, attempting repair, or disassembling will void this warranty.

SmarTek Systems, Inc warrants that its software and firmware designated for use with the SAS-1 or its interface components will execute its programming instructions when properly installed. SmarTek Systems, Inc. does not warrant that the operation of the software or firmware will be uninterrupted or error free.

4.0 SAS-1 Architecture

The SAS-1 architecture is inherently simple and modular since all signal processing, spatial processing, and detection processing is performed in the SAS-1 unit. The SAS-1 electronics and messaging protocols facilitate a number of connection options for getting the processed information from the SAS-1 unit (mounted on a highway structure) to a roadside cabinet that may be only several feet from the SAS-1 or may be hundreds or thousands of feet from the SAS-1. The basic SAS-1 configuration uses a hard-wired home run cable to get power from the cabinet to the SAS-1 and signals/messages from the SAS-1 to the cabinet controller (Figure 6).

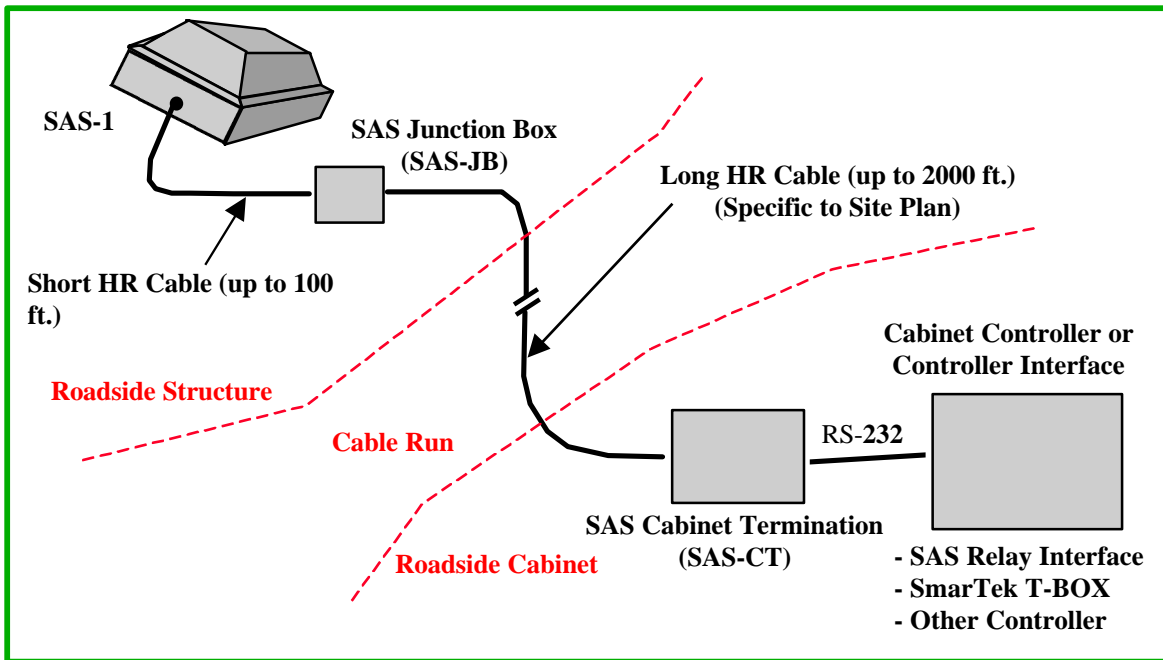


Figure-6 SAS-1 Architecture Using Hard Wire Home Run Cable

The SAS-1 Unit has a small footprint and does all processing necessary for monitoring up to five highway lanes or five zones in a single lane. The SAS-1 unit is configured at the factory with the specified communication protocol (RS-422 or RS-232) and provides solid state surge protection between all data lines and ground and between the +VDC line and ground.

The SAS-Junction Box (SAS-JB) is a small, strap-on, weather-tight enclosure that is mounted conveniently on the roadside structure. It is used to connect the short home run cable for a single SAS-1 or several SAS-1s to a much longer home run cable if long runs to a roadside cabinet are required. The SAS-JB also provides the means to configure the SAS-1 system with an additional stage of gas tube surge protection.

The Short Home Run Cable ships with each SAS-1 unit and is specified at the time of ordering to be between 40 and 100 feet. The short home run cable has four pairs of stranded 24 gauge conductors and a continuous shield with a stranded shield conductor. For long runs, the long home run cable used should be 22 gauge.

The SAS-Cabinet Termination (SAS-CT) is a small circuit card mounted inside the controller cabinet providing the termination point for the home run cable from the SAS-1. The home run cable is terminated with a high quality “pluggable terminal block connector” that is plugged onto the SAS-CT. The SAS-CT provides electrical protocol conversion (RS-422 to RS-232) to facilitate connection to an RS-232 port of the cabinet controller or the RS-232 port of the SAS-Relay Interface (SAS-RI). The SAS-CT provides a single stage of solid state surge protection and an optional additional stage of gas tube surge protection for all data and power lines.

The **SAS-CT to Controller Serial Cable** is used to connect the SAS-CT to the cabinet controller via a modular (RJ-45) connector at the SAS-CT. The other end of the cable is a modular (RJ-45), a DB-9, or a DB-25 connector depending on the controller or communication device it is connected to.

5.0 Unpacking and Quick Checkout

5.0.1 Contents of Shipment

Each SAS-1 System comes fully assembled and configured according to selected options at the time the order was placed. All required electronic hardware necessary for installation is included. SAS-1 ships with a short unterminated home run cable (25 to 100 feet) as specified at the time the order was placed. Inspect the shipping container for any signs of damage. If the contents are incomplete or if there is electrical or mechanical damage, notify SmarTek Systems for repair or replacement.

5.0.2 Additional Items Needed for Install and Setup

The following additional items are required for SAS-1 installation and setup:

- 1) Laptop Computer with Windows 95/98 (133 MHz Pentium or better recommended)
- 2) Installation Tools and Bandit Stainless Steel Strapping
- 3) AC to DC Power Converter or 12 Volt Battery for quick checkout.

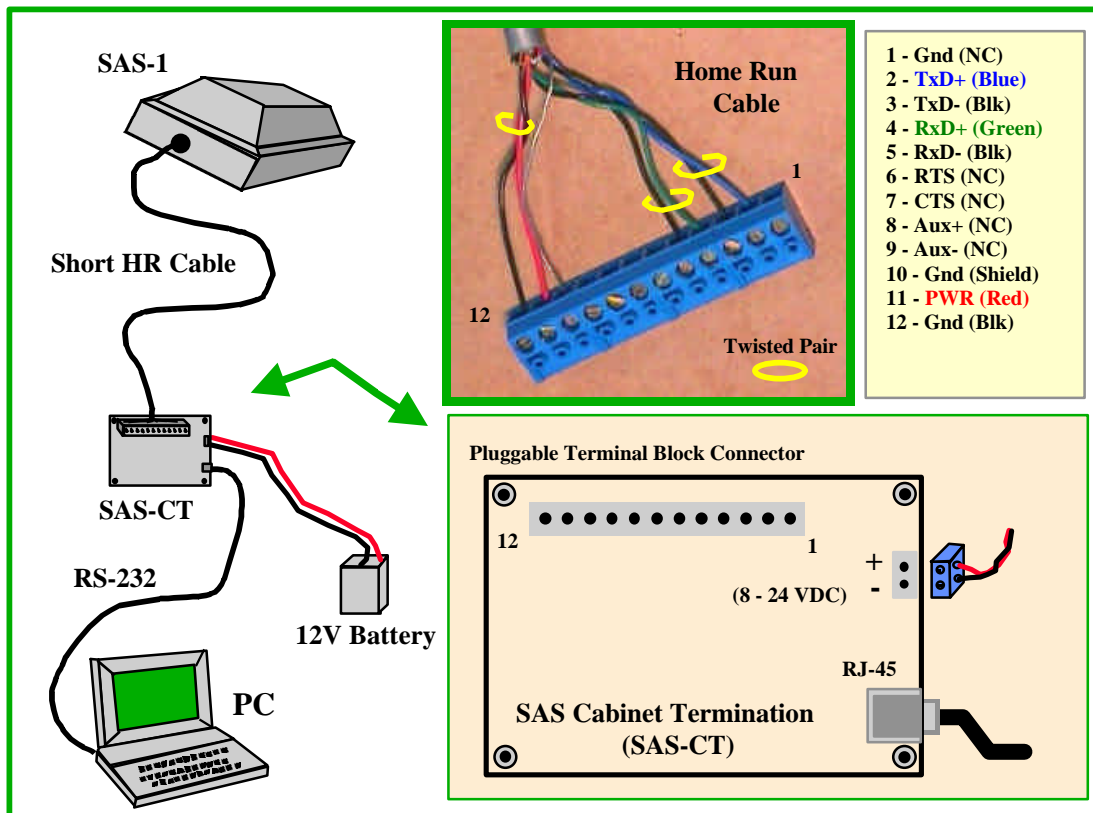


Figure 7 SAS-1 Quick Check Bench Top Out

5.0.3 SAS-1 Quick Checkout

Place the SAS-1 Unit on a workbench and temporarily connect the SAS-1 short home run cable to the SAS-CT and the SAS-CT to the Laptop PC (using the RJ-45 serial cable) as shown in Figure 7. Connect DC power (8 to 24 VDC) to the SAS-CT using the two position pluggable terminal block connector. Power may come from an AC/DC converter (i.e. 9 VDC at 500 milli-amps), or a battery (i.e. 12 VDC). **Be sure the polarity is correct and the blade fuse is in place on the SAS-CT.**

Run the **SAS Monitor and Setup** program on the PC by clicking **Start/Programs/SmarTek Systems/SAS Monitor**. Refer to **Section 7** for detailed directions for using SAS Monitor and Setup.

Make sure the **SAS ID** (upper left of the SAS Monitor Display as shown in Figure 8) is set to **SAS0000** (all SAS-1's will respond to commands with this Global ID) and that the **Mode** is set to **1** (Traffic Acoustic Image Display Mode). The SAS ID may be incremented or decremented by **left clicking** in the **upper** or **lower** portion or the SAS ID Field. **All parameters on the SAS Monitor Display are modified this way.** Holding the **Shift** key down while clicking will increase the size of each increment or decrement.

Click the menu item **Settings/Comm Port** to set the PC Comm Port parameters. The **Comm Port** Number for a laptop PC is typically **1** or **2**. Set the Comm Port Number to the appropriate value corresponding to the external DB-9 connector on the back of the laptop. The first time SAS Monitor and Setup is run, the Comm Port Dialog Window will automatically popup. The rest of the Comm Port parameters should be as follows:

| | |
|--------------------------|------------------|
| Baud Rate | 38400 bps |
| Data Bits | 8 |
| Parity | N |
| Stop Bits | 1 |
| HW Flow Control | Unchecked |
| SW Flow Control | Unchecked |
| Set DTR line high | Checked |
| Set RTS line high | Checked. |

Double check all connections between the SAS-1, SAS-CT, Power Supply (or battery), and the PC. Click the **Start Button** in SAS Monitor and Setup (Figure 8). In the Traffic Acoustic Image (TAI) display area (right side of the SAS Monitor Display), **Blue Lines** should begin to draw from the display top to the bottom. These lines indicate the positions of detection zones set in the SAS-1. The presence of the Blue Lines indicate that SAS-1 is running and communicating properly with the PC and the SAS Monitor and Setup program. If no Blue Lines are present, click on the **Stop Button** in SAS Monitor and then double check all connections, the Mode setting, and the Comm Port settings. With the power plug connected on the SAS-CT, check the voltage at the plug. The voltage should be at least 8 VDC. Repeat the above procedure for starting communications between the SAS-1 and SAS Monitor and Setup.

Once the SAS-1 and the SAS Monitor and Setup program are communicating (Blue Lines are present and drawing from top to bottom), you may perform a simple noise test to check the SAS-1 response. Set the **Display Sensitivity** to **24.00** by left clicking in the **Dspl Sens** field. Stand in front of the SAS-1 about 10 to 15 ft away and make noise by whistling, hissing, crunching paper or plastic, or jingling keys. Note the green response on the TAI display. Repeat the process while at slightly different positions (relative to the short dimension of SAS-1) and note the position change of the response on the TAI display. If you observe the Blue Lines drawing on the TAI and the green response when noise is generated, the SAS-1 operating status is OK. Click the **Stop Button** on the SAS Monitor and Setup program display.

The SAS-1 ID is of the form SASxxxx, where xxxx is a four digit number (i.e. SAS0001, SAS0002, etc.). For installations where only one SAS-1 will be connected to a cabinet controller via a home run cable or wireless link, you should set the SAS-1 ID to SAS0001. **For installations where multiple SAS-1s will be connected to a single cabinet controller via a single home run cable or via wireless links, you must set each SAS-1 ID to consecutive values starting at one (SAS0001).** For example, a traffic monitoring station with three SAS-1s connected to the roadside cabinet controller using a single home run cable, should have the SAS-1 IDs set to SAS0001, SAS0002, and SAS0003. This allows the cabinet controller to distinguish the data from each of the SAS-1 units.

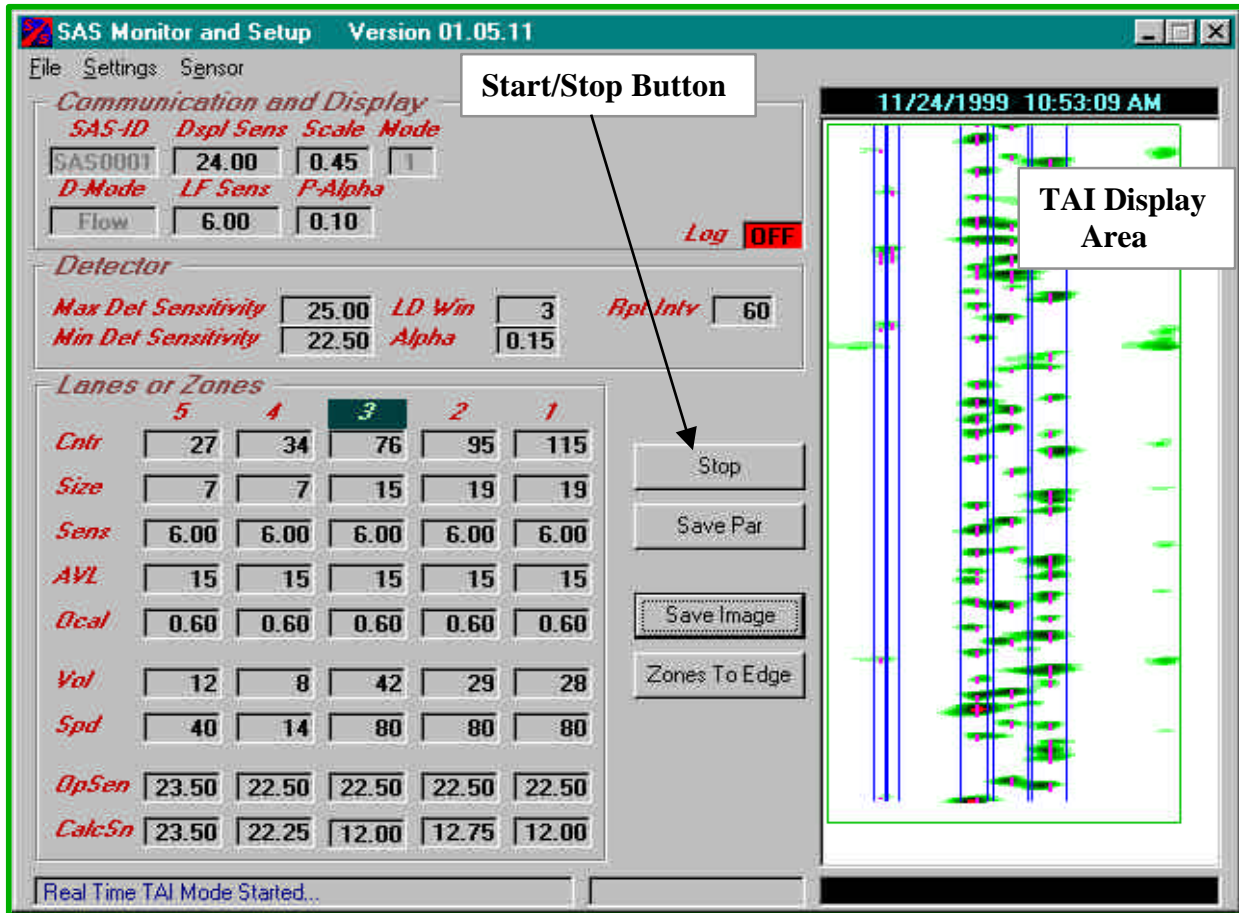


Figure 8 SAS Monitor and Setup Display

To set the SAS-1 ID, click on the **Menu** item, **Sensor/Change SAS ID**. An Information Dialog Window will popup asking for the new SAS-1 ID. The new SAS-1 ID may be incremented or decremented by **left clicking** in the **upper** or **lower** portion of the SAS ID Field. After providing the new SAS-1 ID, click **OK**. The Status Message at the bottom left of the SAS Monitor and Setup Display should indicate a positive response (OK) from the SAS-1 and the SAS-ID Field will be updated to the new ID value. If the “OK” response is received, then click the **Start Button** to verify SAS-1 operation with the new SAS ID value. If the Blue Lines begin to draw as previously described, then the SAS-1 recognizes its new ID. Click the **Stop Button**. If the positive “OK” response is not immediately received, click the **Stop Button** and click on the menu item **Sensor/Get SAS ID**. If the returned ID is not what you set, repeat the above procedure for setting the SAS-ID.

Disconnect the power connector, the pluggable terminal block connector (short home run cable), and the serial PC cable from the SAS-CT.

6.0 Installation at the Traffic Monitoring Site

6.0.1 Sensor Mounting for Multi-Lane Monitoring

Existing highway structures (light poles, sign bridges, overpasses, etc.) are completely suitable for mounting the SAS-1 for multi-lane traffic monitoring. There is no need to mount the SAS-1 over any active lanes (Figure 4). The SAS-1 can provide effective lane by lane monitoring for up to five (5) lanes. The typical height of the SAS-1 mounting position should be 25 to 35 feet (at least 30 ft if four or five lanes are to be monitored). The horizontal distance from the first active lane should be 10 to 20 feet or less. Mounting the SAS-1 just off the shoulder is a good position. Higher mounting positions reduce possible occlusion of smaller vehicles by tall trucks.

The basic mounting bracket for the SAS-1 consists of a 2 inch diameter aluminum tube and a cast aluminum flange (Figure 9). The flange available should be matched to the structure the SAS-1 is mounted on (curved to fit different diameter structures or flat to fit rectangular structures or concrete walls). The flange may be attached to the structure via stainless steel strapping or bolts. The tube screws into the flange and is locked in place with a set screw. For mounting SAS-1 on a round structure such as a light pole or sign bridge, the orientation of the flange depends on whether the mounting position is on a vertical member (i.e. light pole) or on a horizontal member (i.e. cross member of a sign bridge).



Figure 9 Mounting Tube and Flange

To mount the SAS-1 on the highway structure, first attach the flange and tube assembly to the structure so that the mounting tube is approximately parallel to the flow of traffic. Secure the assembly using stainless steel strapping. Position the flange and tube assembly on the down road side of the highway structure if possible (Figure 10). This positioning is highly effective in keeping the SAS-1 out of sight of motorists and therefore, reduces the chance for vandalism.

Once the flange and tube assembly is secure, slide the SAS-1 unit over the aluminum tube so that the SAS-1 home run cable strain relief is toward the mounting flange. Rotate the SAS-1 about the tube until the face of the sensor is toward the center of the lanes that will be monitored as shown in Figure 10. **Remember that the SAS-1 pointing at this point does not have to be precise.** For the highway example shown in Figure 10, the face of the SAS-1 should be pointed toward Lane 3 or Lane 4. Once the SAS-1 is rotated to the desired direction, tighten the stainless steel straps around the 2 inch mounting tube and secure the short home run cable with tie straps to the mounting tube and the highway structure.

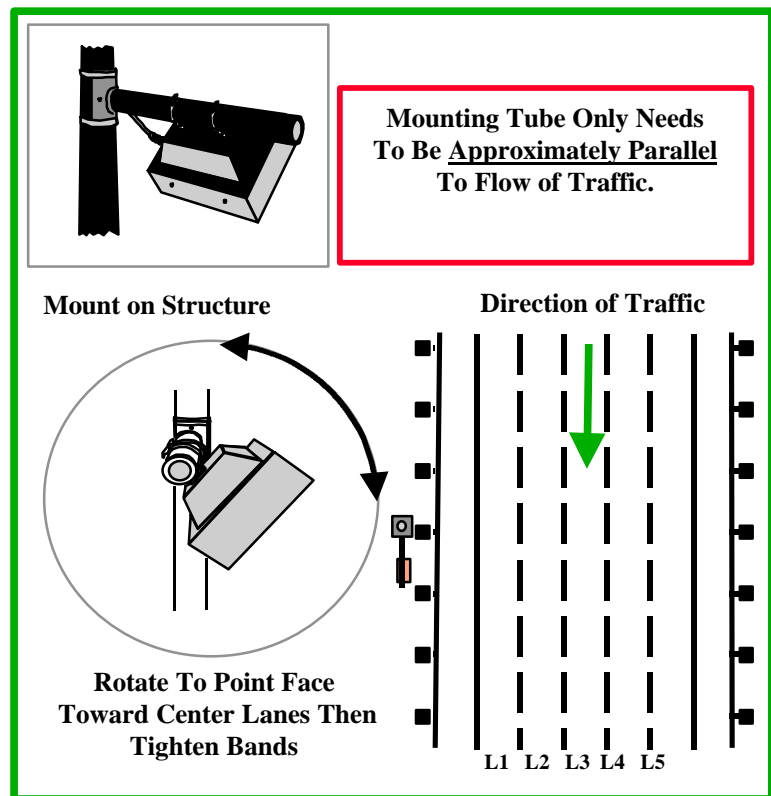


Figure 10 Mounting and Pointing for Multi-Lane Monitoring

6.0.2 Sensor Mounting for Single-Lane Speed Monitoring and Direction

There is no need to mount the SAS-1 over any active lanes (Figure 5). For this mode of operation, the typical height of the SAS-1 mounting position should be 15 to 30 feet. The horizontal distance from the first active lane can be 10 to 40 feet. Mounting the SAS-1 lower will provide wider coverage across the lane. For this mode of operation, the sensor unit is rotated 90 degrees (Figure 11) so that the long dimension of the sensor is in the cross-road direction and the short dimension of the sensor is in the up/down road direction.

Attach the flange and tube assembly to the structure. Secure the assembly using stainless steel strapping. Position the flange and tube assembly on the down road side of the highway structure (Figure 11) if possible.

With the flange and tube assembly secure, slide the SAS-1 unit and channel bracket over the aluminum tube so that the SAS-1 home run cable strain relief is toward the tube (Figure 11). Set the SAS-1 pointing direction, by rotating the SAS-1 about the tube until the face of the sensor is toward the lane that will be monitored. Once the SAS-1 is rotated to the desired direction, tighten the stainless steel strap around the 2 inch mounting tube and secure the short home run cable with tie straps to the mounting bracket and the highway structure.

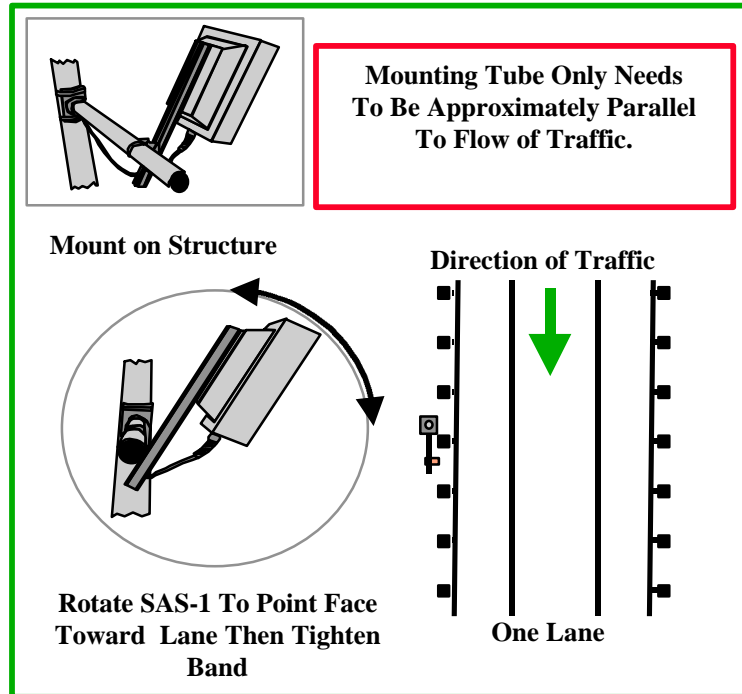


Figure 11 Mounting and Pointing for Single Lane Monitoring

6.0.3 Mounting and Connecting the SAS-Junction Box (SAS-JB)

Multiple SAS-1 units may be connected to a single cabinet controller and communicate over a single home run link using RS-422 or wireless. When using a cabinet controller such as SmarTek Systems' T-BOX, the number of SAS-1 units connected via a single home run cable is only limited by power supply considerations and the communication polling period. When connected via wireless, as many as 255 SAS-1 units can communicate to a single cabinet controller. The actual number is only limited by communication bandwidth constraints.

The SAS-Junction Box (SAS-JB) is used to connect the short home run cable of one or more SAS-1 units to a single long home run cable for long runs to a roadside cabinet. The SAS-JB is also used for attaching an additional stage of gas tube surge protection at the sensor end of the long home run cable. For shorter cable runs to the roadside cabinet, the SAS-JB may not be needed.

Route and secure the short home run cable from each SAS-1 unit along the highway structure to a position selected for mounting the SAS-Junction Box (SAS-JB). Enough cable (short home run) is shipped with the SAS-1 to allow the SAS-JB to be positioned (Figure 12) so that it is easy to reach for maintenance or service without a shoulder closing and, if desired, without using a bucket truck. Mount the SAS-JB on the highway structure using stainless steel bands. If the highway structure used for mounting SAS-1 and the SAS-JB is wood or some other non-conducting material or if the path to earth ground is questionable, then a grounding cable should be provided and connected to the stainless steel mounting saddle on the SAS-JB.

Once the SAS-JB has been mounted, remove the cover and route each cable into the SAS-JB through each strain relief as shown in Figure 12. Remove 4 to 8 inches of the sheathing from each home run cable being careful not to damage the shield wire or the insulation on the other twisted pairs. **Be sure to keep each twisted pair together since there are multiple black conductors.** If more than one SAS-1 units are to be connected to the same long home run cable, they will be connected inside the SAS-JB and terminated using a single pluggable terminal block connector. Strip 1/4 inch of insulation from each conductor in the long home run cable. **Do not let the black wires untwist from the corresponding colored wire of the pair.** Terminate each conductor and the shield wire in the long home run cable using a pluggable terminal block connector (Figure 12). Once the pluggable terminal block connector is complete for the long home run cable, plug it into the appropriate header on the SAS-JB circuit board as shown in Figure 12. Be sure some of the long home run cable sheathing enters the SAS-JB and tighten the strain relief to secure the long home run cable entry into the SAS-JB. Also check to be sure that the bare shield

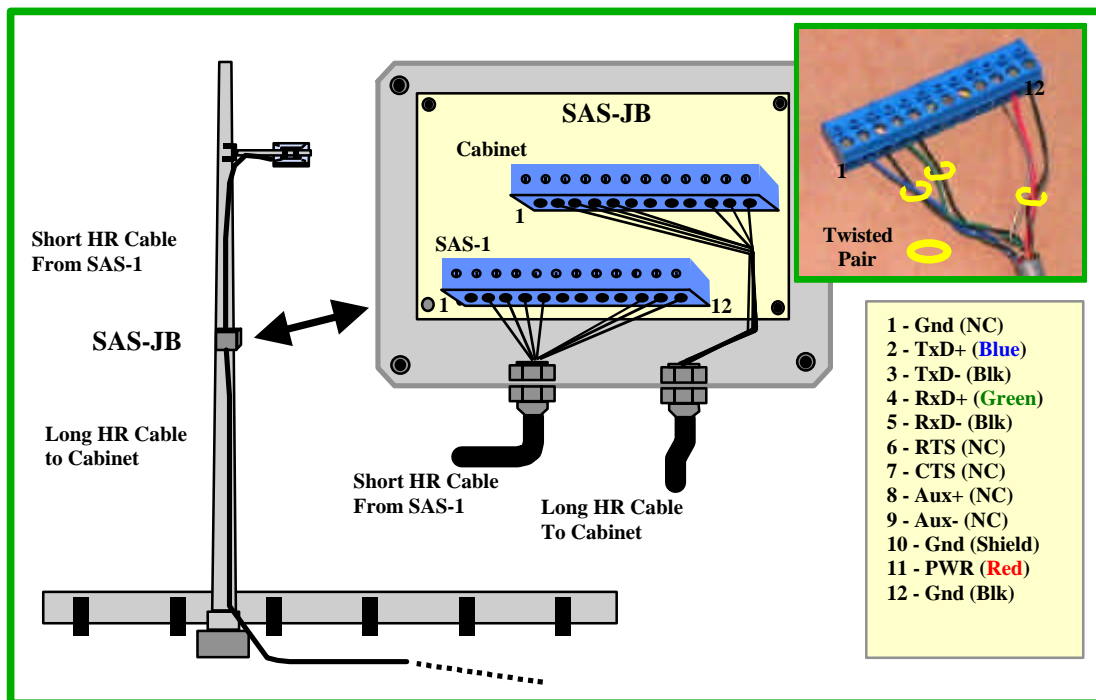


Figure 12 Mounting and Connecting the SAS Junction Box

wire does not short to other cable wires or components in the SAS-JB.

If there is more than one SAS-1 unit to be connected, strip 1 to 2 inches of insulation from each conductor in each short home run cable (from each SAS-1 unit). If you are connecting a single short home run cable, strip 1/4 inch of insulation from each conductor in the short home run cable. **Do not let the black wires untwist from the corresponding colored wire of the pair.** For multiple short home run cables, twist together (and solder) the bare wire from like colored conductors (i.e. blue from each home run, black from each home run, etc.) making sure that each black conductor is from the same twisted pair. Trim the bare wire back to 1/4 inch and terminate using the pluggable terminal block connector (Figure 12). Once the pluggable terminal block connector is complete for the group of short home run cables (or single cable), plug it into the appropriately marked header on the SAS-JB circuit board (Figure 12). Be sure some of the short home run cable sheathing enters the SAS-JB and tighten the strain relief to secure the long home run cable entry into the SAS-JB.

Replace the SAS-JB cover and secure the screws. Be sure the SAS-JB cover is properly seated to ensure a weather tight seal (place a bead of silicone sealant around the lid before securing). Route the long home run cable to the roadside cabinet. For long runs, use at least 22 gauge cable.

6.0.4 Mounting and Connecting the SAS-Cabinet Termination (SAS-CT)

Identify a convenient mounting position on the inside wall of the roadside cabinet and mount the SAS-Cabinet Termination (SAS-CT). Connect the heavy ground wire from the SAS-CT to an appropriate point to create a good path to earth ground. Route the long home run cable into the roadside cabinet through conduit or a strain relief. Inside the cabinet, route the cable to the SAS-CT mounting position. Remove 2 to 3 inches of the sheathing from the cable. Be careful to not damage the shield wire or the insulation on each of the twisted pairs. **Do not let the black wires untwist from the corresponding colored wire of the pair.**

Terminate each conductor and the shield wire in the long home run cable using the pluggable terminal block connector (Figure 13). Once the pluggable terminal block connector is complete for the long home run cable, plug it into the header on the SAS-CT circuit board as shown in Figure 13.

Connect power (8 to 24 VDC) to the SAS-1 by means of a 2 position header on the SAS-CT. Use 18 or 20 gauge stranded cable (red and black color coded) terminated on one end using a pluggable terminal block connector and connected on the other end to the DC power source in the cabinet. Plug the connector onto the header on the SAS-CT as shown in Figure 13. **Be sure the polarity of the power cable and connector are correct and that the blade fuse is in place on the SAS-CT.**

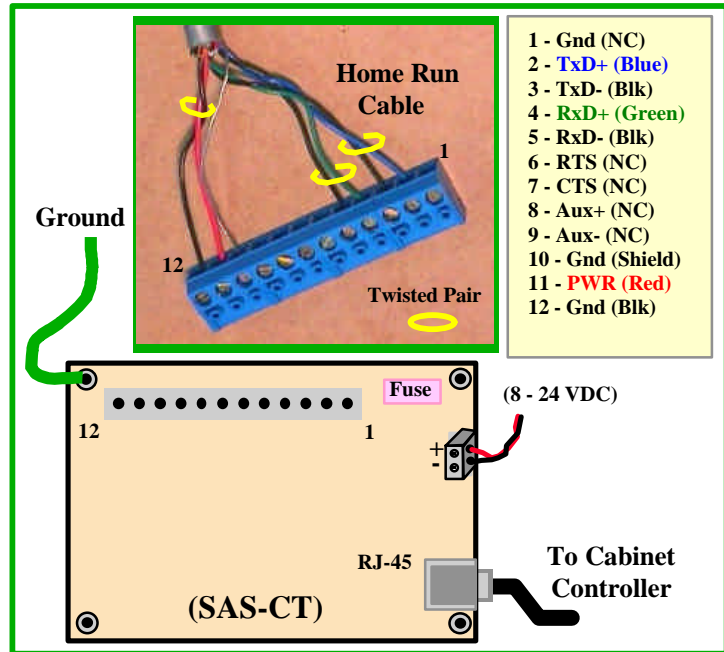


Figure 13 Connecting the SAS Cabinet Termination

Signals and information to and from the SAS-1 and the cabinet controller (or SAS-Relay Interface) are passed over a serial RS-232 cable (Figure 6). One end of the cable is plugged into the SAS-CT via an RJ-45 connector (Figure 13). The other end is plugged into a PC during SAS-1 setup or into the cabinet controller (or SAS-Relay Interface) for operation. This end of the cable may use either a DB-9, a DB-25, or an RJ-45 connector. The SAS-Relay Interface uses an RJ-45 connector while the SmarTek Systems' T-BOX or some other cabinet controller may use a DB-9 or DB-25 connector.

If a SmarTek Systems' SAS-Relay Interface (SAS-RI shelf mount or card) is being used to provide vehicle presence relay signals, connect the serial cable from the SAS-CT (RJ-45) to the SAS-RI (RJ-45 labeled RJA). Connect a second serial cable from the SAS-RI (RJ-45 labeled RJB) to the laptop PC (DB-9) for setup. After setup is complete, this cable will be removed.

If a SmarTek Systems T-BOX or some other cabinet controller is being used, connect a serial cable from the SAS-CT (RJ-45) to the laptop PC (DB-9) for SAS-1 setup. After setup is complete, this cable will be replaced by a serial cable between the SAS-CT (RJ-45) and the cabinet controller for operation. The type of connector used for the cabinet controller depends on the specific controller used.

7.0 SAS-1 Setup Using SAS Monitor and Setup Software

7.0.1 Requirements

The SAS Monitor and Setup software provided by SmarTek Systems is used to setup each SAS-1 unit after the field installation and to monitor operation to verify SAS-1 settings and performance. The SAS Monitor and Setup software is designed to run on a PC with Windows 95/98. The PC should be at least a 133 MHz Pentium with 16 MBytes or more of RAM. For portability, a laptop PC works well. The SAS Monitor and Setup software is provided on floppy disks or CD and is installed by clicking **Start/Run** and entering **a:setup.exe**. If installing from a CD, then use the appropriate drive letter in place of a: (i.e. d: or e:). Click **OK** and follow the on-screen instructions. Use all default settings and folders if possible.

7.0.2 SAS Monitor and Setup Display and Parameters

Run the **SAS Monitor and Setup** program on the PC by clicking **Start/Programs/SmarTek Systems/SASMonitor**. On the Introduction Screen, click **Direct**. The SAS Monitor and Setup's main display (Figure 8) is used to set parameters and to monitor SAS-1 operation and performance in real time.

The area to the right on the SAS Monitor and Setup Display is used to show measurement/signal time history, while the area to the left (upper part) is used for common parameter display and modification. The area in the lower left part of the SAS Monitor and Setup Display is for lane by lane parameter display and modification and for showing the most recent traffic flow measurements on a lane by lane basis.

As can be seen in Figure 8, there are several parameters fields, however, many of these are for adjusting the SAS Monitor and Setup Display. The SAS-1 actually uses very few parameters, many of which do not need modification for a typical installation. **All parameters on the SAS Monitor Display** may be modified by **left clicking** in the **upper** or **lower** portion of each parameter field. For the parameters which have a number value, holding the **Shift** key down while clicking will increase the size of each increment or decrement.

Making changes to certain SAS-1 parameters will cause a yellow parameter flag to be displayed (Figure 8). This flag is a reminder that some or all of the displayed parameters have been changed (only in SAS Monitor) and need to be sent to the SAS-1 and written to the SAS-1's non-volatile memory.

Most of the parameters are grouped in three frames and are described in the following paragraphs.

Communication and Display Parameters: These parameters are used to set or identify the SAS-1 data communication mode and the SAS Monitor and Setup display sensitivity.

SAS-ID - Identifies a specific SAS-1 unit for monitoring and setup.

Dspl Sens - Controls the display of data on the TAI display. Higher values of Dspl Sens, cause more acoustic data to be displayed. This parameter is only used for the SAS Monitor and Setup display.

Scale - This is a scaling parameter for converting acoustic power measurements into the levels of color (green) for the TAI display. Larger values of this parameter would cause each acoustic power measurement to be shown in a darker shade of green.

Mode - Sets the operating mode for the SAS Monitor and Setup program. For each of the available modes, the SAS-1 is told to send specific measurements.

Mode=1 is the Traffic Acoustic Image Mode (real time acoustic power and detection relays).

Mode=2 is the Multi-Lane Flow Mode (vehicle vol, occ, and avg speed per lane).

Mode=3 is the Azimuth Detection Measurements Mode (peak amplitude and LD per detection)..

D-Mode - Displays the default operating mode for the SAS-1 unit to fall back to on power up, reset, or loss of data carrier detect when using modem communications.

LF Sens - Used to limit the acoustic power measurements used for computing the lane finder function.

P-Alpha - Sets the amount of smoothing for the traffic flow measurements display used in Mode=2 operation of SAS Monitor and Setup (1.0 for no smoothing, .01 for significant smoothing).

Detector Parameters: These parameters are used by the SAS-1 unit to adjust vehicle detection sensitivity.

Max Det Sensitivity - Sets the SAS-1's maximum detection sensitivity (sensitivity increases with higher values). Typical value for this parameter = 25.00.

Min Det Sensitivity - Sets the SAS-1's minimum detection sensitivity (sensitivity increases with higher values). Typical value for this parameter = 22.50.

Alpha - Sets the amount of averaging over time of acoustic power before vehicle detection (typical value = 0.12, for no smoothing use 1.0, for heavy smoothing use 0.01).

LD Win - Sets the number of look directions for averaging before vehicle detection (typical value = 3).

Rpt Intv - Sets the reporting interval (1 second to 220 seconds) of the SAS-1 unit when operating in the Flow Mode (Mode=2) or the Azimuth Detection Mode (Mode=3). The default operational value for the reporting interval is set using the Set Default Operating Mode Dialog Window.

Lanes or Zones Parameters: These parameters define each detection zone position and size with respect to 181 TAI display pixels and the 91 look directions for which power is measured in the SAS-1 unit. Calibration parameters for lane occupancy and average speed are also specified on a lane by lane basis.

Cntr - Sets the detection zone center position in terms of 181 TAI display pixels. The SAS-1 unit will convert this value to the appropriate look direction index value.

Size - Sets the detection zone size in terms of 181 TAI display pixels. The SAS-1 unit will convert this value to the appropriate range of look direction index values.

Sens - Specifies the automatic lane by lane detection sensitivity adjustment relative to a real time estimate of the peak acoustic power for each lane or zone (typical value=6.00).

AVL - Used by the SAS-1 unit to calibrate the average speed for each lane (typical value=13).

Ocal - Used by the SAS-1 unit to adjust the lane occupancy for each lane (typical value= 0.6).

7.0.3 SAS-1 Setup

The SAS-1 operating parameters are best set with active traffic in the lanes to be monitored.

Click **Settings/Comm Port** to set the PC Comm Port parameters. The **Comm Port** Number for a laptop PC is typically **1 or 2**. Set the Comm Port Number to the appropriate value corresponding to the external DB-9 connector on the back of the laptop. The rest of the Comm Port parameters should be as follows:

| | |
|--------------------------|------------------|
| Baud Rate | 38400 |
| Data Bits | 8 |
| Parity | N |
| Stop Bits | 1 |
| HW Flow Control | Unchecked |
| SW Flow Control | Unchecked |
| Set DTR line high | Checked |
| Set RTS line high | Checked. |

Note: The first time SAS Monitor and Setup is run, the Comm Port Dialog Window will automatically popup.

The **SAS-1 ID** is of the form SASxxxx, where xxxx is a four digit number (i.e. SAS0001, SAS0002,...SAS0999, etc.). For installations where only one SAS-1 will be connected to a cabinet controller via a home run cable or wireless link, set the SAS-1 ID to **SAS0001** (SAS-1 ID from the factory is SAS0000). **For installations where**

multiple SAS-1s will be connected to a single cabinet controller via a single home run cable or a wireless link, set each SAS-1 ID to consecutive values starting at one (SAS0001). For example, a traffic monitoring station with three SAS-1s connected to the roadside cabinet controller using a single home run cable, should have the SAS-1 IDs set to **SAS0001, SAS0002, and SAS0003.**

Each SAS-1 ID must be set before the units are “wired” together on the same home run cable or wireless link (all are shipped with SAS0001 as their ID from the factory).

To set the SAS-1 ID, click on the **Menu** item, **Sensor/Change SAS ID.** An Information Dialog Window will popup asking for the new SAS-1 ID. The new SAS-1 ID may be incremented or decremented by **left clicking** in the **upper** or **lower** portion of the SAS ID Field. After providing the new SAS-1 ID, click **OK.** The Status Message at the bottom left of the SAS Monitor and Setup Display should indicate a positive response (OK) from the SAS-1 unit. The SAS-ID field will then be updated to the new ID value. If the positive “OK” response is not quickly received, click the **Stop Button** and repeat the Change SAS ID procedure just described.

To begin the setup for a specific SAS-1 unit, set the **SAS ID** field (Figure 8) to that unit’s SAS ID. Set the **Mode** to **1** (Traffic Acoustic Image Display Mode).

Click the **Start Button** in SAS Monitor and Setup. In the Traffic Acoustic Image (TAI) display area (right side of the SAS Monitor Display). **Blue Lines** should begin to draw from the display top to the bottom. These lines indicate the positions of detection zones set in the SAS-1 unit. The presence of the Blue Lines indicate that SAS-1 is running and communicating properly with the PC (SAS Monitor and Setup program). If no Blue Lines are present click on the **Stop Button** in SAS Monitor and Setup and double check all connections and parameter settings, particularly the PC Comm Port number, the Comm Port baud rate, and the SAS ID. Retry the Start Button.

Check and set the following parameters to their respective values as follows:

| | |
|----------------------------|---|
| Dspl Sens | 24.00 (higher values are more sensitive) |
| Scale | 0.45 (increase to make green acoustic response darker) |
| Mode | 1 (Traffic Acoustic Image Mode-TAI) |
| Min Det Sensitivity | 22.50 (higher values-more sensitive) |
| Max Det Sensitivity | 25.00 (higher values-more sensitive) |
| Alpha | 0.12 (toward 1.0 for less smoothing) |
| LD Win | 3 (use 1 for no Look Direction averaging) |
| Sens (per lane) | 6.00 (Larger values increase adaptive sensitivity) |
| AVL (per lane) | 13 (Larger values increase speed estimate) |
| Ocal (per lane) | 0.60 (Larger value increase occupancy estimate) |

If the **Start/Stop** Button is showing **Stop**, then click the **Stop** Button. Next click the **Save Par** Button. After the **Save Par** Button turns to the **Send Par** Button, click it. At this point the detection sensitivity parameters have been sent to the SAS-1 unit. Click the menu item **Sensor/Write SAS Parameters.** **This saves the parameter values to the SAS-1’s non-volatile memory.** Click the **Start** Button to initiate the TAI display (Blue Lines should begin to draw from top to bottom).

7.0.3.1 Multi-Lane Monitoring

The Traffic Acoustic Image (TAI) shows the acoustic power received at the SAS-1 from all directions. If the SAS-1 was properly mounted on the highway structure for multilane monitoring, a TAI display similar to that in figure 8 should be observed. As previously described, the green “blobs” represent each passing vehicles acoustic power.

At this point, detection zones have not been set. The blue lines and magenta detection positions will likely not look consistent with the green acoustic power “blobs”.

For this display, it is important to understand the point of reference. Move the mouse pointer slowly through the TAI display area from left to right. As the mouse pointer moves through, you should see the green readout just

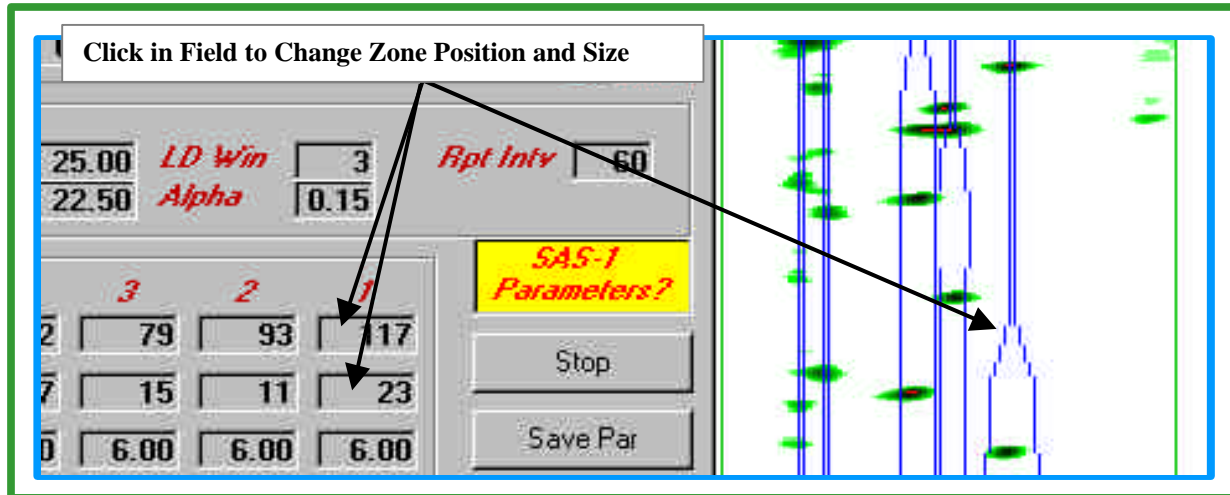


Figure 14 Manually Setting Position and Size of the Detection Zones

below the TAI display area change from Cursor LD=1 to Cursor LD=181. If you were standing just behind the SAS-1 (same end as the strain relief) with the same perspective as in the photograph of Figure 1, to your left would be Cursor LD=1 and to your right would be Cursor LD=181. As vehicles pass by the SAS-1, they appear as the most recent update. Vehicles which passed by several seconds earlier, appear well above on the display. Hence, the top of the display area shows the oldest vehicle acoustic signals, while the bottom shows the newest vehicle acoustic signals. The total display time (vertical) is 30 seconds. Once the display reaches the bottom, it clears and starts again at the top. This display continues until stopped by the installer.

The green vehicle acoustic power “blobs”, as they appear and fill the display, form “columns”. An occasional lane switcher will appear to be “out of line”, however, each “column” of green vehicle “blobs” define each lane’s position. The process of setting the detection zone positions and sizes for the SAS-1 is based on where the “columns” of vehicle “blobs” are located. Clicking in the **Cntr** (lane center) and **Size** (lane size) fields for each lane will cause that lane’s Blue Lines (indicate lane edges) to change on the TAI display (Figure 14). To increment a parameter value, left click in the upper half of the parameter field. To decrement a parameter value, left click in the lower half of the parameter field. Each zone position and size can be adjusted until each pair of Blue Lines (detection zone edges) encompass each column of green acoustic power “blobs”. Before positioning each zone, click the **Zones To Edge** Button. Click the **Stop**, **Save Par**, **Send Par** and the **Start** Buttons. This immediately sets the zone positions to the left edge of the display and sets the zone size to 3 pixels. With all the Blue Lines starting at the TAI display edge, it is easier to set the position and size of each zone. Once satisfied with the zone positioning (as viewed on the TAI display), click the **Stop** Button, click the **Save Par** Button, and then click the **Send Par** Button. This sends the newly adjusted detection zone parameters and any others which might have been changed to the SAS-1 unit. **Note that these parameters have not yet been written into the SAS-1 unit’s non-volatile memory.** Click the menu item **Sensor/Write SAS Parameters** to save the new parameter values to SAS-1’s non-volatile memory.

Click the **Start** Button to start the TAI display and check the position of the columns of green “blobs” with respect to the new lane positions (as in Figure 8). Also check the magenta detection markers to see if all vehicles are detected (a magenta marker for each green “blob”). Each magenta detection marker is placed in the lane or zone center for which the vehicle detection was assigned.

Although manually setting the position and size of each detection zone is rather easy and quick, the SAS Monitor and Setup program includes **Automatic Lane Finder** processing. This processing provides a more automated and quantitative approach for setting the zone or lane positions. To enable Automatic Lane Finder processing, click on the menu item **Settings/Lane Finder**. To increase the sensitivity of the Lane Finder function, **LF Sens** (Lane Finder Sensitivity) can be increased (default value is 6.00). The Lane Finder Function (LFF) will be calculated and displayed as a red plot at the bottom of the TAI display area (Figure 15). The peaks of the LFF show where each lane should be set, while the valleys indicate quiet space between lanes. To choose each lane to be set, move the mouse cursor to the LFF function area and left click. Left click a few times and note the lane number label in the Lanes or Zones frame. After selecting the lane to be set (Lane number should be highlighted with a green box), right click while pointing to a peak in the LFF function. The lane position is set to the same position of the LFF peak. Note the change in the Blue Lane Lines on the TAI display (Figure 15). Continue this process to set the positions of all zones (lanes). Set the zone size by clicking in the **Size** field for each zone (lane). Once satisfied with the zone settings (as viewed on the TAI display), click the **Stop, Save Par**, and the **Send Par** Button. Click the menu item **Sensor/Write SAS Parameters** to save the new parameters to SAS-1's non-volatile memory.

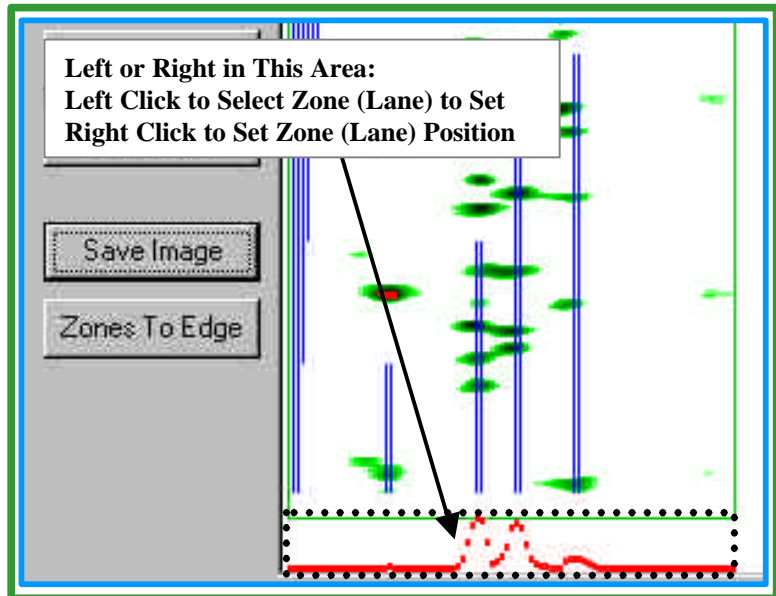


Figure 15 Setting Zones Using the Lane Finder Function

The SAS-1 may now be set to operate in one of two modes. In the **Multi-Lane Flow Mode**, the SAS-1 computes and reports vehicle count, lane occupancy, and average speed for each detection zone (lane). In the **Multi-Detection Zone Relay Signal Mode**, the SAS-1 outputs bit serial relay messages for up to 5 lanes with 1 or 2 relays per lane. For the Multi-Lane Flow Mode, the reporting period for synchronous operation is specified by the **Rpt Intv** parameter which may be from 1 to 220 seconds. The per lane parameters **AVL** (average vehicle length) and **Ocal** (occupancy calibration factor) are used to calibrate the average speed estimate and the lane occupancy measurement on a lane by lane basis. These parameters are set after observing SAS-1 operation with the SAS Monitor and Setup program operating with **Mode=2** (Flow Mode). For this SAS Monitor and Setup mode, the TAI display is replaced by the **Flow Measurements Time History Display**. This display shows the per lane flow measurement time history (magenta) and a smoothed (**P-Alpha** sets smoothing) measurement history for the display only (orange). This operating mode for the SAS-1 and the SAS Monitor and Setup program only has meaning after all detection zones (lanes) have been set using the TAI display (Mode=1) as previously described. To set the SAS-1 unit default operating mode to one of these two modes, click **Sensor/Set SAS Default Mode**. In the popup menu select the operating mode and the corresponding parameters including report interval.

7.0.3.2 Single Lane Monitoring

After mounting the SAS-1 for single lane direction and speed monitoring, a TAI display similar to Figure 16 should be observed. For this SAS-1 configuration, the point of reference is still the same as previously described. If you are just behind the SAS-1 (with the strain relief toward the ground), then to your left would correspond to the left edge of the TAI display (Cursor LD=1) and to your right would correspond to the right edge of the TAI display (Cursor LD=181). A vehicle moving past the SAS-1 unit from left to right will appear as shown in Figure 16.

That is, the green acoustic power response would first appear at the left edge of the TAI display and would build toward the right edge until the vehicle is past the sensor. Each vehicle passing the SAS-1 unit would be observed with a similar horizontal “S” shape response.

For this SAS-1 mounting orientation, all the detection zones are in the up/down road direction. Setting the zone positions and sizes is done exactly as described in the previous paragraphs, however, the zone positions and size dimensions are relative to up and down road directions. The five detection zones available would be set much like a five loop speed trap. Note the magenta markers shown in the TAI of Figure 16. As a vehicle passes through each detection zone, the acoustic signal is detected and the detection marker is displayed. The order in which each detection zone “trips” indicates vehicle direction and the slope of the green response (time between detection in each zone) is vehicle speed.

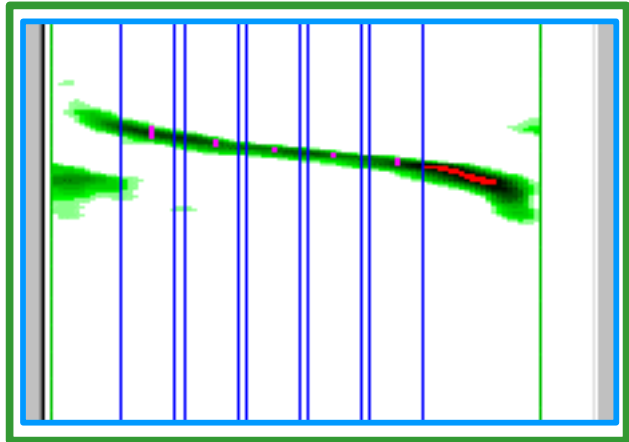


Figure 16 Single Lane Monitoring TAI

The SAS-1 may be set to operate in the **Multi-Detection Zone Relay Signal Mode**. The SAS-1 will output a continuous stream of bit serial relay messages for up to 5 detection zones. To set the SAS-1 default operating mode, click **Sensor/Set SAS Default Mode**. In the popup menu select the operating mode and the corresponding parameters.

7.0.4 Other Menu Options

The SAS Monitor and Setup program has been developed to keep the SAS-1 unit setup as simple, flexible, and intuitive as possible. To this end, some other options are incorporated into the SAS-1 unit and the SAS Monitor and Setup program.

File Menu

Log Flow Measurements - Enables/Disables creation of a spreadsheet ready text measurement file in the PC's application folder (SASxxxx.log). When enabled new data is appended to older data in the file.

Enable Manual Measurements – Enables the collection and logging of manual vehicle counts. This capability uses a special parallel port interface (with buttons) for counting vehicles.

Enable Power Log - Enables/Disables disk logging of the acoustic power. The file is binary and is used by SmarTek Systems for analysis, development, and or debug.

Exit – Terminates SAS Monitor and Setup.

Settings Menu

Comm Port - Opens a dialog window to set the PC Comm Port parameters.

Modem – Opens a dialog window to set the modem parameters.

Old SAS Firmware – Then enables use of SAS Monitor with SAS-1 units which have early versions of operating firmware (pre 9/11/1999).

Create Sensor Polling List - Opens a dialog for creating a multi-sensor polling list. This list is used with special SAS Monitor and Setup modes for analysis, demonstration, and testing.

Visible Message Window - Enables/Disables a text window for observation of the SAS-1's message string.

White Plot Background - Toggles between a white background or black background measurement display.

Flow Mode Beep - Enables/Disables a audible beep to alert the arrival of a flow measurement update message.

Lane Finder - Enables/Disables the Automatic Lane Finder Function Display.

Sensor Menu

Get SAS Parameters - Retrieves current SAS-1 unit parameter settings and displays them in appropriate SAS Monitor and Setup parameter fields.

Send new Executable Code - Sends the SAS-1 new executable software.

Set SAS Baud Rate - Opens a dialog window for setting the SAS-1 unit communication baud rate. Once this value is changed, the SAS Monitor and Setup Comm Port baud rate must be changed to match.

Write SAS Parameters - Instructs the SAS-1 unit to save its current parameters to nonvolatile memory.

Get SAS ID - Instructs the SAS-1 unit to send its ID to SAS Monitor and Setup.

Change SAS ID - Opens a dialog window for changing the SAS-1 unit's ID.

Set SAS Default Mode - Opens a dialog window for setting the SAS-1 unit's default operating mode.

Set SAS Date and Time - Sets the SAS-1's real time clock to the Date and Time of the PC running SAS Monitor and Setup.

Get SAS Date and Time - Gets the Date and Time from the SAS-1 and displays it in the status line at the bottom left of the SAS Monitor Display.

Send SAS Header Data - Sends the SAS-1 new Archive Header records (created using a separate editor).

Get SAS Archive Data - Retrieves the SAS archive and stores it in a sub-folder in the application folder. The archive file may be decoded into a text file using a separate decode program.

Reset SAS - Sends a command to the SAS-1 unit instructing it to execute a software reset. SAS responds with a banner containing configuration information. This information is displayed in the status line at the bottom left of the SAS Monitor Display (when the SAS Monitor Mode is set to 2 or 3). The information includes the software revision number, presence or absence of a battery backed real time clock, the presence and size of the flash memory chip, and the archive update period.

8.0 Default Operating Modes

To set the SAS-1 Default Operating Mode, left click the menu item Sensor/Set SAS Default Mode. The dialog window that appears provides for setting several parameters as described below.

Operating Mode - Flow, Azimuth Detect, Single Relay, or Dual Loop Relay (with loop separation).

Monitor Mode - Freeway (more dynamic detector settings) or Intersection (less dynamic detector settings).

How Many Zones - Up to 5 zones for monitoring (leave this at 5).

Communication Mode - Periodic or Polled.

Report Interval - 1 second to 220 seconds.

Radio Network Number - For wireless, this specifies the spread spectrum hopping pattern set in the wireless base unit (roadside cabinet). Up to 30 network numbers may be used to eliminate interference between radio networks (consult with SmarTek Systems for detailed directions for setting this, keep this setting = 0).

9.0 Detailed SAS-1 Communication Message Formats

The detailed communication message formats and protocols used to communicate with the SAS-1 are published in a separate document entitled SAS-1 Detailed Communication Message Formats. This document is available upon request .

10.0 SAS Relay Interface Configuration and Connection

Many traffic monitoring sites in place (or planned) and traffic counters use the traditional controller interface approach of vehicle presence relay signals. The SAS Relay Interface is used with the SmarTek Acoustic Sensor (SAS-1) to provide physical vehicle presence relay signals to a cabinet controller or traffic counter. The SAS-RI is available in two form factors (Figure 17). The shelf mount version and the Type 170 card version of the SAS-RI connect to the SAS-CT using the supplied cable (RJ-45 connector on both ends).

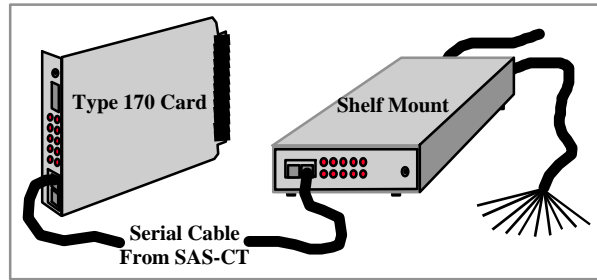


Figure 17 SAS Relay Interface

The function of the SAS-RI is to acquire the bit-serial relay message stream from the SAS-1 and convert the bit-serial relay signals to physical relay signals. These signals are open collector vehicle presence signals and are brought out on individual conductors or on a card edge connector. When using the SAS-RI to provide per lane vehicle presence relay signals, the SAS-1 must be operating in the **Single Relay or Dual Loop Mode**.

10.0.1 Configuration and Installation

Before installation and connection of the SAS-RI, it must be configured using push-pin jumpers on the SAS-RI circuit board. Configuration of the SAS-RI is required to match the specific single or multiple SAS-1 deployment.

The shelf mount version brings ten (10) relay signals out via a multi-conductor cable connected at the rear of the SAS-RI shelf mount unit. This cable is made up of ten (10) conductors (open collector) for ten (10) relay signals and one (1) common conductor (common emitter) as shown in Figure 18. The two “CE” pins (Common Emitter) are common to all the relay signals. Power for the SAS-RI can range from 8 to 24 VDC since the SAS-RI has its own DC to DC regulator.

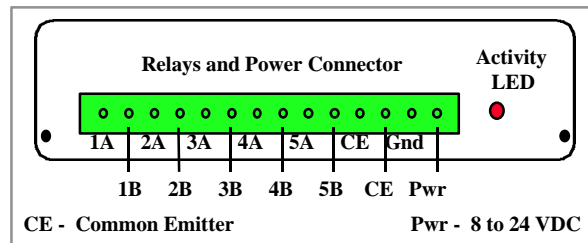


Figure 18 SAS-RI Rear Panel Connector

The SAS-RI has ten (10) LEDs (for detection indication), ten (10) channels of opto-coupled relays, a reset switch, and two RJ-45 receptacles. The ten LEDs are organized with two per channel (1A, 1B, 2A, 2B, etc.). The Reset switch resets the SAS-RI and sends a reset signal to the SAS-1 sensor unit.

10.0.2 Connecting and Routing Relay Signals For The SAS-RI Type 170 Card

The type 170 card version is comprised of a SAS-RI Main Card and up to two SAS-RI Auxiliary or Daughter Cards as shown in Figure 19. Each SAS-RI Main and Auxiliary Card has a ribbon cable header for relay distribution and a Relay Routing Matrix. The Relay Routing Matrix on each SAS-RI Card provides complete flexibility for connecting any of the ten relay signals from each SAS-1 unit to any of the four standard card edge contacts (F, W, S, and Y) as specified for a type 170 card file.

For Type 170 compatible detector cards, there may be up to four relay signals brought out to the card edge connector as follows:

| Card Edge Contact | Signal | Card Edge Contact | Signal |
|-------------------|------------------|-------------------|------------------|
| A and B | Gnd and VDC | U and V | No Connection |
| C | Reset | W | Ch 2 (Collector) |
| D and E | No Connection | X | Ch 2 (Emitter) |
| F | Ch 1 (Collector) | Y | Ch 4 (Collector) |
| H | Ch 1 (Emitter) | Z | Ch 4 (Emitter) |
| J,K,L,M,N,P,R | No Connection | | |
| S | Ch 3 (Collector) | | |
| T | Ch 3 (Emitter) | | |

This example shows how to connect and configure a SAS-RI Main Card and Two SAS-RI Auxiliary Cards to route each of ten relay signals from a SAS-1 unit (bit serial message) to appropriate card edge connector contacts (physical relay signals) in a Type 170 Card File. Since there are ten relay signals to be routed, three SAS-RI Cards (4 relays per card) are required (1 SAS-RI Main Card, 2 SAS-RI Auxiliary Cards).

For each of the SAS-RI cards used, set the Relay Routing Matrix (header JP1) jumpers as shown in Figure 20. These jumpers connect each input relay signal (1A, 1B, 2A, 2B, etc.) from the SAS-1 unit to a card edge contact (F, W, S, Y). From Figure A3 it can be seen that the SAS-RI Main card routes relay signals 1A, 1B, 2A, and 2B to four card edge contacts. The SAS-RI Auxiliary Card 1 routes relays signals 3A, 3B, 4A, and 4B to four card edge contacts. And finally, the

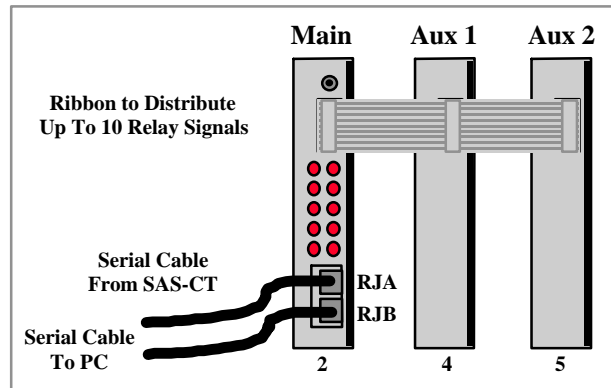


Figure 19 SAS-RI Main and Auxiliary Cards

| RELAY ROUTING MATRIX | | | | | | | | | | | | |
|----------------------|------|------|------|------|------|------|------|------|------|------|----------------|---------------|
| RLY1 (F) | ■ | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | SAS-RI (Main) |
| RLY2 (W) | ● | ■ | ● | ● | ● | ● | ● | ● | ● | ● | | |
| RLY3 (S) | ● | ● | ■ | ● | ● | ● | ● | ● | ● | ● | | |
| RLY4 (Y) | ● | ● | ● | ■ | ● | ● | ● | ● | ● | ● | | |
| | CH1A | CH1B | CH2A | CH2B | CH3A | CH3B | CH4A | CH4B | CH5A | CH5B | | |
| RELAY ROUTING MATRIX | | | | | | | | | | | | |
| RLY1 (F) | ● | ● | ● | ● | ■ | ● | ● | ● | ● | ● | SAS-RI (Aux-1) | |
| RLY2 (W) | ● | ● | ● | ● | ● | ■ | ● | ● | ● | ● | | |
| RLY3 (S) | ● | ● | ● | ● | ● | ● | ■ | ● | ● | ● | | |
| RLY4 (Y) | ● | ● | ● | ● | ● | ● | ● | ■ | ● | ● | | |
| | CH1A | CH1B | CH2A | CH2B | CH3A | CH3B | CH4A | CH4B | CH5A | CH5B | | |
| RELAY ROUTING MATRIX | | | | | | | | | | | | |
| RLY1 (F) | ● | ● | ● | ● | ● | ● | ● | ● | ■ | ● | SAS-RI (Aux-2) | |
| RLY2 (W) | ● | ● | ● | ● | ● | ● | ● | ● | ● | ■ | | |
| RLY3 (S) | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | |
| RLY4 (Y) | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | |
| | CH1A | CH1B | CH2A | CH2B | CH3A | CH3B | CH4A | CH4B | CH5A | CH5B | | |

■ - Jumper Installed

Figure 20 Relay Routing Jumper Matrix

SAS-RI Auxiliary Card 2 routes relay signal 5A and 5B to two card edge contacts. For Type 170 card files, contacts **S** and **Y** are routed to contacts **F** and **W** respectively in the adjacent lower numbered slot (i.e. contacts **S** and **Y** in slot 2 are routed to **F** and **W** in slot 1). Plug each SAS-RI Card into the appropriate **slots** in the Type 170 card file as shown in Figure A4. Note the use of slot 5 instead of slot 6 for SAS-RI Auxiliary Card 2. Since SAS-RI Auxiliary Card 2 routes only two relay signals to card edge contacts **F** and **W**, slot 5 can be used without conflict.

Connect the ribbon cable to each header on each SAS-RI Card. This ribbon cable is used to distribute all ten relay signals from the SAS-RI Main Card to each of the Auxiliary Cards. Connect the serial cable to the SAS-CT (RJ-45) and to the SAS-RI Main Card (RJ-45 receptacle marked **RJA**). Connect an RS-232 cable from the SAS-RI Main Card (RJ-45 receptacle marked **RJB**) to the DB-9 Comm port connector on the PC. Apply power to the card file and to the SAS-1 unit (SAS-CT). Run SAS Monitor and Setup to configure the SAS-1 unit as described in Section 7.0 of this manual. After the SAS-1 unit or units have been setup, you may disconnect the serial cable from **RJB** on the SAS-RI Main Card and the DB-9 Comm port connector on the PC. Push the **Reset** switch to reset the SAS-RI and the SAS-1 unit or units. The system is now operating. Observe the detection indicator LEDs to verify proper operation.

10.0.3 Connecting Multiple SAS-RIs For Up To Seven SAS-1 Units

When multiple SAS-1 units are connected to a single SAS-CT (one home run cable or multiple home run cables), each must have a corresponding SAS-RI. Each SAS-RI is configured to identify the bit serial relay “message packet” (from a specific SAS-1 sensor) that it will acquire and route to it’s relay signal cable or card edge. To configure each SAS-RI, the header **JP2** should be jumpered as follows (Yes-jumper present, No-jumper absent):

| JP2 | SAS-RI #1 (SAS0001) (Master) | SAS-RI #2 (SAS0002) | SAS-RI #3 (SAS0003) | SAS-RI #4 (SAS0004) | | SAS-RI #7 (SAS0007) |
|-----|------------------------------------|------------------------|------------------------|------------------------|-------|------------------------|
| A0 | Yes | No | Yes | No | | Yes |
| A1 | No | Yes | Yes | No | | Yes |
| A2 | No | No | No | Yes | | Yes |

Note: When using multiple SAS-1 sensors connected to multiple SAS-RIs as shown in Figure 21, the default mode for each SAS-1 must be set for Single Relay or Dual Loop with Polled Communication.

When a single SAS-1 sensor is connected to a single SAS-RI, the default mode for the SAS-1 must be set for Single Relay or Dual Loop with Periodic Communication.

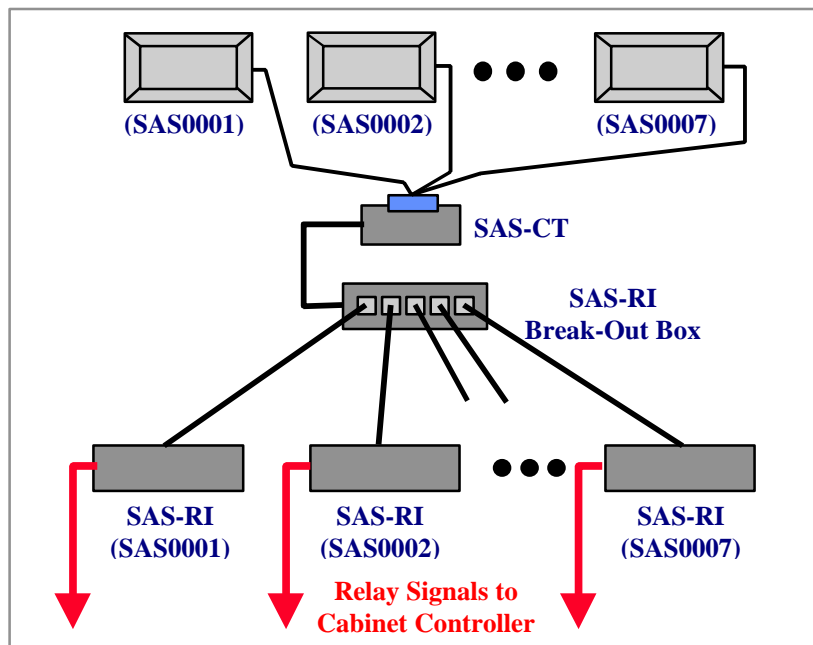


Figure 21 Connecting Multiple SAS-1s and SAS-RIs