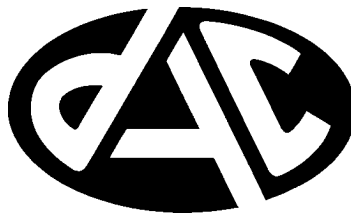


SAM II

Speech Activity Monitor with Buffer and Automatic Recorder Control



User's Manual



Digital Audio Corporation
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"Technology to Make Listening Easier"

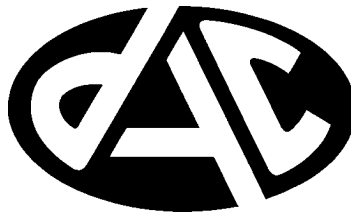
SAM II

Speech Activity Monitor with Buffer and Automatic Recorder Control

User's Manual

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1.0 OVERVIEW

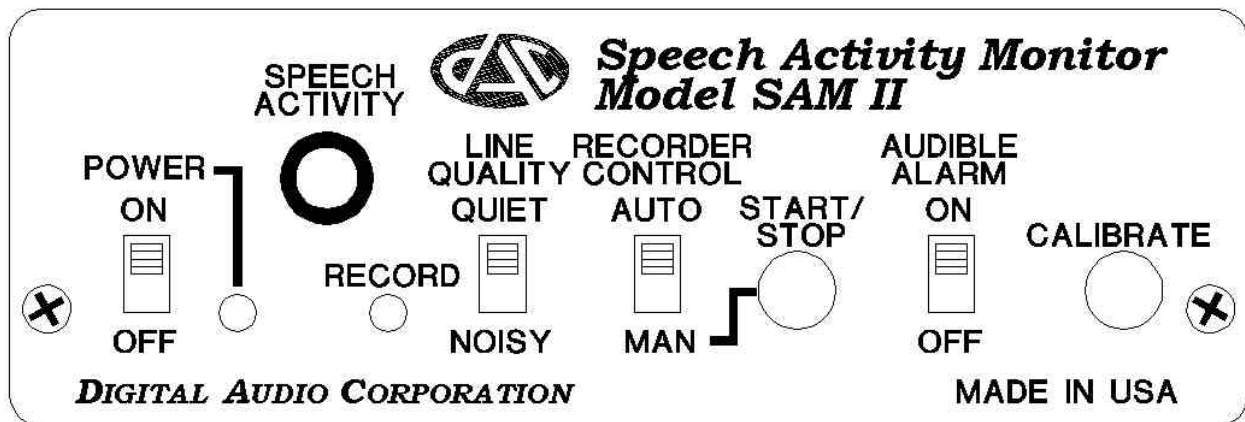


Figure 1. SAM II Front Panel

The SAM II is an easy-to-use digital audio VOX and buffer device and is used in conjunction with an audio tape or solid-state recorder. Unlike conventional VOX switches, the SAM II automatically "tracks" background noises and detects speech using a thresholded, spectrally-weighted algorithm. It functions very accurately in both QUIET and NOISY audio environments.

The SAM II has two basic modes of operation: AUTOMATIC and MANUAL. In MANUAL mode, the instrument provides both visual and audible indication of speech via the high-intensity SPEECH ACTIVITY LED and a built-in piezo electric buzzer ALARM. The ALARM can be disabled by a front panel switch. Whenever activity is detected, the user can press the START/STOP switch to manually activate/deactivate the external recorder. Thus, the MANUAL mode of operation is designed to assist a human operator, which is consistent with normal procedure for law enforcement recording.

In AUTOMATIC mode, the instrument stores all detected speech in its internal solid state buffer. When the buffer fills, or when a built-in timeout elapses, the external recorder is automatically switched on, and the stored speech is recorded onto the tape. By buffering the speech in this way, tape recorder on/off operations are minimized, reducing wear on the record mechanism. AUTOMATIC mode is intended for use in unmanned audio surveillance applications.

Additional SAM II features include a CALIBRATE tone, which produces a reference record level for the tape recorder, and a built-in relay, which allows the unit to remotely control an external tape recorder by contact closure. All audio input and output uses balanced differential signaling, which eliminates the possibility of "ground loop" hum when coupled to balanced cabling. Audio level is adjusted automatically by the microprocessor.

The SAM II may be connected to both analog and digital recorders. Pre-detection times are internally adjustable to accommodate record start latencies and DAT backup-and-overwrite times. The SAM II incorporates a LINE QUALITY control for collectively setting the VOX algorithm's optimum pre- and post-delays (guard bands), threshold, and smoothing time constant for either QUIET or NOISY signals. Other panel features include a SPEECH ACTIVITY LED, a RECORD LED, a RECORDER CONTROL switch, a START/STOP push button, an AUDIBLE ALARM ON/OFF switch, and a CALIBRATE push button. Internal DIP switches allow the technician to specify recorder latency delay. Rear panel connectors include balanced stereo inputs and outputs, a relay connector for automatic recorder control, and a power connector.

The SAM II is packaged in a compact, rugged aluminum enclosure. It is intended for field surveillance applications. The unit may be powered from 9-18 VDC, or from AC using the supplied AC adapter.

2.0 THEORY OF OPERATION

The “smart VOX” algorithm, as implemented in the SAM II, is functionally illustrated in Figure 2. The block diagram is shown for a single channel. The SAM II is actually a stereo instrument, and two parallel detection and speech buffer channels exist. Recorder control is based on speech detection on either or both channels.

In the figure, input audio is passed to a voice detection circuit and a speech FIFO buffer circuit. The detection circuit controls the audio collection, the SAM II's 15-second buffer, and subsequent audio output to the tape recorder.

2.1 Voice Detection

The input audio is initially bandpass filtered to select the spectral segment which gives preference to voice energy. This filter is centered at 200 Hz and has a 500 Hz bandwidth.*

The average energy, E is then computed for each 32 msec segment of bandpassed audio.

The algorithm then compares the average energy, E , with two time-varying reference levels. These levels are based on the smoothed minimum values of E . Each 512 msec, the minimum value of E , which would be the smallest of the most recent 16 E values, is computed. This minimum value, MIN , is then smoothed using a lowpass filter with a long time constant, typically 9 seconds.

The voice detect level, L_D , consists of SM (the smoothed MIN values) plus the voice detect threshold, TH_D . If E exceeds this voice detect level, the algorithm considers this to be a speech event and the SPEECH ACTIVITY LED will be illuminated. When a speech event occurs, the logic assumes that the voice occurred before and after the detection. BEFORE TIME, T_B , and AFTER TIME, T_A , values are thus applied to each detection, thereby expanding it in time in both directions. These BEFORE and AFTER TIMES are preprogrammed and are specified by the LINE QUALITY control. During speech, the detections typically occur frequently enough for the overlaps to form a continuous stream of detected speech, which is then passed to the control logic.

*Due to the way the bandpass filter is constructed, the center frequency can be less than half the bandwidth.

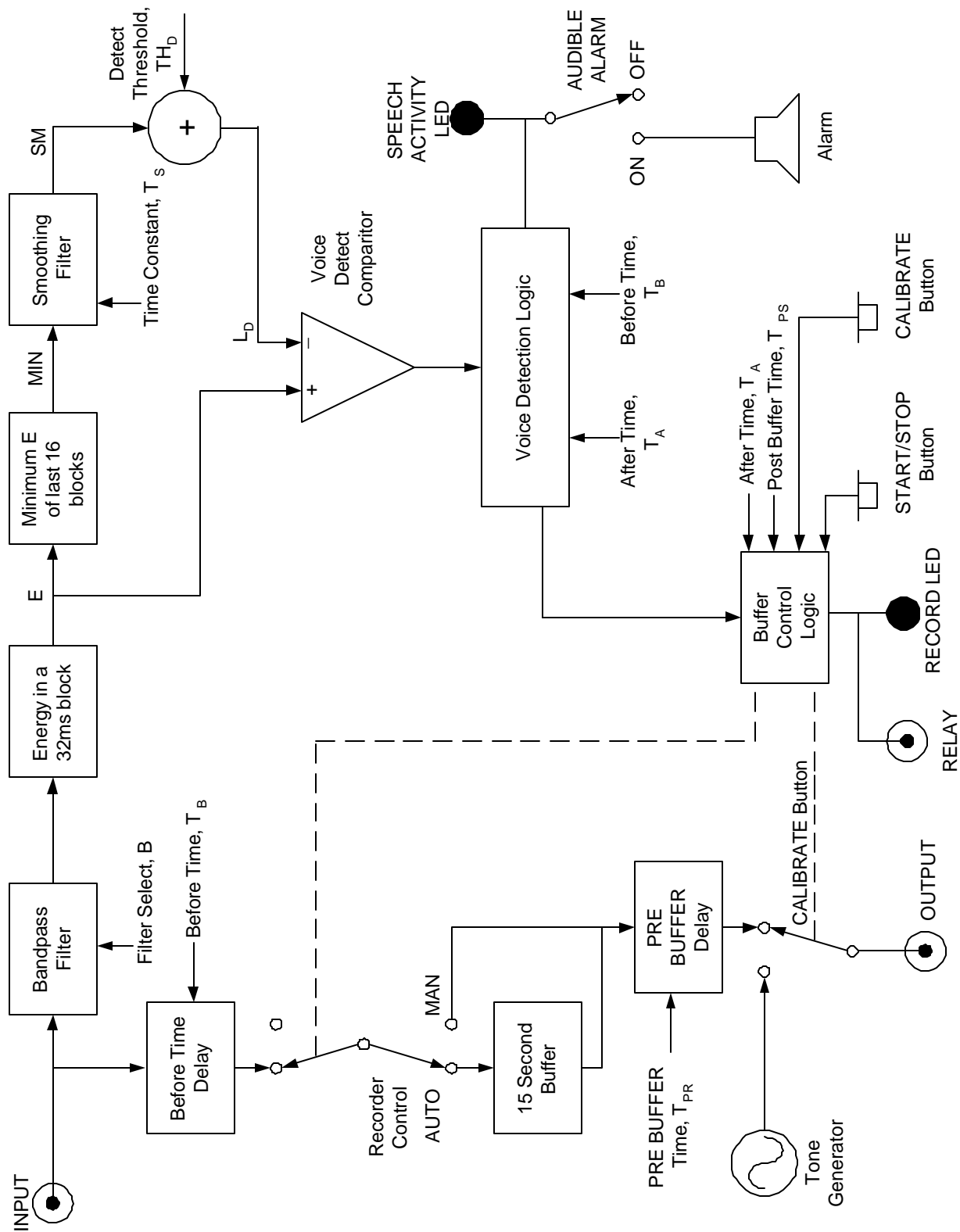


Figure 2. SAM II Block Diagram

2.2 Voice Buffering

The buffer control logic selects and isolates the detected voice segments and stores this audio in the 15 second digital FIFO buffer. The logic also controls the external tape recorder.

The BEFORE TIME, T_B , in the voice detection algorithm requires the audio to be collected *in advance* of an actual speech detection event. This is accomplished by placing an audio delay of T_B seconds to the input audio path. The delayed audio is isolated and accumulated in the 15 second buffer by the buffer control logic.

When the 15 second buffer is nearly full, the buffer control logic activates a record sequence, consisting of the following steps:

1. The tape recorder is switched on for a predetermined PRE BUFFER TIME, T_{PR} . This step allows adequate time for the recorder to come up to speed before audio is output by the SAM II.
2. Audio from the buffer is recorded on the tape. If the SAM II is currently collecting speech, this step is continued until the buffer is completely empty.
3. A silence of T_{PS} , the POST BUFFER TIME, is recorded as a trailer. This silence period permits, as occurs with certain DAT recorders, the next record startup to *back up* over a brief segment of the previous recording without destroying collected speech. The POST BUFFER TIME is set to 0.5 seconds on the SAM II.

The SAM II will automatically dump its buffer contents to the recorder if no dump has occurred for 15 minutes. This feature minimizes losses should power or instrument failure occur. Also, this dump may be *forced* manually, initiated with the front panel START/STOP push button. This button is pressed at the end of an operation to clear out a partially filled buffer before powering down the equipment.

3.0 CONTROL AND CONNECTORS

The SAM II is controlled by front panel push buttons and slide switches. An internal DIP switch enables the user to select the appropriate PRE BUFFER TIME delay for the type of recorder being used. All signal, control, and power connections are made to the unit's rear panel.

3.1 FRONT PANEL Controls

3.1.1 POWER Switch

The POWER switch is used to switch ON power to the SAM II. When power is ON, the POWER LED on the front panel is illuminated.

3.1.2 SPEECH ACTIVITY LED

The SPEECH ACTIVITY LED lights whenever speech is sensed by the algorithm, and is a good indicator of the detection algorithm's performance.

3.1.3 RECORD LED

The RECORD LED lights when audio is being output to the external tape recorder, and the relay is activated.

3.1.4 LINE QUALITY Switch

The SAM II has two LINE QUALITY settings: QUIET and NOISY. The user should select the ACTIVITY setting which most closely describes the *maximum noise* in the environment. For example, most telephone conversations and most office environments could be recorded using the QUIET position. However, telephone conversations from cordless or pay telephones in congested areas or noisy office environments with typewriters and printers might require selecting NOISY.

TIP: When in doubt, use the NOISY position. When the SAM II is left unattended, also use the NOISY position.

3.1.5 RECORDER CONTROL Switch

The SAM II has two basic modes of operation, AUTOMATIC and MANUAL. In AUTOMATIC mode, the unit functions as a stand-alone speech collection device. No input from the operator is required. When the unit detects speech in the incoming audio, the SPEECH ACTIVITY LED will illuminate and the audio will be buffered into the unit's 15-second solid state memory. When this buffer is full, when 15 minutes have elapsed, or when the START/STOP button is pressed, the unit switches on the tape recorder and dumps the contents of the buffer onto tape. The outgoing speech may be delayed by an adjustable PRE BUFFER amount to allow the tape recorder to bring the tape up to proper record speed before the new recording begins. The amount of this PRE BUFFER delay is adjustable by configuring DIP switches 2 and 3 on the main board of the unit. (See Table 1, Section 5.1) If new speech activity occurs during a buffer dump, it will continue to be buffered into the solid state memory, so no speech will be lost.

The MANUAL mode is a supervised mode, in which the operator uses the START/STOP button to manually start and stop the recorder. When the unit detects speech in the incoming audio, the SPEECH ACTIVITY LED will illuminate, prompting the operator to press the START/STOP button to initiate a new recording. In this mode, audio could be lost due to slow reaction time from the operator, so an AUDIBLE ALARM is provided to quickly get the operator's attention. As an additional precaution against the loss of speech, the audio output of the SAM II can be delayed with respect to the SPEECH ACTIVITY indicators using the PRE BUFFER delay feature. The amount of this delay can be adjusted by configuring DIP switches 2 and 3 on the main board of the unit. (See Table 1, Section 5.1)

3.1.6 START/STOP Push button

In AUTO mode, the START/STOP push button forces all contents of the internal buffer to be output and recorded to tape. In this mode, the recorder automatically switches on and a buffer dump occurs whenever the internal buffer is full. If 15 minutes elapses without such an automatic dump, a forced buffer dump takes place. Therefore, at the end of an operation, the buffer could contain some collected speech. Thus, the START/STOP push button should be pressed prior to either changing tapes or terminating a record session, to avoid the loss of this collected speech.

In MANUAL mode, the START/STOP button is used to manually toggle the state of the recorder between recording and standby. The unit's 15-second buffer is disabled in this mode.

3.1.7 AUDIBLE ALARM Switch

The AUDIBLE ALARM switch is used to enable or disable the speech activity alarm. This alarm follows the activity of the SPEECH ACTIVITY LED. The alarm buzzer can be permanently disabled by removing Jumper #1 (JP1) on the main board of the unit. This may be desirable if the unit is to be installed in a sensitive area.

3.1.8 CALIBRATE Push button

The CALIBRATE push button is used to output a +6 dBV, 814 Hz tone to both output channels of the SAM II, and thus to the tape recorder inputs. This tone is the loudest audio producible by the SAM II, and should be used to set the record level of the tape recorder, typically 0VU. At this setting, it should be impossible for the SAM II to overload the recorder.

3.2 REAR PANEL Connectors

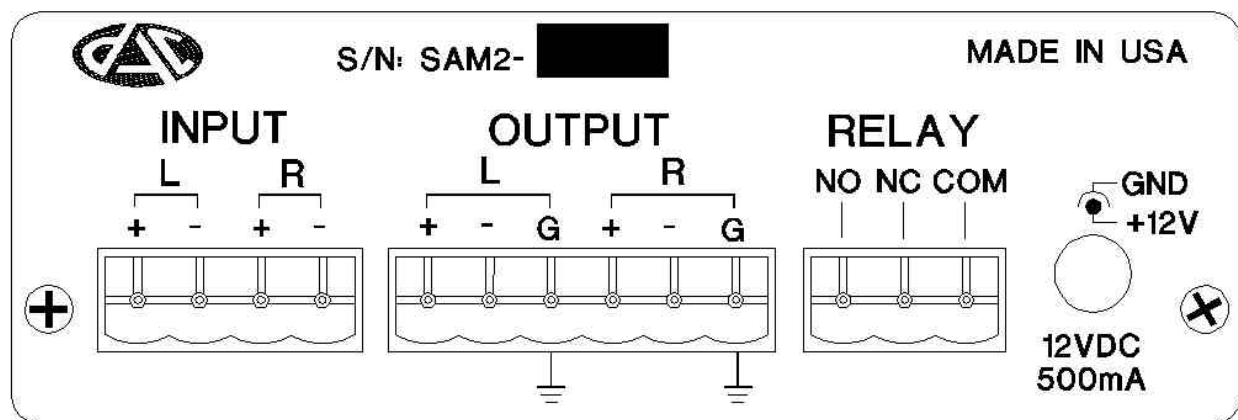


Figure 3. SAM II Rear Panel

3.2.1 INPUT and OUTPUT Connectors

Left and Right INPUT and OUTPUT jacks are Phoenix-type connectors with supplied terminal strip plugs. Wiring of these plugs is required by the user upon installation (see Figure 4). The output connectors have a nominal +6 dBV output level. The input connectors accept audio over a range -11 to +9 dBV. These audio jacks can accommodate balanced (differential) or unbalanced (single-ended) line-level signals.

3.2.3 RELAY Connector

This Phoenix-type connector provides the normally open (NO), normally closed (NC), and common (COM) terminals of the internal relay, and is used for automatic tape recorder control. Operation of the relay follows the RECORD LED; when the RECORD LED is on, the NO and COM terminals will be connected, and the NC terminal will be open-circuited. When the RECORD LED is off, the NC and COM terminals will be connected and the NO terminal will be open-circuited. For most portable cassette recorders, the NO/COM pair would be wired into a 2.5 mm phone plug and connected to the recorder's REMOTE jack for proper operation.

3.2.4 DC POWER

The SAM II requires 9-18 VDC power. A 2.1 mm "barrel" connector with a positive center conductor is used.

4.0 SAM II OPERATION

4.1 SAM II Cabling Connections

Figure 4 illustrates the connection of the SAM II to a monaural portable cassette system using an unbalanced (single-ended) connection and to a professional stereo cassette recorder using a balanced (differential) connection. For mono applications, only the cabling for the LEFT channel is required. For stereo or two channel applications, the LEFT and RIGHT channels are used.

SAM II has a built-in Automatic Level Control, which will automatically apply a gain to the input signal as necessary to achieve adequate level for analog to digital conversion. The adjustment of gain is from 0 dB to +20 dB, which will allow full scale analog to digital conversion of input signals ranging from –11 dBV to +9 dBV.

4.2 Operational Adjustments

Operating the SAM II consists of four basic steps:

1. Selecting LINE QUALITY that is most suitable for site conditions.
2. Setting record level of tape recorder.
3. Selecting AUTOMATIC or MANUAL mode of RECORDER CONTROL.
4. Arming tape recorder for record operation.
5. Maintaining tape recorder (change tapes, etc.).

Instructions for these four steps are outlined in the following sections.

4.2.1 Selecting Proper LINE QUALITY Setting

Section 3.1.4 discusses adjustment of the LINE QUALITY Switch. When in doubt, however, use the NOISY setting to minimize false alarms.

4.2.2 Setting the Record Level of the Tape Recorder

Connect the SAM II to the tape recorder as specified in Section 4.1, and activate RECORD on the tape recorder. Press the SAM II's CALIBRATE push button, and adjust

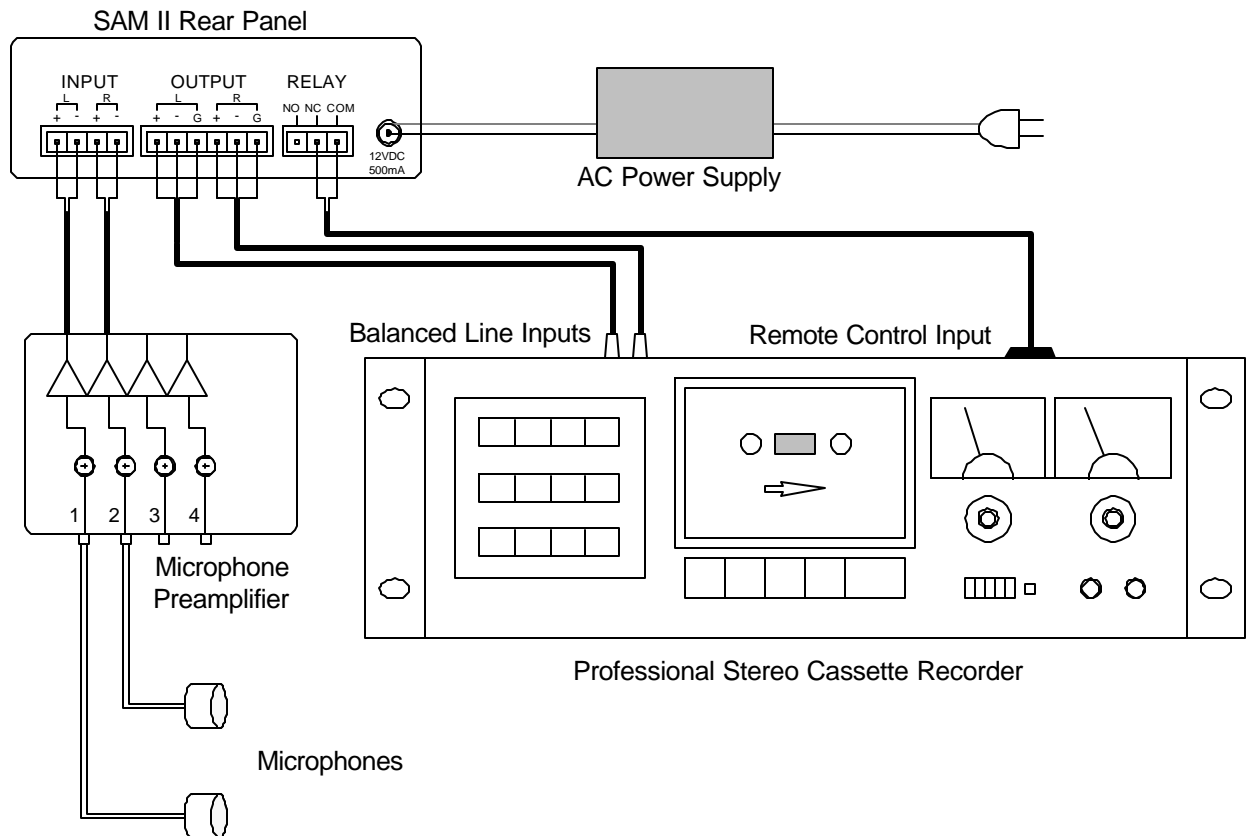
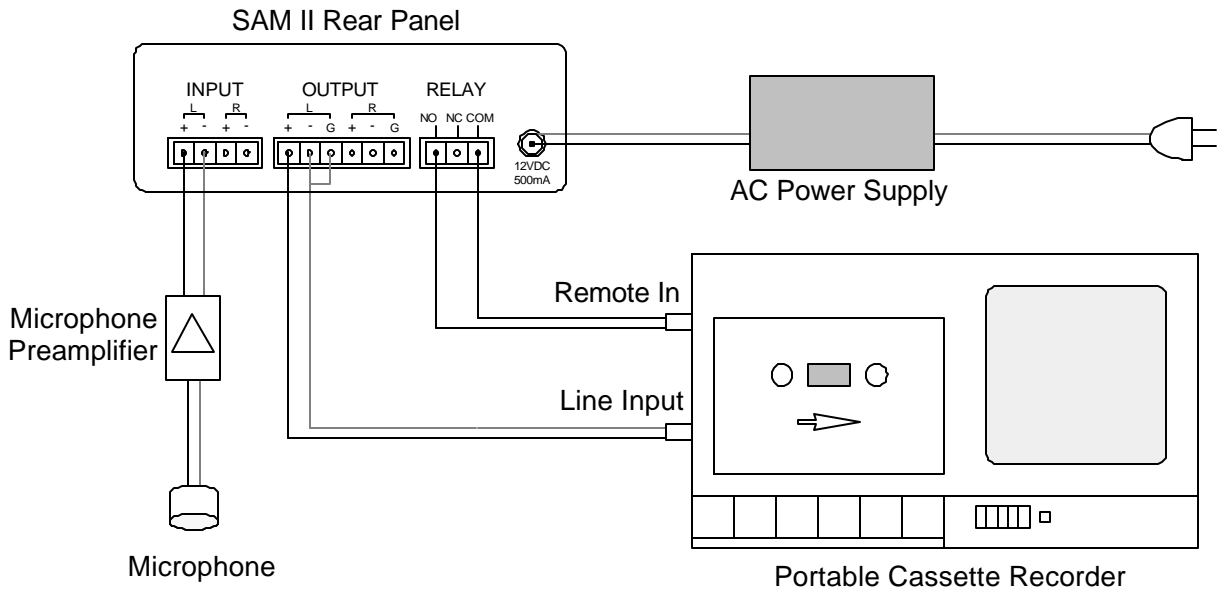


Figure 4. SAM II System Connections

the record level control(s) on the tape recorder for an indicated level of 0VU. Once the level has been adjusted, release the CALIBRATE push button.

4.2.3 Selecting AUTO or MAN Recorder Control

If the SAM II is being used in an unmanned surveillance operation, set the RECORDER CONTROL switch to AUTO, then verify that as speech is detected and accumulated into the 15-second buffer (indicated by the SPEECH ACTIVITY LED), the recorder turns on at least once every 15 minutes, or more frequently if there is a lot of speech activity.

For manned surveillance operations, set the RECORDER CONTROL switch to MAN, then verify that the recorder toggles on and off as the START/STOP pushbutton is pressed.

4.2.4 Arming Tape Recorder for Record Operation

For many analog cassette tape recorders, the SAM II's RELAY jack will be connected by cable to the 2.5 mm REMOTE control jack on the recorder. Activating the record mechanism generally requires pushing down the RECORD and PLAY buttons simultaneously. With the remote cable connected to the SAM II, the recorder should only turn on when the RECORD LED is illuminated on the SAM II front panel. Refer to the manufacturer's instructions for remote controlling the specific recorder being used.

4.2.5 Maintaining Tape Recorder at Site

AUTOMATIC Mode:

The SAM II should require minimum attention while operating in AUTO mode. However, it will be necessary to periodically check the tape recorder and change the tape if it is nearly full. The procedure for changing a tape that is nearly full is as follows:

1. Press the START/STOP push button on the SAM II front panel to record any remaining captured speech in its buffer on to the tape.
2. If the recorder switches ON, wait for the RECORD LED on the SAM II front panel to turn OFF.
3. Press the STOP and/or EJECT button(s) on the tape recorder, remove the recorded tape, insert a fresh blank tape, and rearm the tape recorder for record operation. These tasks should be accomplished within 15 seconds in order to prevent losing any speech which may have accumulated in the SAM II's buffer while changing tapes.

MANUAL Mode:

Periodically check the tape recorder and change the tape if it is nearly full. Change the tape quickly to avoid losing speech events.

4.4 Power Requirements

The SAM II is designed to operate from a single +12 VDC power supply. The input voltage range is 9 VDC to 18 VDC, and the supply must be capable of delivering 500 mA. The SAM II is internally protected against reverse polarity, and includes a resettable fuse. No special external overcurrent protection is required.

The SAM II may be wired directly to a +12 VDC electrical system, or alternatively may be powered by either 115 VAC or 230 VAC (50-60 Hz) utilizing the universal AC power adaptor (included). Connection is via a 2.1 mm “barrel” connector, with center conductor positive and sleeve ground.

5.0 CONFIGURATION

5.1 Setting Internal DIP Switches

The internal DIP switch block enables the user to customize the amount of PRE BUFFER delay on the output of the SAM II, tailoring it for specific recording situations and tape recorders. In most applications, no delay is needed, which is the default factory setting. However, when using rotary-head external recorders such as DAT or VHS machines, up to 7 seconds of delay may be required to give the tape time to be loaded and the record head engaged, without losing speech.

The locations of the DIP switches are shown in the Circuit Board Layout of Figure 5. Table 1 shows the four delay amounts possible in the SAM II and the DIP switch combinations used to achieve them.

Table 1: PRE BUFFER Delay Configuration

DIP Switch			Delay Amount
1	2	3	
OFF	OFF	OFF	OFF*
OFF	OFF	ON	1 Second
OFF	ON	OFF	3 Seconds
OFF	ON	ON	7 Seconds

Note 1: DIP Switch 1 is used to activate a special diagnostics mode and should always be set to the OFF position unless directed otherwise by a DAC technical support person.

Note 2: The asterisk (*) denotes the default positions as they were set at the factory.

5.2 Disabling the Audible Alarm

The audible SPEECH ACTIVITY alarm may be turned on and off using the front panel switch; however, there may be times when the operator may wish to permanently disable the alarm, to prevent accidental activation in the field. Figure 5 shows the location of Jumper #1 (JP1) on the mainboard of the unit. Removing the shunt from this jumper disconnects the alarm buzzer from the speech activation circuitry and eliminates the possibility of an accidental sounding of the alarm in the field.

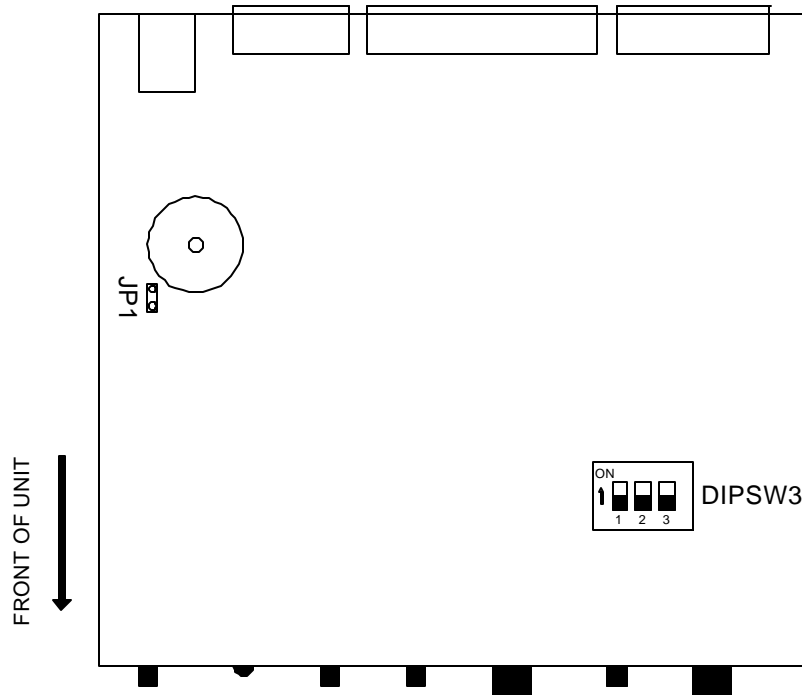


Figure 5. SAM II Mainboard

5.3 Speech Detection Algorithm Parameters

Table 2 contains a listing of the parameters associated with the *Quiet* and *Noisy* LINE QUALITY settings.

Table 2: Speech Detection Parameters

LINE QUALITY Setting	Record Before Time	Record After Time	Threshold	Center Frequenc y	Bandwidth	Time Constant
Quiet	0.3 sec	0.6 sec	7 dB	200 Hz	500 Hz	9 sec
Noisy	0.5 sec	1.0 sec	7 dB	200 Hz	500 Hz	9 sec

6.0 SAM II SPECIFICATIONS

Analog

- Line Inputs (Two) · -11 to +9 dBV
 - $Z_{in} = 25\text{ KO}$ minimum
- Line Outputs (Two) · Stereo
 - +6 dBV output level
 - $Z_{out} = 50\text{ O}$
 - $Z_{load} = 600\text{ O}$
- Bandwidth · 30 to 5500 Hz
- Sampling Filters (Four) · 0.0025 dB max ripple,
stopband attenuation > 85 dB
- Analog Converters · Stereo 24-bit delta-sigma analog-to-digital
converter with 128x oversampling and
digital decimation filters
 - Stereo 24-bit delta-sigma digital-to-analog
converter with 128x oversampling and
digital interpolation filters
- Sample Frequencies · DSP: 13.0208 kHz
 - A/D: 39.0625 kHz
 - D/A: 39.0625 kHz

Digital

- Control Processor · TMS320F206, 20 MHz, 16/32 bit fixed point DSP
- Buffer/Delay RAM · 2 megabytes total DRAM
 - 1 second per channel pre-trigger delay for detection algorithm
 - 0, 1, 3, or 7 seconds per channel PRE BUFFER delay to allow
for recorder startup

	<ul style="list-style-type: none"> 15 seconds per channel capture buffer in AUTO mode
Interfaces	<ul style="list-style-type: none"> A/D, D/A, panel switches (4), panel push buttons (2) DIP switches (3), panel LEDs (3), recorder control relay
<u>Packaging</u>	
Enclosure	<ul style="list-style-type: none"> 4.1 W x 5.0 D x 1.6 H inches aluminum
Front Panel	<ul style="list-style-type: none"> POWER ON/OFF switch POWER, SPEECH ACTIVITY, and RECORD LEDs Audible speech activity alarm (can be disabled) ACTIVITY QUIET/NOISY switch RECORDER CONTROL AUTO/MAN switch START/STOP push button AUDIBLE ALARM ON/OFF switch CALIBRATE push button, which when pressed outputs full-scale test tone for adjusting recorder input level
Rear Panel	<ul style="list-style-type: none"> Balanced stereo INPUT and OUTPUT Phoenix connectors with removable terminal strip plugs RELAY N/O, N/C and COM Phoenix connector with removable terminal strip plugs Concentric barrel POWER connector, center conductor positive.
Power	<ul style="list-style-type: none"> 9-18 VDC, 250 mA continuous Universal AC adaptor supplied

Specifications as of June 1, 2000 and subject to change without notice.

7.0 SERVICE

For service or technical questions concerning the Digital Audio Corporation Model SAM II Speech Activity Monitor with Buffer and Automatic Recorder Control, please contact:

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Any comments or suggestions concerning this product would be greatly appreciated.