

# **DSP-9**

## **Audio Noise Reduction Filter**

Operating Manual

**Timewave Technology Inc.**

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Rev. 2.00

# 1. Introduction to the DSP-9

The DSP-9 is an audio noise filter for amateur radio voice and CW operation. The DSP-9 filters and reduces noise and interference to improve radio reception. The DSP-9 uses digital signal processing technology to implement algorithms that perform three basic filter functions: 1) Random noise reduction, 2) Adaptive multi-tone notch filtering (Tone noise reduction) and 3) Bandpass filtering. Push-button switches permit simultaneous selection of the three functions.

## **RANDOM/TONE NOISE REDUCTION**

The noise reduction functions of the DSP-9 operate by examining a characteristic of signals and noise called *correlation*, and dynamically filtering out the undesired signals and noise. The degree of correlation is relative. Random noise such as white noise or static is uncorrelated. Speech is moderately correlated. Repetitive noise such as a heterodyne is highly correlated. The DSP-9 measures correlation and filters out signals and noise that are outside its correlation thresholds. There is little degradation of the desired speech signal. The amount of noise reduction varies according to the correlation characteristics of the noise. Typical noise reduction ranges from 5 dB to 20 dB for random noise and up to 50 dB for heterodynes.

## **BANDPASS FILTERS**

The DSP-9 has bandpass filters that are used in voice and CW modes. In a typical example of a voice mode application, a bandpass filter can improve a signal with a poor signal-to-noise ratio. A bandpass filter removes the high and low audio frequency components that do not contribute significantly to the speech intelligibility, thus improving signal quality. Another common voice mode example is the improvement of a SSB signal corrupted by adjacent channel interference (QRM). The steep skirts of the bandpass filters allow the interference to be eliminated with minimal effect on the desired signal. In the voice mode, two front panel push buttons select one of three voice bandpass filter bandwidths from two sets of filters. An internal jumper behind the back panel selects the filter set, either 1.6, 2.0, and 2.4 kHz., or 1.8, 2.4, and 3.1 kHz.

CW signals require Bandpass filters with steep skirts and linear phase response. Linear phase response maximizes the usable signaling rate for a given bandwidth and minimizes ringing often heard on extremely sharp filters. The DSP-9 has six different CW filters with skirts so steep that a signal literally falls off the edge of the pass band as you tune through a CW signal. The bandwidths of these filters range can be selected at either 500, 200 or 100 Hz. The center frequency for the CW Bandpass filters can be either 600 or 750 Hz. The narrow filters are useful for trying to dig out extremely weak signals from the noise and QRM. The wider filters allow easy tuning and listening to multiple CW signals simultaneously.

## 2. SPECIFICATION

### AUDIO INPUT

Impedance 22 Ohms default setting or 10,000 Ohms, jumper selectable

### AUDIO OUTPUT

Speaker output power 1.6 watts into 8 ohms at 13.8 VDC  
3.2 watts into 4 ohms at 13.8 VDC

Distortion less than 1% at rated output

### VOICE FILTERS

	<b>Frequency range</b>	<b>Attenuation</b>	<b>Type</b>	<b>Delay</b>
Random Noise Reduction	entire freq. range of selected Bandpass filter	Up to 20 dB, varies with noise characteristics	Adaptive	10 ms max.
Tone Noise Reduction (automatic notch)	entire freq. range of selected Bandpass filter	Up to 50 dB, varies with noise characteristics	Adaptive	10 ms max.
Bandpass - Voice	300 Hz - 3.4 kHz, 300 Hz - 2.7 kHz, and 300 Hz - 2.1 kHz, or (jumper selectable) 300 Hz - 2.7 kHz, 300 Hz - 2.3 kHz, and 300 Hz - 1.9 kHz	60 dB at 180 Hz outside the passband	FIR Linear phase	10 ms max

Note: The random noise reduction, tone notch and voice Bandpass filters can operate simultaneously.

### CW FILTERS

Bandpass - CW	Bandwidth = 100 Hz, 200 Hz and 500 Hz. Center freq. = 600 Hz. & 750 Hz. , or (jumper selectable) 400 Hz. & 500 Hz.	60 dB at 50 Hz outside the passband	FIR Linear phase	30 msec max
Random Noise Reduction	entire freq. range of selected Bandpass filter	Up to 20 dB, varies with noise characteristics	Adaptive	10 ms max.

Note: The random noise reduction and CW Bandpass filters can operate simultaneously.

### SIGNAL PROCESSING

A-D/D-A Converter 16 bit linear, sigma-delta conversion  
Signal Processor 16 bit, 81ns Analog Devices ADSP-2105

### CONTROLS

#### FRONT PANEL

Volume/power on-off  
Bypass switch  
Voice/CW switch  
Random Noise Reduction  
Tone Noise Reduction  
Filter bandwidth (2)  
Overload LED (red)  
Normal LED (yellow)

#### REAR PANEL

Audio In put Phono jack - RCA style  
Speaker Audio Output Phono jack - RCA style  
Power In 5.5 mm / 2.1 mm power jack (center pin positive +)

### DIMENSIONS

Size 6.0 in. wide x 6.0 in. deep x 1.75 in. high (153 mm wide x 153 mm deep x 45 mm high)  
Weight 2 lb. (0.9 Kg.)

### POWER

12-16 VDC @ 1000 ma

## 3. Installation

To install a DSP-9 in a station, an operator must provide power to the DSP-9 and make audio input and output connections to the DSP-9. A typical DSP-9 installation is shown below in Figure 3.1.

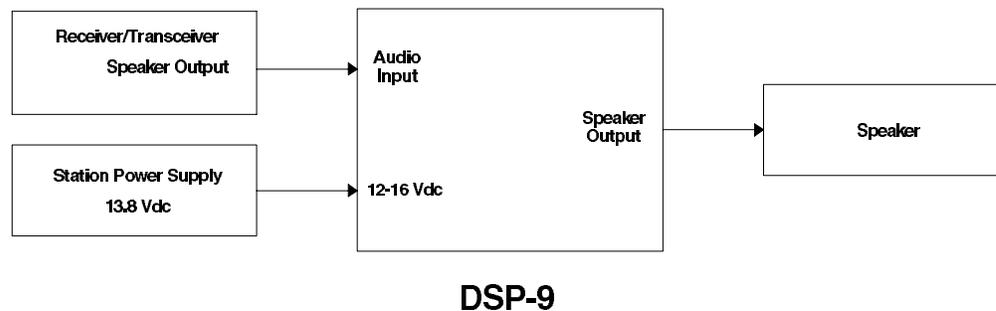


Figure 3.1

### POWER SUPPLY

The DSP-9 requires a power source of 12 to 16 Volts dc. at 1.0 Amperes. **The center pin of the power connector is POSITIVE (+).**

Acceptable power sources include:

- 13.8 volt dc. transceiver power supply (recommended power source for the DSP-9 because it is better regulated than most plug-in wall outlet supplies). Note that some transceivers with internal power supplies have accessory power jacks with insufficient current output.
- Radio Shack 273-1653 12 V.d.c. @ 1 Ampere plug-in wall supply

Switching power supplies are generally **not** recommended.

### Connecting Cables

Shielded coaxial cables with RCA phono connectors should be used to minimize the possibility of RF interference to the DSP-9. Timewave recommends coaxial video cables with metal adapters to match the connectors on transceivers and speakers. **The center pin on the DSP-9 audio input connector must not be connected to the transceiver speaker ground.**

### AUDIO INPUT

The audio input of the DSP-9 is an RCA phono connector on the rear panel of the DSP-9. Matching the output level of the radio to the input level of the DSP-9 is necessary to take

maximum advantage of the wide dynamic range of the DSP-9. The best way to make these levels match is to use an adjustable audio output of the radio (typically the speaker output) as the input to the DSP-9. After connecting the DSP-9 to the radio, follow this simple procedure to match the audio levels. First, tune the radio to a strong signal after setting the radio output level gain control to a convenient midrange position. Then, adjust the output level control on the radio so the **Overload** indicator LED on the front panel of the DSP-9 rarely flashes and the **Normal** indicator LED always flashes with the normal audio input levels. Proper adjustment ensures optimum signal-to-noise ratio and minimum distortion. Adjust the radio output level only to maintain the proper input level to the DSP-9. Use the **Gain** control on the DSP-9 to control the listening volume.

The factory default input impedance of the DSP-9 is 22 ohms. This impedance is appropriate for most radios when driven by the speaker output of the radio. The DSP-9 can be configured for a high input impedance by removing a shorting jumper (position 1). This jumper is accessed by removing the back bezel and the back panel of the DSP-9.

## AUDIO OUTPUT

The DSP-9 has two audio outputs:

- 1) On the lower left hand corner of the DSP-9 front panel is a 3.5 mm headphone jack connected for stereo headphones. **Use of mono-headphones requires a stereo-to-mono adapter.** The DSP-9 speaker output is muted when a headphone plug is inserted.
- 2) The Speaker Output RCA phono jack on the rear panel of the DSP-9 provides adequate output to drive a 4 or 8 Ohm speaker. The front panel gain control adjusts the audio level from this output. The maximum output power is approximately 3.2 watts into a 4 Ohm speaker, or 1.6 watts into an 8 Ohm speaker.

# 4. Operation

## Introduction

One knob and six push-button switches on the front panel control the DSP-9. The knob controls power and sets the audio output level of the DSP-9. Two of the push buttons select the operating mode of the DSP-9. The remaining four push buttons select the operational parameters of the DSP-9.

## Power Switch/Gain Adjust Control

The **Gain** knob on the front panel of the DSP-9 is the power switch/gain adjust control. Rotate the **Gain** control clockwise to turn on the DSP-9 and increase the volume. Rotate the **Gain** control counter-clockwise to turn off the DSP-9 and decrease the volume.

## Selecting the mode

The two leftmost push buttons on the DSP-9 select one of three operating modes for the DSP-9. Depressing the **Bypass** push-button places the DSP-9 into a bypass mode. In the bypass mode, the audio input of the DSP-9 is digitized by the analog-to-digital converter and then looped back to the digital-to-analog converter. The loopback through the

converter is done without any digital signal processing of the signal. The DSP-9 must be powered to operate in the Bypass mode. This active bypass mode allows the DSP-9 signal processing functions to be switched in and out without changing gain settings to maintain a desired audio output level. The **Bypass** mode has precedence over the **Voice** and **CW** modes. When the DSP-9 is in bypass, the settings of the parameter select push buttons do not affect bypass operation.

When the **Bypass** push-button is not in engaged, the **Voice/CW** push-button selects the operating mode of the DSP-9 and the four parameter select push buttons operate.

### **CW Mode**

Depressing the red **Voice/CW** push-button places the DSP-9 in CW mode. The red text below the push-buttons indicates the CW filter choices.

In CW mode, the DSP-9 filters the audio input using one of twelve CW bandpass filters and also can reduce random noise. Back panel internal jumpers preset one of two sets of two filter center frequencies. There are three bandwidths for each center frequency. The front panel "600/750" push-button selects one of the two preset filter center frequencies. Depress the button marked "600/750" Center" in red text to select 600 Hz. center frequency. In the out position of the "600/750" push-button, the center frequency of the CW filter is 750 Hz. Note that depressing a push-button always selects the first of the two parameters. Factory settings for center frequencies are 600 Hz. and 750 Hz. An alternate set of CW filters is provided in the DSP-9 V2.0X firmware release. These alternate filters have center frequencies of 400 Hz. and 500 Hz. Select the alternate set by shorting configuration header #2 with a jumper. (Remove the back bezel and the back panel to reach the back panel internal jumpers. Do not remove the circuit board from the DSP-9). The configuration headers are located between the RCA audio input and output connectors.

Two parameter select push buttons, marked "Bandwidth" in red, select the bandwidth of the CW filter. These buttons select a bandwidth of either 500, 200 or 100 Hz. When both bandwidth select buttons are out, the bandwidth is 500 Hz. When the "200/500" button is pushed in and the other bandwidth select button is out, the bandwidth of the CW filter is 200 Hz. If the "100/500" bandwidth select button is pushed in, it has precedence and the CW filter bandwidth is 100 Hz., independent of the state of the other button. No matter what the state of the CW filter switch settings on the DSP-9 front panel, one of the six CW filters is always active in the CW mode.

The CW mode can also operate with random noise reduction. To enable the random noise reduction feature for CW operation, simply press in the button marked "NRr".

### **Voice Mode**

In Voice mode, the DSP-9+ filters the audio input using one of six bandpass filters, adaptively reduces random noise, and adaptively eliminates multi-tone noise (heterodynes). These three functions can operate simultaneously or independently. The operational parameters for the voice mode are in blue text.

In the voice mode, two front panel push buttons , marked "1.8k/3.1k" and "2.4k/3.1k" , select the bandwidth of the voice filter. These buttons select 1.8 kHz., 2.4 kHz., and 3.1 kHz. bandwidths from one of two sets of voice filters. With both front panel bandwidth select buttons out, the filter bandwidth is the 3.1kHz. When the "2.4k/3.1k" button is pushed in and the other bandwidth select button is out, the bandwidth of the voice filter is 2.4 kHz.. If the "1.8k/3.1k" bandwidth select button is pushed in, it has precedence and the voice filter bandwidth is 1.8 kHz., regardless of the state of the other button. An alternate set of voice filters is provided in the DSP-9 V2.0X firmware release. These alternate filters have bandwidths of 1.8 kHz., 2.0 kHz., and 2.4 kHz. Select the alternate set by shorting configuration header #3 with a jumper. (Remove the back bezel and the back panel to reach the back panel internal jumpers. Do not remove the circuit board from the DSP-9). The configuration headers are located between the RCA audio input and output connectors. Factory setting is 1.8 kHz., 2.4 kHz., and 3.1 kHz.

To activate heterodyne/tone elimination and random noise reduction, depress the push-buttons marked "NRt" and "NRr", respectively. Tone elimination, random noise reduction and bandpass filtering can operate simultaneously or independently. Just depress the desired combinations of push-buttons. One voice bandpass filter is always active in the voice mode.

A new feature to V2.0X voice filter firmware is the addition of Automatic Gain Control (AGC) to the NRt algorithm. This feature enhances the ability of the DSP-9 to eliminate weak heterodynes.

## 5. Troubleshooting

### Self-Test

The DSP-9 has a self-test feature that verifies proper hardware and firmware operation. If a problem arises in the initial installation or in day-to-day operation of the DSP-9, running the self-test may help determine the nature of the problem. The self-test checks the following operational aspects of the hardware:

1. Front panel push-button operation
2. Rear panel configuration header operation (optional)
3. Audio circuitry performance

### Self-Test Hardware Configuration

1. Rotate the DSP-9 volume control fully counter-clockwise to the "OFF" position.
2. To run the optional back panel configuration header test, remove the DSP-9 rear bezel and back panel with a #1 phillips screwdriver. The shorting jumpers must be removed from configuration headers 2 and 3. ( Header 1 is the 22 ohm speaker loading resistor and is not tested in the DSP-9 self-test.) The configuration jumpers are located between the RCA phono audio input and output connectors. At power up when the DSP-9 processor is scanning the front panel switches to determine if the self-test is to be invoked, it also checks if a shorting jumper is

across either configuration header positions 2 or 3. If jumpers are in place, the rear panel configuration header test is skipped. The DSP-9 is shipped from the factory with the jumpers in the non-shortened position, therefore, the DSP-9 will attempt to run the back panel configuration header test. Note: Changing the configuration jumpers will change the operation of the DSP-9, so record the jumper positions before removing the jumpers so the DSP-9 can be restored to its preferred operating configuration when the self-test is complete.

3. Apply power to the DSP-9 through the power input jack on the DSP-9 back panel. Note: Power supply requirements for the DSP-9 are 12 - 16 Vdc @ 1 A min.
4. Connect DSP-9 audio output to a speaker.
5. Disconnect headphones or any other outputs that may be plugged into the headphone jack on the front panel of the DSP-9.
6. Push all DSP-9 front panel push-buttons in.

### **Starting the DSP-9 Self-Test**

Once the DSP-9 self-test hardware configuration has been completed, turn on the DSP-9. During power-up, the DSP-9 toggles the Normal and Overload LEDs to indicate that power is applied and the digital signal processor is operating. *If the LEDs do not go through the toggled preamble on power-up, then either the firmware that is controlling the DSP-9 is a release earlier than V2.00 (which does not support the self-test) or there is a fundamental problem with the processor core of the filter.* The DSP-9 self-test is invoked by releasing the bandwidth push-button closest to the volume control during the blinking light sequence. If the timing of the release is correct and the volume control is turned up, an audible 500 Hz tone will be heard from the loudspeaker indicating that the self-test has begun.

### **Front Panel Switch Test**

In the self-test mode, when a single push-button is released on the front panel, the DSP-9 generate a 500 Hz tone. If two or more push-buttons are released, a 2 kHz tone will sound. Finally, if all the push-buttons are in, no tone will be audible from the speaker.

Sequence through the six front panel switches alternately releasing each switch to generate the tone and pushing the switch back in to remove the tone. The order that each switch is cycled does not matter. When the final push-button switch is cycled out and then in, one of two situations will occur. First of all a 500 Hz. tone may be on all the time independent of the state of the front panel switches. This will occur when shorting jumpers are on back panel configuration positions 2 and/or 3 and each front panel pushbutton switch was cycled independently. The second case is the situation when the back panel configuration header test is to be run. No tone will be heard after all six front panel switches are cycled.

### **Back Panel Configuration Header Test**

If no tone is present after all six front panel switches are tested, the back panel configuration header can be tested. Similarly to the front panel test, a shorted jumper on one either header 2 or 3 will generate a 500 Hz tone. Jumpers on both of them will generate a 2 kHz. tone and if neither header 2 or 3 has a shorting jumper, no tone will sound. Cycle both configuration headers shorted then open. If both configuration headers

cycled independently, then a 500 Hz tone will be heard independent of how the configuration jumpers are set.

### **Audio Circuitry Test**

This test uses the DSP-9 audio output to generate an audio test tone that can be looped back into the audio input to check the audio levels in the DSP-9.

1. With the DSP-9 powered up and a tone audible at the speaker, disconnect the speaker from the DSP-9.
2. Loopback the audio output of the DSP-9 to the audio input using an RCA phono to RCA phono cable.
3. Adjust the DSP-9 volume control to approximately the 11 o'clock position. The normal LED on the DSP-9 front panel should be on.
4. Increasing the volume control to approximately the 12 o'clock position should like the overload LED.
5. If the LEDs do not operate in a manner consistent to that noted in steps 3 and 4, there may be some problem with the loopback cable or in the audio circuitry of the DSP-9.

### **Ending the DSP-9 Self-Test**

1. Power down the DSP-9.
2. Disconnect audio loopback cable.
3. Restore configuration jumpers to preferred operating options.
4. Put back panel and rear bezel back on the DSP-9 housing. (Don't forget the star washers over the RCA phono connectors.)
5. Install the DSP-9 into your station per the installation recommendations in this manual.

### **"Normal" LED does not flash on audio peaks.**

Check power connection to DSP-9.

Check audio input connections.

Bypass the DSP-9 and verify the audio level out of the radio by monitoring the speaker.

### **"Overload" LED flashes on audio peaks.**

Check power connection to DSP-9.

Reduce audio input level with receiver audio output level control

### **No audio output**

Check power connection to DSP-9.

Check audio input connections.

Increase audio input level with receiver audio output level control

Check audio output (Audio Output and headphone) connections.

Check audio output device (speaker or headphone).

Turn front panel audio level control clockwise.

If the DSP-9 does not seem to work correctly after carefully following the installation, operation and troubleshooting instructions in this manual, call, write or FAX the Timewave Customer Service Department for additional help.

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**FAX 612-452-4571**

## **6. Product Warranty**

Timewave Technology Inc. products carry the following warranty:

Timewave hardware products are warranted against defects in materials and workmanship. If Timewave receives notice of such defects during the warranty period, Timewave shall, at its option, either repair or replace hardware products which prove to be defective.

Timewave software and firmware products which are designated by Timewave for use with a hardware product are warranted not to fail to execute their programming instructions due to defects in materials and workmanship. If Timewave receives notice of such defects during the warranty period, Timewave shall, at its option, either repair or replace software media or firmware which do not execute their programming instructions due to such defects. Timewave does not warrant that operation of the software, firmware, or hardware shall be uninterrupted or error free.

The warranty period for each product is one year from date of invoice from your dealer.

Limitation of Warranty: The foregoing warranty shall not apply to defects resulting from:

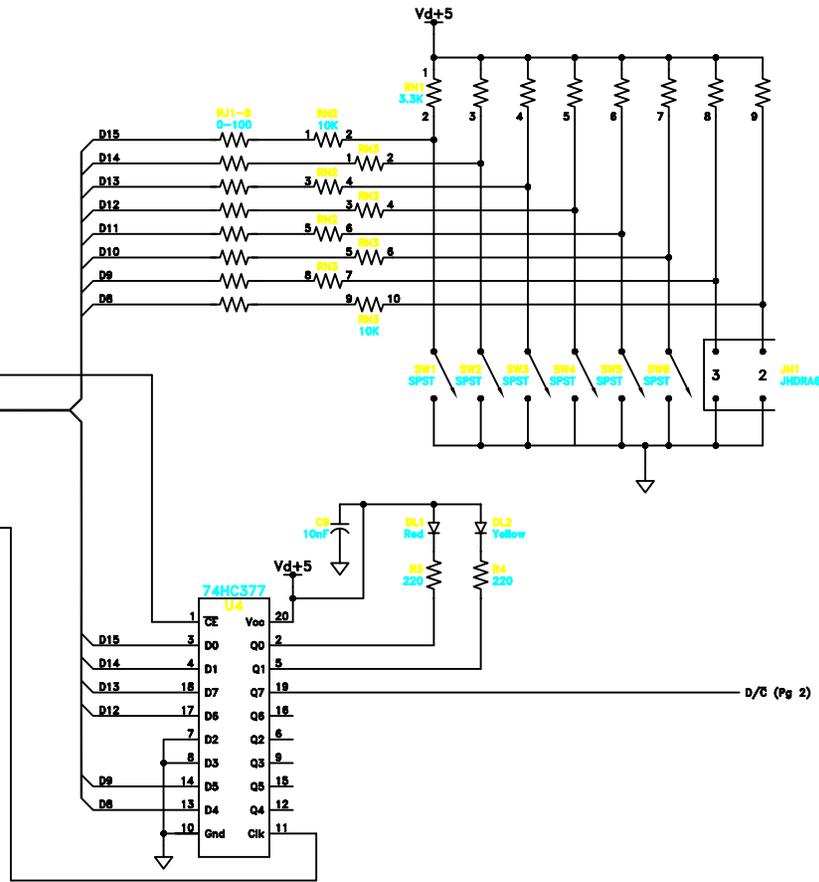
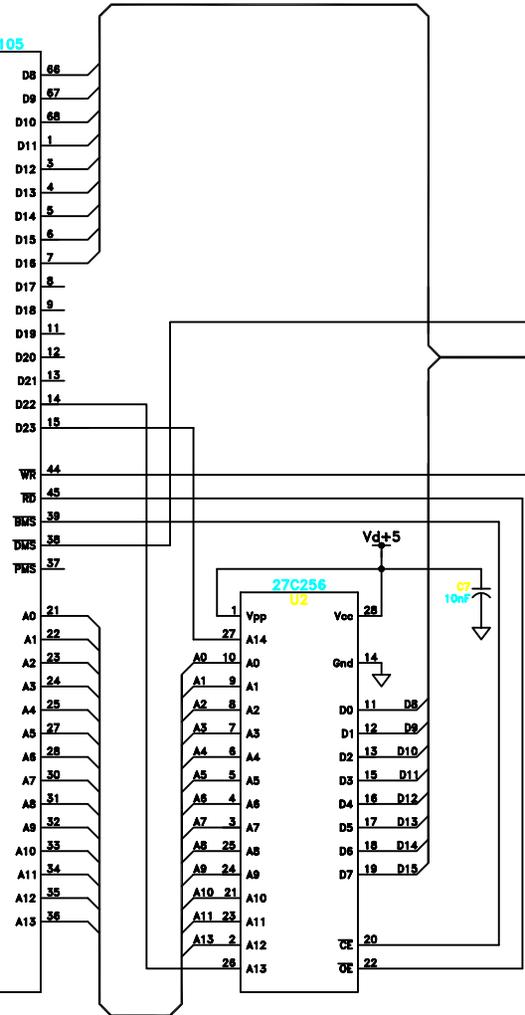
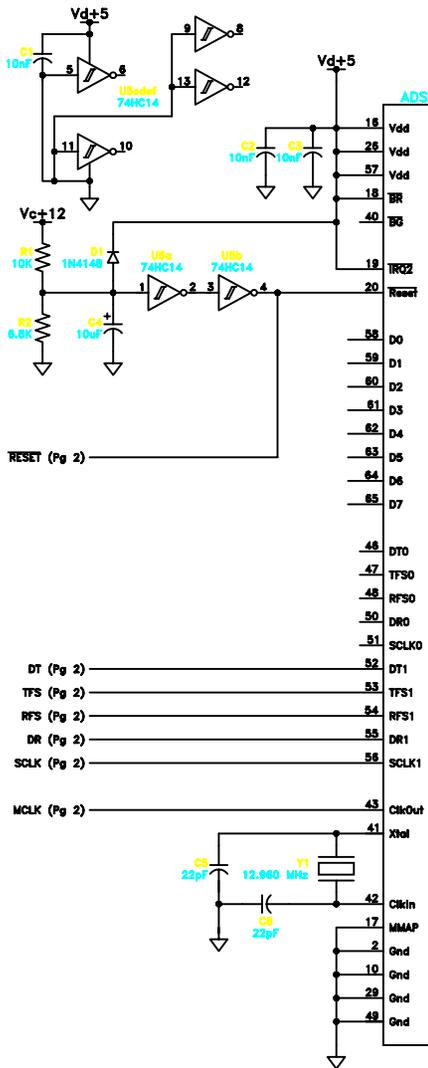
1. Improper or inadequate maintenance by the Buyer;
2. Buyer-supplied software or interfacing;
3. Unauthorized modification or misuse;
4. Operation outside the environmental specifications of the product;
5. Improper site preparation and maintenance.

Exclusive Remedies:

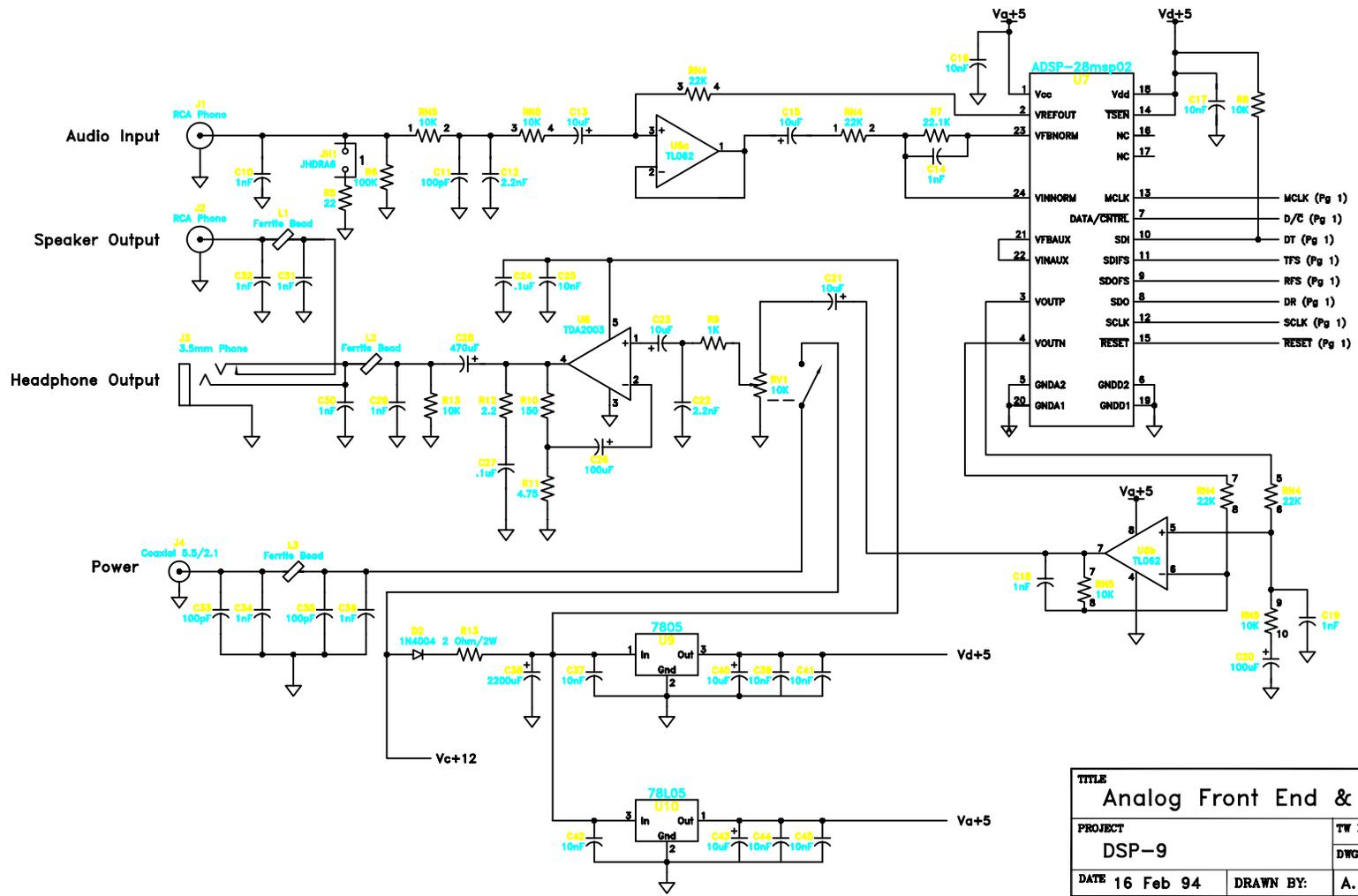
The remedies provided herein are the Buyer's sole and exclusive remedies. In no event shall Timewave be liable for direct, indirect, special, incidental or consequential damages (including loss of profits) whether based on contract, tort, or any other legal theory.

## **7. Schematic Diagrams**

The following schematic is the current version of the DSP-9. This circuitry is subject to change without notice.



TITLE <b>DSP Core</b>			
PROJECT <b>DSP-9</b>		T/W P/N <b>6.1AF.05950B</b>	
		DWG NO. <b>SA05950B</b>	
DATE <b>16 Feb 94</b>	DRAWN BY: <b>A. Clark</b>	SHEET 1 OF 2	
SCALE:	ENGINEER: <b>A. Clark</b>		
<b>Timewave Technology Inc.</b> St. Paul, Mn.			



TITLE Analog Front End & Power Supply			
PROJECT DSP-9		TW P/N 6.1AF.05950A	
		DWG NO. SB05950A	
DATE 16 Feb 94	DRAWN BY: A. Clark	SHEET 2 OF 2	
SCALE:	ENGINEER: A. Clark		
Timewave Technology Inc. St. Paul, Mn.			