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Personnel Access Safety System
Self Test Audio Sensor

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1.0 Introduction

1.1 Statement of Need

The Global Machine Safety Systems (GMSS) group expressed a need for an audio sensor to determine the status of the speakers in the Accelerator String Test Facility (ASST). Thus eliminating the need to send personnel into the enclosure ASST to inspect the speakers.

1.2

The requirements for the audio sensor were stated simply as being capable of functioning on a single supply of 24v and returning 24v or 0v to the operators in the control room of the ASST.

2.0 Description

2.1 Speaker Test

The speakers will be tested using a loud tone projected by the horns in the ASST. The horns will be mounted at various intervals in the enclosure. The sensor must be able to react to a horn far away or a horn right next to it. To account for this variable, the sensor circuit has an amplifier with a variable gain.

2.2 Transducer

The audio sensor circuit uses the speaker itself as a transducer. The 1Watt tap of the secondary of the transformer on the speaker is used for the transducer. When the horns in the ASST emit the test tone, the speaker acts as a microphone. That is, the speaker cone vibrates, inducing a current in the primary windings of the speaker transformer. This induced current creates an emf which induces a current in the secondary of the speaker transformer. An ac voltage signal representing the sound that caused the speaker cone to vibrate appears at the positive side of the 1 Watt tap of the secondary of the speaker transformer.

2.3 Signal Reference

The ac signal appearing at the positive side of the 1Watt tap of the secondary of the speaker transformer is referenced to 12v regulated dc. This is done by placing a 1MΩ resistor between the positive side of the 1Watt tap of the secondary of the speaker transformer and 12v regulated dc. The ac signal is thus coupled onto the 12v level. Any of movement of the speaker cone will modulated the 12v dc level.

2.4 Signal Conditioner

2.4.1 Voltage Follower

The ac signal representing the sound that caused the speaker cone to vibrate is fed into a voltage follower when it comes off the positive side of the 1Watt tap. The voltage follower buffers the transformer from the signal conditioning circuitry.

2.4.2 Gain Circuit

The signal from the voltage follower goes into an operational amplifier with an inverting gain. The gain is variable, but it has a minimum value of 10 and a maximum value of 110. The variable gain allows adjustment of the sensitivity of the circuit to match test tones of different magnitude, ie. horns that are farther away from the speaker than others.

2.4.3 Full Wave Rectifier
The amplified ac signal coming out of the gain circuit is fed into a full wave rectifier. The rectifier is a full diode bridge. The inverting input of the rectifier is tied to 12v regulated dc and the noninverting input is tied to the output of the gain amplifier. The dual ended output of the bridge is loaded by a 100KΩ resistor.

2.4.4 Filter
The rectified signal from the full wave rectifier is filtered directly after the rectifier by a low pass filter. Filtering the signal before it goes into the comparator results in a smoother signal at the output.

2.4.5 Comparator
The comparator has two inputs: a reference voltage of 12.5v dc and the output of the rectifier/filter portion of the circuit. If the input from the rectifier/filter is greater than 12.5v, the output of the comparator goes high (approximately 24v dc). If the input from the rectifier/filter is below 12.5v, the output of the comparator goes low (approximately 2v).

3.0 Interface Requirements

3.1 Output of 0v when the speaker is not working and 24v when the speaker is working.

4.0 Operational Requirements

4.1 Capable of operating off of a single 24v supply.

4.2 Capable of determining if the speaker is working by detecting the test tone emitted from the warning horns in the ASST.

5.0 Problems

5.1 Single Power Supply Problem
Initially there was a problem powering the dual opamp chips off of a single 24v dc supply. The voltage follower circuit was railing at 2.122v initially. Since the voltage follower was using a single supply, its low rail was 2.122v and its high rail was 23v. The input signal from the speaker was in the milivolt range which is below 2.122v. Therefore, the voltage follower was railing low. To correct this, the signal from the speaker was referenced to 12v regulated dc. Thus, the input signal to the voltage follower was always some ac value riding on a 12v dc level. The same problem occured on the gain circuit. In this case, the noninverting input was tied to 12v dc. This forced the amplifier to attempt to drive the inverting input to 12v and amplify the difference between the inverting and noninverting inputs.

5.2 Noise
A 0.1μf capacitor was placed between the 24v supply and the input of the 12v regulator. This seemed to eliminate any noise from the power supply.

6.0 Conclusions

6.1 After testing the speaker's response to the warning horn while both were in the ASST, it appears that the maximum signal the audio sensor will receive is 0.2v and the minimum signal is 0.1v (at 300'). This means that the gain of the circuit will have to be adjusted according to where the speaker is placed in relation to the nearest warning horn.

6.2 It is not known at this time how the normal use of the speaker will affect the audio sensor circuit. This will have to be determined once the audio sensor circuit is in place.

6.3 The audio sensor is sensitive enough to detect the test tone from the warning horns in the ASST.

6.4 Filtering the rectified signal before it enters the comparator produces a cleaner circuit at the output of the comparator.

7.0 Schematics

See attached page.

8.0 Components

8.1 2-Motorola 1458P1 dual opamp - monolithic, 8 pin device

8.2 resistors: 1MΩ, 100KΩ, 1.5MΩ, 1KΩ, 3-10KΩ, 1-100KΩ pot, 1-50KΩ pot.

8.3 diodes: 4-1N4006

8.4 1-Texas Instruments TL 780-12C Voltage Regulator

8.5 A standard speaker

8.6 capacitors: 0.1μf, 3μf

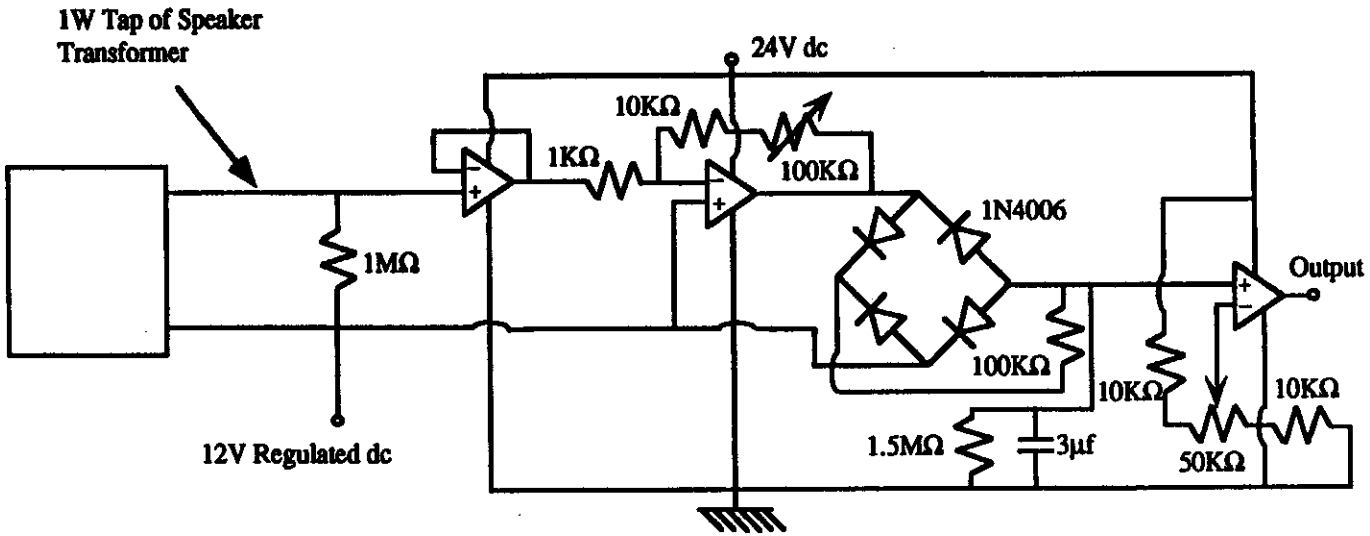

Figure 1: ASST Audio Sensor