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Applications Note 4A

AGC Circuit for ISD4000 Series Devices

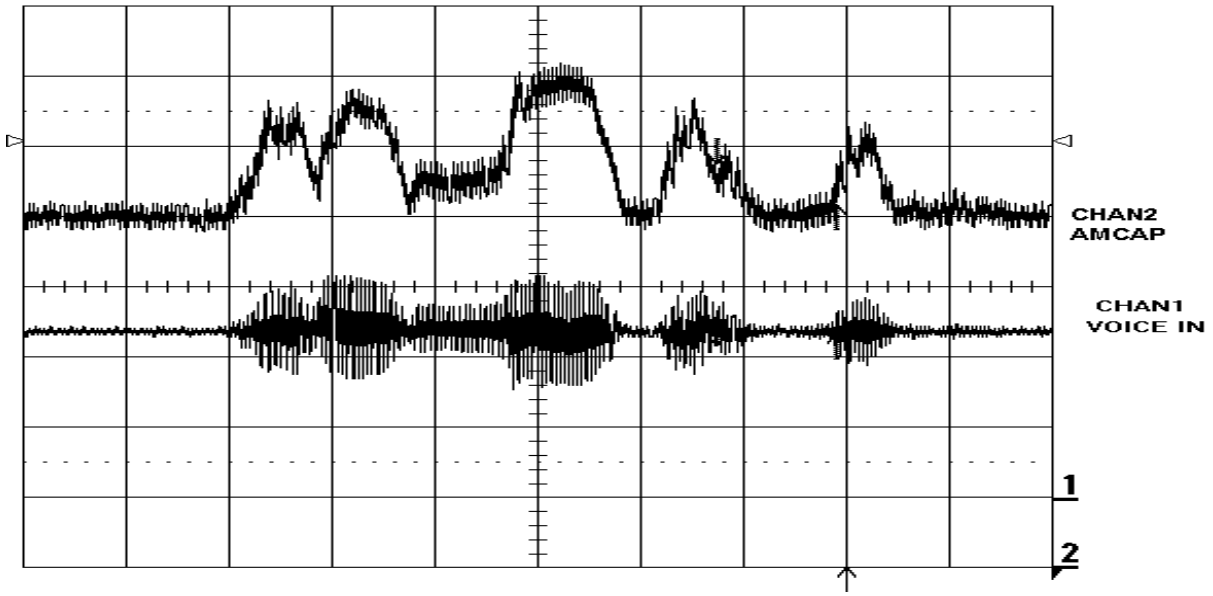
INTRODUCTION

The ISD4000 series is intended to operate with systems that already include an input amplifier and a speaker driver. However, an `off-the-shelf ` 3 V microphone preamplifier with AGC is NOT a common item. Even if one is available, the device may not be economical for some applications. Fortunately, the ISD4000 has the building block in place to support a 3V microphone preamplifier and an AGC circuit using a handful of external components. The solution is made possible by using part of the Playback AUTOMUTE control circuitry during the Record mode.

The circuit diagram in Fig. 2 provides an overview of the solution. This AGC application requires one LM324 quad op amp, six carbon resistors, three capacitors, one 'low noise' general purpose JFET, and an electret microphone. The circuit monitors the AMCAP voltage level. It compares it to a known voltage reference level. It generates the necessary gain factor to amplify the microphone's output level to within the ISD4000's dynamic range requirement.

AGC CIRCUIT BLOCK

The key to understanding how the circuit works lies in the AUTOMUTE section. Fig. 1 "AUTOMUTE" provides a simplified AutoMute block diagram. During the Play operation, the array output signal is filtered and it is directed to the AUTOMUTE circuitry. The filter output is also connected to the negative peak detector (NPDETL). The negative peak detector is a half wave rectifier. Therefore, only the negative cycle of the signal is used to generate a DC level at AMCAP pin. This signal is then used to control the AUTOMUTE gain level. The differential signal between ANAIN+ and ANAIN- is amplified, filtered and stored directly into the array during the record operation. The peak detector is also active in the Record mode, thus the negative cycle of the input signal is rectified and a corresponding DC signal is generated. The scope picture below shows the input signal at the filter's output and AMCAP during a Record operation. The signal at CHAN2 (AMCAP) increases with CHAN1's (VOICE) amplitude and decreases when there is no input (1).



The external circuitry uses CHAN2 signal to control ANAIN+ level. Fig. 2 shows the components required to realize this function.

The circuit contains three major blocks:

1. Block #1 comprised of U1A and U1B

   U1A isolates and buffers the ANAIN- DC level for microphone biasing. This amplifier turns off the microphone circuit during power down thus reducing power consumption. The ANAIN- cannot bias the microphone without causing a large DC offset in the array. It reduces the usable dynamic range.

   U1B buffers the AMCAP level. The AMCAP pin is a high impedance node and any load > 1 μa changes the peak detector's rise and fall time. Such a load will prevent this node from tracking the input signal.

2. Block #2 contains U1C, R5, and R6. It forms the gain control function by subtracting the buffered ANAIN- level from the AMCAP signal.

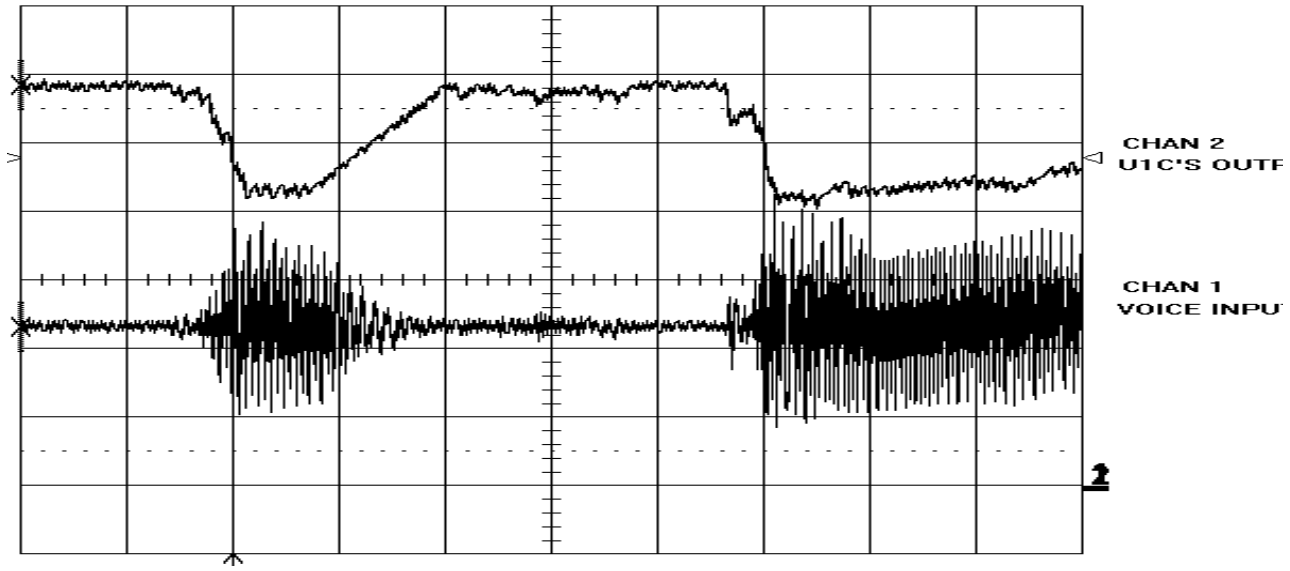
   U1C's output signal has the following transfer function:

   VOUT= VANAIN - (VANAIN - VAMCAP)* (R6/R5) (1)

   VANAIN: DC level at ANAIN- terminal.

   VAMCAP: Signal at AMCAP terminal.

CHAN2 in the scope picture below shows U1C's response to a typical voice pattern. When there is no voice (input signals flat) U1C is at it highest level. This signal becomes more negative when a voice pattern is present.



3. Block #3 contains U1D, R9, R8, R7, and Q1.

   It forms the variable gain stage for the microphone circuit. This block has three states:

   State1 is an attenuate state. This happens when U1C output level equals (VANAIN-0.5). During this period, Q1's channel resistance is greater than R7. The output level is determined by:

   VOUT= VMIC*(-R9/R8) (2)

   State2 is the full gain state. This condition exists when AMCAP voltage is equal to ANAIN- bias level. The gain is determined by R9/(R8//(R7+$Q1_{rdson}$))). In practice Q1's $_{rdson}$ << R7 and R8 >> R7 so the output level can be estimated by:

   VOUT= VMIC*(-R9/R7) (3)

   State3 is the variable gain state. The output level is controlled by the difference between U1C's output and ANAIN- bias voltage. The difference voltage sets the VG_{Soff} which changes Q1's channel resistance. Therefore, the output level will range between equation(2) and equation(3) levels.

Setting Up the Prototype

It is highly recommended that the user prototype this circuit before committing to a PC board version. The prototype should be used to determine the best component values for the particular application.

The user will need a low distortion 1 KHz sine wave source, an oscilloscope, and a DVM. Fig. 3 shows the modifications for the prototype circuit. In this circuit, R1 and the microphone were replaced with R10, R11. This forms a 100:1 attenuator for the sine wave source. This is not necessary if the source can supply 0.5 mVRMS and 20.0 mVRMS. Connect the DVM's negative input to U1B-7 and the positive input to U1A -1. Replace R6 with R12, R7 with R13 (R12, R13 is a 10 KΩ trimpot). Set both trim pots to 5 KΩ before installing them.

This is a 2-step process.

Step 1 determines a bias level for Q1 with maximum input level.

Set the sine wave source to 20 mVRMS at input (C2). Adjust R12 until the DVM reads 250 mV DC.

Step 2 finds the gain setting for minimum signal level.

Set the sine wave source to 0.5 mVRMS at C2. Adjust R13 until the DVM reads 250 mVdc. Remove R12, R13, measure their resistances and substitute with the nearest value fixed resistors. The minimum and maximum values were chosen to match the electret condenser microphone output with the R_{bias}= 4.7 kΩ and V_{bias}= 1.2 V. Other bias voltages and resistances may require readjustment of gain and attenuation level.

Improvements

The following bill of materials shows a typical component list. Although the LM324 worked at 3 V, its output could not swing closer to ground than Vss+0.5v. A low voltage CMOS op amp would be more suitable for this application. Q1 was shown as an NTE458 but another N channel JFET with VG_{Soff} < 1.5v could be used. R7 may have to be readjusted to match the new transistor's channel resistance vs. VGS characteristic. Lastly, the circuit draws less than 800 ma supply current. At this level, a typical microcontroller I/O pin can be used as power supply. This allows the circuit to be completely shut down when it is not used.

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Bill Of Materials
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Table 1:

Item	Quantity	Reference	Part
1	3	C1,C2,C4.2	2 µF
2	1	C3	1µF
3	1	C5	.1µF
4	1	C6	1µF
5	1	Q1	NTE458
6	1	R1	4.7k
7	1	R5	4.7K
8	1	R6	10K
9	1	R7	8.2K
10	1	R8	470K
11	1	R9	47K
12	1	U1	LM324
13	1	U2	ISD400
14	1	X	Electret Condenser Microphone

CONCLUSION

Until an integrated 3 V microphone preamplifier/AGC IC becomes widely available and at a lower cost, the circuit described above provides a 'Low Cost' and serviceable alternative. Further information regarding the circuit is available from the Information Storage Device Applications Group.

NOTE *This scope plot was taken with the device in a test mode for demonstration purpose. Test modes are not available for normal product use.*

Figure 1: Automute

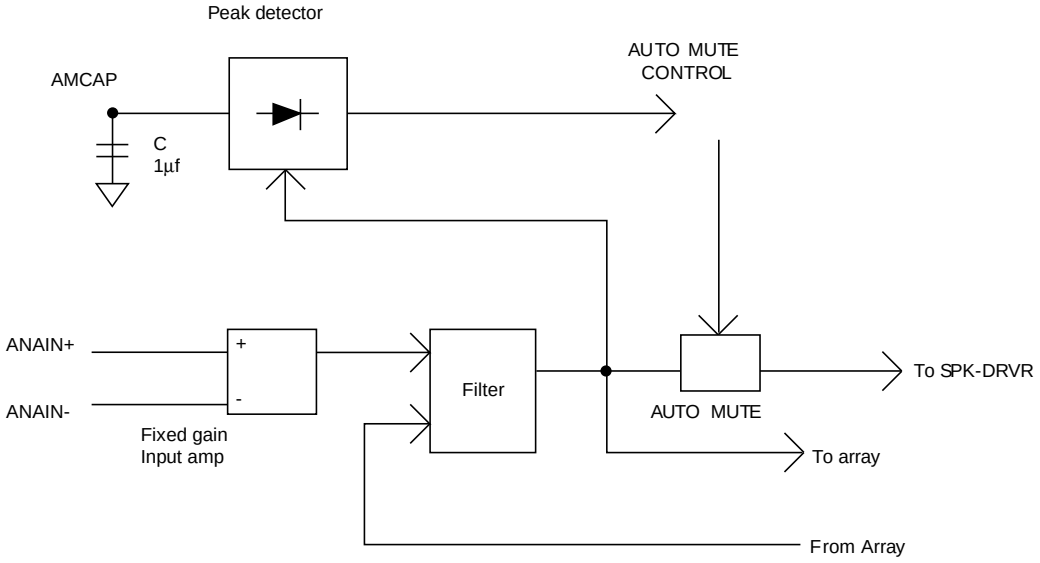

Figure 2: 3V AGC

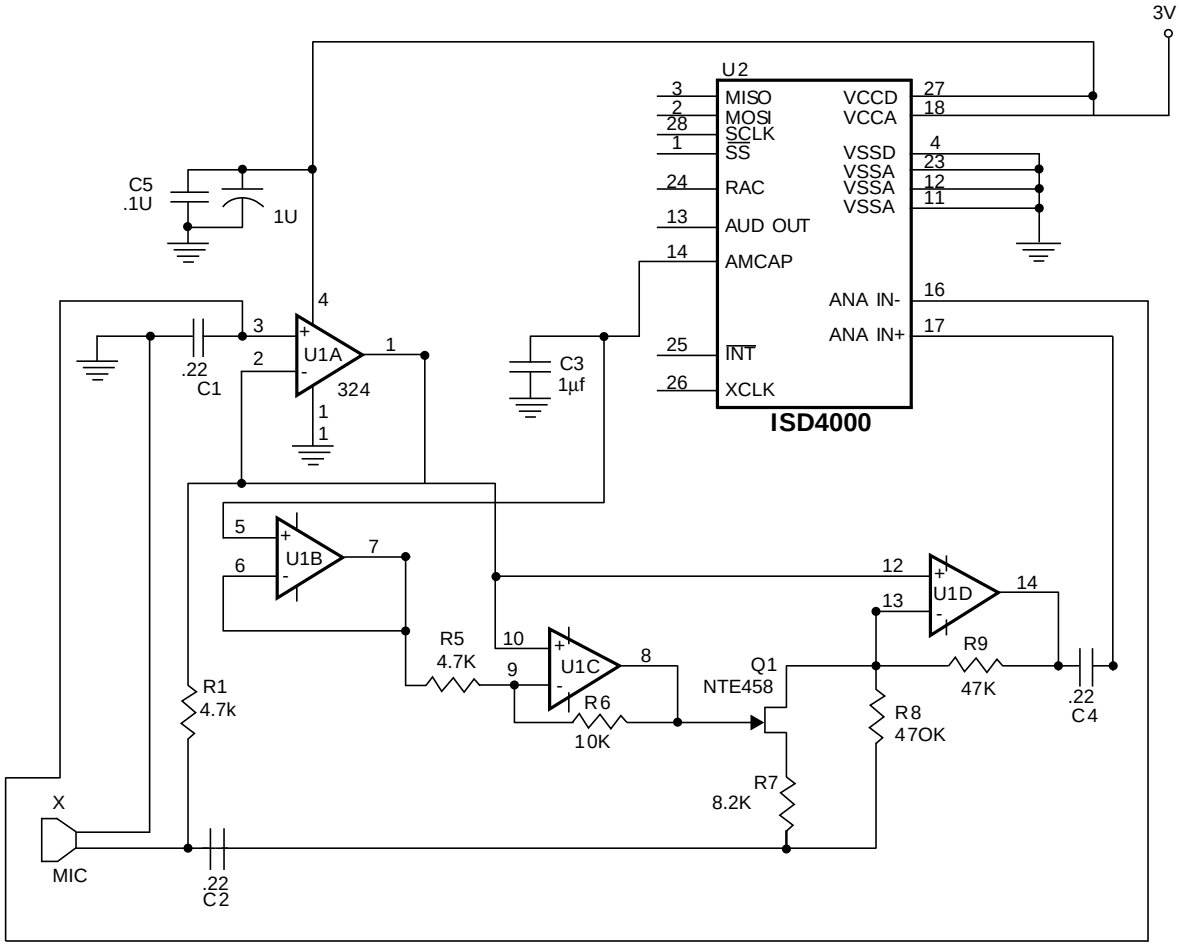

Figure 3: Prototype