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Design of Power Life-Span Testing System for Mobile Phone Loudspeaker

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Abstract. In order to obtain the power life-span of mobile phone loudspeaker, a mobile phone loudspeaker test system was designed. The C8051 was taken as the main control core.The sinusoidal signal which was provided by AD9833 signal generating module was amplified by power amplifier module for power life-span test of mobile phone loudspeaker. At the same time, the feedback voltage signals of the system were collected by AD7366. The test software was designed to realize the real-time monitoring and analysis of the power life-span test process of the mobile phone loudspeaker. After many tests, the results manifest that the system runs stably and reliably, and the measurements of each channel are accurate.

1. Introduction

The National standard "GB/T 12060.5-2011. Methods of measurement for Characteristics of loudspeakers", the power life-span test requirement for mobile phone loudspeaker is: A sine wave signal of a specified degree is apply to the loudspeaker, and Dynamically monitor the electrical performance changes of each speaker in real time, during the whole test [1].

According to test requirements, a sinusoidal excitation signal based on DDS (Direct Digital Frequency Synthesis Technology) was designed to provide power life-span test to loudspeakers. The voltage and current through the speaker which continue working for the rated time does not cause a large deviation, then the speaker is determined to pass the power life-span test; when the deviation is too large or almost 0, it is determined that the speaker does not pass the power life-span test.

2. The Overall Design of Test System

The test system is designed to be modular entirety. Mainly divided into MCU control unit, signal generator, power amplifier and voltage and current detection module. The high-precision programmable DDS chip AD9833 is used to provide a sinusoidal excitation signal in the signal generation module for power life-span test. The range of output frequency is20Hz-20kHz, and the accuracy of frequency is ±0.05%. The test system output voltage can be adjusted from 0.5V to 12V. The power amplifier module has a maximum output power of 15W per channel, a maximum total output power of 300W, and a load impedance of 4Ω-32Ω. The voltage error across the speaker is less than±0.5 dB which detected by the voltage and current detection module with reference to the calibration specification[2].

The designed test system is divided into AB groups, 20 channels in total, which can be connected with20 loudspeakers for test to improve test efficiency. The overall structure block diagram of the system is shown in Figure 1. First, the MCU control module C8051 controls the signal source AD9833 chip to generate a sine signal, which is amplified and output to the AB two-stage power amplifier module, which is provided to the loudspeaker power test. During the test, the voltage and current signals at both ends of the speaker are fed back to the MCU control unit through the voltage and

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current detection module for real-time monitoring to meet the power life-span test requirements of the loudspeaker.

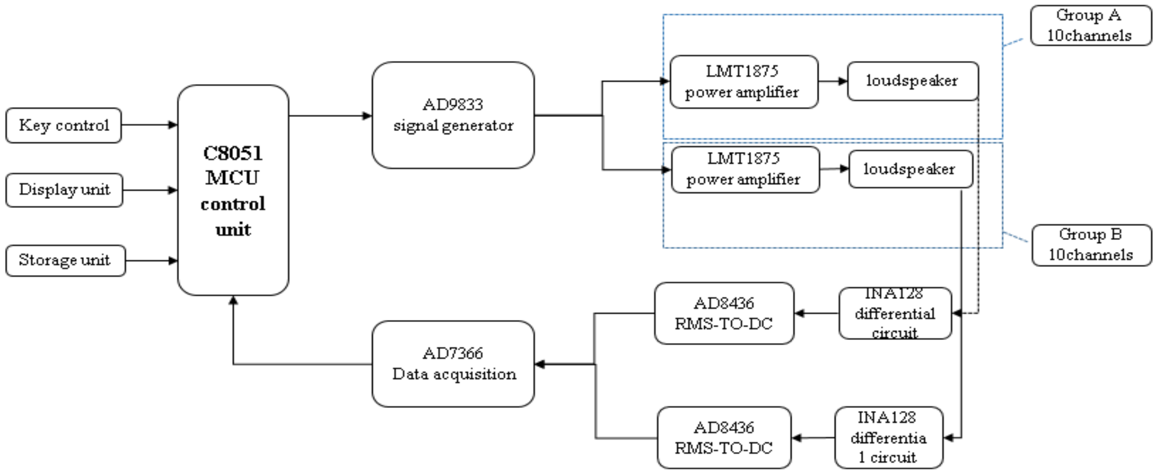

Figure 1. The overall structure diagram of the system.

3. The Hardware Design of Test System

3.1. The MCU Control Unit Module

The MCU control unit module is the control core of the entire power test system. As shown in Figure1, the chip manufactured by Silicon LAB is used, which is a fully integrated mixed-signal, system-on-a-chip MCU with a high-speed 8051-compatible CIP-51 core (100 MIPS). The 128K on-chip Flash memory also has the ability to reprogram in- system, and its function fully meets the test requirements [3]. It mainly communicate with the unit man-machine test interface of Figure 1, which accept the command of the button control unit and performs corresponding drive control on the test system signal generation module according to the instruction, and finally returns the parameter collection result of the data acquisition module to the test interface.

3.2. Signal Generation Module

The signal in the test system is provided by the chip's AD9833 high-precision programmable waveform generator. The AD9833 is a low power, DDS device that requires no external components. The output frequency and phase are software programmable and easy to adjust. The frequency register is 28 bits wide[4]. The output frequency of the AD9833 is:

$$f\text{out} = \mathrm{M}\cdot f_{\mathrm{MCLK}} /228 \tag{1}$$

The f_{MCLK} is the clock frequency; M is the frequency control word, given by external programming.

Since the output signal frequency is in the range of 20Hz~20kHz, the reference clock uses a 1MHz active clock. According to Nyquist's sampling law, the clock source meets the actual demand, The frequency resolution is calculated as follows:

$$\Delta f=1\mathrm{MHz}/228=0.004\mathrm{Hz} \tag{2}$$

The sinusoidal signal generation module is shown in Figure 2. The MCU control unit C8051 can write data to the AD9833 through a 3-wire SPI interface to control the generation of a sine wave signal. The FSYNC pin in the AD9833 is an enable pin, level-triggered. When serial data is transmitted, FSYNC is asserted low and is biased, amplified, and filtered to produce a sine wave signal SinA[5].

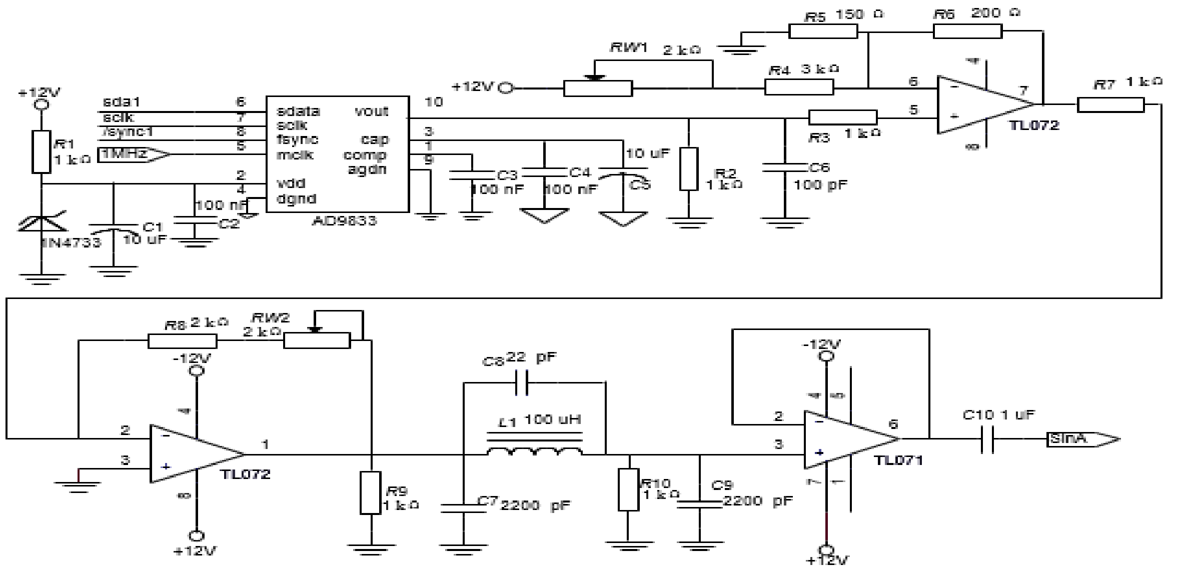

Figure 2. Group A signal generation circuit.

3.3. Power Amplifier Module

The signal generated by the signal distribution module is transmitted to the power amplifier module to drive the loudspeaker to work. One of the power amplifier modules is shown in Figure 4, Which is composed of the operational amplifier NE5532 and the LM1875T power amplifier circuit produced by American Semiconductor Device company. The LM1875T power supply voltage is ±25V.The undistorted power is 20W (THD=0.08%), and the distortion is only 0.015% at 1 kHz, 20 W. At the same time, in order to protect the amplifier from the low resistance in the high frequency state, the resistor is connected in parallel with the inductor at the output of the LM11875T. The amplification gain of LM1875 is determined by the ratio of resistors R20 and R19[6].

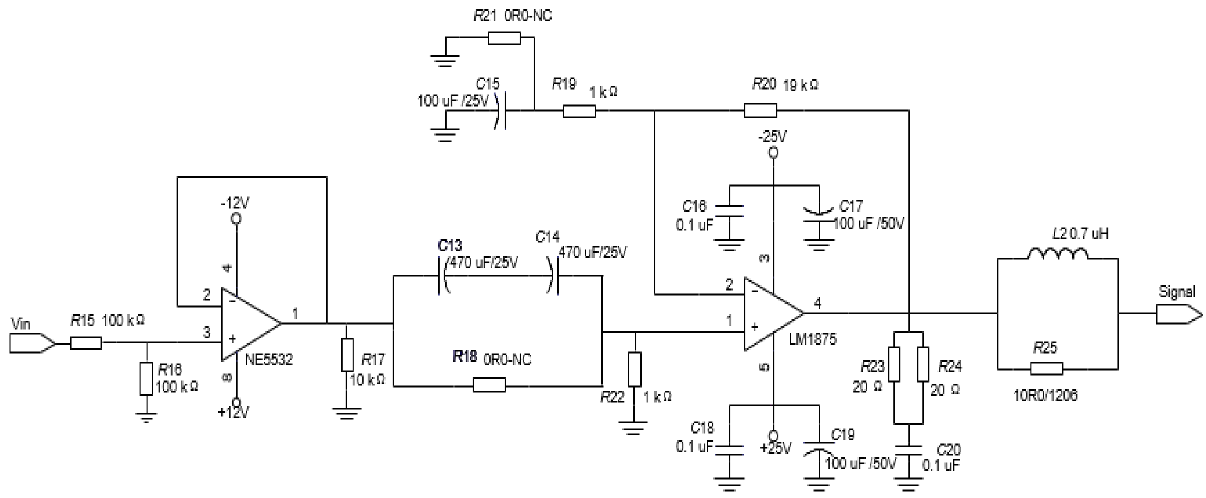

Figure 3. One of the power amplifier circuit.

3.4. The Signal Detection Module

The voltage detection is mainly to collect the voltage across the speaker. Since the voltage across the speaker will be relatively large, in order to protect the chip in the next level circuit,

The voltage detection is first divided by a high-resistance R27 resistor to obtain a smaller voltage Vu.

The current detection mainly uses a differential circuit to detect the loop current of the speaker unit. The loop current is indirectly obtained by the voltage across the high-precision small resistor R26 (0.1Ω/5W) in the acquisition loop. The differential circuit uses a low-power, high-precision instrumentation amplifier, INA128. One of the differential amplifier circuit is shown in Figure 4, which has an RG resistance of 2.63KΩ, so the amplification gain is

$$G=1+50K\Omega/RG=1+50K\Omega/2.63K\Omega=20 \tag{3}$$

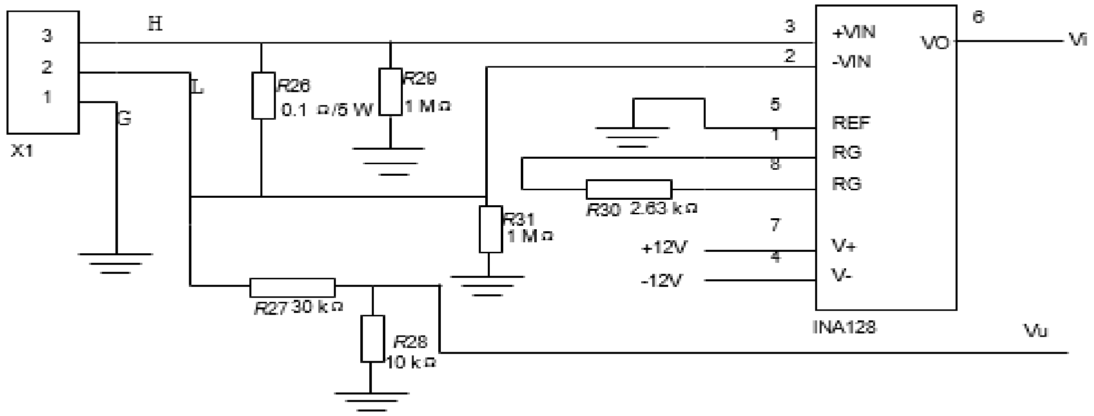

Figure 4. One of the differential amplifier circuit.

3.5. *Signal True RMS Conversion Module*

After the multi-channel sorting and voltage boosting of the respective channel voltages obtained by the signal detection module, the true effective value of the voltage is detected by the AD8436 true RMS chip, and the effective value of the AC voltage is obtained through internal calculation. The conversion circuit is shown in Figure 5. The AD8436 accurately calculates the RMS value of the AC waveform. The RMS conversion accuracy depends on the input signal frequency and the external capacitor CAVG value. At the same input frequency, the larger the CAVG, the smaller the conversion error, and the higher the frequency of the input signal of the same CAVG value, the higher the accuracy. The minimum value of CAVG can be determined based on the frequency of the input signal [7].

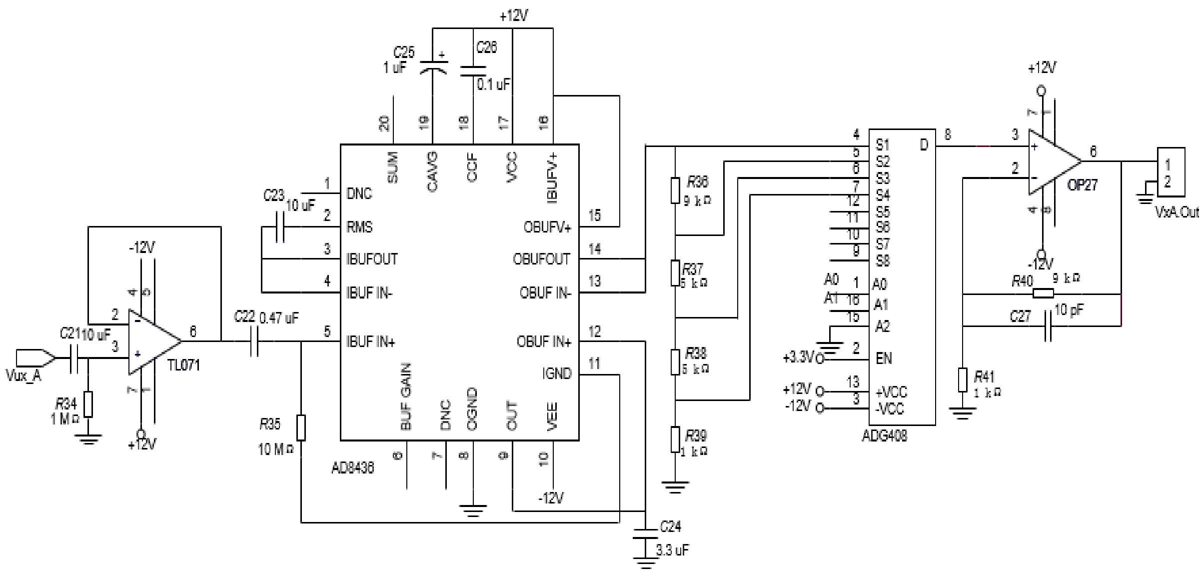

Figure 5. Group A RMS-to-DC circuit.

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3.6. Signal Acquisition Control Module

The voltage and current signals (VxA, IxA, VxB, IxB) in Figure 6 are transmitted to the analog-to-digital converter AD7366 via LM358 operational amplification. The AD7366 is a dual-core, 12-bit, high speed, low power, successive approximation analog-to-digital converter (ADC) with a maximum sample rate of 1 MSPS. Two ADCs are built in, and two sets of dual channel multiplexers and a low noise, wide bandwidth sample-and-hold amplifier are available for simultaneous sampling and conversion of two channels [8]. After the data conversion and processing of the AD7366, the data is transmitted to the MCU control system and the real-time monitoring data is displayed through the LCD interface.

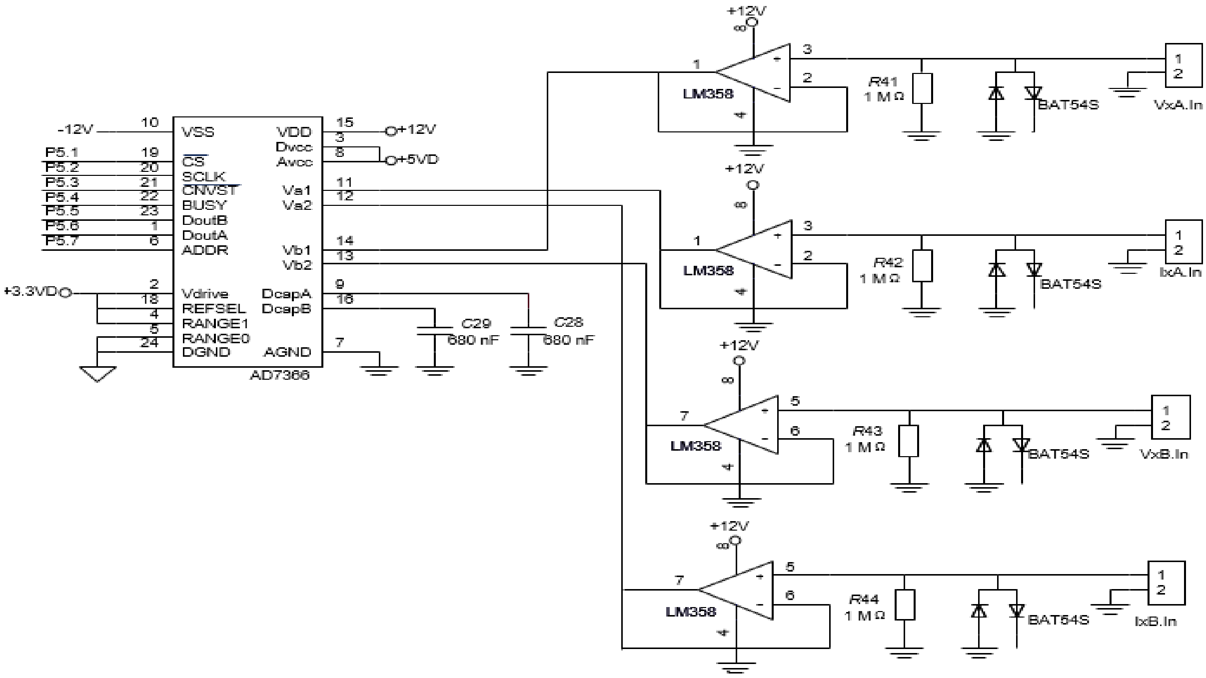

Figure 6. Signal acquisition circuit.

4. The Software Design of Test System

The software of the test system is mainly designed in C++ language, realizing the real-time monitoring of multiple parameters (voltage or current, impedance) and test time of multiple sets of loudspeaker units. According to the actual needs of the test system, the software of the whole system includes an initialization module, a main program module (including a clock module, a display module, a timer interrupt module), a timer interrupt module (including a measurement module, a timing module, a communication module), and a key interrupt module (Contains start-stop module, setup module), etc [9].

After the test system is powered on self-test, the initialization of each component is completed, and then sets the state environment (frequency range, voltage) required by the power life-span test through the button interrupt module. etc.), as well as the start and manual stop of the test. Finally, parameters such as monitoring voltage, current, resistance and test time are displayed on the display panel.

5. The Test Results

The test results shows the real-time voltage monitoring data of the sine sweep test of 20 speakers of the same model and the same batch, and also includes the true RMS value of the voltage across the loudspeaker measured by the Fluke287C digital multimeter, and compares two sets of data. The test type is a sinusoidal signal sweep test. The rated output voltage is 3.86V, the test time is set to 50h, and the rated impedance is 8Ω.

From the data that after the time required for the loudspeaker to continue working under rated power conditions, the error between the real-time voltage and the true RMS value monitored during the test is small (voltage error is less than ±0.5 dB), and the channel consistency is very high. According to the <JJF1203-2008 Calibration Specification for Electro-acoustic Products (Loudspeakers) Power Life-span Measurement Equipments>, the set of loudspeakers passed the power life-span test. The test results show that the speaker power life-span test system meets the design requirements and meets the requirements of the enterprise for power life-span test of the speaker.

6. Conclusion

The mobile phone speaker test system was designed in this paper adopts the modular design concept, which solves the problems of complicated structure of previous experiments, real-time data cannot be recorded and monitored in real time, and low efficiency. The design structure is simple, the system is easy to operate, and the test data can also be saved in the software for subsequent tracking of the product. To meet the requirements of the company's mobile phone speaker power life-span test, you can better promote your own products.

7. References

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