DESIGN AND CONSTRUCTION OF A WOBBULATED 1-kHZ TONE GENERATOR FOR ANALOG-SPEECH TESTING

A simple and inexpensive wobbulated 1-kHz tone generator can be assembled to test analog-speech communication systems for the presence of speech-correlated emanations.

Edward E. Wetherhold, Honeywell Inc., Signal Analysis Center, Annapolis, MD

INTRODUCTION

As with previous *ITEM* articles[1,2,3] this article discusses a practical solution to one of the problems frequently encountered by those responsible for testing communications systems. For example, when testing analog-speech communication systems for the presence of speech-correlated emanations, the customary practice is to use a wobbulated 1-kHz tone to simulate the speech input test signal. The non-speech lines of the equipment under test (EUT) are then examined in the audio, video and RF ranges for the presence of wobbulated tone. Because of its distinctive "warble," the 1-kHz tone is easily heard among the hum, noise, clock signal harmonics and similar sounds present on the black lines of a typical EUT. The "problem" associated with this test occurs when the test engineer attempts to generate the wobbulated tone. The problem is usually solved by using commercial equipment such as a function generator, which can cost as much as $1,000. Although the performance of this equipment is quite satisfactory, the use of such expensive equipment to provide a relatively simple test signal is inappropriate.

This article shows how a simple and inexpensive wobbulated 1-kHz tone generator, costing less than $40 for parts, can be assembled by the average electronics technician. The more expensive and versatile function generators can then be made available for the more demanding applications.

TONE GENERATOR DESIGN

Figure 1 shows the circuit diagram of the 1-kHz wobbulated tone generator. The active components consist of three integrated circuits (IC's), two of which are the National Semiconductor Voltage Controlled Oscillator, LM566CN (U1 and U2). The third IC (U3) is the National Semiconductor LM380N-8 Audio Power Amplifier. The availability of these three inexpensive IC's through many distributors makes a wobbulated tone generator suitable for analog-speech testing purposes convenient and easy to design and assemble. For example, the 8-pin Dual-in-Line Package (DIP) LM566CN and LM380N-8 IC's are available from Digi-Key[4] or Jameco Electronics[5].

The LM566CN is a general purpose voltage controlled oscillator which may be used to generate square and triangular waves, the frequency of which is a very linear function of a control voltage and also a function of an external resistor and capacitor. For this application, U1 is wired to run at 1 kHz as determined by the 15-kohm resistor and the 33-nF capacitor connected to pins 6 and 7, respectively, of U1. The sliding contact of the 2-kohm potentiometer connected to pin 5 permits the 1-kHz frequency to be slightly varied. The 1-kHz output of U1 is taken from pin 4, where a triangular waveform is present.

Unlike other function generator IC's, such as the Exar XR2206, the LM566CN does not have the option of a sine wave output; instead, it provides only triangular or square wave outputs. However, because the LM566 is smaller, less expensive and more conveniently available than the XR2206, and because the LM566 triangular output is easily filtered into a sine wave, it was chosen for this application. For example, the odd harmonic composition (magnitude) of a triangular waveform consists of 81-percent fundamental, 9-percent third harmonic and 3.2-percent and 1.6-percent fifth and seventh harmonics respectively. There are no even harmonics. With some minor r-c filtering, the third and higher harmonics of the LM566 triangular output can be virtually eliminated, thereby giving a close approximation

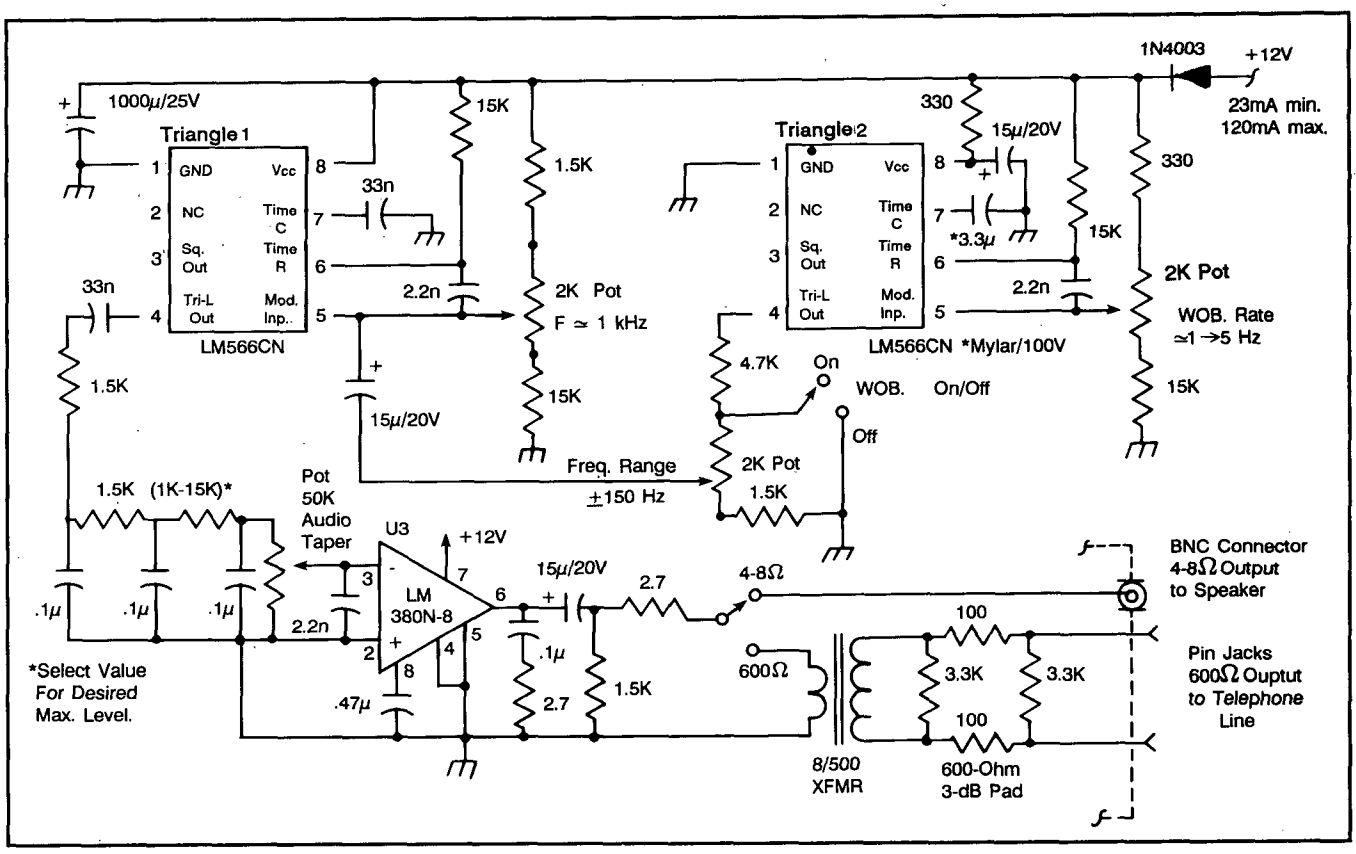

Figure 1. Circuit Diagram of 1-kHz Wobbulated Tone Generator.

of a sine wave that is adequate for the 1-kHz tone generator.

The triangular 1-kHz output is capacitivity coupled from pin 4 of U1 via a 33-nF capacitor to a three-section r-c filter. The r-c filter has a cutoff frequency of about 1 kHz to reduce the odd harmonics so as to make the waveform near sinusoidal. The r-c filter is terminated in a 50-kohm audio taper potentiometer which serves as a volume control for the LM380N-8 audio amplifier, U3. This potentiometer is available from All Electronics Corporation.[6] The 2.2 nF capacitor between pins 3 and 2 of the audio amplifier input eliminates the amplification of undesired high-frequency signals. A similar value capacitor between pins 5 and 6 of U1 prevents parasitic oscillations that may occur during VCO switching. The 0.47-μF capacitor at pin 8 of U3 provides a power supply decoupling of about 30 dB at 1 kHz.

The output of U3 has a 0.1-μF and 2.7-ohm resistor to ground to prevent high-frequency oscillations that otherwise might occur under certain load conditions. The audio output is coupled to a 1.5-kohm resistor to ground via a 15-μF/20V capacitor and a series-connected 2.7-ohm resistor. The purpose of the 1.5-kohm resistor serves to keep the 15-μF capacitor charged to prevent a loud "pop" from occurring when a speaker or other load is connected to the 4-ohm output. The 2.7-ohm resistor serves to provide a small degree of output loading.

The audio output is switchable between a low-impedance load, such as a small 4 to 8-ohm speaker, or to a 600-ohm telephone line via an 8/500-ohm transformer. The transformer is a 0.4-watt unit available from Mouser Electronics.[7] The 600-ohm, 3-dB pad provides some loading on the transformer output and tends to stabilize the impedance seen by the load. The transformer coupling also removes any ground reference so it may be connected to the input telephone line of the EUT.

The wobbulated tone generator uses two oscillators -- one to produce the 1-kHz fixed tone, and a second to produce a slow oscillation of 1 to 5 Hz which is used to modulate the 1-kHz fixed oscillator. The U2 circuit uses a 3.3-μF metallized Mylar[R] capacitor at pin 7 and a 15-kohm resistor at pin 6 to produce the modulated signal. The 2-kohm potentiometer connected to pin 5 permits the modulated rate to be varied between 1 and 5 Hz. When the arm of the pot is gradually moved from one end to the other, the effect on the 1-kHz signal is to make the tone sound like:"whaaaaaa...whaaaaaa...whaaaaaa...whaaaaaa..."or"whaa...whaa...whaa...whaa..." or "whawhawhawha." A 3.3 μF/100V 10-percent metallized

Mylar® capacitor at pin 7 of U2 is recommended for long-term stability as opposed to using an electrolytic capacitor. This capacitor is available from Digi-Key, Part No. E1335.

The modulation output is taken from pin 4 of U2 using a resistor network and a 2-kohm potentiometer to give a voltage maximum and minimum that determines the amount of frequency sweep on either side of the 1-kHz tone. The 2-kohm potentiometer is adjusted for a change of frequency of about 150 Hz above and below the 1-kHz tone. The sinewave is coupled to pin 5 of U1 via a 15-μF electrolytic capacitor. The wobbulation of the 1-kHz oscillator may be turned off with the WOB on/off switch.

The 2.2-nF capacitor between pins 5 and 6 of U2 serves the same purpose as in U1. The U2 Vcc voltage at terminal 8 is decoupled by a 330-ohm resistor and a 15-μF capacitor to prevent interaction between the two oscillators. The 1N4003 rectifier protects the IC's from damage that might occur if a power source of the wrong polarity is connected to the circuit. The entire circuit is relatively insensitive to resistor or capacitor variations, and resistors and capacitors having values near the specified values in the schematic should work just as well as the exact values specified. An attempt was made to use the same values for most of the resistors and capacitors to simplify the ordering of parts.

CIRCUIT ASSEMBLY AND CONSTRUCTION

For a wobbulator design to be acceptable, it must be easy to assemble and test, and if necessary, easy to modify until it works effectively. After this, the circuit can be assembled on a printed-circuit (PC) board and mounted in a suitable box. Normally, putting the wobbulator circuit on a PC board is a tedious and messy job because the circuit must first be laid out on a blank copper-clad board, and then etched using a corrosive chemical. All this fussing with a PC board can be eliminated by using the following procedure.

First, the circuit of Figure 1 is assembled on a "poke board." The poke board is so called because it contains many interconnected finger-grip contacts arranged on a 0.1-inch grid into which the component leads can be poked, thus eliminating the need for soldering. Because the components can be easily removed from the poke board and replaced with components of different values, the circuit is easily modified. The components are then transferred to a special printed circuit board which is an exact duplicate of the poke board, except that the PC board has solder tracks on the underside. After all the components are installed on the PC board, they are soldered to the PC board tracks. In this way, the final circuit is quickly and conveniently moved from the poke board to the PC board without the usual fuss associated with building a PC board.

The Experimentor (TM) EXP-300 Solderless Breadboarding Socket (poke board) and the EXP-300PC (PC board duplicate of the EXP-300) are both available from Global Specialties.[8] Figure 2 is a photograph showing the wobbulator components assembled on the Global EXP-300 poke board. Plastic-insulated #24 solid wire was used to interconnect the resistors and capacitors on the poke board. After the poke board assembly was completed and tested, the same wires and components were transferred to the EXP-300PC and soldered together to complete the final assembly. After all the wires and components are transferred to the EXP-300PC, the poke board can be used for breadboarding other circuits.

Power Supply. Before starting the tone generator construction, a decision must be made as to what kind of power supply will be used. If the supply is to be external, the aluminum box containing only the wobbulator circuit and associated controls can be 5-inches long, by 4-inches wide by 3-inches high. Jameco[5] has such a box (Part No. B2320). Jameco also has a suitable dc wall transformer supply (Part No. 1210) rated for an input of 120V/60 Hz and an output of 12 VDC at one ampere. If the B2320 box is used, about one-half inch must be sheared off each end of the EXP-300PC board so it will fit inside the box. On the other hand, if the power supply is to be inside the box with the wobbulator circuit, a larger box will be required to contain the additional power supply parts. For the purposes of this article, it will be assumed that an external 12-volt dc power supply, such as the Jameco dc wall transformer, will be used.

Potentiometers. Three 2-kohm 1/2-watt potentiometers are needed to adjust the 1-kHz frequency, the wobbulation rate and the range of frequency change. Once the correct pot settings are found, they need not be changed. Consequently, it is recommended that the pots be installed on the PC board with the IC's, resistors and capacitors. If the pots are installed on the PC board instead of on the side of the case, the settings of the pots are less likely to be inadvertently changed after they have been set. Also, the 2-kohm pots are much easier to wire into the wobbulator circuit if they are placed directly on the PC board. Usually, after the pots have been set for the desired center frequency, wobbulation rate and frequency range, there is no need to change the settings. The only pot that needs to be accessible for external adjustment is the 50-kohm audio-output volume control. The 1/2-watt linear taper, single-turn Cermet type is recommended for the 2-kohm pots, and this part is available from any of the parts distributors given in

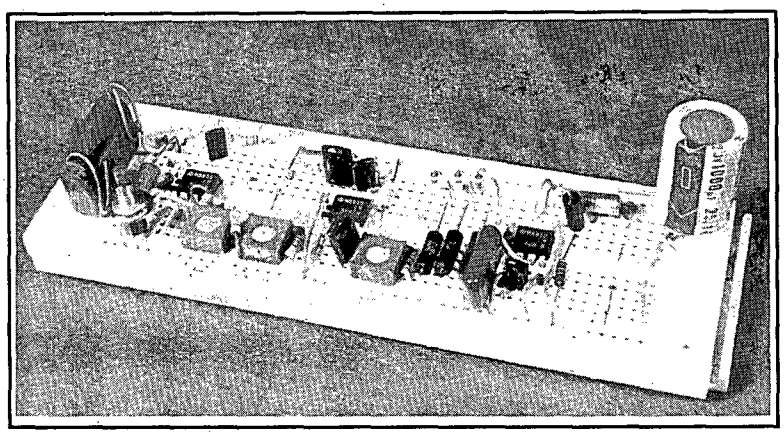

Figure 2. Wobbulator Components Assembled on the Global EXP-300 Poke Board.

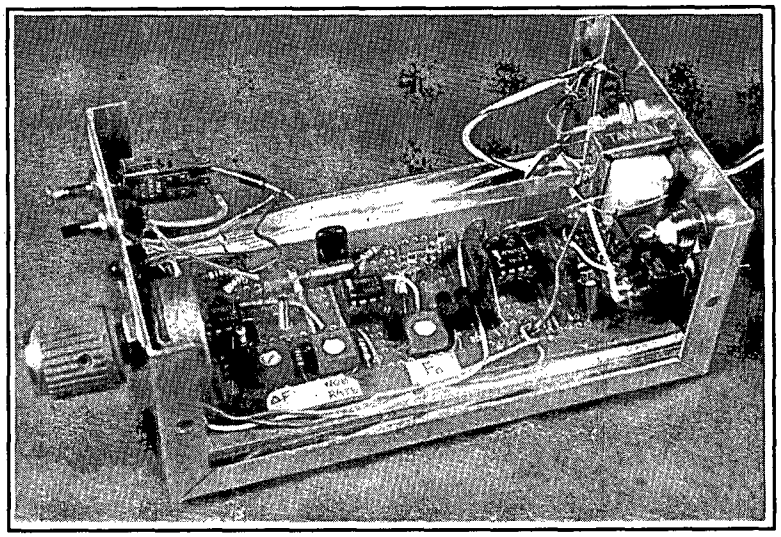

Figure 3. Wobbulator Circuit Installed in an Aluminum Box.

the reference listings. The PC pins of the pots are arranged on a 0.100-inch grid and plug directly into the poke board or the PC board.

The 50-kohm audio taper potentiometer has a standard 3/8-inch by 32 bushing with a 1/4-inch shaft and it should be mounted on the front wall of the box to allow easy external adjustment of the audio volume during normal operation of the generator. All Electronics Corporation lists a suitable 50-kohm audio taper pot in their catalog under CAT# ATP50K. If this part is out of stock, the ATP25K pot will be equally suitable. If a potentiometer having an audio-taper cannot be found, a linear taper pot can be used, but adjusting the audio level will not be as easy as using a pot with an audio-taper.

Switches. The two SPST toggle switches may be obtained from either All Electronics (CAT# MTS-4) or Jameco (Part No. MPC123). Both switches should be mounted on the box so they are accessible from outside the box. The WOB on/off switch turns the wobbulation on or off, and it should be mounted on the front of the box so it is easily accessible by the operator. The 4-8/600-ohm output impedance selector switch should be mounted on the rear panel of the box near the output jacks. This switch is needed only when setting up the test so it need not be as conveniently accessible as the WOB on/off switch.

Resistors, Capacitors and Transformers. All resistors may be 1/8- or 1/4-watt, 5- or 10-percent tolerance, and may be ordered from either of the previously mentioned mail-order houses. Most of the capacitors may also be ordered from the same sources. Those capacitors with a polarity mark are electrolytic and should be installed in the correct orientation. The capacitors without a polarity mark are ceramic monolithic or Mylar with a 25-, 50- or 100-volt rating. The 8/500-ohm transformer and 3.3-μF/100-volt metallized Mylar capacitor are available from Mouser Electronics and Digi-Key, respectively.

Installation of Parts. After obtaining all of the necessary resistors, capacitors and IC's from either Jameco, Digi-Key or Mouser, and after obtaining the EXP-300 breadboard and an EXP-300PC PC board from Global Specialties, the assembly of the wobbulator circuit may begin. First, insert the three IC's into the poke board. The resistors and capacitors are then installed in accordance with the schematic diagram shown in Figure 1. Figure 2 shows what the assembly will look like after most of the components are installed on the poke board. The 50-kohm audio-taper potentiometer and the toggle switches will be mounted on the enclosure walls. Temporarily connect the audio-taper pot and switches to the poke-board circuit with insulated wires, and then apply power to the wobbulator circuit to make it operational. After the circuit is operating as desired, transfer all the parts to the EXP-300PC PC board and then install the PC board in a suitable box. Use a sheet of cardboard to serve as a buffer between the bottom of the PC board and the aluminum box to prevent

shorting the PC tracks. Punch two holes in the PC board, the cardboard and the bottom of the box, and use two 4-40 machine screws to hold the PC board and cardboard in place. Install 8-pin I-C sockets on the PC board before transferring the IC's from the poke board. Figure 3 shows the wobbulator circuit installed in a Bud aluminum box.

Signal Output Connectors. In the fully-assembled wobbulator shown in Figure 3, two BNC connectors were used for the 600-ohm and 4/8-ohm outputs, with a toggle switch for selecting either output. However, after the wobbulator assembly was completed, it was decided that the 600-ohm output should be completely isolated from ground instead of being grounded at one end. Although the schematic diagram indicates this improvement, the assembly in the box was not changed before the photograph was taken. It is recommended that the 600-ohm output be wired as shown in the schematic diagram of Figure 1. Two pin jacks mounted on the rear of the case will allow convenient connection to a telephone line or a similar circuit requiring a ground-isolated signal source.

SUMMARY AND CONCLUSION

This article demonstrated how a simple, inexpensive and easy-to-build wobbulated 1-kHz tone generator can replace the more expensive commercial function generators usually used as a wobbulated signal source for analog-speech testing. Using a "poke-board" enables one inexperienced with PC board construction to quickly assemble and test the wobbulator circuit, and after the circuit has been debugged, it is easily transferred to a PC board duplicate of the poke-board for the final wiring.

Building simple test equipment for non-demanding applications may be more convenient and less expensive than renting or purchasing precision commercial equipment having high performance capabilities that too frequently are not optimum for simple test functions. In addition to providing an inexpensive alternative to the more costly generators, the construction and testing of this 1-kHz wobbulated tone generator provides good training experience for the beginning technician. ■

NOTE

Information on a parts kit is available by sending a stamped, self-addressed business-sized envelope to E. Wetherhold, 1426 Catlyn Place, Annapolis, MD 21401.

REFERENCES

1. "Easy-to-Build Bandpass Filters for Analog-Speech Testing," ITEM 1987, pp. 264-272.
2. "Simplified Design and Evaluation of Chebyshev Passive LC Filters," ITEM 1988, pp. 139-153.
3. "Simplified Design and Construction of Audio-Frequency 50-ohm Bandpass Filters," ITEM 1989, pp. 26-70.
4. Digi-Key Corporation, 701 Brooks Avenue, South, P.O. Box 677, Thief River Falls, MN 56701-0677. Tel: (800) 344-4539. Catalog available.
5. Jameco Electronics, 1355 Shoreway Road, Belmont, CA 94002. Tel: (415) 592-8097. Catalog available.
6. All Electronics Corporation, P.O. Box 567, Van Nuys, CA 91408. Tel: (800) 826-5432. Catalog available.
7. Mouser Electronics, 11433 Woodside Avenue, Santee, CA 92071. Tel: (800) 346-6873. Catalog available.
8. Global Specialties, P.O. Box 1405, New Haven, CT 06505. Tel: (800) 345-6251. In CT: (800) 445-6250. Catalog available.