Build the Super Audio Sweep Generator

PROVIDES LOG AND LINEAR SWEEP. DELIVERS 1 Hz TO 100 kHz SINE, TRIANGLE, SQUARE WAVEFORMS AT A BREAKTHROUGH LOW COST

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ONE of the most valuable pieces of audio test equipment is the audio sweep generator. Unfortunately, it is not widely used because heretofore only costly professional instruments contained the desirable functions and accuracy: a logarithmic function which eliminates tedious point-by-point frequency plots, a frequency range extending virtually flat to beyond 20 kHz, calibrated attenuators, and high stability. Now, you can build the "Super Sweeper" audio sweep generator and have a laboratory-quality instrument for about the same you would expect to pay for a common audio signal generator *without* the sweep function.

Also, the Super Sweeper sacrifices nothing as a conventional wide-range audio signal generator. Its controls can be set to provide any frequency- and amplitude-adjustable square, sine, or triangle waveform for signal tracing or what have you.

The overall block diagram for the Sweeper is shown in Fig. 1, with the various blocks referring to the schematics in Figs. 2 through 6. Rather than go through a lengthy stage-by-stage discussion of how the Sweeper works, we will be concentrating on calibration precedures and how to use the instrument.

Construction. For ease of assembly, we recommend the use of a PC board. Due to the complexity of the board, the foil pattern is not shown here. A foil pattern and component layout (included in the step-by-step instructions) or a completed board are available from the source in the Parts List. Mount the following switches and control potentiometers on the Sweeper's front panel: SWEEP RATE *(R4)*, FREQUENCY *(R33)*, FREQUENCY RANGE *(S4)*, WAVEFORM *(S5)*, AMPLITUDE *(R60)*, ATTENUATOR *(S7)*, SWEEP MODE *(S2)*, RESET *(S8)*, SWP TYPE *(S3)*, and SWEEP RATE *(S1)*. Also locate on the front panel the PILOT lamp and the six binding posts for the outputs. All other controls are to be mounted on the PC board.

You can use any type of chassis that suits your fancy. However, if you're looking for a professionally pre-drilled and screened chassis/cabinet, you can get one from the same company specified in the Parts List as the kit supplier.

Calibration. Using a VTVM and an oscilloscope, perform the calibration of the Super Sweeper as outlined in the Table. The procedure given will yield a frequency calibration accurate to within 10 percent.

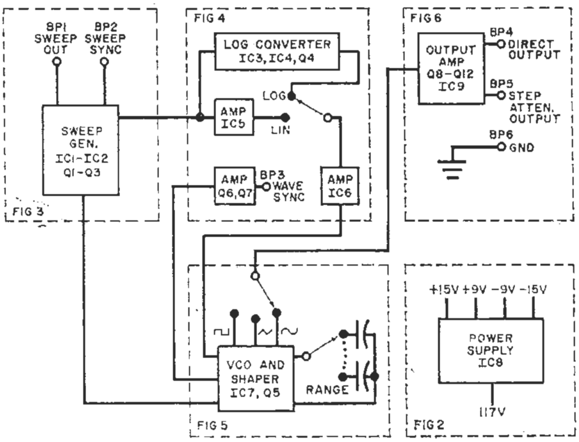

Fig. 1. Overall block diagram showing signal flow in the Sweeper. Blocks are given in detail in other figures.

PARTS LIST

BP1-BP6—Five-way binding post
C1,C12—1-µF, 50-volt, 10% Mylar capacitor
C2—100-µF, 15-volt, 10% tantalum capacitor
C3,C23,C24—0.01-µF, 50-volt disc capacitor
C4,C14—100-pF, 50-volt disc capacitor
C5,C17,C18—0.001-µF, 50-volt disc capacitor
C6,C11—0.1-µF, 50-volt, 10% Mylar capacitor
C7,C8,C19,C20—15-µF, 20-volt tantalum capacitor
C9—910-pF, 100-volt, 10% mica capacitor
C10—0.01-µF, 50-volt, 10% Mylar capacitor
C13—10-µF, 25-volt, 10% tantalum capacitor
C15,C16—1000-µF, 25-volt electrolytic capacitor
C21—150-pF, 50-volt disc capacitor
C22—3.3-pF, 50-volt, 10% disc capacitor
C25—5-pF, 50-volt, 10% disc capacitor
D1-D6,D9-D12—1N914 or 1N4148 signal diode
D7,D8—1N4001 50-volt rectifier diode
F1—¼-A 3-AG fuse and holder
IC1,IC3-IC6—741 op amp IC
IC2,IC9—301A op amp IC
IC7—Function generator IC (Intersil ICL8038CC)
IC8—Voltage regulator IC (Raytheon RC4194TK)
LED1—Light emitting diode (Monsanto MV5023)
Q1,Q10—2N4250 transistor
Q2,Q3,Q6,Q7,Q11—2N3642 transistor
Q4—2N4955 dual npn transistor (Fairchild)
Q5—MPF-111 n-channel FET (Motorola)
Q8,Q9—2N5210 transistor
Q12—2N3645 transistor
R1—2400-ohm, ¼-watt, 5% resistor
R2,R36—1000-ohm trimpot
R3,R16—5600-ohm, ¼-watt, 5% resistor
R4—500,000-ohm, log taper potentiometer
R5,R53—3900-ohm, ¼-watt, 5% resistor
R6,R41—2000-ohm trimpot
R7—1800-ohm, ¼-watt, 5% resistor
R8,R17,R26,R29,R52—4700-ohm, ¼-watt, 5% resistor
R9,R20,R42—4020-ohm, 1% resistor
R10,R25,R32—5010-ohm, 1% resistor
R11-R13,R61—10,000-ohm, ¼-watt, 5% resistor
R14—3300-ohm, ¼-watt, 5% resistor
R15—8600-ohm, ¼-watt, 5% resistor
R18,R27,R31—5000-ohm trimpot
R19,R56—22,600-ohm, 1% resistor
R21—100-ohm, 1% resistor
R22,R51—82,000-ohm, ¼-watt, 5% resistor
R23—10,000-ohm trimpot
R24—330,000-ohm, ¼-watt, 5% resistor
R28,R30,R35,R37—10,000-ohm, 1% resistor
R33—10,000-ohm, linear taper potentiometer
R34—1100-ohm, 1% resistor
R38,R39—100,000-ohm trimpot
R40—4750-ohm, 1% resistor
R43,R62—15,000-ohm, ¼-watt, 5% resistor
R44,R58—100,000-ohm, ¼-watt, 5% resistor
R45,R49—22,000-ohm, ¼-watt, 5% resistor
R46—33,000-ohm, 1% resistor
R47—120,000-ohm, ¼-watt, 5% resistor
R48—30,000-ohm, ¼-watt, 5% resistor
R50—6800-ohm, ¼-watt, 5% resistor
R54—680-ohm, ½-watt, 5% resistor
R55—71,500-ohm, 1% resistor
R57—68,000-ohm, ¼-watt, 5% resistor
R59—2200-ohm, ¼-watt, 5% resistor
R60—1000-ohm, linear taper potentiometer
R63—39,000-ohm, ¼-watt, 5% resistor
R64—100-ohm, ¼-watt, 5% resistor
R65,R66—1500-ohm, ¼-watt, 5% resistor
R67,R68—51-ohm, ¼-watt, 5% resistor
R69—6200-ohm, ¼-watt, 5% resistor
R70,R72,R73—620-ohm, ¼-watt, 5% resistor
R71—62-ohm, ¼-watt, 5% resistor
R74—560-ohm, ¼-watt, 5% resistor
R75—20,000-ohm, 1% resistor
S1,S2—Dpdt miniature toggle switch
S3—Spdt miniature toggle switch
S4—5-position, 1-pole shorting rotary switch
S5,S7—3-position, 1-pole shorting rotary switch
S6—Spst miniature toggle switch
S8—Spst normally open pushbutton switch
T1—Transformer; secondary: 12 V at 150 mA
Misc.—Suitable chassis, mounting hardware, wire, solder, etc.
Note—The following are available from: MITS, 6328 Linn, N.E. Albuquerque, NM 87108: PC board at $6.00; step-by-step instructions, including foil pattern and component layout at $3.00; complete kit, including board, instructions, and enclosure, $119.95; complete unit assembled, $149.95.

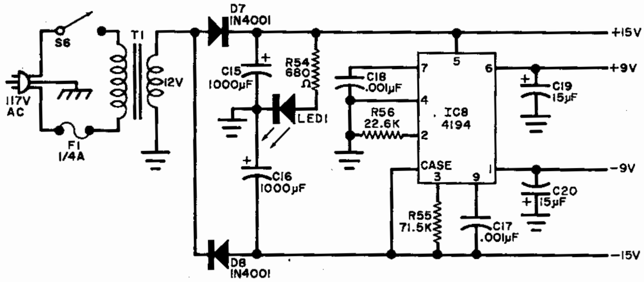

Fig. 2. The power supply has a single IC and a conventional rectifier filter approach.

If greater accuracy is desired, the range capacitors can be selected or padded to be within 1 percent of the specified value.

An alternate method of calibration is to measure the frequency of the sine-wave CW output of the Sweeper by comparison with the output of a well-calibrated audio oscillator, using Lissajous figures. Set the Sweeper's FREQUENCY control *(R33)* to 10, its fully CW position, and measure the output frequency for each range. Set the FREQUENCY RANGE switch *(S4)* to the setting that had the greatest error *below* the indicated frequency. Then set LIN CAL *(R31)* so that the frequency of this range is accurate to within 1 percent. Now, all of the other ranges will be high in frequency; pad each of these ranges with a capacitor until all outputs are accurate to within 1 percent.

Operation. For use as a fixed-frequency oscillator, set the SWEEP MODE switch to CW and SWP TYPE switch to LIN. The sweep rate

SPECIFICATIONS

Modes: CW, linear sweep, log sweep
Waveforms: sine, square, triangle
Range (5 steps): 1 to 100,000 Hz
Response: ±0.1%, to 20,000 Hz; ±0.15%, to 100,000 Hz
Distortion (sine): 1.5%, 10 to 20,000 Hz
Rise time (square): 2 μs
Output voltage: 0-5 V rms sine; 0-7 V peak sine, square, triangle
Attenuator: 0, 20, 40 dB ±1 dB; 600 ohms constant impedance
Sweep time (2 steps): 10 ms to 100 s
Sweep output (ramp): 0 to 5 V, 5000 ohms output impedance
Sync Outputs: 4-V positive pulses, 5000 ohms impedance. Sweep sync pulse starts at end of sweep, returns to zero start of next sweep. Can be used for blanking; 5 μs rise time. Wave sync is square wave, amplitude independent of control settings; 0.5 μs (maximum) rise time.

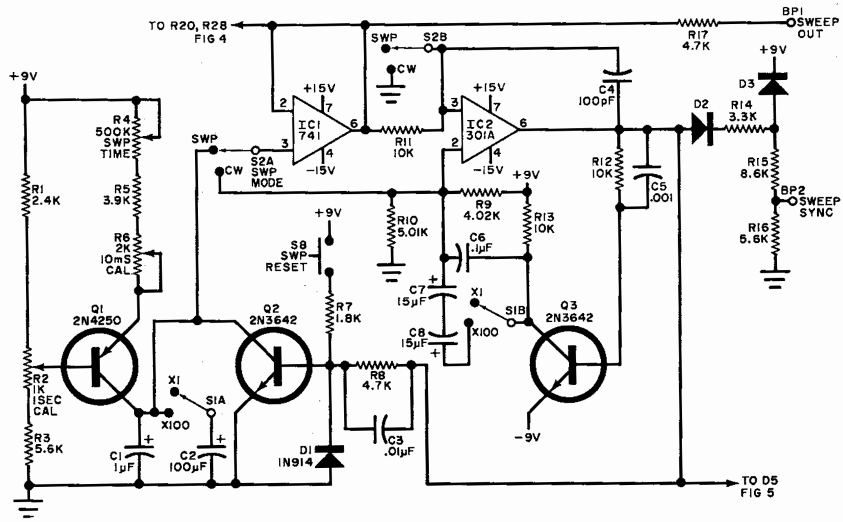

Fig. 3. A linear sweep voltage is generated in Q1 and Q2, available at BP1. Output of IC2 is a pulse which is attenuated and brought out to jack BP2.

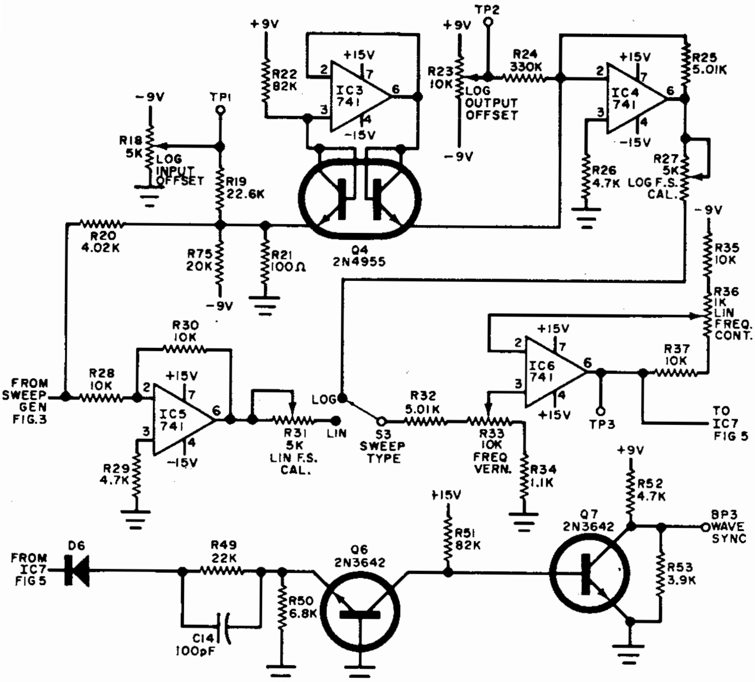

Fig. 4. Converter circuit shapes the linear sweep into logarithmic waveform, since second half of Q4 has current flow proportional to the exponent of applied voltage. IC4 converts the current to voltage. S3 selects either the linear or logarithmic output.

controls will now have no effect on the Sweeper's output. When the WAVEFORM switch is set to sine, *BP4* (OUTPUT DIR) will supply a 0-5-volt rms sine wave at 600 ohms impedance. In the triangle and square positions of the WAVEFORM switch, the output at *BP4* will have a peak voltage variable between 0 and 7 volts. The *BP5* (OUTPUT ATTEN) binding post will have the same open-circuit output as the direct output when the ATTENUATOR switch is set for 0 dB. In the 20-dB position, the output will be 1/10 of the direct output, while in the 40-dB position it will be down to 1/100. Loads (or short circuits) on either of these outputs will have no effect on the other.

The output frequency can be set at any point from 1 Hz to 100 kHz by adjusting the FREQ RANGE switch and FREQUENCY control. The SYNC WAVE output (*BP3*) provides a 4-volt, positive-going square wave for sync or counter use.

Refer to Fig. 7 for setting up a sweep display. In the sweep mode, the output voltages and waveforms are the same as they are in the CW mode, but the frequency is swept from nearly zero up to the frequency set by the FREQ RANGE switch and FREQUENCY control. The SWEEP RATE control varies the time for a full sweep from 10 ms

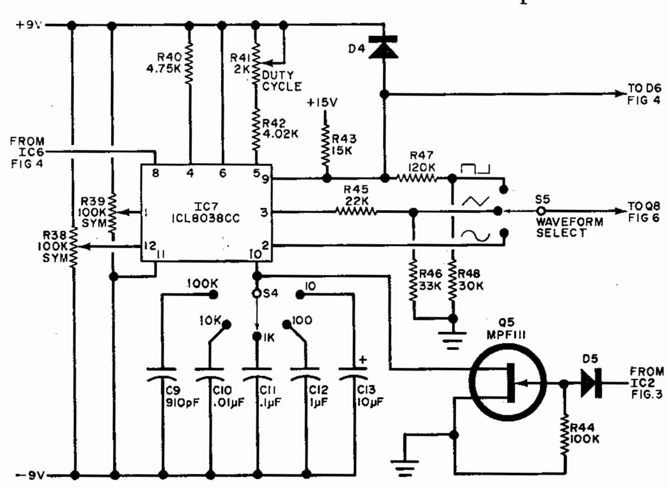

Fig. 5. The vco uses one LSI IC to generate sine, triangle, or square wave output. The chip is reset from the sweep generator. Switch S4 selects range.

PROJECT EVALUATION
(Hirsch-Houck Labs Report)

In our tests, the Super Sweeper easily met or surpassed all of its performance specifications. In fact, the rated accuracy and response uniformity of our laboratory-grade test equipment was not adequate to verify the "flatness" of the Sweeper's output. However, it left us with no doubts as to the capabilities of this versatile instrument.

The uniformity of output in the CW mode was within ±0.1 dB from 5 Hz to 100 kHz. Using an oscilloscope, we judged that the output rose to +0.8 dB at 1 Hz, although this involved some guesswork. In the sweep mode, we recorded the output on a General Radio 1521-B Graphic Level Recorder, whose rated flatness is comparable to that of the Sweeper. The chart calibration was not synchronized in frequency with the swept signal, but it showed a total variation of less than 0.25 dB over the full 100-kHz sweep in the linear mode. The logarithmic sweep was almost perfectly flat up to and beyond 60 kHz (on the 100-kHz range); and the output then dropped about 0.5 dB as the sweep continued to 100 kHz. Using less than the maximum sweep capability of the unit, the flatness was generally well within 0.1 dB.

The maximum output voltage (sine) was 5.3 volts into an open circuit, dropping to 2.6 volts with a 600-ohm load. The attenuator error at 1000 Hz was —0.1 dB at the 20-dB setting and —1 dB at the 40-dB setting.

The harmonic distortion (sine wave output) varied with frequency. The lowest reading, 1.0%, was measured at 20 Hz, and the highest, 1.9% to 2.0%, was in the range between 100 and 1000 Hz. Over the audio range, the average distortion was about 1.5%. Of course, one would not use this instrument for making distortion measurements of high-quality amplifiers: it is principally a tool for frequency response measurements.

The frequency calibrations proved to be surprisingly accurate. The error was typically less than 3% and at only one point did it even approach the 10% figure specified.

The square and triangle waves appeared to be good, judging from a visual examination on an oscilloscope. The square-wave rise time was approximately 2 microseconds.

The logarithmic sweep, a virtual necessity for meaningful audio measurements, is rarely found—even on generators costing many times the price of this one. The lack of a logarithmic frequency calibration is a minor inconvenience, but an external marker generator can be mixed with the output of the Sweeper; and once the calibration has been made for a commonly used frequency range (such as up to 20 kHz), it should remain valid for a long time without further checks.

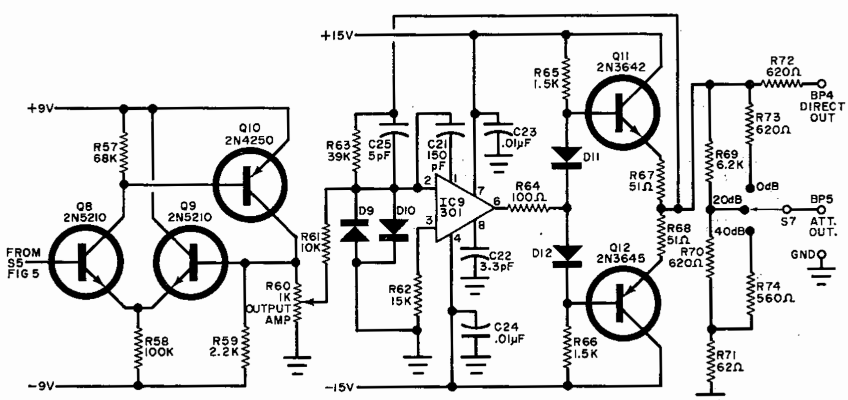

Fig. 6. In the output stage, Q8, Q9, and Q10 form a unity gain buffer, whose output is applied to amplitude control R60 and is then amplified by IC9. Transistors Q11 and Q12 provide high output current. A three-step attenuator is made up of R69 to R74 with amount of attenuation selected by S7. Output impedance is 600 ohms.

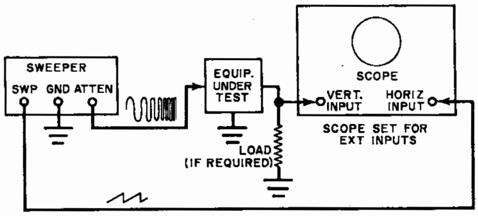

Fig. 7. This is setup for hooking the sweeper to the gear under test and to a scope (preferably dc). Sweep rate is adjusted to correct value by observing output on scope.

ALIGNMENT PROCEDURE

CONTROL/SETTING	OBSERVE	ADJUST	DESIRED
POWER/on SWP/lin	IC8-5 IC8-case IC8-6 IC8-1	— — — —	+15 ±3 V −15 ±3 V +9 ±0.1 V −9 ±0.1 V
SWP MODE/SWP SWP RATE/X1 SWP RATE/1 sec	SWP out	R2	1-s sweep time (1 Hz)
As above with SWP RATE/10 ms	SWP out	R6	10-ms sweep time (100 Hz)
FREQ RANGE/10K FREQUENCY/10 SWEEP RESET/in	OUTPUT DIR	R36	30-90-Hz output
As above with SWEEP MODE/CW SWEEP RESET/out	OUTPUT DIR	R31	10-kHz output
As above with WAVEFORM/square SWEEP MODE/CW	OUTPUT DIR	R41	Equal time for both states of square wave
As above with WAVEFORM/sine FREQ RANGE/1K FREQUENCY/5	As above	R38 R39 R41	Minimum distortion (on sine wave)
SWP TYPE/LOG SWEEP MODE/SWP SWEEP RATE/X1	TP1	R18	−5 V
SWEEP RATE/1 SEC	TP2	R23	−5 V
As above	TP3	R18	Sweep voltage should drop 10% (middle of trace)
As above with FREQ RANGE/10K FREQUENCY/10 SWEEP RESET/in	OUTPUT DIR	R23	30-70-Hz output
As above with SWEEP MODE/CW SWEEP RESET/out	OUTPUT DIR	R27	10-kHz output

Note: All observation points (Column 2) referenced to ground.

to 1 s in the FAST and 1 s to 100 s in the SLOW position. The sweep rate is adjusted to the correct value by observing the output display with an oscilloscope. Sweeping too fast causes the display to smear. Sweeping too slowly will cause a flicker in the display and make observation difficult. The point at which display smearing occurs depends on the bandwidth of the unit being tested and on the sweep width setting.

The linear sweep allows the frequency of any point on the plot to be read directly, since the frequency starts at zero and changes at a constant rate. The only disadvantage of the linear sweep is that only a narrow region of the audio band is shown in detail. Thus, for a 10-kHz sweep, the bass and midrange (20-1000 Hz) are compressed into the first 10 percent of the sweep, with the remaining 90 percent covering the treble response in detail.

The logarithmic sweep solves this problem by devoting equal area to each band of audio. The rate of frequency change with time increases at a constant pace. The log sweep covers two decades, or about six octaves. Notice that the starting point is not dc (zero frequency), but is offset, since the logarithm of zero is minus infinity.

The ability of the sweeper to go as slowly as 100 seconds/sweep permits plots of systems with narrow bandwidths. A graphic chart plotter or an oscilloscope camera will give a permanent record of the response curve.

The audiophile can use the 100-second sweep to detect resonant objects in a room by "playing" the sweeper through his audio system and moving around the room, listening for resonances. When using slow sweeps, the SWEEP RESET pushbutton is handy for restarting the sweep before it is completed. Holding the button down permits synchronizing the sweep manually.

Applications. An audio sweep generator has many applications. For example, it simplifies setting a tape recorder's bias and aligning head azimuth. Line and load regulation and output impedance *vs* frequency for power supplies can be checked easily. It can also be used to test room and speaker enclosure resonance, microphone-element sensitivity, ultrasonic system response, phase locked loops, SSB filters and telecommunications systems, not to mention the host of all-audio applications. ◈