NIOSH/TC/P-014

INDUSTRIAL SOUND LEVEL METER SQUARE LAW CHARACTERISTIC TEST

Robert J. Koshut

National Institute for Occupational Safety and Health

Testing and Certification Branch

Physical Agents Section

944 Chestnut Ridge Road

Morgantown, West Virginia 26505

Released

Subject to Future Revision

Available from NTIS

ACKNOWLEDGMENTS

The author is grateful to all present and past NIOSH employees who have contributed to the development of this test procedure.

DISCLAIMER

Mention of company name or product does not constitute an endorsement by the National Institute for Occupational Safety and Health. Equivalent equipment may be used.

CONTENTS

*Industrial Sound Level Meter

LIST OF ILLUSTRATIONS

LIST OF TABLES

I. INTRODUCTION

The indicating instrument of an ISLM should respond to the root mean square (RMS) of its input signal for its response to be directly proportional to the energy content of measured noise. This test verifies that the indicating instrument of an ISLM approximates square law behavior by using the Rule of Combination Measurement Procedure described in Appendix B of ANSI S1.4-1971, "Specification for Sound Level Meters." For inputs of pure tone and of 1/3 octave bands of noise, which have equal RMS values, the corresponding ISLM readings should be within 0.5 decibel of each other. This test is performed at 1 dB and 10 dB below ISLM full scale reading.

II. REFERENCE TEST REQUIREMENTS

The test requirements are derived from the following sources:

A. NIOSH regulation which gives a program for certifying industrial sound level meter sets (42 CFR 82, FEDERAL REGISTER, Vol. 41, No. 197, pp. 44396-44403).

B. American National Standards Institute's (ANSI) S1.4-1971 "Specification for Sound Level Meters."

Excerpts from each of these documents are as follows:

A. 42 CFR 82.64(j): The indicating instrument of the industrial sound level meter shall meet the requirements for Type 2 sound level meters specified in Section 5.2 of ANSI S1.4-1971. The requirement of Section 5.2 shall be verified by the Rule of Combination Measurement Procedure described in Appendix B of ANSI S1.4-1971 but with the following modifications:
   (1) One-third octave bands of noise shall be used. Octave bands of noise shall not be used.
   (2) The voltage developed across the resistor shall be applied as an electrical input to the industrial sound level meter in series with the microphone, with the acoustic pickup made negligible.
   (3) Only A-weighting shall be used in the measurement procedure.
   (4) Only the "SLOW" meter characteristic of the industrial sound level meter shall be used in the measurement procedure.

   42 CFR 82.64(k): The industrial sound level meter shall employ an indicating system equally responsive

to instantaneous sound pressures both above and below ambient static pressure (i.e., full-wave or true square law rectification shall be employed).

B. ANSI S1.4-1971(5.2): Rule of Combination for Complex Sounds. The indicating instrument shall be of the square law type as verified by the Rule of Combination Measurement Procedure described in Appendix B. The rule of combination shall be satisfied within 0.5 decibel for the Type 1 and Type 2 meters and within 1.1 decibels for the Type 3 meter.

ANSI S1.4-1971(Appendix B): Method of Checking the Rule of Combination of the Indicating System for Noise.

Arrange a circuit wherein a series of sine waves and one-third octave or octave bands of noise may be applied alternately to a resistor. The resistor current is measured by a thermocouple meter operating in the range in which its reading is proportional to the square of the current. The voltage developed across the resistor is applied as an electrical input to the sound level meter through a suitable network replacing the microphone, or in series with the microphone, if the acoustic pickup can be made negligible. The resistor should have a resistance no greater than one percent of the absolute value of the input impedance of the sound level meter.

Apply a sine wave voltage at a frequency of 1000 Hz and adjust the thermocouple current and sound level meter gain controls to values that yield an indicating instrument deflection 1.0 decibel below full scale deflection. Now, instead of the sine wave, substitute a one-third octave or octave band of noise centered at 1000 Hz and adjust to obtain the same thermocouple current as before. Note the resulting average reading of the indicating instrument. The specification given in 5.2 may be considered satisfied if this reading is within the appropriate tolerances required, as compared with the reading for the 1000 Hz tone.

Repeat the operation given in the preceding paragraph for a deflection of the indicating instrument 10 decibels below full scale deflection. The average reading for the noise should be the same within the required tolerance.

Repeat the above two tests for a tone and a one-third octave or octave band of noise at frequencies of

6300 Hz and 63 Hz. Do both pairs of tests with the sound level meter set for C weighting or FLAT weighting if they are provided. For the test at 63 Hz, use the SLOW meter characteristic and determine the average deflection in the following manner: After the noise signal has been applied for at least ten seconds, note the instantaneous deflection. Continue in this manner until at least 50 values have been recorded. The average of these values is the desired average deflection.

The one-third octave or octave bands of noise should be derived from a gaussian noise source that is "pink" over the range from at least 20 Hz to 20,000 Hz, within ±1 decibel, by means of one-third octave band filters that meet the requirements of American National Standard Specification for Octave, Half-Octave, and Third-Octave Band Filter Sets, S1.11-1966, Type 2 or 3. Here "pink" is used to mean a spectrum-level downward slope of 10 decibels/10:1 frequency span. The spectrum level of the noise source beyone 20,000 Hz should continue to decrease at a rate of at least as great as 10 decibels/10:1 frequency span.

If neither C nor FLAT weighting is provided, the signals may be inserted in the linear electronic section of the sound level meter between the weighting networks and the detection system of the sound level meter.

If A or B weighting must be used for the tests, the test at 63 Hz should be modified as follows: Determine the cutoff frequencies of the one-third octave or octave band filters used. For the purpose of this test, these frequencies may be selected as the frequencies at which the response of the filter is 4 decibels less than the maximum response of the filter. For one-third octave band filters and A weighting, set the pure tone at a frequency of 1.01 times the geometric mean of the two cutoff frequencies to account for the shift of the effective center of the band by the weighting. For one-third octave band filters and B weighting, set the pure tone at a frequency of 1.007 times the geometric mean. For an octave band of noise, the corresponding ratios are 1.07 for A weighting and 1.03 for B weighting.

III. ISIM SQUARE LAW CHARACTERISTIC TEST

A. Test Equipment

1. Programmable calculator, Hewlett Packard (HP) 9830A.

a. FD-30A Mass Memory, Infotek.
b. Printer, HP 9866A or HP 8871A.

2. Frequency synthesizer, HP 3320B or HP 3330B.
3. Preamplifier, Crown IC150.
4. Power amplifier, Crown DC300A.
5. Multimeter, HP 3490A.
6. Random noise generator, Gen Rad (GR) 1382.
7. Multimeter, Fluke 853A.
8. Bandpass filter set, Bruel & Kjaer (B&K) 1615.
9. Decade attenuator, GR 1450-TB.
10. RMS voltmeter, HP 3403A or HP 3403C (2 required).
11. Load box #1.
12. Soundproof enclosure.
13. ISLM (with signal insertion leads).
14. Relay switches.

B. Test Procedure

1. Set up the equipment according to Figure 1.
2. Connect the relays as shown in Figure 1. Use relays 8 and 2.
3. Set the equipment on the following settings:
   a. Preamplifier, Crown IC150.
      (1) AUX 2.
      (2) LOUDNESS - out.
      (3) VOLUME - fully CCW.
      (4) BALANCE - normal.
      (5) PANORAMA - mono.
      (6) FLAT response button - in.
   b. Power amplifier, Crown DC 300A.
      (1) Channels 1 and 2 fully CCW.
   c. Random noise generator, GR 1382.
      (1) Pink noise.
      (2) Volume fully CCW.
      (3) Middle two banana output posts should be shorted together and the output taken from the uppermost two outputs.
   d. Multimeter, Fluke 853A.
      (1) AC DIR.
      (2) IV range.
   e. Bandpass filter set, B&K 1615.
      (1) SCANNING - manual.
      (2) 1/3 octave.
      (3) Range I.
   f. Decade attenuator, GR 1450-TB.
      (1) 11.5 dB (1/1/5).
   g. RMS voltmeter #1, HP 3403A or HP 3403C.
      (1) AC, dB.
      (2) Range as required.
      (3) SLOW response.
   h. RMS voltmeter, #2, HP 3403A or HP 3403C.
      (1) DC volts.

(2) Range as required.
(3) SLOW response.

i. Load box #1.
(1) HIGH setting.

4. Turn on the equipment and allow a 15 minute warm-up period.
5. Calibrate the ISLM according to the applicant's instructions.
6. Set the ISLM to SLOW response, A weighting, and the 90 dB range (if a range attenuator is provided).
7. Place the ISLM in the soundproof enclosure and make the proper connections.
8. Turn on the ISLM and close the soundproof enclosure.
9. Take DISKETTE D-01 and place it into the FD-30 mass memory.
10. Press LOAD #5, 7, EXECUTE.
11. After the diskette stops, press RUN, EXECUTE.
12. After the diskette stops, remove it from the FD-30A mass memory.
13. Enter the following information about the applicant's ISLM. After typing in each piece of information, press EXECUTE.
    a. Name of applicant.
    b. ISLM model number.
    c. ISLM serial number.
    d. Calibrator model number.
    e. Date test is being run.
    f. Model number of the synthesizer being used (3320B or 3330B).
14. Enter the model number of the printer being used 9871A or 9866A) and press EXECUTE. NOTE: If the 9871A printer is being used, insert a 10" X 8-1/2" data sheet into the printer and press CONT, EXECUTE.
15. Enter the DC calibration curve constants (A and B) for the ISLM under test and press EXECUTE (see Appendix).
16. Enter the DC calibration curve error and press EXECUTE (see Appendix).
17. Enter the maximum scale reading of the ISLM (e.g., 10, or 120 for a wide range meter) and press EXECUTE.
18. Enter the pure tone value used when the noise frequency is 63 Hz and press EXECUTE. (Check the bandpass filter and Appendix B of ANSI S1.4-1971 for the appropriate value.)
19. Set the bandpass filter to the indicated frequency. After setting the frequency, press CONT, EXECUTE.

THE PURE TONE (FROM SYNTHESIZER) IS APPLIED TO ISLM

20. Adjust the Crown preamplifier and Crown power amplifier to obtain the dB below full scale on the ISLM

that is indicated by the programmable calculator. If it is not possible to obtain the appropriate ISLM reading without staying below -22.0 dB on RMS voltmeter #1, turn down the Crown power amplifier volume and reduce the decade attenuator setting by 0.1 dB. Readjust the Crown power amplifier to get the appropriate ISLM reading. Repeat this step, if necessary.

21. After obtaining the appropriate ISLM reading, press CONT, EXECUTE. Enter the DC range of RMS voltmeter #2 (range giving an on scale reading) and press EXECUTE.
22. The programmable calculator will now determine the ISLM scale reading (with the pure tone signal applied) using the ISLM's DC calibration curve.
23. Enter the AC, dB range of RMS voltmeter #1 and press EXECUTE. The programmable calculator will now determine the RMS level coming from the synthesizer.
24. Record the AC, dB level from RMS voltmeter #1 and press CONT. EXECUTE. The random noise generator has now been switched into the system.

THE 1/3 OCTAVE BAND NOISE IS APPLIED TO THE ISLM

25. Adjust the output of the random noise generator while observing the Fluke multimeter and RMS voltmeter #1. Proceed until the same AC, dB level is obtained (on RMS voltmeter #1) as in step 24. However, do not put more than 1V into the bandpass filter. If the same AC, dB level as in step 24 is obtained, press CONT, EXECUTE. Since the decade attenuator was not changed in this step, enter NO and press EXECUTE. Continue at step 26. However, if the AC, dB level of step 24 cannot be duplicated, turn the amplitude control of the random noise generator fully counterclockwise and reduce the decade attenuator setting by 0.1 dB. readjust the output of the random noise generator to produce the same AC, dB level of step 24. Retaining this decade attenuator setting, turn down the output of the random noise generator. Press CONT, EXECUTE. Since the decade attenuator was changed in this step, enter YES and press EXECUTE. Continue at step 20.
26. The programmable calculator will now determine the RMS level from the random noise generator and compare it with the RMS level from the synthesizer (as calculated in step 23). If the two levels are equal within ±0.1 dB, the programmable calculator will read the Crown power amplifier volume. If the RMS levels are different, the programmable calculator will indicate the amount of change required for the decade attenuator. Continue at step 27.

27. After changing the decade attenuator by the appropriate amount, press CONT, EXECUTE. The pure tone signal is not reapplied to the ISLM.
28. Check the ISLM to see if it is reading on scale. After checking the ISLM reading, press CONT, EXECUTE.
29. The programmable calculator will now determine the ISLM reading (with the pure tone signal applied) using the ISLM's DC calibration curve. If the ISLM reading is the same as the reading in step 22, the programmable calculator will read the ISLM's DC meter output voltage with the 1/3 octave band noise applied. After the ISLM reading has been determined, lower the Crown power amplifier volume and continue at step 30. If the ISLM reading is not the same as the reading in step 22, the programmable calculator will tell you to reset the decade attenuator. Reset the decade attenuator to the setting of step 26. Lower the Crown power amplifier volume. Press CONT, EXECUTE and continue at step 20.
30. After the programmable calculator reads the ISLM's DC meter output voltage with the 1/3 octave noise, (63 Hz and 1 dB below ISLM full scale) applied, follow the table below for the remainder of the test. Also, lower the output of the random noise generator after the programmable calculator is finished reading the ISLM with the 1/3 octave band noise applied.

TABLE 1

TESTING CONDITIONS				
FREQUENCY	DB BELOW ISLM FULL SCALE	ISLM ATTENUATOR SETTING	STARTING DEC. ATTEN. SETTING	CONTINUE AT STEP
63 Hz	10	90 dB	11.5 dB	20
1000 Hz	1	90 dB	11.5 dB	19
1000 Hz	10	90 dB	11.5 dB	20
6300 Hz	1	90 dB	11.5 dB	19
6300 Hz	10	90 dB	11.5 dB	20

NOTE: Some points should be made concerning Table 1.

(1). The ISLM ATTENUATOR SETTING should not go below 80 dB to prevent any significant influence from loud ambient noise.

(2). The STARTING DECADE ATTENUATOR SETTING is only a recommendation. The only restriction on the decade attenuator setting is that you obtain the indicated ISLM reading with an AC, dB level of less than -22.0 dB (step 20).

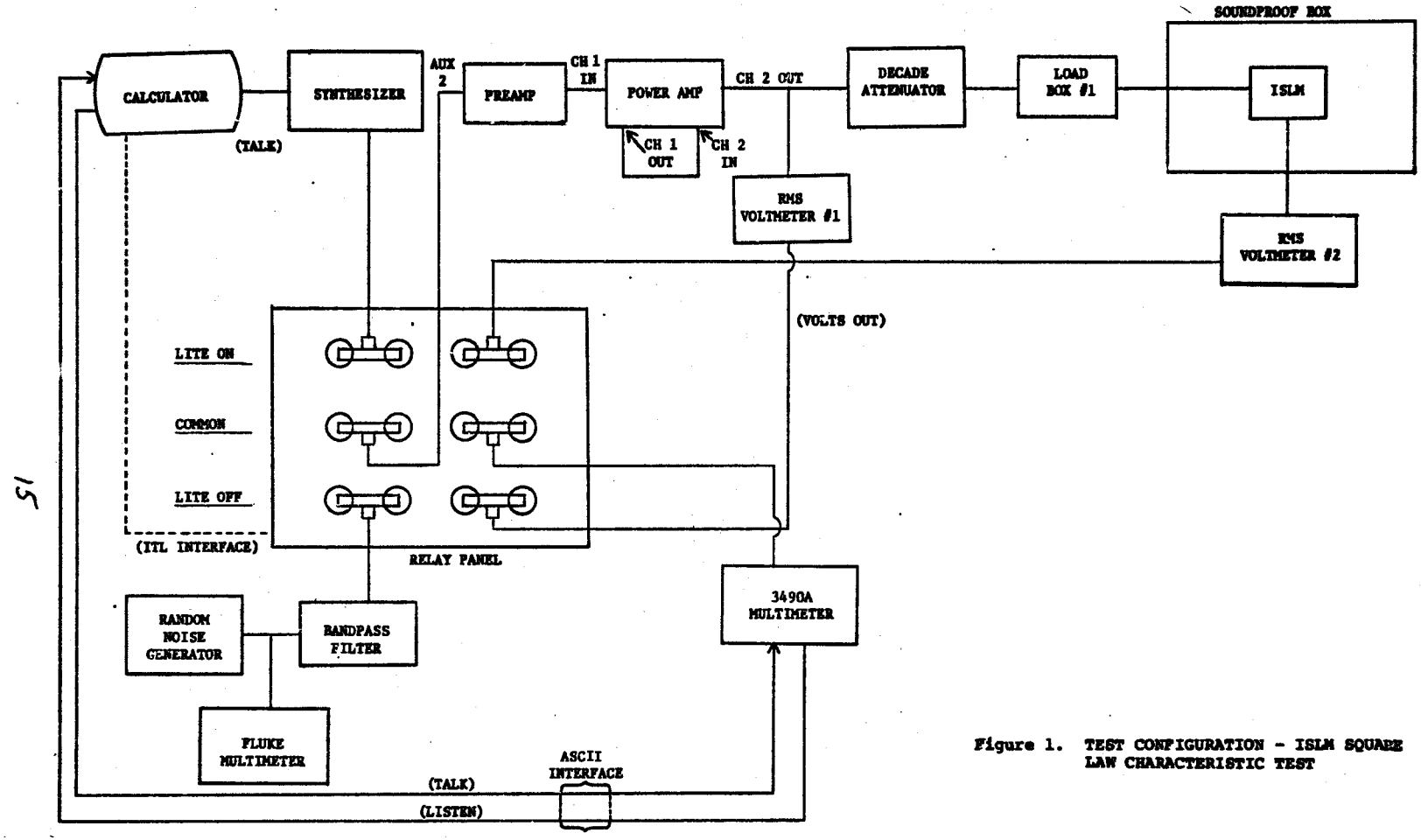
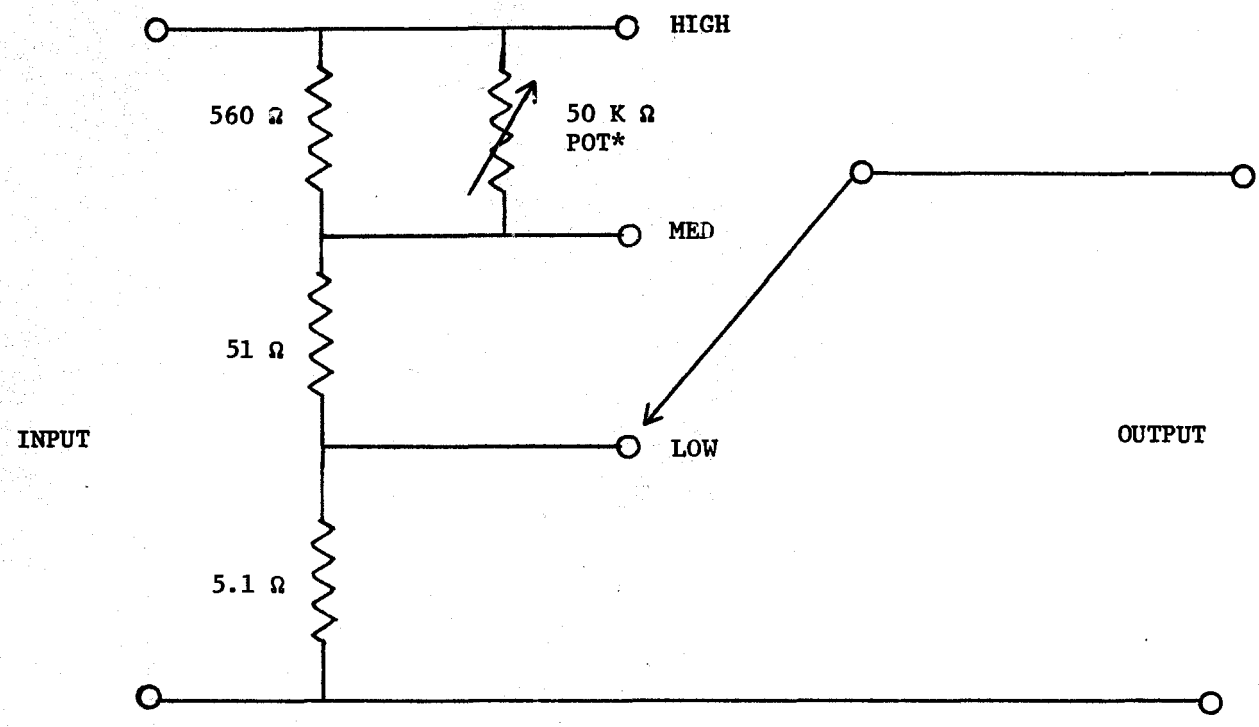


Figure 1. TEST CONFIGURATION - ISLM SQUARE LAW CHARACTERISTIC TEST



*ADJUST TO OBTAIN 600 Ω INPUT IMPEDANCE

Figure 2. SCHEMATIC OF LOAD BOX #1

IV. CALCULATIONS AND ANALYSIS

For inputs of pure tone and of 1/3 octave bands of noise, which have equal RMS values, the corresponding ISLM readings should be within 0.5 decibel of each other. From the data sheet, the column "ERROR BETWEEN TWO READINGS" should be within the values contained in the "TOLER" column. That is, the ISLM reading of 1/3 octave band "pink" noise should be within 0.5 decibels of the ISLM reading of a pure tone signal.

NOTE: The "TOLER" column contains the ±0.5 decibel error and also any testing and equipment error.

APPENDIX

DATA SHEET: SQUARE LAW CHARACTERISTIC

DATA SHEET: ISLM SQUARE LAW CHARACTERISTIC (EQUIPMENT SERIAL NUMBERS)

COMPUTER PROGRAMS (WRITTEN IN BASIC LANGUAGE)

CALCULATIONS OF ISLM READINGS

SOUNDPROOF ENCLOSURE

DATA SHEET
SQUARE LAW CHARACTERISTICS

MANUFACTURER:
ISLM MODEL NO.:
ISLM SER. NO.:
CALIBRATOR MODEL NO.:
CALIBRATOR SER. NO.:
DATE:

ISLM READING PURE TONE (DB)	FREQUENCY= 63 HZ ISLM READING 1/3 OCTAVE NOISE (DB)	ERROR BETWEEN TWO READINGS (DB)	TOLER. (DB)
9.00	8.76	-0.24	+- 0.63
0.00	-0.27	-0.27	+- 0.63

ISLM READING PURE TONE (DB)	FREQUENCY= 1000 HZ ISLM READING 1/3 OCTAVE NOISE (DB)	ERROR BETWEEN TWO READINGS (DB)	TOLER. (DB)
9.00	9.14	0.14	+- 0.63
0.00	0.14	0.14	+- 0.63

ISLM READING PURE TONE (DB)	FREQUENCY= 6300 HZ ISLM READING 1/3 OCTAVE NOISE (DB)	ERROR BETWEEN TWO READINGS (DB)	TOLER. (DB)
9.00	9.19	0.19	+- 0.63
0.00	0.15	0.15	+- 0.63

DATA SHEET

ISLM SQUARE LAW CHARACTERISTICS

EQUIPMENT SERIAL NUMBERS

1. Multimeter, HP 3490A_____
2. Random noise generator, GR 1382_____
3. Multimeter, Fluke 853A_____
4. Bandpass filter set, B&K 1615_____
5. Decade attenuator, GR 1450-TB_____
6. RMS voltmeter #1, HP 3403A or HP 3403C_____
7. RMS voltmeter #2, HP 3403A or HP 3403C_____
8. Load box #1_____
9. Frequency synthesizer, HP 3320B or HP 3330B_____
10. Programmable calculator, HP 9830A_____
11. Preamplifier, Crown IC150_____
12. Power amplifier, Crown DC 300A_____

COMPUTER PROGRAMS

(WRITTEN IN BASIC LANGUAGE)

MAIN PROGRAM

```
10 REM**SQUARE LAW CHARACTERISTIC**
20 LOAD  KEY #5,8
30 REWIND #5
40 DIM F$[3],A$[40],M$[100],N$[50],O$[40],P$[20],R$[40],S$[40],Z$[30]
50 DIM C$[40],D$[40],E$[40],F$[40],G$[40],H$[40],P$[200],T$[40]
60 DISP "MANUFACTURER IS";
70 INPUT N$
80 DISP "ISLM MODEL NO. IS";
90 INPUT T$
100 DISP "ISLM SER. NO. IS";
110 INPUT S$
120 DISP "CALIBRATOR MODEL NO. IS";
130 INPUT D$
140 DISP "CALIBRATOR SER. NO. IS";
150 INPUT F$
160 DISP "DATE IS";
170 INPUT H$
180 M$="MANUFACTURER:"
190 O$="ISLM MODEL NO.:"
200 R$="ISLM SER. NO.:"
210 C$="CALIBRATOR MODEL NO.:"
220 E$="CALIBRATOR SER. NO.:"
230 G$="DATE:"
240 M$[14]=N$
250 O$[16]=T$
260 R$[15]=S$
270 C$[22]=D$
280 E$[21]=F$
290 G$[6]=H$
300 DISP "WHICH SYNTHESIZER IS BEING USED";
310 INPUT Z$
320 DISP "WHICH PRINTER IS BEING USED";
330 INPUT P$
340 IF P$#"9871A" THEN 460
350 DISP "PUT IN 10.5 BY 8 DATA SHEET"
360 STOP
370 N=INT(10.5*96)
380 N1=INT((8-1)*120)
390 FORMAT 15B
400 WRITE (15,390)27,77;
410 WRITE (15,390)27,49;
420 WRITE (15,390)27,84;
430 WRITE (15,390)27,76,INT(N/64),N;
440 WRITE (15,390)27,70,INT(N/64),N;
450 WRITE (15,390)27,87,INT(N1/64),N1;
460 WRITE (15,*)"                                    DATA SHEET"
470 WRITE (15,*)"                        **SQUARE LAW CHARACTERISTIC**"
480 PRINT
490 WRITE (15,*)M$
500 WRITE (15,*)O$
510 WRITE (15,*)R$
520 WRITE (15,*)C$
530 WRITE (15,*)E$
540 WRITE (15,*)G$
550 PRINT
560 DISP "A=?,B=? FOR ISLM";
570 INPUT A,B
```

```
580 DISP "DC CALIBRATION CURVE ERROR IS";
590 INPUT Z1
600 DISP "MAX. ISLM SCALE READING IS";
610 INPUT K
620 DISP "PURE TONE USED FOR 63HZ NOISE";
630 INPUT F1
640 J=-10
650 FOR I=1 TO 3
660 READ F[I]
670 NEXT I
680 DATA 63,1000,6300
690 F[1]=F1
700 C=1
710 T=0.5
720 FORMAT B
730 WRITE (1,720)0;
740 WAIT 500
750 E=1
760 DISP "SET FILTER TO"INT(F[E])"HZ"
770 STOP
780 Q=FNF(F[E])
790 P2=FNL(J)
800 DISP "CONT AT STEP 20 OF PROCEDURE"
810 WAIT 5000
820 D1=FNO(C)
830 WAIT 200
840 D=FND(C)
850 IF D#1 THEN 880
860 J=-10
870 GOTO 780
880 D3=D-D1
890 IF D3>0.1 OR D3<-0.1 THEN 1090
900 WRITE (1,720)8;
910 WAIT 5000
920 X1=FNM(C)
930 GOTO C OF 940,990
940 WRITE (15,*)"                    FREQUENCY="INT(F[E])"HZ"
950 WRITE (15,*)"ISLM READING      ISLM READING      ERROR BETWEEN"
960 WRITE (15,*)" PURE TONE      1/3 OCTAVE NOISE    TWO READINGS      TOLER.
970 WRITE (15,*)"    (DB)             (DB)              (DB)           (DB)'
980 WRITE (15,*)"************    ***************    *************    *******
990 WRITE (15,1000)X3,X4,(X1-X),(T+T2)
1000 FORMAT 2X,F7.2,12X,F7.2,14X,F5.2,8X,"+","-",F5.2
1010 WAIT 5000
1020 GOTO C OF 1060,1030
1030 C=1
1040 PRINT
1050 GOTO 1340
1060 C=2
1070 J=-10
1080 GOTO 780
1090 WRITE (1,720)1;
1100 WAIT 500
1110 J=J+D3
1120 P=FNL(J)
1130 WAIT 200
1140 IF D3>0 THEN 1190
1150 BEEP
1160 DISP "DECREASE DECADE BY"D3;"DB"
```

```
1170 STOP
1180 GOTO 1220
1190 DISP "INCREASE DECADE BY"D3;"DB"
1200 BEEP
1210 STOP
1220 WAIT 5000
1230 DISP "CHECK ISLM READING"
1240 STOP
1250 S=FNA(C)
1260 IF S=2 THEN 900
1270 J=-10
1280 WRITE (1,720)0;
1290 WAIT 500
1300 BEEP
1310 DISP "RESET DECADE ATTENUATOR";
1320 STOP
1330 GOTO 780
1340 E=E+1
1350 IF E=4 THEN 1380
1360 J=-10
1370 GOTO 760
1380 DISP "THE TEST IS COMPLETE"
1390 END
```

SPECIAL FUNCTION KEYS

```
10 DEF FNO(C)
20 REM**SETS REFERENCE LEVEL**
30 WRITE (1,50)1;
40 WAIT 500
50 FORMAT B
60 GOTO C OF 70,110
70 K1=K-1
80 DISP "SET 1 DB DOWN USING CROWNS"
90 STOP
100 GOTO 140
110 K1=K-10
120 DISP "SET 10 DB DOWN USING CROWNS"
130 STOP
140 DISP "WHAT IS DC RANGE OF RMS#2";
150 INPUT A1
160 WAIT 2000
170 Y=FNV(10)
180 L=Y*A1
190 L1=((L*0.00004)+(1*0.00001))
200 L2=1/(L*B)
210 L3=L1*L2
220 X=10+((LOGL-LOGA)/B)
230 IF C=1 THEN 260
240 X3=0
250 GOTO 270
260 X3=9
270 WRITE (1,50)2;
280 WAIT 2000
290 Z=0
300 DISP "WHAT IS AC,DB RANGE OF RMS#1";
310 INPUT A0
320 FOR I=1 TO 10
330 DISP "READING SYNTHESIZER,I="I
340 WAIT 5000
350 D2=FNV(10)
360 D6=D2*A0
370 D4=D6^2
380 Z=Z+D4
390 NEXT I
400 W=SQR(Z/10)
410 D1=20*LGT(W)
420 DISP "RECORD AC,DB LEVEL ON RMS#1";
430 STOP
440 RETURN D1
450 END
```

```
10 DEF FND(C)
20 REM**WORKS WITH RANDOM NOISE**
30 V=0
40 WRITE (1,60)10;
50 WAIT 500
60 FORMAT B
70 DISP "ADJUST RANDOM NOISE GENER. TO"
80 WAIT 5000
90 DISP "SET RMS#1 TO AC,DB OF STEP 24";
100 STOP
110 DISP "HAS THE DEC. ATTEN. CHANGED?";
120 INPUT A$
130 IF A$="NO" THEN 160
140 D=1
150 GOTO 270
160 Q9=100
170 FOR I=1 TO Q9
180 DISP "READING NOISE GENERATOR,I="I
190 WAIT 5000
200 V2=FNV(10)
210 V6=V2*A0
220 V4=V6^2
230 V=V+V4
240 NEXT I
250 W1=SQR(V/Q9)
260 D=20*LGT(W1)
270 RETURN D
280 END
```

```
10 DEF FNM(C)
20 REM**READS ISLM WITH 1/3 OCTAVE BAND NOISE**
30 P8=X8=M8=0
40 P=0
50 M2=0
60 IF INT(F[E])#63 THEN 90
70 Z9=200
80 GOTO 100
90 Z9=100
100 FOR I=1 TO Z9
110 DISP "READING ISLM WITH NOISE,I="I
120 WAIT 2000
130 M0=FNV(10)
140 M1=M0*A1
150 P1=10+((LOG(M1)-LOGA)/B)
160 P=P+P1
170 M5=((M1*0.00004)+(1*0.00001))
180 M6=1/(M1*B)
190 M7=M5*M6
200 M2=M2+M7
210 NEXT I
220 X1=P/Z9
230 M4=M2/Z9
240 X4=(X1-X)+X3
250 T2=SQR((L3^2)+(M4^2)+(0.1^2)+(Z1^2)+(Z1^2)+(0.04^2)+(0.04^2))
260 RETURN X1
270 END
```

```
10 DEF FNF(F9)
20 FORMAT F2.0,F4.0,2F2.0
30 IF Z$="3330B" THEN 60
40 CMD "?U3","K,"
50 GOTO 70
60 CMD "?U$"
70 IF F9>10 AND F9<100000 THEN 100
80 PRINT "FREQ OUT OF AUDIO RANGE"
90 RETURN F9
100 IF Z$="3330B" THEN 150
110 F7=2+(F9 >= 999.95)+(F9 >= 9999.5)
120 F8=F9/10^(F7-3)+0.5
130 OUTPUT (13,20)"R"F7,",",F"INT(F8/10),",",V"INT(F8)-10*INT(F8/10),",";
140 RETURN INT(F8)*10^(F7-3)
150 F8=F9
160 FORMAT "L",F1000.1,"="
170 OUTPUT (13,160)F8
180 RETURN F9
190 END


10 DEF FNL(L9)
20 IF Z$="3330B" THEN 60
30 CMD "?U3","D3,"
40 GOTO 70
50 REM.....^^...USE D4 FOR NO LEVELING, D3 FOR SLOW LEVELING..
60 CMD "?U$"
70 L8=INT(L9*100+0.5)
80 IF L8<2700 AND L8>-7301 THEN 110
90 PRINT "LEVEL OUT OF RANGE"
100 RETURN L9
110 IF Z$="3330B" THEN 150
120 OUTPUT (13,130)"A"L8,",";
130 FORMAT 2F5.0
140 RETURN L8/100
150 L8=L9
160 IF L8<0 THEN 200
170 FORMAT "N",F1000.2,";"
180 OUTPUT (13,170)L8
190 GOTO 220
200 FORMAT "N",F1000.2,"<"
210 OUTPUT (13,200)L8
220 RETURN L8
230 END
```

```
1000 DEF FNV(V9)
1020 IF V9#1234 THEN 1060
1030 CMD "?U6","M1E","?5V"
1040 V6=V9
1050 GOTO 1360
1060 V6=7
1070 IF INT(10*V9)=0 THEN 1130
1080 V6=LGT(INT(10*V9))
1090 IF INT(V6)=V6 THEN 1120
1100 DISP "ILLEGAL FNV INPUT"
1110 STOP
1120 V6=6-V6
1130 V7=INT(100*V9)-10*INT(10*V9)
1140 V7=V7*0.1+2*(V7>1)-(V7=4)
1150 IF V7>3 THEN 1100
1160 V8=INT(1000*V9)-10*(INT(100*V9))
1170 IF V8>2 THEN 1100
1180 CMD "?U6","M2T3"
1190 OUTPUT (13,1200)"R",V6,"F",INT(V7),"S3M3T3E";
1200 FORMAT 3F2.0
1210 IF V8=2 THEN 1250
1220 CMD "?U6"
1230 OUTPUT (13,1240)"S",3*(V7=0.1),"T",V8+1,"E";
1240 FORMAT F2.0
1250 CMD "?5V"
1260 IF RBYTE13=79 THEN 1350
1270 ENTER (13,1280)V6
1280 FORMAT 3X,F10.0
1290 IF V8#2 THEN 1320
1300 CMD "?U6","M2T3"
1310 OUTPUT (13,1200)"S",3*(V7=0.1),"T2E";
1320 IF V7#2.3 THEN 1340
1330 V6=20*LGT(V6)
1340 GOTO 1360
1350 V6=9999
1360 RETURN V6
1370 END
```

```
10 DEF FNA(C)
20 REM**RECHECKS ISLM READING**
30 WRITE (1,40)1;
40 FORMAT B
50 WAIT 5000
60 Y=FNV(10)
70 L=Y*A1
80 L1=((L*0.00004)+(1*0.00001))
90 L2=1/(L*B)
100 L3=L1*L2
110 X2=10+((LOGL-LOGA)/B)
120 IF X2<(X+0.04) AND X2>(X-0.04) THEN 150
130 S=1
140 GOTO 160
150 S=2
160 RETURN S
170 END
```

CALCULATIONS OF ISLM READINGS

In order to determine the response of an ISLM without reading its indicating meter (and involve any scale inaccuracy), we make a connection to monitor the DC voltage which goes to the indicating meter of the ISLM. However, if the ISLM already has a DC output jack, we do not have to make a meter connection.

After making the connection, we apply an acoustical signal to the ISLM to obtain a full scale reading. Then we record the corresponding DC meter output voltage. Then we reduce the signal in 1 dB steps as indicated by the response of a reference microphone. After each 1 dB decrease, we record the corresponding DC meter output voltage. After obtaining all the DC meter output voltages, we plot these voltages vs. the number of dB steps below ISLM full scale. We then do a least squares fit analysis to the data. The equation we obtain may be one of the following types:

(1) $Y = Ae^{Bx}$ (for logarithmic ISLM scales)

(2) $Y = A + BX$ (for linear ISLM scales)

A, B are constants for each equation

Y = DC meter output voltage

X = dB below ISLM full scale

This procedure would be the same if the ISLM already had a DC output jack.

Equation (1) or (2) would then be used to calculate the ISLM reading corresponding to the observed DC voltage from the ISLM. Associated with each curve is a DC calibration error which represents the error involved in calculating ISLM readings from this curve.

1. CALCULATED ISLM READINGS USING DC METER OUTPUT VOLTAGES

Equation (1):
To calculate the ISLM reading, use the following equation:

$$X = 10 \text{ dB} + [(\ln Y - \ln A)/B] = \text{ISLM reading in dB}$$

where, Y = DC meter output voltage

Equation (2):
To calculate the ISLM reading, use the following equation:

$$X = 10 \text{ dB} + \frac{Y - A_0}{A_1}$$

where, Y = DC meter output voltage

2. CALCULATED ISLM READINGS USING DC OUTPUT VOLTAGES

The calculations are the same as in 1. The values for Y are read from the ISLM DC output jack.

SOUNDPROOF ENCLOSURE

The main purpose of this enclosure is to provide acoustic isolation when a signal is being inserted in series with the microphone of the ISLM. The enclosure has a large mass to prevent low frequency noise from disturbing the meter. The interior is lined with acoustic tile to absorb any noises which may reach the interior of the enclosure. A small window is provided for viewing the ISLM scale. With this type of enclosure, the ambient noise can be reduced to approximately 35 dBA.