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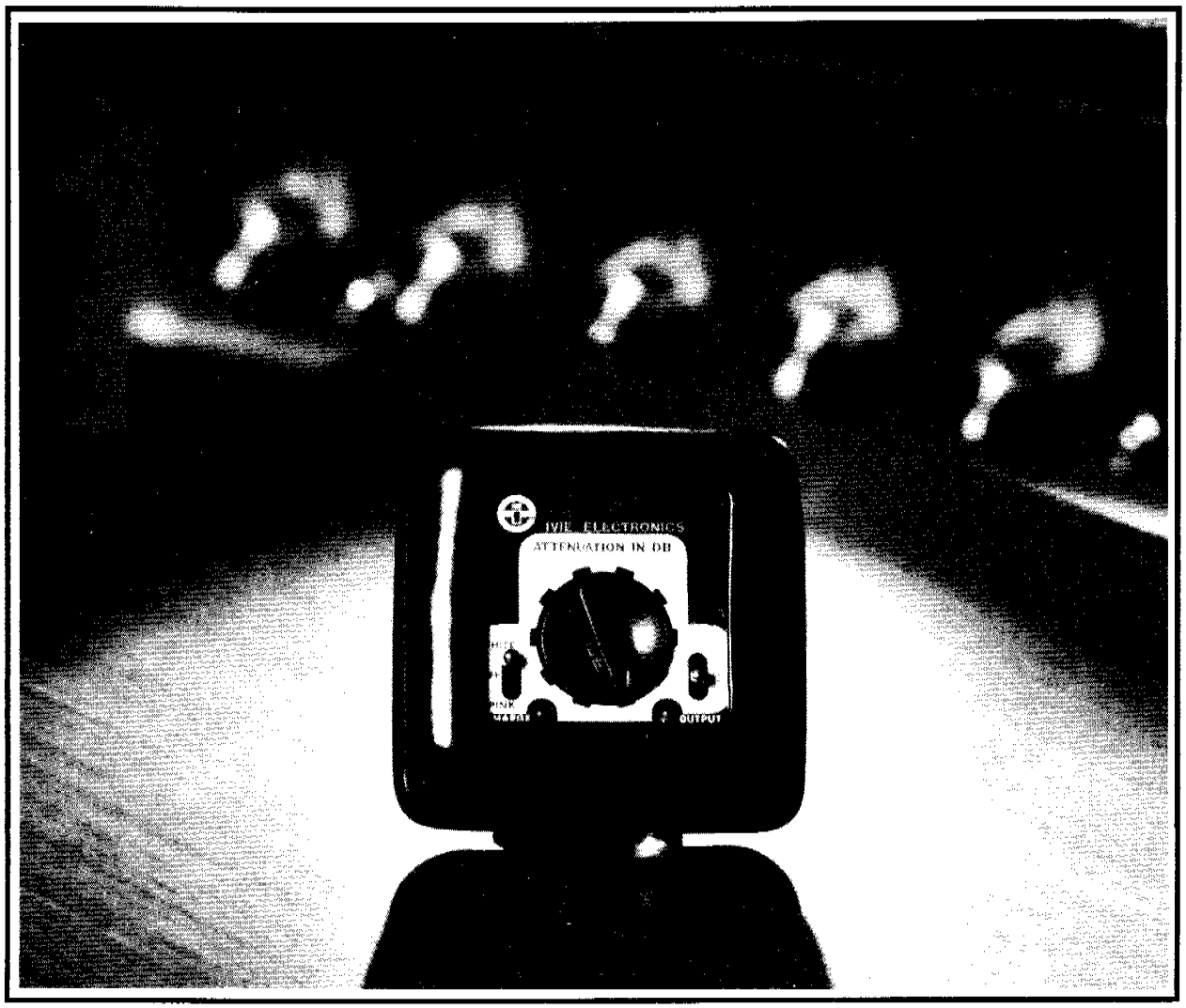
IE-20B MANUAL



Operation and Owners Manual for the
IE-20B Pink & White Noise Generator

Printed in U.S.A.

IE-20B WARRANTY

The IE-20B is warranted against defects in materials and workmanship for one (1) year from the date of purchase. During the warranty period, Ivie Technologies will repair, or at its option, replace components which prove to be defective, provided the generator is returned, shipping prepaid, to an authorized Ivie Technologies service facility. Defects caused by modifications, misuse or accidents are not covered by this warranty. No other warranties are expressed or implied. Ivie Technologies is not liable for consequential damages. All requests for repair and information should include the instrument serial number to assure rapid service.

CONTENTS

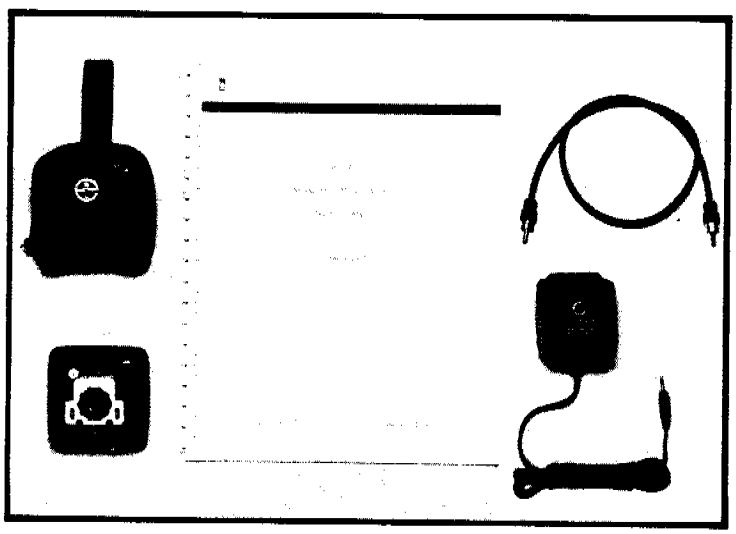
ILLUSTRATIONS

INTRODUCTION

It is the intention of Ivie Electronics to provide high quality equipment of innovative design to help satisfy the ever increasing technical needs of the audio industry. We are always ready to lend engineering support and assistance when the need occurs. When questions arise, please contact us. We are interested in your applications.

We believe in rugged quality — that an instrument should be able to withstand constant and demanding usage. Your new IE-20B Noise Generator is such an instrument, and properly cared for, it will give you long and reliable service.

With your IE-20B you should have received the following items pictured below:



IE-20B Noise Generator

"Fast Charge" nickel cadmium batteries mounted inside the IE-20B.

AC adaptor/charger that provides continuous line operation.

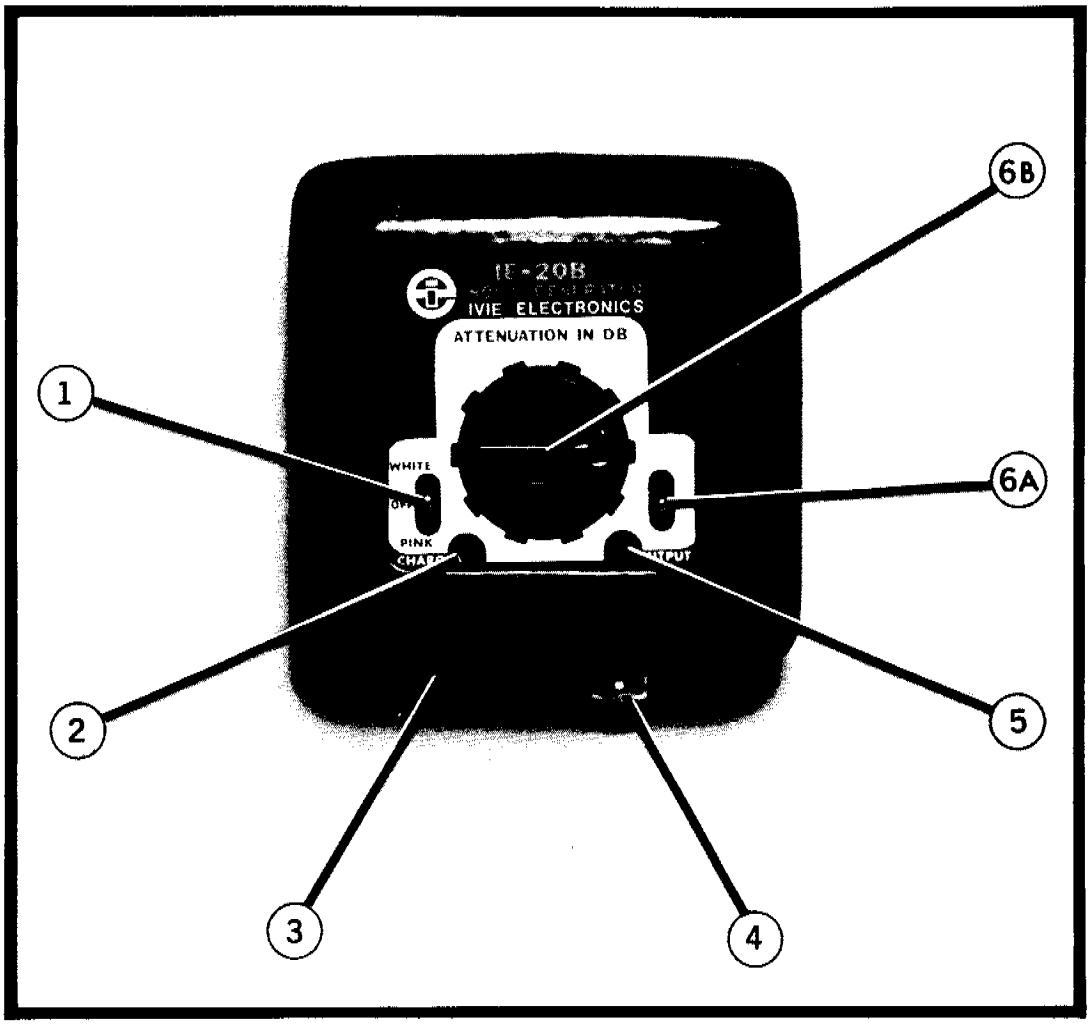
Vinyl carrying case with belt loop.

Standard phono plug patch cord.

Operator's Manual with illustrations and examples.

It is recommended that your IE-20B be charged for three hours after it is unpackaged. This will assure a full ten hours of operating time before recharging is again necessary.

Make sure the voltage selection switch on the IE-165A Adaptor/Charger is in the correct position for the line voltage being used (either 115v. or 230v. AC at 50-60 Hz).



IE-20B Front Panel Controls
Figure 1

IE-20B OPERATION

FRONT PANEL DESCRIPTION

The IE-20B has been designed for ease of operation. Referring to Figure 1, the controls are as follows.

(1.) Power Switch. Selects pink noise output, white noise output, or power off.

(2.) "Charge" indicator. This LED indicator has two important functions. It lights when the IE-20B is being charged, thus providing indication of a properly working battery charger. Its second function is providing indication of battery level. It illuminates when the NI-Cad batteries are low and require charging.

(3.) Input jack for the battery charger.

(4.) Noise Output jack.

(5.) Noise Output indicator.

(6.) Precision attenuator. The attenuator is comprised of two controls, the "Range" toggle (6A) and the Dial (6B) . Total output attenuation is determined by adding the Dial setting to the Range setting.

BATTERY AND LINE OPERATION

An IE-165A Adaptor/Charger has been supplied with your IE-20B Noise Generator that will recharge the batteries in about 3 hours. The IE-20B will operate approximately 10 hours between charges.

When the "CHARGE" LED lights indicating low batteries, recharging is immediately necessary. The noise output ceases to be accurate shortly after the LED illuminates.

> CAUTION: Use of an adaptor/charger other than the IE-165A may cause damage to your IE-20B.

The IE-165A Adaptor/Charger is selectable for voltages of 115v. or 230v. AC at 50 to 60 Hz. Make sure the voltage switch on the IE-165A is in the correct position for the AC power line being used. Using the IE-165A with AC power other than 115v. or 230v. at 50-60 Hz may cause damage to your IE-20B.

The IE-20B may also be operated directly from the AC power line using the IE-165A as an adaptor. The Ni-Cad batteries will continue to charge when the noise generator is being operated in this manner.

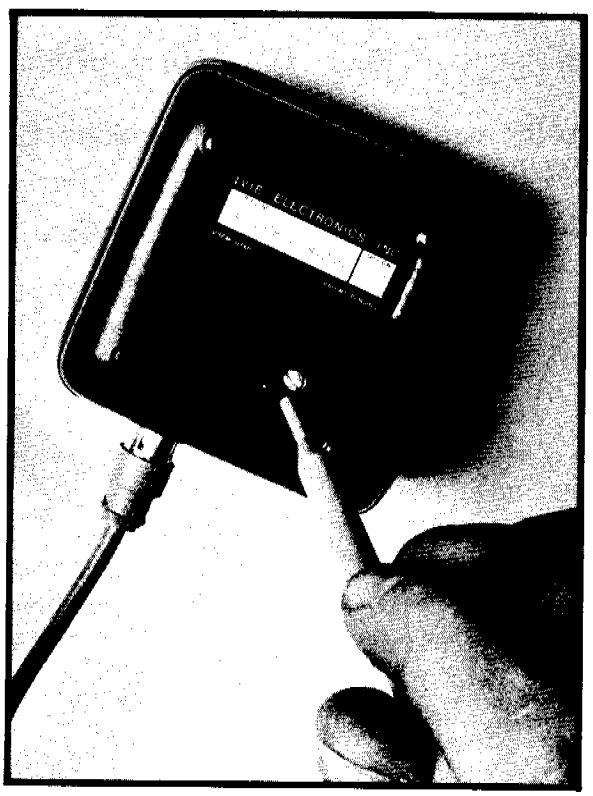
The Ni-Cad batteries in the IE-20B are of the highest quality and are capable of withstanding extended overcharging. It is recommended that they be completely discharged (until the "Charge" LED on the IE-20B illuminates) from time to time to minimize the possibility of "memory effect" on the batteries. Ni-Cad batteries can loose their ability to give up 100% of their charge if they are only partially discharged on a frequent basis.

If permanent power line operation of the IE-20B is desired, it is recommended that the Ni-Cad batteries be removed and that a line operated DC power supply of 6V. and 50ma be provided in their place. The external power supply can be conveniently provided to the IE-20B through the charge jack (3 Figure 1) (center pin is positive).

CHANGING THE REFERENCE LEVEL

The REFERENCE level on the IE-20B is defined as the rms output voltage level when the attenuator is set to 0dB. At the factory the reference is set to .940v RMS (pink noise output) because this output level corresponds to calibrations on the IE-10A Audio Spectrum Analyzer.

For many applications it may be desireable to change the reference output level on the IE-20B. The reference level is adjustable between 0 V rms and 1.0 V rms using the potentiometer which is accessed through the back of the noise generator as demonstrated in Figure 2. Rotating the shaft clockwise increases the reference output level and counter-clockwise motion reduces the reference level.



Changing the Reference Level
Figure 2

It should be noted that changing the reference level does not change the accuracy of the attenuator. The attenuator will provide 0-58dB of signal reduction (in 2dB steps), regardless of the reference level setting.

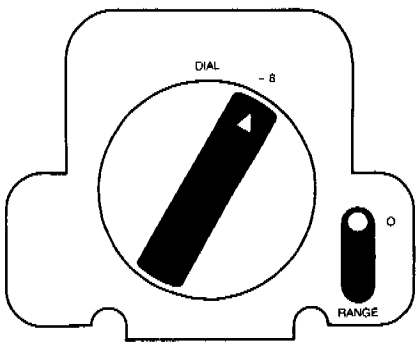
USING THE ATTENUATOR

One of the unique features of the IE-20B Noise Generator is its calibrated output. For loads greater than 600 ohms, the step attenuator on the front panel allows up to 58dB of attenuation from the reference output level, selectable in 2dB increments.

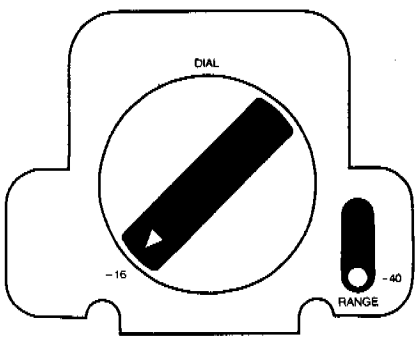
The step attenuator is comprised of the "dial" and the "range" toggle switch. (See figure 1, 6A & 6B, page 4). To determine total attenuation in dB, add the dial and the toggle values together. The two illustrations below provide simple examples. The total attenuation in figure 3 is -8dB. In figure 4, the attenuation selected is -56 dB.

Figure 3: Dial = - 8, Range = 0; (-8) + 0 = -8dB.
Figure 4: Dial = -16, Range = -40; (-16) + (-40) = -56dB.

The 2dB increments of the step attenuator are very precise. Cumulative error is not more than ± .5dB over the entire 58dB range.



Attenuator set to −8dB
Figure 3



Attenuator set to −56dB
Figure 4

TABLE OF ATTENUATION VERSUS OUTPUT VOLTAGE

Frequently, it is desirable to select a specific rms output voltage from the IE-20B for a particular application. The following table was constructed to allow a convenient means of selecting a particular voltage output level for a given IE-20B attenuator setting. The voltage levels in the table below are for an IE-20B that has been calibrated for use with an IE-10A. A conversion table is not required when using the IE-20B with an IE-30A, because the IE-30A is capable of measuring the true rms output voltage of a noise generator directly in dBμV.

IE-20B ATTENUATOR SETTING	PINK NOISE OUTPUT LEVEL MILLIVOLTS RMS	WHITE NOISE OUTPUT LEVEL MILLIVOLTS RMS
— 0 dB	940.0 mv	620.0 mv
— 2 dB	747.0 mv	492.0 mv
— 4 dB	593.0 mv	391.0 mv
— 6 dB	471.0 mv	311.0 mv
— 8 dB	374.0 mv	247.0 mv
—10 dB	297.0 mv	196.0 mv
—12 dB	236.0 mv	156.0 mv
—14 dB	188.0 mv	124.0 mv
—16 dB	149.0 mv	98.0 mv
—18 dB	118.0 mv	78.0 mv
—20 dB	94.0 mv	62.0 mv
—22 dB	75.0 mv	49.0 mv
—24 dB	59.0 mv	39.0 mv
—26 dB	47.0 mv	31.0 mv
—28 dB	37.0 mv	25.0 mv
—30 dB	30.0 mv	20.0 mv
—32 dB	24.0 mv	16.0 mv
—34 dB	19.0 mv	12.0 mv
—36 dB	15.0 mv	10.0 mv
—38 dB	12.0 mv	8.0 mv
—40 dB	9.4 mv	6.2 mv
—42 dB	7.5 mv	4.9 mv
—44 dB	5.9 mv	3.9 mv
—46 dB	4.7 mv	3.1 mv
—48 dB	3.7 mv	2.5 mv
—50 dB	3.0 mv	2.0 mv
—52 dB	2.4 mv	1.6 mv
—54 dB	1.9 mv	1.2 mv
—56 dB	1.5 mv	1.0 mv
—58 dB	1.2 mv	0.8 mv

USES OF THE IE-20B NOISE GENERATOR

The IE-20B has been designed to meet a wide range of applications. Its attenuatable output level allows it to directly drive a broad spectrum of equipment from ultra sensitive preamps to high power amplifiers.

A noise generator can be used alone for some applications such as noise masking and acoustical shielding, but its full potential as a test instrument is realized when it is used in conjunction with a good real time analyzer such as the IE-10A, or the IE-30A Audio Spectrum Analyzer.

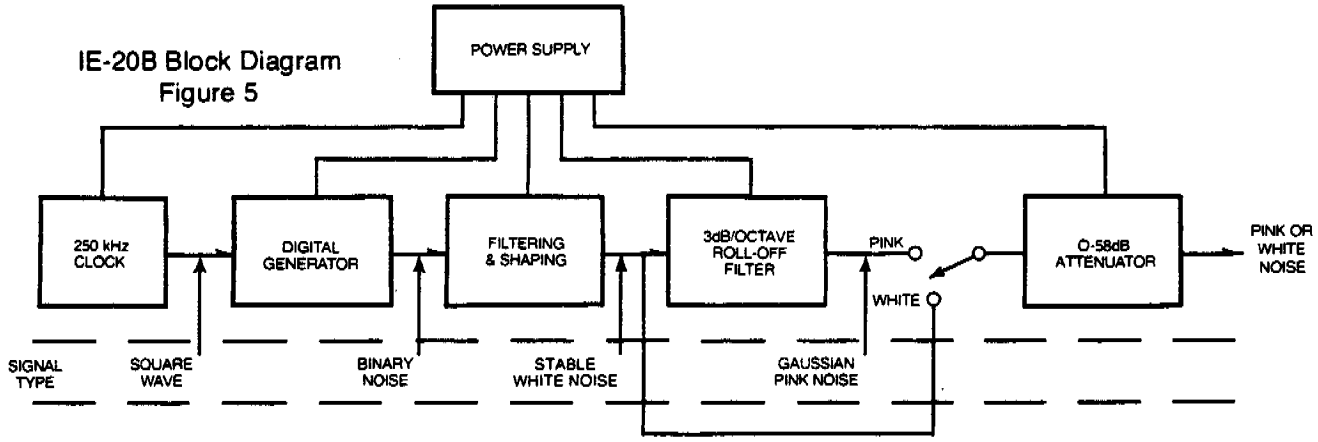
Together, the noise generator and audio spectrum analyzer can be used for a wide variety of audio applications such as:

* Equalizing audio components and systems
* Checking flatness and gain on microphones, preamps, amplifiers and mixers
* Measuring transducer dispersion angles at all octaves
* Measuring speaker response
* Trouble shooting and tracing audio circuits
* Evaluating filter response
* Analyzing audio transmission systems
* Noise masking
* Tape recorder equalization
* Tape recorder azimuth alignment
* Hearing aid testing

Of all the tools in the audio field, a noise generator and a real time analyzer are two of the most versatile and useful. The sound reinforcement and hifi professional, the musician, technician and serious audiophile alike, will find the combination invaluable.

CIRCUIT DESCRIPTION AND THEORY

IE-20B Block Diagram
Figure 5



The IE-20B is a state-of-the-art noise generator, designed to handle the most exacting laboratory requirements. Unlike gas-discharge tube and noise-diode methods, the digital techniques used in the IE-20B generate noise signals that are statistically well-defined and very stable, even at low frequencies.

The IE-20B (See Figure 5, Block Diagram) employs a digital process with special filtering and shaping to produce a very flat pink, or white noise output over a wide range of frequencies.

A linear feedback shift register is used to produce very flat binary (two-level) noise having a digital word length of more than two billion bits. Using a clock frequency of 250KHz allows the noise signal to be random over a 2.4 hour period of time before the digital word sequence begins to repeat.

Random binary noise is not considered to be a good audio test signal because it's output amplitude is confined to two levels only. Signals with multilevel amplitudes, like random Gaussian noise, more closely correlate with audio program material.

Binary noise can be converted to high-quality white noise (a multilevel waveform having a stable distribution) through use of additional filtering as shown in Figure 5.

For audio work, pink noise (constant energy per octave) is generally preferred over white noise (constant energy per hertz) because white noise delivers greater energy at upper frequencies which could damage drivers. Pink noise, by contrast, delivers equal energy at the higher octaves.

Real time audio analyzers are designed with octave, or fractional octave, bandwidth filters and are intended to be used with pink noise generators. A pink noise input signal will produce a flat response on such an analyzer.

Converting white noise to an accurate pink noise signal requires a precision 3dB per octave rolloff filter as shown in the block diagram of the IE-20B.

To enable the user to make accurate audio substitution measurements when using the IE-20B in conjunction with an audio analyzer, a precision attenuator has been designed into the output stage of the noise generator.

WHEN IS NOISE FLAT?

Never! That's right, noise isn't flat! The question . . . how flat is your noise generator? . . . can be very misleading. The reader should be aware that the output voltage levels of any "noise generator" are random in nature. This means that if we try to measure the output voltage level of a noise generator with an ordinary voltmeter, we will obtain numerous readings at different voltage levels.

We can obtain an accurate, stable voltage reading from a noise generator only when we time-average its output signal over a sufficiently long time interval, using a true rms voltmeter.

The longer we sample the voltage levels of random noise, the more stable it appears. In essence, noise is never flat; it can only be made to appear flat if we allow sufficient sample time. Noise is a statistical phenomenon. A more reasonable question should be . . . how flat are the filters in your noise generator? If the filters in a noise generator are very flat, then the **time averaged** output will appear very flat.

Pink noise appears to be reasonably stable and flat when fed into a real-time spectrum analyzer like the IE-10A, or the IE-30A, because the analyzer detectors were designed to time-average the random noise. You will notice the very random amplitude characteristic of noise if the selected detector response in the spectrum analyzer is "too fast" causing narrow, low frequency filters to flutter over a several dB range. Making pink noise appear flat is as much a function of a good spectrum analyzer, as it is a function of a high quality noise generator, like the IE-20B.

If sufficient averaging time is allowed, a spectrum analyzer can display ultra flat noise. The analyzer would however, require an excessive amount of time between readings, and could hardly be referred to as a "real-time" analyzer. Obviously, a tradeoff must be made between a reasonable level of noise flatness, and the time required between measurements. Ivie real-time spectrum analyzers are designed to allow a noise amplitude flutter of about 1.0 dB plus or minus.

IE-20B SPECIFICATIONS

FREQUENCY RANGE

* 10Hz to 40 KHz 3dB bandwidth
* 20Hz to 20 KHz ± 0.5 dB.

NOISE GENERATION

* Digitally generated by CMOS circuitry.
* Word length greater than 2 billion bits.
* Clock rate: 250 KHz
* Word repetition time: 2.4 hours.
* Noise distribution approximates Gaussian.

OUTPUT

* Pink: Output level variable from 0.0 — 1.0v RMS
* White: Output level variable from 0.0 — 0.65v. RMS
* Crest factor: 3.75
* Output attenuation selectable in 2 dB increments from 0 dB to −58 dB. Cumulative error not more than ± 0.5 dB for loads ≥ 600 ohms.
* Output short circuit protected.
* Output connector: standard phono jack.

POWER

* BATTERY OPERATION: rechargeable nickel cadmium.
* Operating time approximately 10 hours continuous at 25° C.
* Fast charge cycle of 3 hours.
* Low battery indicator light.
* AC LINE OPERATION from AC Adaptor/Charger.
* 115/230 VAC 50/60 Hz.
* Charge indicator light.

ENVIRONMENTAL

* All circuits temperature compensated.
* Operating Temp. −10°C to +50°C.
* Nonoperating Temp. −30°C. to +65°C.
* Operating Humidity 0 to 90%.

MECHANICAL

* Aluminum case fusion bonded with nylon.
* Dimensions (w x h x d) 69 x 69 x 44 mm. (Approx. 2¾ x 2¾ x 1⅝ in.)
* Weight: Net 200 gm (approx. 7 oz.)
  Shipping 680 gm (approx. 1½ lbs.)

ARCHITECT'S AND ENGINEER'S SPECIFICATIONS

The pink noise generator shall be battery operated using fast charge nickel cadmium batteries. The generator shall operate not less than 10 hours between charges, and shall have a low battery and charge indicator. The generator shall be capable of direct operation from line voltages of 115v. and 230v. AC at 50-60Hz. The dimensions of the generator shall be approximately 69 X 69 X 39mm and it shall weigh approximately 200 grams.

The noise generator chassis shall be aluminum, coated with black, baked enamel.

The generator shall produce pink and white noise, digitally, utilizing CMOS circuitry. The clock rate shall be 250kHz. Output shall be calibrated providing up to 58dB of attenuation in precise 2dB increments. Cumulative attenuator error shall not be greater than ± 0.5db. Output voltage levels shall be variable between 0.0v. and 1.0v. RMS for pink noise, and 0.0v. and 0.65 v. RMS for white noise.

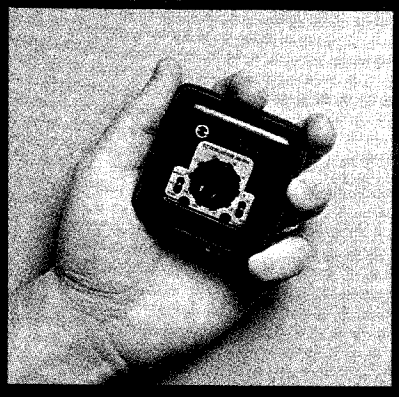
The noise generator shall be the IE-20B manufactured by Ivie Technologies Incorporated.

SERVICE

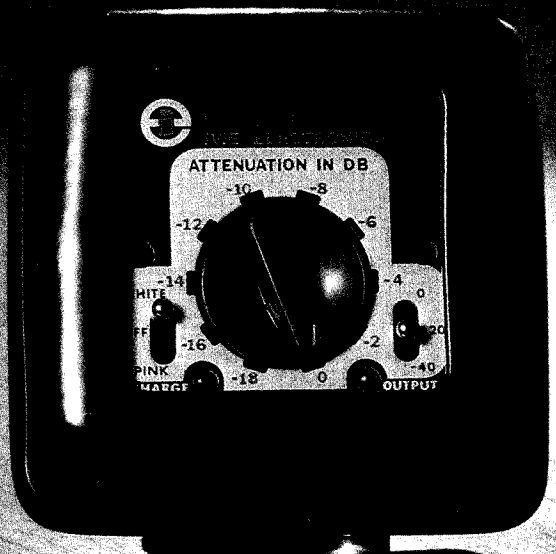
It is the intention of Ivie Technologies to provide quality service for the IE-20B whether in or out of the warranty period. If the IE-20B should require service, please return it, shipping prepaid, to an Ivie Technologies service facility. Shipping the instrument in its original packaging is recommended. Repair will be made and the unit will be returned prepaid as soon as possible.

Due to the subminiaturized packaging techniques used, Ivie Technologies cannot assume responsibility for repairs made at other than an authorized service center.

IE-20B
Pink and White Noise Generator

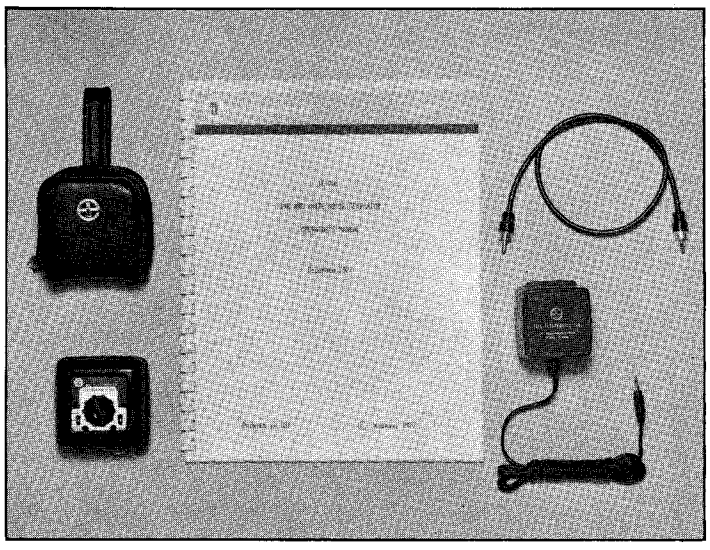


Small enough to fit on your belt . . .
powerful enough to handle your
toughest audio applications.



A pocket-sized noise generator from Ivie Electronics.

IE-20B
Pink and White Noise Generator



The IE-20B comes with . . .

- **IE-20B Noise Generator.**
- **"Fast Charge" nickel cadmium batteries.**
- **AC adaptor/charger that provides continuous line operation.**
- **Vinyl carrying case with belt loop.**
- **Standard phono plug patch cord.**
- **Operator's Manual with illustrations and examples.**

Portability, Economy and High Performance.

The IE-20B is a truly portable, state-of-the-art noise generator, designed to handle the most exacting laboratory requirements. Unlike gas-discharge tube and noise diode methods, the digital techniques used in the IE-20B allow the generation of noise signals that are statistically well-defined and very stable.

The IE-20B Noise Generator makes audio analysis fast and convenient. It operates for more than 10 hours without a battery charge and a low battery indicator warns the operator when recharging is necessary.

For most applications the need to use long cables is eliminated because the IE-20B is a self contained noise generator that can be placed right at the point of signal input. It is so small and inexpensive that it could be built into an existing audio system for use as a permanent test signal.

The IE-20B has a calibratable output, and a built-in precision attenuator that provides up to 58 dB of attenuation in 2 dB steps. From the measurement of amplifiers, limiters, compressors and expanders to the equalization and alignment of tape recorders, the IE-20B will drive a wide spectrum of audio equipment.

Typical of uncompromising quality, the IE-20B's circuitry and nylon bonded aluminum case are designed for a lifetime of service. It's small enough to be with you when you need it, yet rugged enough for day-in, day-out use.

IE-20B Specifications

FREQUENCY RANGE

- 10 Hz to 40 KHz 3dB bandwidth.
- 20 Hz to 20 KHz ± 0.5 dB.

OUTPUT

- Variable Output reference levels:
  Pink noise 0 — 1.0Vrms
  White noise 0 — 0.65Vrms
- Crest factor 3.75.
- Output attenuation selectable in 2 dB increments from 0 dB to 58 dB. Cumulative error not more than ± 0.5 dB for loads ≥ 600 ohms.
- Short circuit protected.
- Output connector: standard phono jack.

NOISE GENERATION

- Digitally generated by CMOS circuitry.
- Word length greater than 2 billion bits.
- Clock rate: 250 KHz.
- Word repetition time: 2.4 hours.
- 6-pole filter insures superior flatness.

POWER

- BATTERY OPERATION: rechargeable nickel cadmium.
- Operating time approximately 10 hours continuous @ 25° C.
- Fast charge cycle of 3 hours.
- Low battery indicator light.
- AC LINE OPERATION from adaptor/charger.
- 115/230 VAC 50/60 Hz.
- Charge indicator light.

ENVIRONMENTAL

- All circuits temperature compensated.
- Operating Temp. −10° C. to +50° C.
- Nonoperating Temp. −30° C. to +65° C.
- Operating Humidity 0 to 90%.

MECHANICAL

Aluminum case fusion bonded with nylon.
Dimensions (w x h x d) 69•69•39 mm.
(Approx. 2¾ x 2¾ x 1⅝ in.)
Weight net 200 gms (approx. 7 oz.)
shipping 680 gms (approx. 1½ lbs.)

Warranty

The IE-20B is warranted against defects in materials and workmanship for one (1) year from the date of purchase. During the warranty period, Ivie Electronics will repair or, at its option replace, components which prove to be defective provided the unit is returned, shipping prepaid, to an authorized Ivie Electronics service facility. Defects caused by modifications, misuse or accidents are not covered by this warranty. No other warranties are expressed or implied. Ivie Electronics is not liable for consequential damages. All requests for repairs and information should include the instrument serial number to assure rapid service.

IVIE ELECTRONICS INCORPORATED
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Orem, Utah 84057
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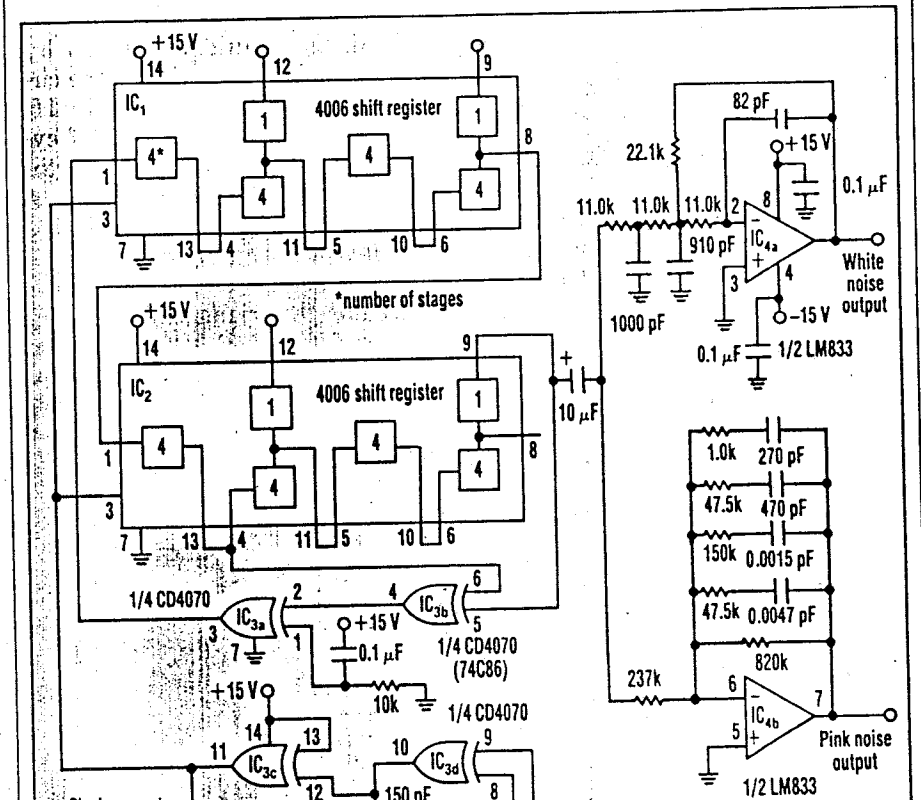
CIRCLE 522 CREATE AN ACCURATE NOISE GENERATOR

KERRY LACANETTE
National Semiconductor, 2900 Semiconductor Dr., P.O. Box 58090, Santa Clara, CA 95052; (408) 721-5000.



THIS WHITE and pink noise-generation circuit is based on a pseudorandom noise source consisting of two 4006 shift registers, NOR gates, a clock, and two active filters.

Make an accurate noise-generator circuit that produces white and pink noise from a digital pseudorandom noise source consisting of a pair of 4006 shift registers (IC_1 and IC_2) and four exclusive NOR gates (IC_3) *(see the figure)*. White noise is characterized by constant spectral density per unit bandwidth, while pink noise has constant power in each octave or decade of frequency. Noise generators that yield such noise are useful in many applications. These include audio, acoustical, and audiological testing, loudspeaker burn-in, sound-effects generation, and dither for analog-to-digital converters.

There are 36 shift-register stages available in the two shift registers. Using 33 stages generates the longest possible pseudorandom sequence from the two shift registers. The 0.1-μF capacitor and the 10-kΩ resistor ensure that the circuit will always start with a few "1s" loaded into the register. If the circuit starts with all "0s," it will never produce an output. Built around half of IC_3, the circuit's oscillator supplies a 330-kHz clock waveform. At this clock frequency, the repetition rate of the pseudorandom noise sequence is less than once every 25 hours.

The output of the pseudorandom sequence generator can be filtered to supply the type of signal desired. For example, a low-frequency bandpass filter can be applied to produce low-frequency noise for sound effects (earthquakes and other rumbling sounds), or subsonic frequencies can be useful as random-driving signals for shaker tables. The most commonly used noise signals, however, are those that contain white or pink spectral characteristics.

To convert the digital pulse train from the shift registers into an analog white-noise output, the pseudorandom sequence is filtered by a third-order active Butterworth low-pass filter with a 40-kHz cutoff frequency (IC_{4a}). The low-pass filter yields a flat noise spectrum that is down only 0.25 dB at 25 kHz.

To produce pink noise, a random noise signal must be filtered so that the noise power at each frequency increases with the inverse of frequency. Therefore, a 3-dB/octave roll-off rate is required. The pink-noise filter (IC_{4b}) uses alternating poles and zeros to approximate this slope. The accuracy of the pink-noise output spectrum using the values shown is better than ±0.4 dB over the audio frequency range.□

CIRCLE 523 ONE IC DOUBLES FREQUENCY

V. LAKSHMINARAYANAN
Centre for Development of Telematics, Sneha Complex, 3rd Floor, 71/1 Miller Rd., Bangalore 560 052, India.

An inexpensive frequency doubler and duty-cycle-variation circuit can be designed around one IC—a monostable 4047 that's triggered directly by a low-to-high or high-to-low transition. The circuit uses two RC differentiators to detect the leading and trailing edges of a digital input signal *(see the figure, left)*. The

1. Adjust input clock frequency to 500 Hz.
2. Set switch S to 1-ms position.
3. Set R_3 to midrange.
4. Set R_2 to full clockwise (cw) position.
5. Adjust R_4 for 1-ms output-pulse width.
6. Set R_2 to full counter clockwise (ccw) position.
7. Adjust R_3 for 100-microsecond output-pulse width.

Repeat steps 4–7 until the rotation of R_2 from full counterclockwise to full clockwise changes the width of the output pulse from 100 μs to 1 ms.

The warning indicator can be checked by switching switch S to the 10-ms position. The indicator will light until the output pulse width is less than 1 ms.

Any function generator can provide a suitable clock signal. If a bipolar generator is used, diode D_1 eliminates negative pulses. □

Shift register with feedback generates white noise

by Marc Damashek
Clarke School for the Deaf, Northampton, Mass.

A shift register with linear feedback generates a pseudorandom sequence of pulses that can be used without digital-to-analog conversion or audio processing as extremely high-quality audio white noise. The output from the register, fed directly to an audio amplifier, produces a power spectrum that is flat to within ±1 decibel over the entire audio range.

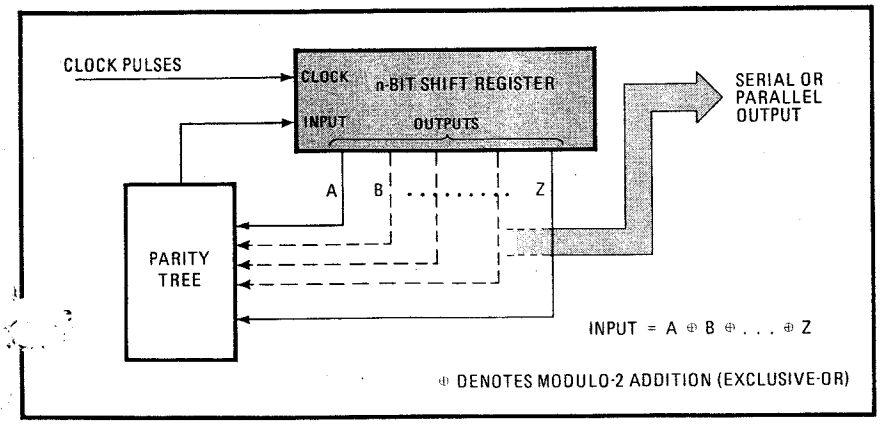
The operating principles of a linear-feedback shift register (LFSR) are illustrated in Fig. 1. The input to the first stage of an n-bit register is determined at each clock pulse by the exclusive-OR (parity) function of some output taps of the register. Choosing these taps is a crucial step in constructing a LFSR that performs as required.

For an n-bit shift register, taps can be chosen so that the register cycles through $2^n - 1$ different states before repeating any previous state. All possible n-bit words are generated except the word containing only 0s [*Electronics*, Nov. 27, 1975, p. 104]. In addition, with the use of only two taps, some shift-register lengths can produce these maximal-length sequences. A partial list of such registers is given in the table, which is excerpted from "Shift Register Sequences," by S. Golomb (Holden-Day Inc., San Francisco, 1967). As the table shows, even shift registers that are only moderately long can produce astronomically long sequences.

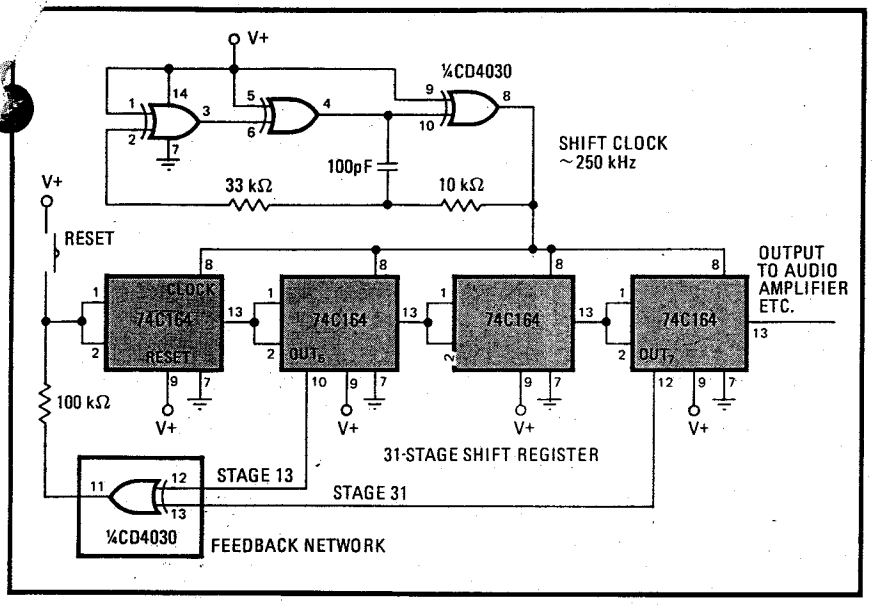
An appropriate clock and a sufficiently long register generate a flat power spectrum of audio white noise, using the digital bit stream itself as the noise source. Fig-

MAXIMUM-LENGTH LINEAR-FEEDBACK SHIFT REGISTERS THAT REQUIRE ONLY TWO FEEDBACK TAPS

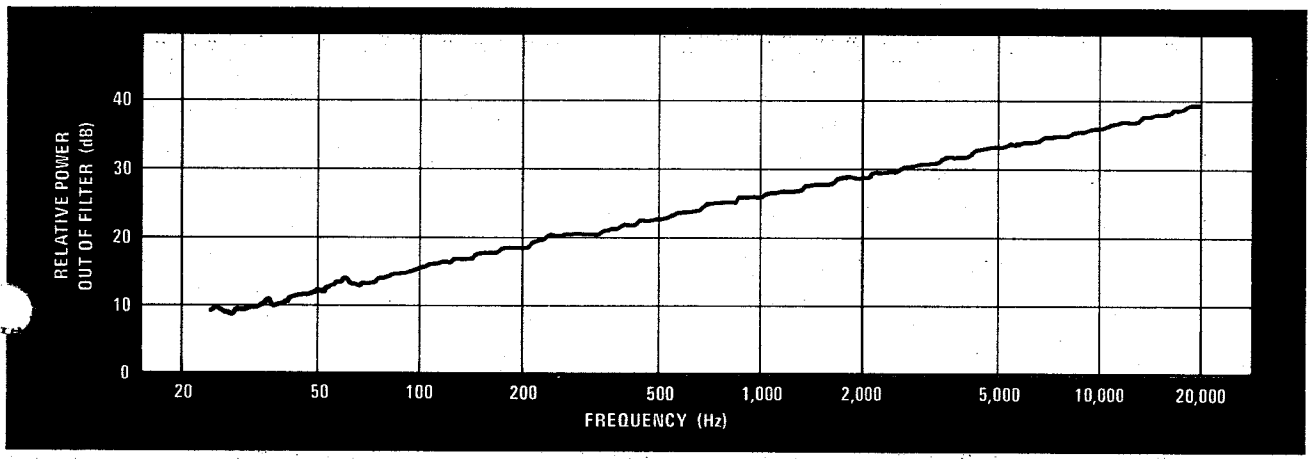
No. of stages	Stages at which taps are placed	Sequence length	Duration of sequence using 250-kHz clock
7	1, 7	127	0.51 ms
	or 3, 7		
9	4, 9	511	2.0 ms
10	3, 10	1,023	4.1 ms
11	2, 11	2,047	8.2 ms
15	1, 15	32,767	131 ms
	or 4, 15		
	or 7, 15		
17	3, 17	131,071	0.52 s
	or 5, 17		
	or 6, 17		
18	7, 18	262,143	1.0 s
20	3, 20	1,048,575	4.2 s
21	2, 21	2,097,151	8.4 s
22	1, 22	4,194,303	17 s
23	5, 23	8,388,607	34 s
	or 9, 23		
25	3, 25	33,554,431	2.2 m
	or 7, 25		
28	3, 28	268,435,455	18 m
	or 9, 28		
	or 13, 28		
29	2, 29	536,870,911	36 m
31	3, 31	2,147,483,647	2.4 h
	or 6, 31		
	or 7, 31		
	or 13, 31		
33	13, 33	8,589,934,591	9.5 h
35	2, 35	34,359,738,367	1.6 d
36	11, 36	68,719,476,735	3.2 d
39	4, 39	5.5×10^{11}	25 d
	or 8, 39		
	or 14, 39		
41	3, 41	2.2×10^{12}	102 d
	or 20, 41		



1. Pseudorandom pulses . . . In this linear-feedback shift register, some of the output ports are connected back to the input through an exclusive-OR circuit. Depending upon which output taps are fed back, a nonrepeating sequence of any length up to $2^n - 1$ binary words can be generated.



2. . . . generate noise . . . This 31-stage linear-feedback shift register is arranged to produce a maximum-length pseudorandom bit sequence by connection of stages 13 and 31 back to input. Output bit stream, which can be taken from any port, constitutes a white-noise source.



3. . . . like this. The output power spectrum of the circuit in Fig. 2, measured directly at the output of stage 31, slopes upward because filter bandwidth is proportional to frequency. The slope of 3 dB/octave indicates white noise. Reference level (0 dB) was chosen arbitrarily.

ure 2 shows a 31-stage LFSR, with taps at stages 13 and 31 and a shift clock running at 250 kilohertz.

Any shift register that provides access to the required feedback bits will serve. For instance, two CD4006s might have been used instead of the 74C164s. With only three ICs, these shift registers can give access to bits 13 and 31. For a white-noise generator in audio applications, the component values are noncritical. The reset button ensures that at least a single 1 is initially in the shift register, but the manual button can be replaced by a more elaborate initialization circuit if desirable.

The audio-power spectrum from the circuit in Fig. 2, measured directly at the output of stage 31, is shown in Fig. 3. A series of ⅓-octave filters measures the spectrum. The curve is inclined upward at a rate of 3 decibels per octave, matching the increasing bandwidth of the filters. The deviation from a straight line inclined 3 dB/octave is less than 1 dB over the frequency interval from 25 Hz to 20 kHz. The largest deviation occurs at ? power-line frequency of 60 Hz. The table shows that ...e string produced by this register is longer than 2 billion bits and, at a 250-kHz clock rate, will take more than two hours to repeat.

The LFSR pulse sequences are also used for error-correcting codes, spread-spectrum techniques [*Electronics*, May 29, 1975, p. 127], and other random-selection processes. In a maximum-length LFSR n bits long, the bit string produced is statistically identical to $2^n - 1$ flips of an ideal coin (one with precisely equal probabilities of landing heads or tails). Thus, for example, a 17-stage LFSR can generate the equivalent of 131,071 coin-flips. Any stage of the register may provide the output, since every bit is eventually shifted the entire length of the register.

Such a device could be useful for producing uncorrelated stimuli in a psychophysical experiment, because it could easily determine which of two possible stimuli to present to a test subject. It can do so with an undiscernible, yet repeatable, pattern so that a second test subject could be given the same sequence of stimuli. If the bit string from the 31-stage register in Fig. 2 were used for test stimuli with an average interval between stimuli of 5 seconds, it would not repeat for 340 years. □

Designer's casebook is a regular feature in Electronics. We invite readers to submit original and unpublished circuit ideas and solutions to design problems. Explain briefly but thoroughly the circuit's operating principle and purpose. We'll pay $50 for each item published.

Instrumentation Power Supply

IE-20

Input
Switchable
110-220

Output
6 Volts
165mA to 200mA
Tip positive
2.5mm dia 12mm length

IE-30

Input
switchable
110-220

Output
6 volts
2 Amps
IE-30 draws up to 1.5 Amp when nicad ~~Lead~~ Charging and unit is running
Tip positive
5.5mm dia - 11mm long
2.5mm Id

PC-40

Input
110-220
Switchable

Output
9 volts
3 Amps
PC-40 draws 2.0 Amps when nicad charging + unit is running
T.p positive
5.5mm dia - 11mm long
2.5m Id

IVIE ELECTRONICS INC.

500 WEST 1200 SOUTH
OREM, UTAH 84057
(801) 224-1800

IE-20A
PINK NOISE GENERATOR

OWNER'S MANUAL

JANUARY 1977

PRINTED IN U.S.A.

IE-20A WARRANTY

The IE-20A is warranted against defects in materials and workmanship for one (1) year from the date of purchase. During the warranty period Ivie Electronics will repair, or at its option, replace components which prove to be defective provided the generator is returned shipping prepaid to an authorized Ivie Electronics service facility. Defects caused by modifications, misuse or accidents are not covered by this warranty. No other warranties are expressed or implied. Ivie Electronics is not liable for consequential damages. All requests for repairs and information should include the instrument serial number to assure rapid service.

CONTENTS

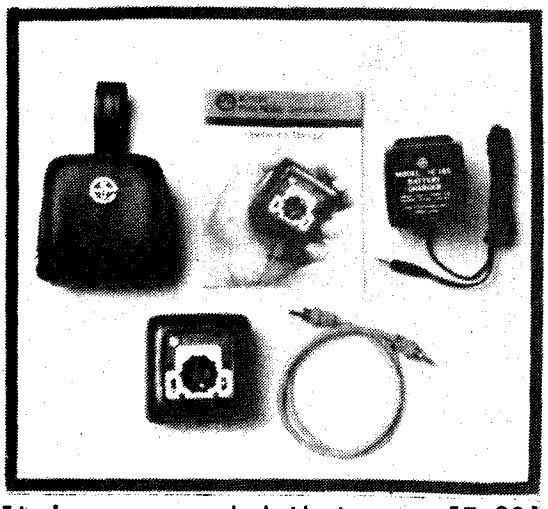
ILLUSTRATIONS

INTRODUCTION

It is the intention of Ivie Electronics to provide high quality equipment of innovative design to help satisfy the ever increasing technical needs of the audio industry. We are always ready to lend engineering support and assistance when the need occurs. When questions arise, please contact us. We are interested in your applications.

We believe in rugged quality - that an instrument should be able to withstand constant and demanding usage. Your new IE-20A Pink Noise Generator is such an instrument, and properly cared for, it will give you long and reliable service.

With your IE-20A you should have received the following items pictured below:



IE-20A Pink Noise Generator.

"Fast Charge" nickel cadmium batteries mounted inside the IE-20A.

AC adaptor/charger that provides continuous line operation.

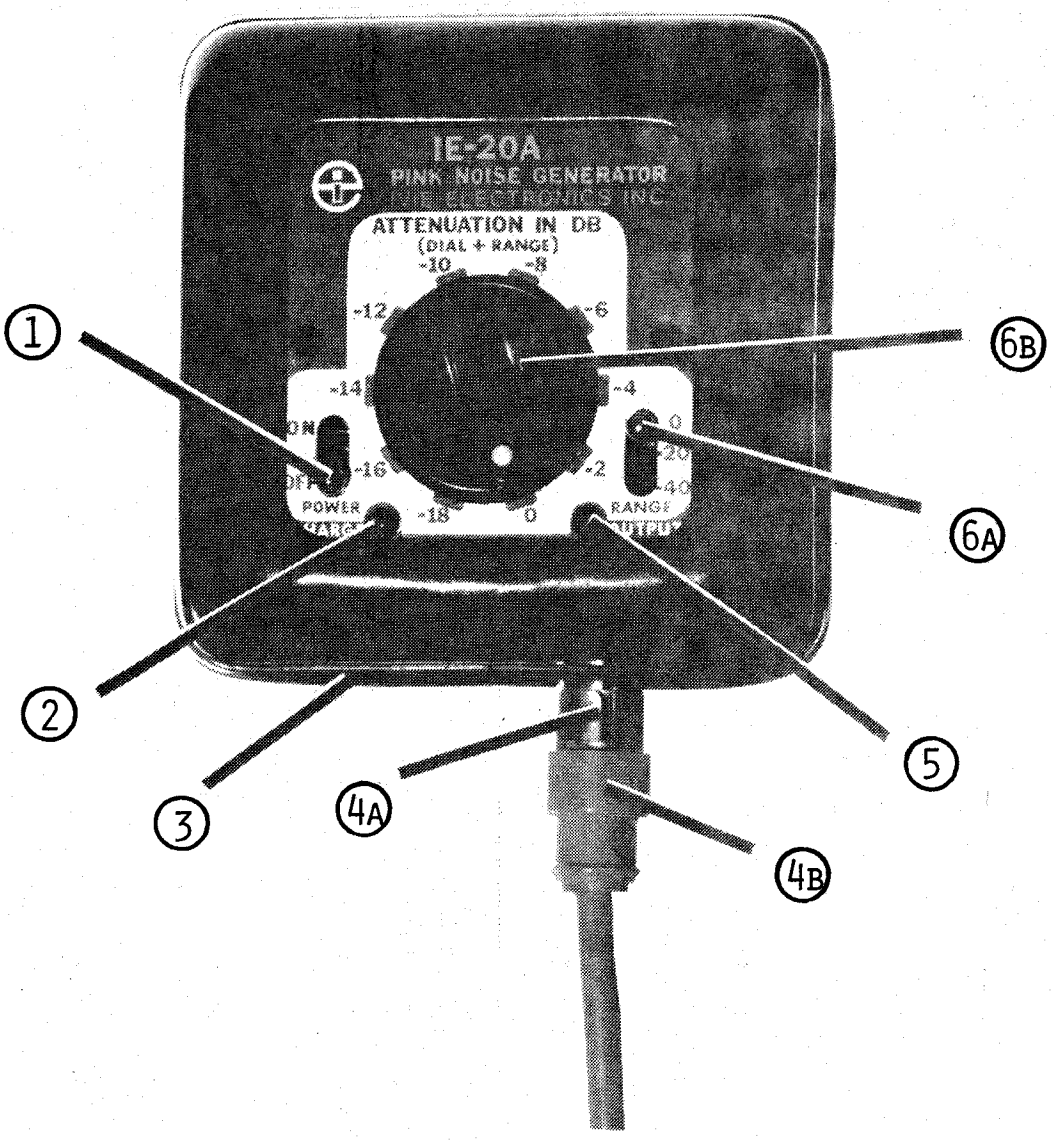
Vinyl carrying case with belt loop.

Standard phono plug patch cord.

Operator's Manual with illustrations and examples.

It is recommended that your IE-20A be charged for four or five hours after it is unpackaged. This will assure a full twelve hours of operating time before recharging is again necessary.

Make sure the voltage selection switch on the IE-165 Charger/Adaptor is in the correct position for the line voltage being used (either 115v. or 230v. AC at 50-60 Hz).



IE-20A Front Panel Controls
Figure 1

IE-20A OPERATION

FRONT PANEL DESCRIPTION

The IE-20A has been designed for quick and easy operation. The controls are as follows:

(1) Off-on toggle switch

(2) "Charge" indicator. This LED indicator has two important functions. It lights when the IE-20A is being charged, thus providing indication of a properly working battery charger. Its second function is providing indication of battery level. It illuminates when the Ni-Cad batteries are low and require charging.

(3) Input jack for the battery charger.

(4) Pink Noise Output jack, (4A) , with patch cord, (4B) , attached.

(5) Pink Noise Output indicator.

(6) Precision attenuator. The attenuator is comprised of two controls, the "Range" toggle (6A) and the Dial (6B) .

BATTERY AND LINE OPERATION

An IE-165A Adaptor/Charger has been supplied with your IE-20A Pink Noise Generator that will recharge the batteries in about 3 hours. The IE-20A will operate approximately 12 hours between charges.

When the "CHARGE" LED lights indicating low batteries, recharging is immediately necessary. The pink noise output ceases to be accurate shortly after the LED illuminates.

> CAUTION: Use of an adaptor/charger other than the IE-165A may cause damage to your IE-20A.

The IE-165A Adaptor/Charger is selectable for voltages of 115v. or 230v. AC at 50 to 60 Hz. Make sure the voltage switch on the IE-165A is in the correct position for the AC power line being used. Using the IE-165A with AC power other than 115v. or 230 v. at 50-60Hz. may cause damage to your IE-20A.

The IE-20A may also be operated directly from the AC power line using the IE-165A as an adaptor. The Ni-Cad batteries will continue to charge when the pink noise generator is being operated in this manner.

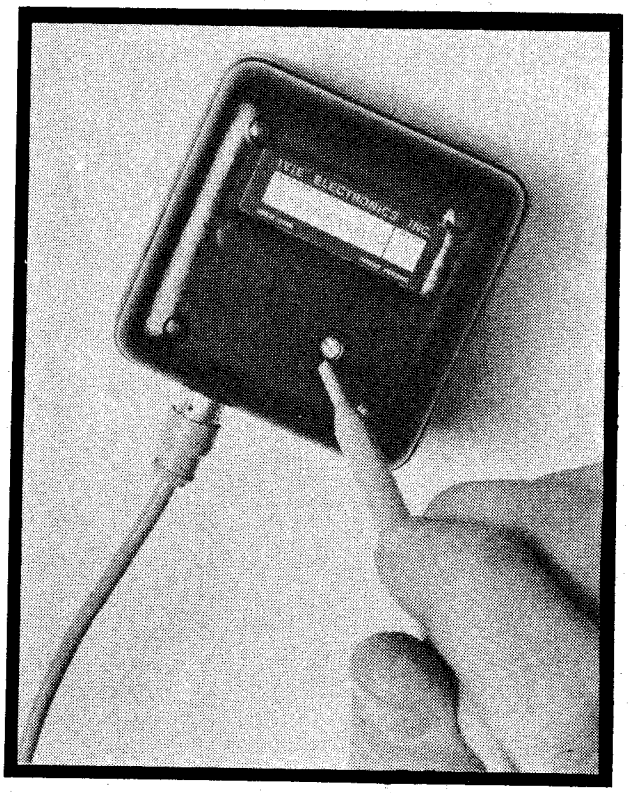
The Ni-Cad batteries in the IE-20A are of the highest quality and are capable of withstanding extended overcharging. It is recommended that they be completely discharged (until the "Charge" LED on the IE-20A illuminates) from time to time to minimize the possibility of "memory effect" on the batteries. Ni-Cad batteries can loose their ability to give up 100% of their charge if they are only partially discharged on a frequent basis.

If permanent power line operation of the IE-20A is desired, it is recommended that the Ni-Cad batteries be removed and that a line operated DC power supply of 6v. and 50ma be provided in their place. The external power supply can be conveniently provided to the IE-20A through the charge jack (③ Figure 1) (center pin is positive).

CHANGING THE REFERENCE LEVEL

The REFERENCE level on the IE-20A represents the voltage output (RMS) when the attenuator is set to 0dB. At the factory the reference is set to .940v RMS because this output level corresponds to calibrations on the IE-10A Audio Spectrum Analyzer.

For many applications it may be desireable to change the reference output level on the IE-20A. The reference level is adjustable between 0v.RMS and 1.0v. RMS using the potentiometer which is accessed through the back of the pink noise generator as demonstrated in fig. 2. Rotating the shaft clockwise increases the reference output level and counter-clockwise motion reduces the reference level.



Changing the Reference Level
Figure 2

It should be noted that changing the reference level does not change the accuracy of the attenuator. The attenuator will provide 0-58dB of signal reduction (in 2dB steps), regardless of the reference level setting.

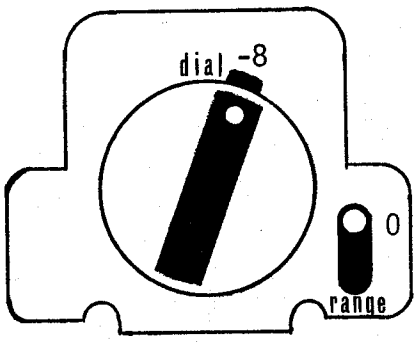
USING THE ATTENUATOR

One of the unique features of the IE-20A Pink Noise Generator is its calibrated output. For loads greater than 600 ohms, the step attenuator on the front panel allows up to 58dB of attenuation from the reference output level, selectable in 2dB increments.

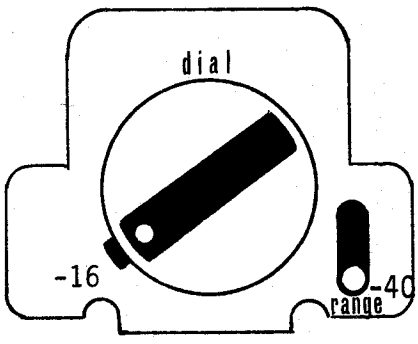
The step attenuator is comprised of the "dial" and the "range" toggle switch. (See figure 1, 6A & 6B, page 4). To determine total attenuation in dB, add the dial and the toggle values together. The two illustrations below provide simple examples. The total attenuation in figure 3 is -8dB. In figure 4, the attenuation selected is -56 dB.

Figure 3: Dial = - 8, Range = 0; (- 8) + (0) = - 8dB.
Figure 4: Dial = -16, Range = -40; (-16) + (-40) = -56dB

The 2dB increments of the step attenuator are very precise. Cumulative error is not more than +/- .5dB over the entire 58dB range.



Attenuator set to -8dB
Figure 3



Attenuator set to -56dB
Figure 4

TABLE OF ATTENUATION VERSUS OUTPUT VOLTAGE

Often it is desirable to select a specific output voltage from the IE-20A Pink Noise Generator. For loads of 600 ohms or greater, the following table can be used to determine output voltage when the reference output level of the IE-20A is at the factory preset level of .940v. RMS.

ATTENUATOR SETTING	OUTPUT VOLTS RMS
- 0db	940 mv
- 2db	747 mv
- 4db	593 mv
- 6db	471 mv
- 8db	374 mv
-10db	297 mv
-12db	236 mv
-14db	188 mv
-16db	149 mv
-18db	118 mv
-20db	94 mv
-22db	75 mv
-24db	59 mv
-26db	47 mv
-28db	37 mv
-30db	30 mv
-32db	24 mv
-34db	19 mv
-36db	15 mv
-38db	12 mv
-40db	9.4 mv
-42db	7.5 mv
-44db	5.9 mv
-46db	4.7 mv
-48db	3.7 mv
-50db	3.0 mv
-52db	2.4 mv
-54db	1.9 mv
-56db	1.5 mv
-58db	1.2 mv

USES OF THE IE-20A PINK NOISE GENERATOR

The IE-20A has been designed to meet a wide range of applications. Its attenuated output level allows it to directly drive a broad spectrum of equipment from ultra sensitive preamps to high power amplifiers.

A pink noise generator can be used alone for some applications such as noise masking and acoustical shielding, but its full potential as a test instrument is realized when it is used in conjunction with a good real time analyzer such as the IE-10A Audio Spectrum Analyzer.

Together, the pink noise generator and audio spectrum analyzer can be used for a wide variety of audio applications such as:

* Equalizing audio components and systems
* Checking flatness and gain on microphones, preamps, amplifiers and mixers
* Measuring transducer dispersion angles at all octaves
* Measuring speaker response
* Trouble shooting and tracing audio circuits
* Evaluating filter response
* Analyzing audio transmission systems.

Of all the tools in the audio field, a pink noise generator and a real time analyzer are two of the most versatile and useful. The sound reinforcement and hifi professional, the musician, technician and serious audiophile alike, will find the combination invaluable.

CIRCUIT DESCRIPTION AND THEORY

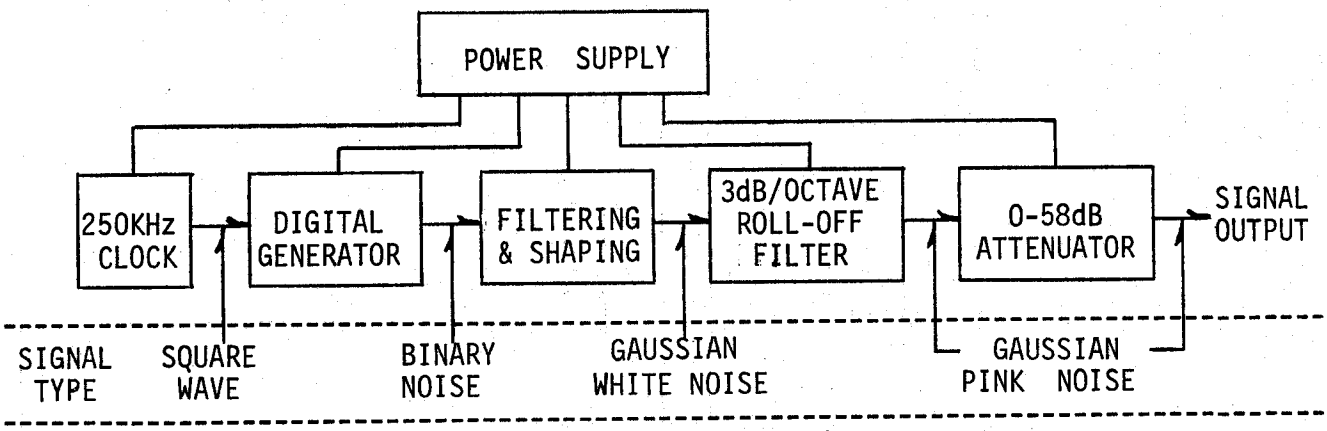


Figure 5 IE-20A Block Diagram

The IE-20A is a state-of-the-art noise generator, designed to handle the most exacting laboratory requirements. Unlike gas-discharge tube and noise-diode methods, the digital techniques used in the IE-20A generate noise signals that are statistically well-defined and very stable.

The IE-20A (See Fig. 5, Block Diagram) employs a digital process with special filtering and shaping to produce a very flat pink noise output over a wide range of frequencies.

A linear feedback shift register is used to produce very flat binary (two-level) noise having a digital word length of more than two billion bits. Using a clock frequency of 250KHz allows the noise signal to be random over a 2.4 hour period of time before the digital word sequence begins to repeat.

Random binary noise is not considered to be a good audio test signal because it's output amplitude is confined to two levels only. Signals with multilevel amplitudes, like random Gaussian noise, more closely correlate with audio program material.

Binary noise can be converted to high-quality white noise (a multilevel waveform having a Gaussian distribution) through use of additional filtering as shown in Fig. 5.

For audio work, pink noise (constant energy per octave) is generally preferred over white noise (constant energy per hertz) because white noise delivers greater energy at upper frequencies which could damage drivers. Pink noise, by contrast, delivers equal energy at the higher octaves.

Real time audio analyzers are designed with octave, or fractional octave, bandwidth filters and are intended to be used with pink noise generators. A pink noise signal input will produce a flat response on such an analyzer.

Converting white noise to an accurate pink noise signal requires a precision 3dB per octave roll-off filter as shown in the block diagram of the IE-20A.

To enable the user to make accurate audio substitution measurements when using the IE-20A in conjunction with an audio analyzer like the IE-10A, a precision attenuator has been designed into the output stage of the pink noise generator.

IE-20A SPECIFICATIONS

FREQUENCY RANGE

* 10 Hz to 40 KHz 3dB bandwidth.
  20 Hz to 20 KHz +/- 0.5 dB.

OUTPUT

* Output level variable from 0.0 - 1.0v. RMS
* Crest factor: 3.75
* Output attenuation selectable in 2 dB increments from 0 dB to -58 dB. Cumulative error not more than +/- 0.5 dB.
* Output short circuit protected.
* Output connector: standard phono jack.

NOISE GENERATION

* Digitally generated by CMOS circuitry.
* Word length greater than 2 billion bits.
* Clock rate: 250 KHz.
* Word repetition time: 2.4 hours.
* Noise distribution approximates Gaussian.

POWER

* BATTERY OPERATION: rechargeable nickel cadmium.
* Operating time approximately 12 hours continuous at 25°C.
* Fast charge cycle of 3 hours.
* Low battery indicator light.
* AC LINE OPERATION from AC Adaptor/Charger.
* 115/230 VAC 50/60 Hz.
* Charge indicator light.

ENVIRONMENTAL

* All circuits temperature compensated.
* Operating Temp. -10°C. to +50°C.
* Nonoperating Temp. -30°C. to +65°C.
* Operating Humidity 0 to 90%.

MECHANICAL

* Aluminum case fusion bonded with nylon.
* Dimensions (w x h x d) 69 x 69 x 44 mm.
  (Approx. 2-3/4 x 2-3/4 x 1-5/8 in.)
* Weight: Net 200 gms (approx. 7 oz.)
  Shipping 680 gms (approx. 1½ lbs.)

ARCHITECT'S AND ENGINEER'S SPECIFICATIONS

The pink noise generator shall be battery operated using fast charge nickel cadmium batteries. The generator shall operate not less than 12 hours between charges, and shall possess a low battery and charge indicator. The generator shall be capable of direct operation from line voltages of 115v. and 230v. AC at 50-60Hz. The dimensions of the generator shall be approximately 69 x 69 x 39 mm and it shall weigh approximately 200 gms.

The pink noise generator chassis shall be aluminum, fusion bonded with nylon.

The generator shall produce pink noise digitally, utilizing CMOS circuitry. The clock rate shall be 250 KHz. Output shall be calibrated, providing up to 58dB of attenuation in 2dB increments. Cumulative attenuator error shall not be greater than +/- 0.5dB. Output reference level shall be variable between 0.0v. and 1.0v. RMS.

The pink noise generator shall be the IE-20A manufactured by Ivie Electronics Incorporated.

SERVICE

It is the intention of Ivie Electronics to provide quality service for the IE-20A whether in or out of the warranty period. If the IE-20A should require service, please return it shipping prepaid to an Ivie Electronics service facility. Shipping the instrument in its original packaging is recommended. Repair will be made and the unit will be returned prepaid as soon as possible.

Due to the subminiaturized packaging techniques used, Ivie Electronics cannot assume responsibility for repairs made at other than an authorized service center.

NOTES

IE-20B Assembly

1. Inspect the boards for mechanically defective components and broken or poor solder connections. Make necessary repairs.

2. Plug the power supply board into the attenuator board. Use care to mate all molex pins with their sockets.

3. Plug the generator-filter board onto the power supply and attenuator board assemblies.

4. Tighten the two 5/16" nuts onto the toggle switches.

5. Solder the batteries to the battery wires.

6. Turn on the IE-20B, set its attenuator controls to zero, putting the signal into an IE-10A. Manually rotate the 2 dB/step attenuator shaft to the 0 position (one step clockwise should cause -18 attenuation on the IE-10A). Slide the knob on the shaft aligning pointer to zero mark and secure it by tightening the two set screws. Touching the circuitry injects erroneous signals and can stop the 250 KHz clock.

7. Insert the two longer mounting bolts into the two inward holes in the generator-filter board.

8. Insert the PC board assembly into the front case carefully aligning the LED's. Secure the assembly by inserting and tightening the two shorter bolts into the front case. Double check alignment of knob pointer with dial markings.

9. Place the paper spacer between the PC board assembly and the battery compartment.

10. Place the batteries inside the front case (the knob needs to be sufficiently high to not rub on the batteries).

11. Mold the foam around the batteries.

12. Replace the extrusion.

13. Replace the back.

14. Carefully align and tighten the back case screws securing the back in place.

    DO NOT OVER-TIGHTEN. IT MIGHT FRACTURE THE PRINTED CIRCUITRY OR BEND THE ALUMINUM CASE.

15. Final test the IE-20B.

IE-20B Disassembly

1. Document customer's complaint on the Customer Service report before disassembly.

2. Set unit on soft non-scratch pad.

3. Disengage the two case screws seven turns counter clockwise.

4. Gently pull back off of IE-20B.

5. Remove extrusion.

6. Pull foam from around batteries.

7. Tip batteries and paper spacer out of front case using care to avoid contact of battery with the printed circuit boards.

   Unsolder the batteries to prevent accidental shorting.

8. Loosen and remove two screws to release the PC board assembly from the front case.

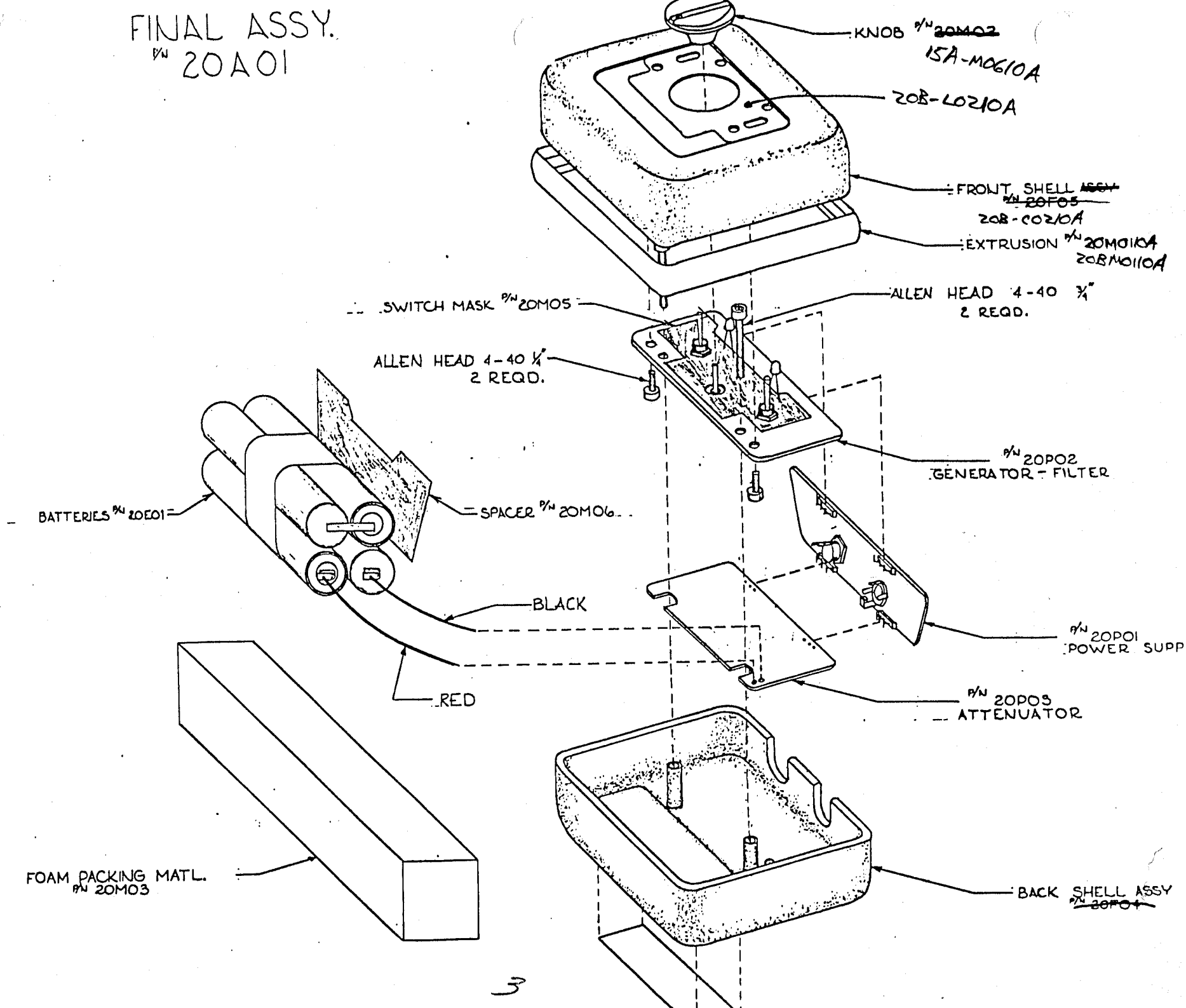
9. Remove the IE-20B knob by loosening two allen set screws and pulling the knob off of shaft.

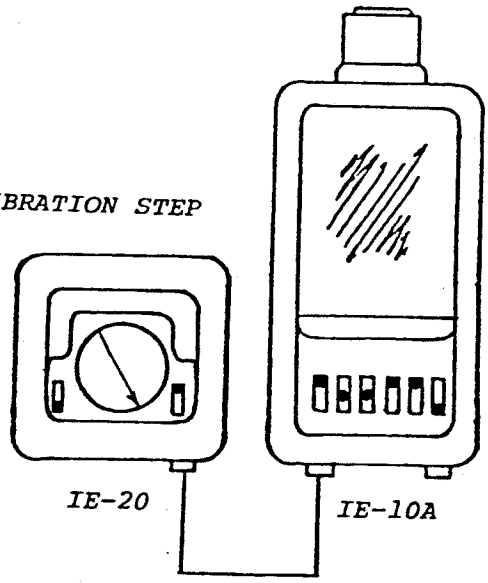
10. Using a 5/16" nut driver loosen the two nuts from the two toggle switches.

11. Unplug the generator-filter board from the assembly.

12. Unplug the power supply board from the attenuator.

FINAL ASSY.
P/N 20A01





Connect IE-20 Out to IE-10A

IE-10 Manual Page 10 & 11 Fig. 6

Horizontal Line 0 dB — No — Adjust calibration potentiometer on IE-20 back. Substitute generator/filter, attenuator modules.

Occasional flickering of lower four octaves +/1 dB normal.

+/- 1dB flickering of slowest freq. normal

drain ~ 40mA From NICAD2

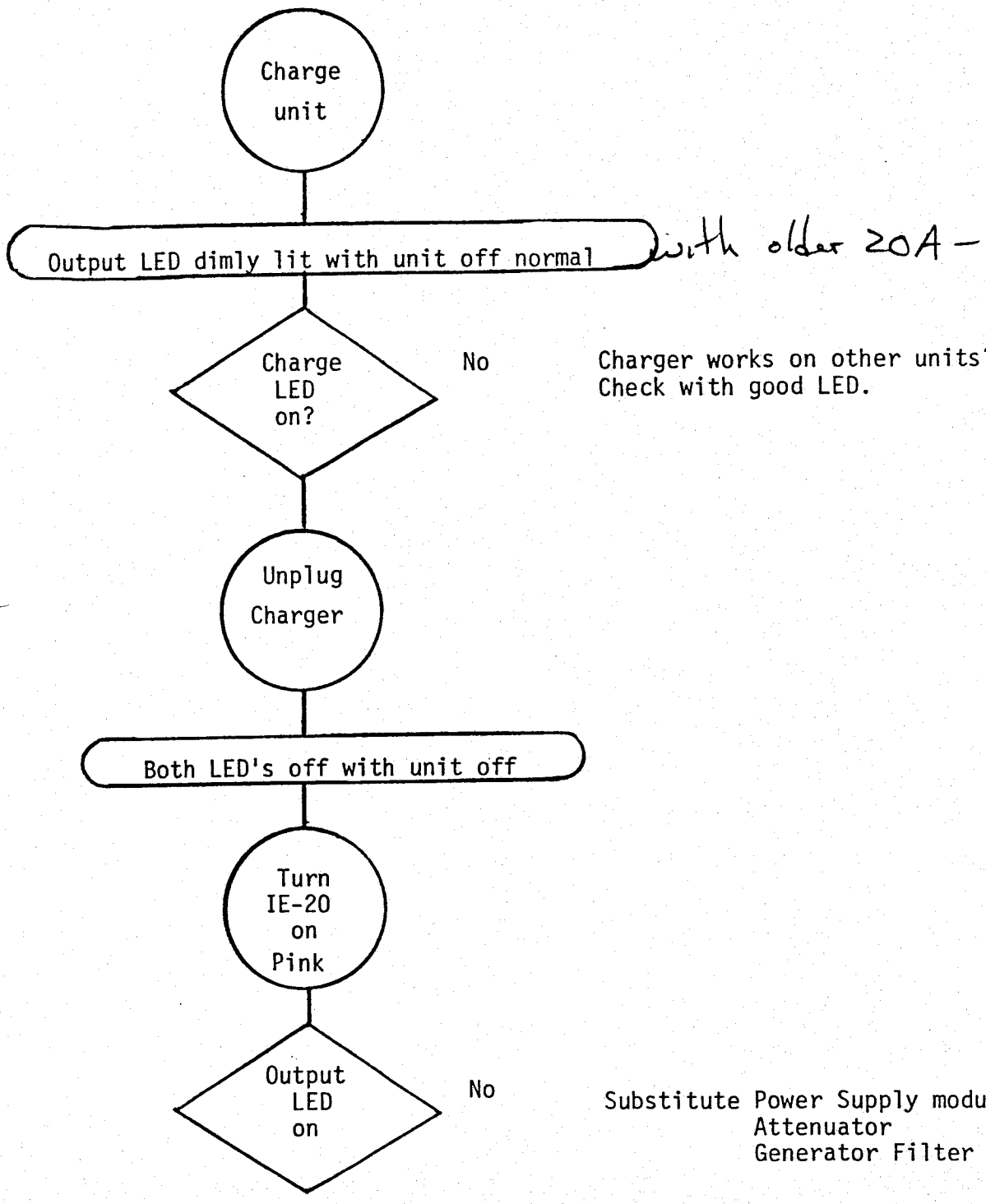
White Noise increases 3 dB/ Oct. — No — Generator Filter module.

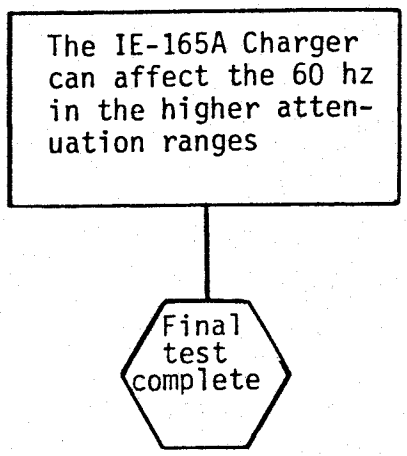
2 dB/ step attenuation 10A — No — Attenuator module.

Step through each 2 dB step from 0 to -58 dB

IE-20

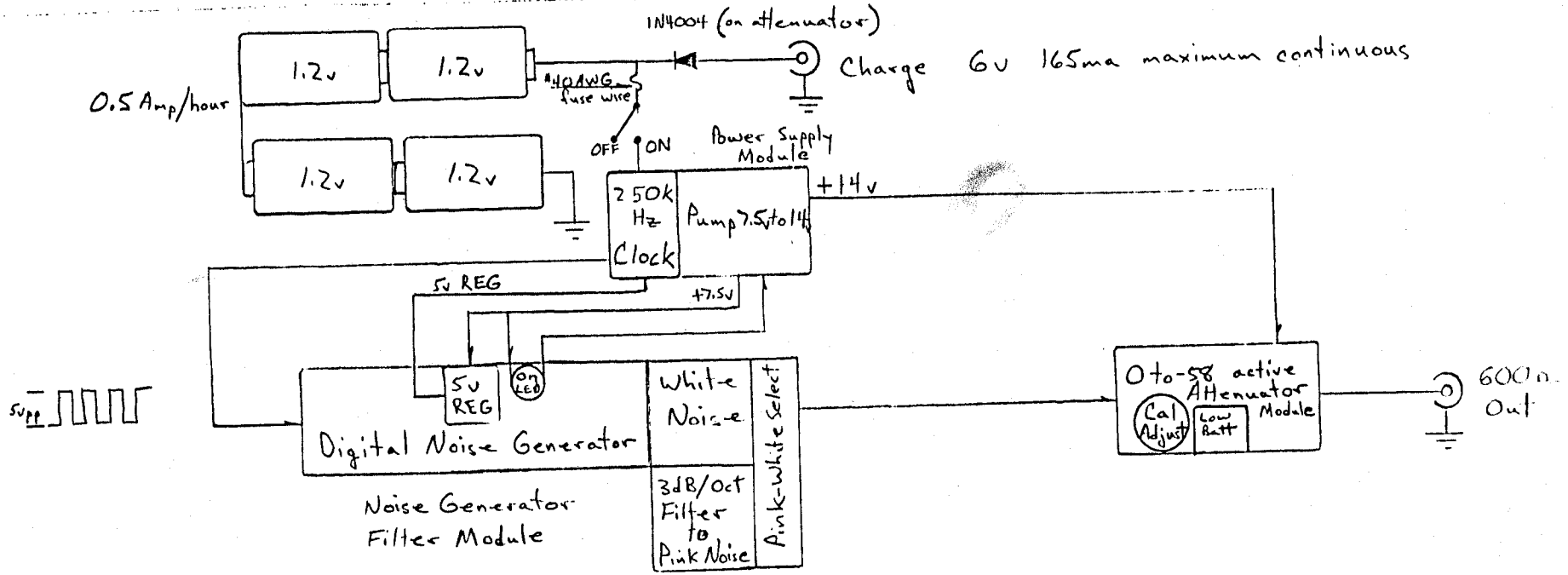
Final Test and Trouble Shooting Flow Chart

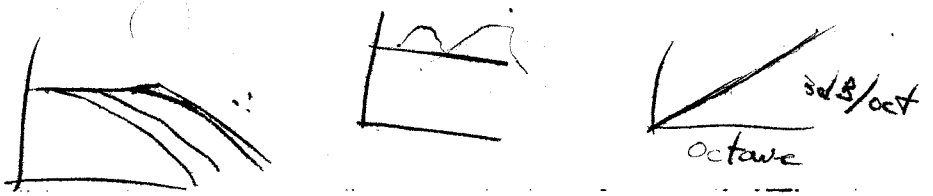




Apply Armor All sparingly

IE-20
Pink/White Noise Generator

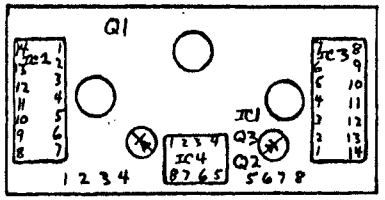




DATE	SYM	REVISION RECORD	DR	CK
11-9	E	PRODUCTION IE-20B		
11-21	G	ECO 79086		

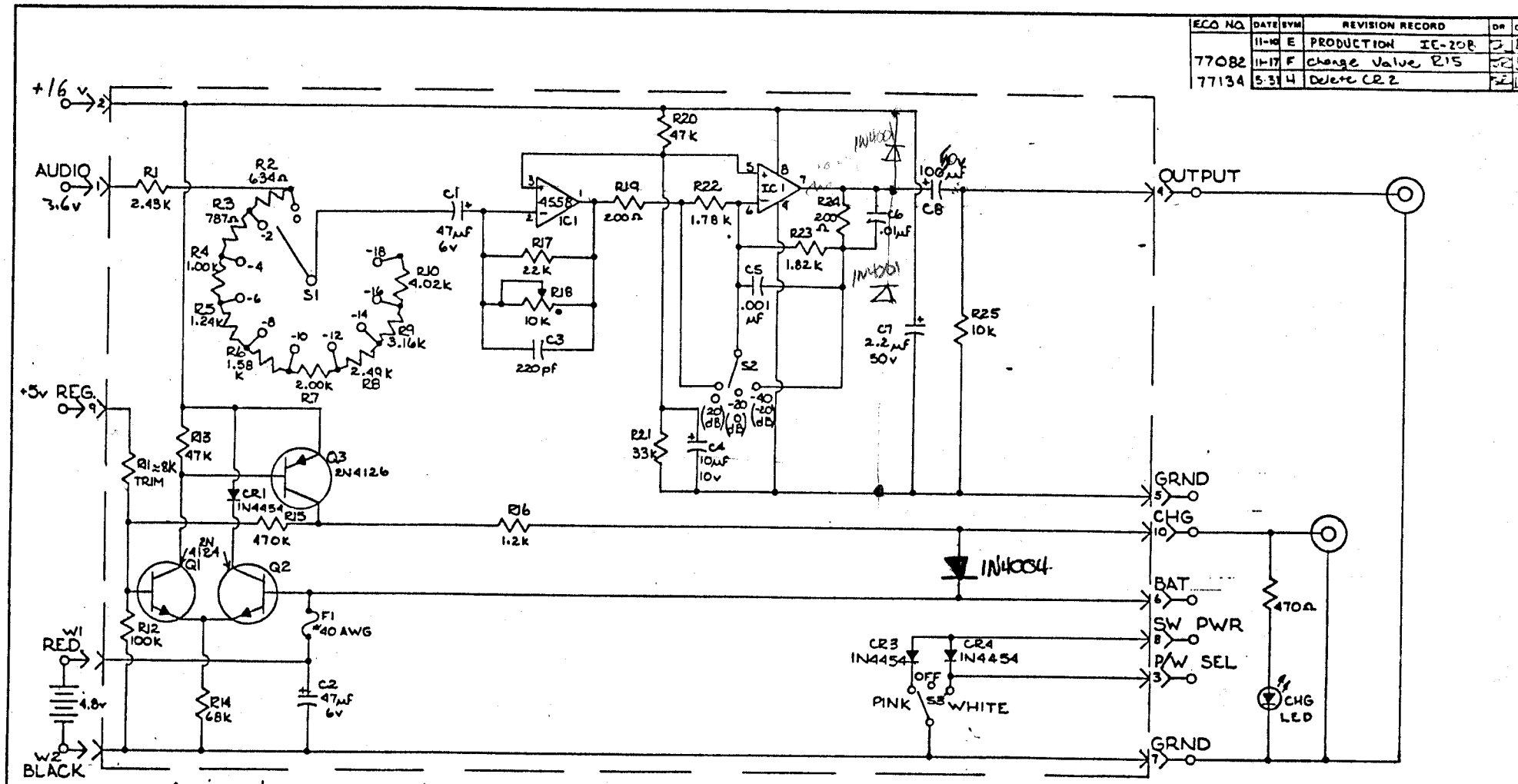
9.0v
IC1 78L05
C1 1µf 35v
DS2 OUTPUT LED
PUMP 9.4v
+5v REG
R13 140Ω
R11 499Ω
R12 5.62K
C11 470pF
Q2 10E06 (<5.0v)
IC4 4558
3.6V AUDIO
CLOCK
5VPP 0V
IC 2 CMOS 4006
IC 3 CMOS 4006
R4 100K
CR5 IN4454
R7 47K
R9 6.8K
3.7V
R6 10K
C3 4.7µF 10v
4558 IC4 3.6VDC
4.53K R10
White Noise
16K @ -2dBm
+8.8Bm Fluke
R8 130K
C4 .47µF 35v
C5 1µF
C6 .47µF
C7 .22µF
C8 .1µF
C9 .047
C10 .033
R20 5.62K
Q3 10E03 (<2.5v)
R14 4.64K
R15 2.21K
R16 1.00K
R17 464Ω
R18 221Ω
R19 100Ω
CHARGE LED
DS1 CHARGE LED
Q1 2A
R2 47K
CR1 CR2 CR3 CR4 IN4454 4x
R3 47K
R1 47K
exclusive OR
00 | 0
01 | 1
10 | 1
11 | 0
R21 10M
R22 10M
GRND
P/W SEL
Pink 12V
White 0.5V

Circuit Side View



TOLERANCES (EXCEPT AS NOTED)	IVIE ELECTRONICS			
DECIMAL ±	IE-20B	SCALE NONE	DRAWN BY	
FRACTIONAL ±	TITLE GENERATOR-FILTER		APPROVED BY	
ANGULAR ±	DATE 11-9-77	DRAWING NUMBER S20P02	REV. G	P/N 20P02

GAP DRAFTRACE 290



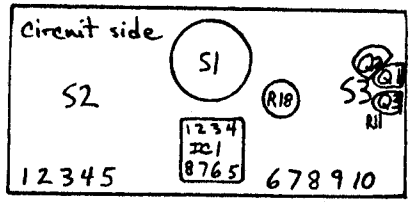
ECO NO.	DATE	SYM	REVISION RECORD	DR
	11-16	E	PRODUCTION IE-20B	
77082	11-17	F	change value R15	
77134	5-31	H	Delete CR2	

R11 Trim for low charge LED on at 4.6 V ±0.05

4558 IC fails when DC or AC volts enters output

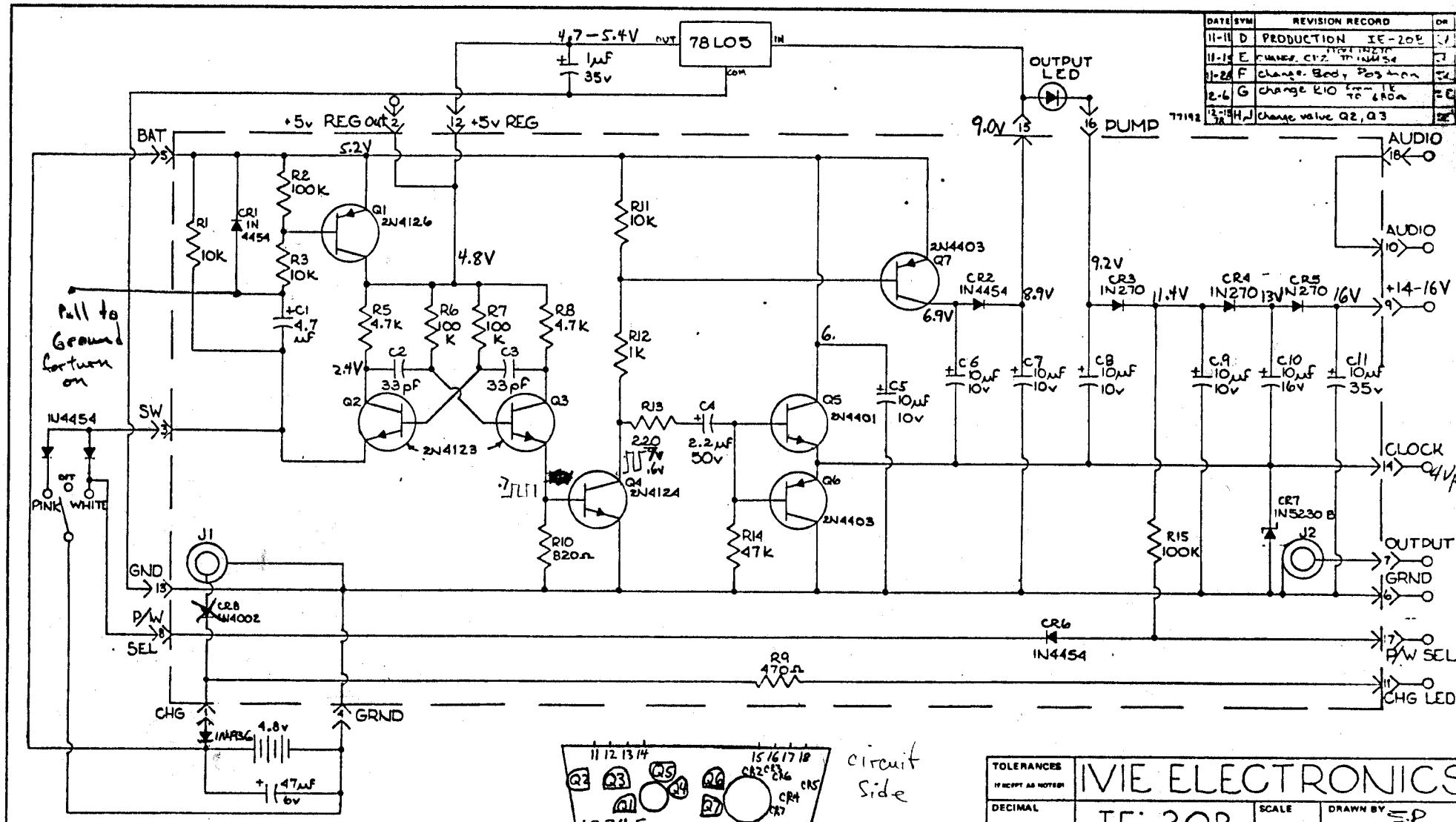
Failure modes

1. Poor freq response
2. Loading of 16v supply
3. Clipping Signal



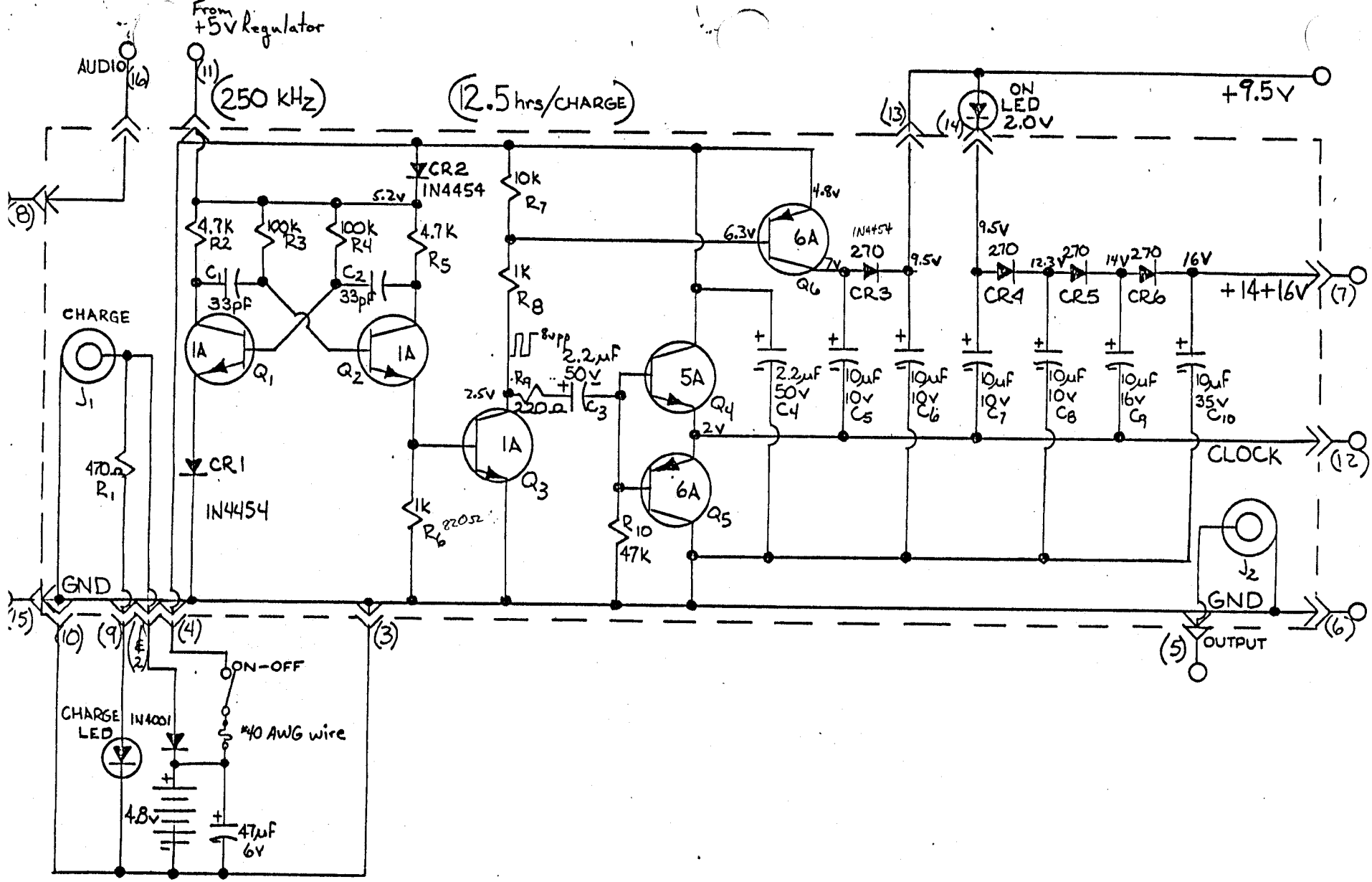
TOLERANCES (IF NOT AS NOTED)	IVIE ELECTRONICS			
DECIMAL ±	IE-20B	SCALE NONE	DRAWN BY ST	APPROVED BY
FRACTIONAL ±	TITLE ATTENUATOR			
ANGULAR ±	DATE 11-10-77	DRAWING NUMBER 520P03	REV. H	P/N 20P03

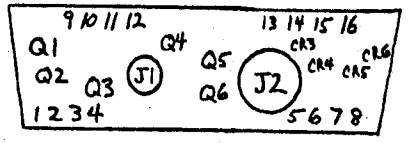
DAF DRAFTRACE 250



DATE	SYM	REVISION RECORD	OK
11-11	D	PRODUCTION IE-20B	
11-15	E	CHANGE CR2 TO IN4454	
11-28	F	change Body Position	
12-6	G	change R10 from 1K to 680Ω	
12-19-78	H	change value Q2, Q3	

77192





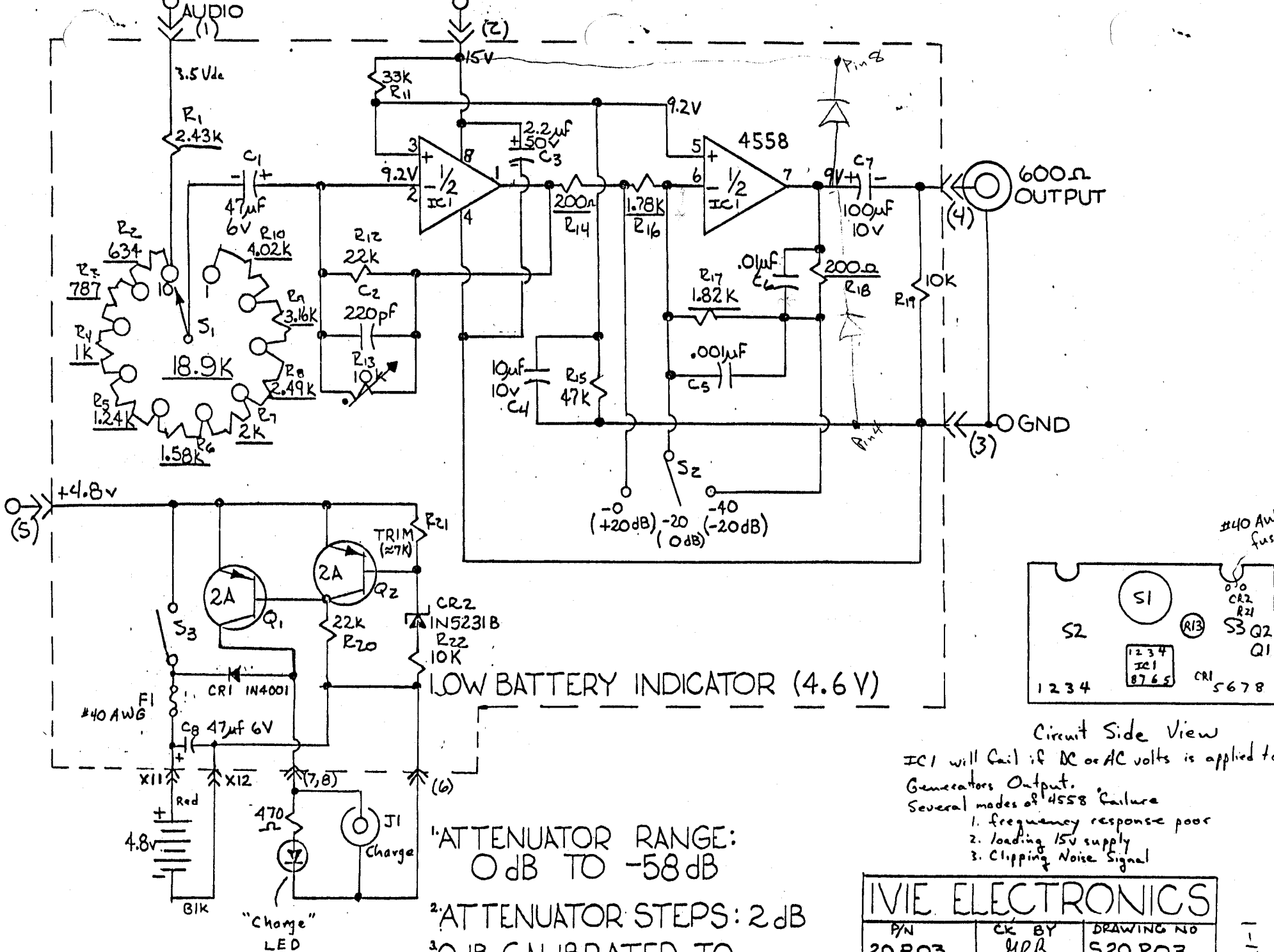
6A 2N4403
5A 2N4401
1A 2N4124

IVIE ELECTRONICS

IE-20A POWER SUPPLY NPS

Shane Robbins	REV A, B, C	2/24/77
BY GK	P/N	DRAWING NO 5-20B-4-1-1

9



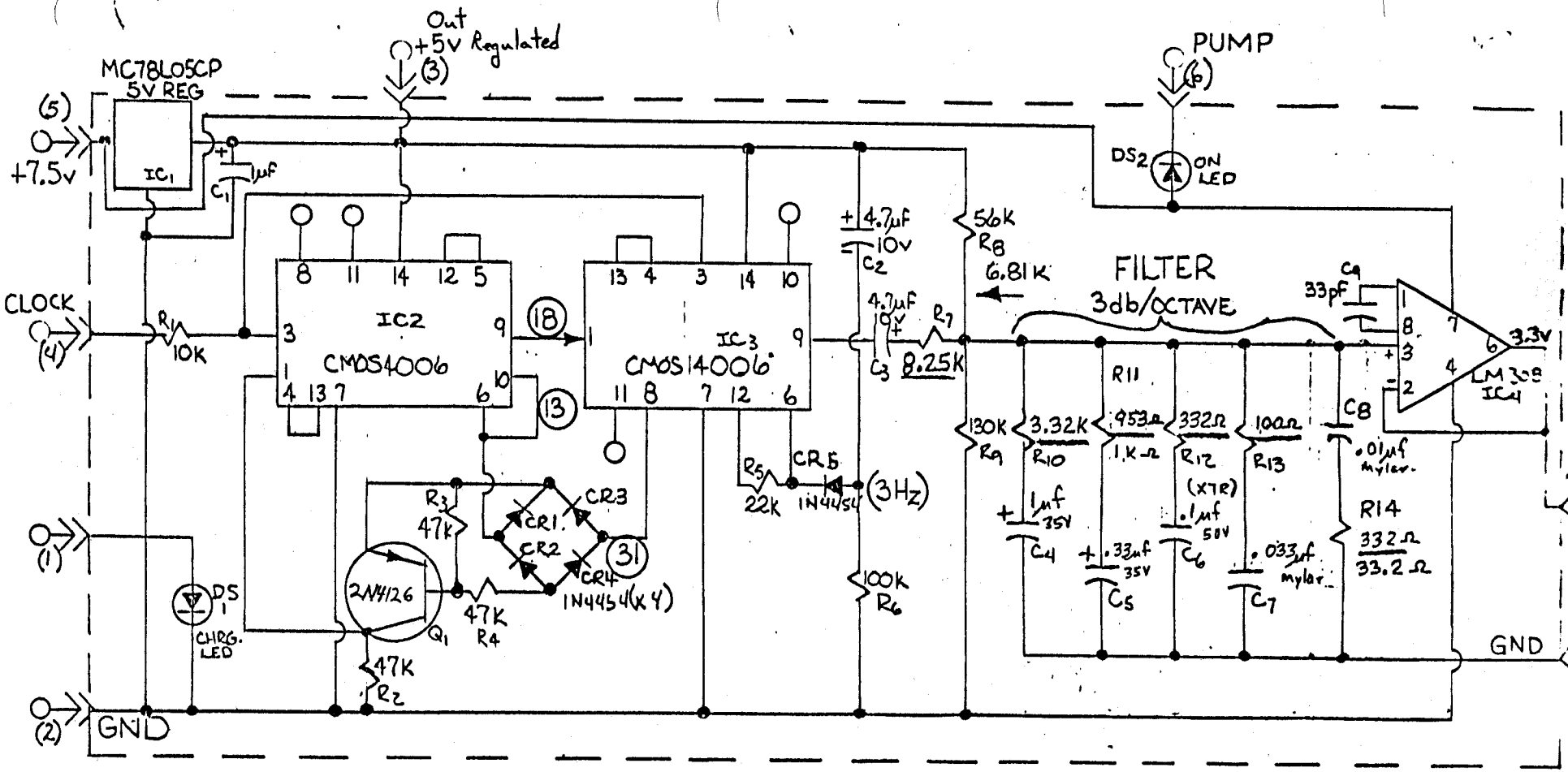
Circuit Side View

IC1 will fail if DC or AC volts is applied to Generators Output.
Several modes of 4558 failure
1. frequency response poor
2. loading 15V supply
3. Clipping Noise Signal

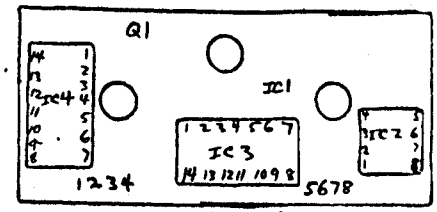
1. ATTENUATOR RANGE: 0dB TO -58dB
2. ATTENUATOR STEPS: 2dB
3. 0dB CALIBRATED TO 1E-10A = 940mv

IVIE ELECTRONICS		
P/N 20P03	CK BY MRB	DRAWING NO S20P03
NVA ATTENUATOR		

08-11-1



PSEUDO-RANDOM WORD LENGTH 2,147,483,647 BITS
CYCLE TIME 2.4 HRS. @ 250 KHz



Circuit Side View

Value Sets

A

R_{11} = 1K ±1%
R_{14} = 33.2Ω ±1%
C_4 = 1µf (-5% to 0)
C_5 = .33µf (-8% to 0)
C_6 = .1µf ±6%

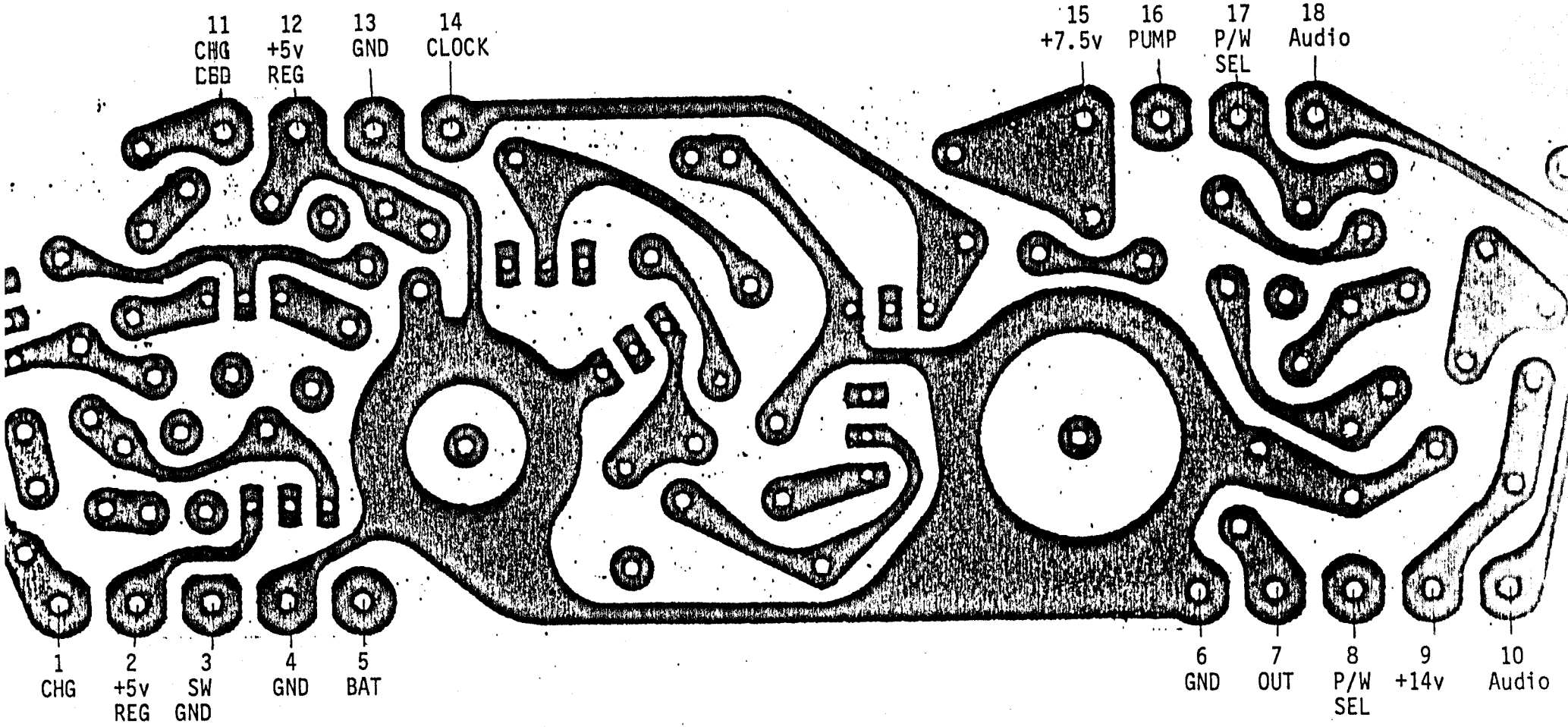
B

R_{11} = 953Ω ±1%
R_{14} = 332Ω ±1%
C_4 = 1µf (0 to +5%)
C_5 = .33µf (0 to +5%)
C_6 = .1µf ±6%

IVIE ELECTRONICS		
P/N 20P02	CHCK. BY: [illegible]	DRAWING NO. S20P02
NGF NOISE GEN FILT		

1-17-80

IE-20B
Power Supply



IE-20A

Power Supply
NPS