The
SIMULATION
COUNCIL
Newsletter

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BITS

Noise is annoying, we all agree. When we don’t want it we often can’t get rid of it; when we want it we might have to generate it (”Take one small child . . .”). Then we must measure it to see what we’ve got. Usually we find it isn’t right so we have to change it. If we finally get it right, how do we use it? If you’d like to know what some authorities have to say on the subject, read Bernie Loveman’s notes under “Pieces.” Also under “Pieces” you will find Norm Irvine’s preliminary report on the organizational meeting of the Central States Simulation Council, and a description (based on info supplied by Stan Rogers) of the last meeting of the DDA Council.

PIECES

EASTERN S/C MEETING OF 16 JULY ON “NOISE IN SIMULATION”

Approximately 58 members representing 28 organizations met at the Princeton Computation Center to attend the ESC meeting of 16 July 1956 on “Noise In Simulation.” Six study groups met during lunch.*

Favreau Defines Noise

Ro Favreau (Princeton Computation Center, Electronic Associates, Monmouth Junction, N. J.) gave an “Introduction to Noise” in which he described its important characteristics.

Noise is a random variable—i.e., given the signal up to a certain time, it is impossible to predict what the signal will be thereafter. One example is the output of a receiver having zero input. In order to consider the statistical properties of noise we must consider an ensemble of such signals—an infinite number of signals produced by receivers operating under identical conditions. The statistical characteristics at a given time may then be defined:

The probability density function is defined as the probability of finding the signal at a specified voltage. The probability is plotted as a function of voltage from minus infinity to plus infinity. The area under this curve must equal one because there is unity probability of finding the signal between the infinite limits.

The cumulative distribution function (CDF) is the probability that the signal lies below a given value; it too is plotted as a function of the voltage from minus infinity to plus infinity.

In general the CDF is bounded by zero at minus infinity and one at plus infinity.

A stationary random signal is one for which the statistical characteristics do not vary as a function of time. In addition, the ergodic hypothesis states that the ensemble averages are the same as the time averages. This is helpful if you have only one receiver available.

Because of the unpredictable nature of noise, a frequency response for the signal is not meaningful. However, the power to be found in a unit frequency interval can be determined. This is called the power spectral density G(f), and for a voltage signal the units are usually volts squared per cycle per second. Note that the power spectral density gives no information on the phase relations between the various frequency components.

Another way to describe the frequency properties of a random signal is by means of the autocorrelation function R(r) which is defined as

$$R(r) = \lim_{T \to \infty} \frac{1}{T} \int x(t)(t + r) dt$$

where x(t) is the random signal.

The spectral density G(f) and the autocorrelation function R(r) are different ways of defining the same property of a random signal.
It may be shown that
\[ G(f) = 4\pi R(\tau) \cos 2\pi f \tau \, d\tau \]
and similarly from the power spectral density
\[ R(\tau) = \frac{1}{2\pi} \int_{-\infty}^{\infty} g(f) \cos 2\pi f \tau \, df. \]

One term which is used rather loosely is "purely random" signal or "white" noise. For this signal a statistical description cannot be given for future points even if all the past history of the signal is specified. The power spectral density of such a signal will be uniform and have infinite bandwidth and therefore infinite energy. Naturally such a signal does not exist. The usual simulation procedure is to assume that the noise generator has a much wider bandwidth than the system to which it is applied. Then the frequency limitations of the noise source will not affect the system output.

In most simulation problems the random signal will have a normal or Gaussian probability density function. This particular distribution,\[ P(x) = \frac{1}{\sqrt{2\pi} \sigma} \exp\left[ - \frac{(x-x_\sigma)^2}{2\sigma^2} \right] \]
where \( x_\sigma \) is the mean and \( \sigma \) is the standard deviation, behaves very nicely with respect to linear systems —i.e., when noise with a Gaussian probability distribution is introduced into a linear filter, the output will also be Gaussian. Note that only two parameters are required (\( x_\sigma \) and \( \sigma \)) to define a normal distribution. Thus with a known Gaussian noise input it is only necessary to determine two parameters to define the statistical output of a linear system.

In measuring the statistical properties of noise there are statistical accuracy limitations as well as measuring equipment errors to be considered. For example, in determining the probability density function, 10 or 20 points will give a rather rough histogram. It takes a very large number of points to get a smooth function. The measurement of the mean of the signal with normal distribution is another example of statistical limitations to accuracy. One way to make the measurement is to integrate the signal. In this case the accuracy of the measurement increases only as one over the square root of the integration time.

**Connolly on a Thyratron Noise Generator**

Tom Connolly (Electronic Associates) described a thyratron noise generator used at the Princeton Computation Center. The original development was done at Hughes Aircraft and is described in Project Cyclone Symposium I, p. 83. The unit is commercially available from Electronic Noise Generator Company, Los Angeles, Calif.

A 2D21 gas thyratron is used as the primary noise source. Its output is amplified, rectified, and integrated to produce a signal to stabilize the power in the frequency band from 30 cps to 3 kc. The noise is then fed to a bandpass filter having a bandwidth of approximately 400 ± 5 cps. A chopper demodulator removes the 400-cps component and is followed by a low-pass filter which removes the higher harmonics. A block diagram of the system is shown in Fig. 1.

The output is monitored by a meter, the movement of which is immersed in a silicon fluid for damping, giving a time constant of several minutes. The output noise has a Gaussian distribution with a power spectral density at low frequencies of approximately \( N_0 = 4 \text{ volts squared per cps} \). The mean value of the noise is less than 50 millivolts. The spectral density is flat ± 0.1 db from zero to 35 cps.

Measurements were made to determine the mean and the power spectral density. The former is measured by integrating the noise generator output for \( T \) seconds. If the integrator output after this time is \( E \) volts, then the mean is:
\[ m = \frac{E}{T} \pm 2\sqrt{N_0/2T} \]

To measure the mean to an accuracy of ± 30 millivolts, the integration time must be four hours. The power spectral density is determined by feeding the noise through a bandpass filter. This output is then squared and integrated. Typical integration time is 1800 seconds. Fig. 2 shows a schematic.

**Hermann on the Goodyear Generator**

Paul J. Hermann (Goodyear Aircraft Corp.) described the Goodyear noise generator. The basic idea is to generate a symmetric square wave for which the zero crossings are random with the duration of pulses having a Gaussian distribution. This signal can be used with analog-computer circuits to generate not only Gaussian but other random-amplitude distributions.

The first noise generator contained a radioactive source, Geiger-Muller Counting Tube, multivibrators, etc. Operating experience showed that the system had disadvantages—(1) low tube life, (2) expensive components, (3) lack of stability.

So they built a noise generator using a gas tube in a permanent magnetic field. Fig. 3 shows a block diagram. The output of the thyratron is amplified and triggers a blocking oscillator; its output is a series of pulses having Gaussian distribution. The multivibrator and feedback loop are used to regulate the mean counting rate. The flip-flop and buffer amplifier control the feedback impedance of the amplifier. Electronic switches 1 and 2 operate alternately. The output of amplifier B is a symmetric square wave; its period has Gaussian distribution.

The noise generator has a uniform
frequency spectrum from 0.01 to 10 radians per second.

Seifert on Servo Evaluation

Bill Seifert (Massachusetts Institute of Technology, Cambridge 39, Mass.) discussed the use of random signals in evaluation of servo performance. Bill pointed out that the standard techniques for evaluating servo performance are (1) frequency-response methods in which amplitude and phase shifts are plotted against frequency, and (2) transient methods, in which the response to step or velocity inputs is measured. However, the input which a servo is normally required to follow is random in character rather than a sinusoid or step. Therefore it is desirable to study high performance nonlinear servos by using random inputs.

Getting a good noise source is difficult. At MIT their gas-tube noise source has the usual long-term drifts. To overcome this the noise was recorded on magnetic tape as it was monitored and adjusted manually to give a stable result. This recorded noise is used for servo measurements.

Also required is a method for measuring the RMS value of the random signal. At MIT they rectify the signal and then pass it through a long time-constant filter. For Gaussian noise the filter output is a measure of the RMS value.

Bill described how the response to a random input may be used to evaluate a servo with simple nonlinearity.*

Rubin on Missile Simulation

Art Rubin (Electronic Associates) described the application of noise generators to a typical simulation of a guided missile. Radar introduces two types of noise in guided missiles: angular noise as a result of multiple reflections from the target, and amplitude noise due to atmospheric disturbances. These random signals are uncorrelated.

Other noise generators are also required because some of the inputs to the system are random variables. These include: (1) initial heading, (2) seeker error, (3) body angle error, (4) gyro uncertainty (amount of drift is a random variable), and (5) target maneuver.

Random signals are required to establish the initial conditions for these variables. The first three initial conditions have correlated values.

Fig. 4 shows how two noise generators may be used for random variables in the pitch plane of a three-dimensional missile problem. A similar circuit is required for the yaw plane.

CENTRAL STATES S/C ORGANIZATIONAL MEETING, 15 OCTOBER 1956

Norm Irvine (Mid-Century Instrument Co.) wrote us: "Today’s organizational meeting of another section of the Simulation Council was a roaring success. The technical session held in the morning (10:00 AM) drew much discussion from the floor and from many individuals, not just a few. More about this later from the secretary."

"Some of the pertinent facts which I can present with reasonable assurance of accuracy are as follows: Elected Officers James A. Pierce—Beech Aircraft, Wichita, Kansas, Chairman of the Steering Committee for 6 months Arthur C. Cotts—Midwest Research Institute, Kansas City, Missouri, Secretary for one year Vice-Chairman and Treasurer, if necessary, to be elected next meeting."

"An elected Steering Committee as follows: Bruce Estes (McDonnell Aircraft, St. Louis, Missouri); L. N. Freeman (Phillips Oil); Jack L. Moon (Kansas State University, Manhattan, Kansas); Harry B. Cordes (Boeing Aircraft, Wichita, Kansas)."

DDA COUNCIL, 15 OCTOBER 1956, ON "STABILITY OF DIGITAL SOLUTIONS"

The DDA Council held their third meeting at Litton Industries in Beverly Hills, Calif. on Monday, 15 October. Some 50 people gathered to hear and participate in a panel discussion, "Stability of Digital Solutions," which was led by Max Palevsky and Roy Kier (both of Bendix Computer). Charts prepared at the University of Pennsylvania and showing effects of various algorithms for integration or solutions were considered.

The group held a short business meeting which resulted in the election of Stan Rogers (Convair-San Diego) as first Chairman of the Steering Committee*. Previously he had been elected Chairman pro tem.

A show of hands on several topics proposed for discussion resulted in "Simulation of Digital Differential

*Stan was the second to be elected to the same position by the original Simulation Council.

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Analyzers on General-Purpose Computers” being the subject of the afternoon session.

A tour of the Litton plant concluded the meeting. Construction of the Litton 20 “a marvel of miniaturization,” was shown, but your editor understands that a “space suit” designed to allow the wearer full mobility under atmospheric pressures as low as 1 mm 10g stole the show. “Just like Buck Rogers!”

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**Information (Without Theory)**

Many of us who are concerned with simulation and related subjects have been interested in the activities of some study groups initiated by the Eastern Simulation Council. Here is a summary of their July 16th luncheon meetings:*

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**Physical Simulation**

Thirteen members representing nine different organizations attended the Physical Simulation study group (H. Wexler). Their discussion included:

1. Simulation of random gusts,
2. simulation of human operator,
3. transducers, and
4. three-axis simulators.

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**Operations Research**

Nine members representing five different organizations attended the Operations Research study group (J. Strong). Three of these organizations—Electronic Associates, Johns Hopkins, and Reeves—have work in O.R. actually in progress. At Johns Hopkins both analog and digital computers have been used to solve O.R. problems. E.A.I. and Reeves have constructed special computers for linear programming and simultaneous equations. The group talked about:

1. The difference between optimization problems that are static (e.g., linear programming) and those that are dynamic;
2. Limitations of analog computers for O.R. problems;
3. Special O.R. analog computers compared to manual calculations.

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**Dead Time Simulation**

Nine members representing seven different organizations attended the Dead Time Simulation study group (B. Loveman), and considered the following techniques:

1. Transfer functions,
2. tape recorders, and
3. electro-mechanical storage elements.

The group discussed the amount of time delay and the response to step and sinusoidal inputs of these units. Also mentioned were the lack of standards for evaluation of time delay specifications and of a good bibliography on the subject.

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**Analog Recorders**

Eight members representing seven different organizations attended the Analog Recorder study group (J. Lehman) and discussed recording on magnetic tape. Both Electronic Associates and Rensselaer Polytechnic Institute have recorded analog quantities in the form of time division pulses. Accuracies of 0.1% have been achieved.

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**Transfer Functions**

Seven members representing six different organizations attended the Transfer Function study group (H. Mori) and discussed the simulation of transfer functions with a minimum number of amplifiers. The group also considered the need for a network to simulate a quadratic transfer function with pole determined by dial settings.

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**Noise Study**

Twelve members representing ten different organizations attended the noise study group (R. Favreau). Discussion centered around the characteristics of noise generators and theoretical results to be expected from those with AGC.

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**SOUTHEASTERN SIMULATION COUNCIL**

Bill Bradley (Murphy and Cota, Atlanta, Ga.), Secretary of the SSC, writes:

“ar Steering Committee Meeting will be held at 11.30 AM, December 5th, at Remond’s Restaurant.

“The Technical Meeting will be held Wednesday night at the ODK Dining Hall, at Georgia Tech. This meeting will begin at 6:30 PM. Subject of this meeting will be ‘Error Analysis in Analog Computations’.

“Our host for this meeting will be Lockheed Aircraft Corp., Georgia Division, Marietta, Ga. Mr. W. C. Bennett will represent Lockheed as host. A tour of the Lockheed Plant for Thursday morning, December 6, from 9:00 until 11:00 AM for all Simulation Council members has been planned.”

* * *

Your Editor and Secretary enjoyed a letter from Fred Dixon (Georgia Institute of Technology, Atlanta, Ga.) which reads in part:

“I can’t help saying here that the described remarkably sudden turn of events to yield a condition assumed by John McLeod in the first place makes one wonder if he isn’t in league with some supernatural agency or force, other than the Air Force. It is of course known that many strange cults exist in California, such as Convair, NAMT, etc., but I would never have believed till now that their high priests could attain such powers of divination or influence. We should probably not delve too deeply into this matter (after all, I have a family) but simply request that you substitute Mr. Prince’s name for mine in the advance registration list . . .”

The next time anyone doubts the veracity of our crystal ball we’re going to show them Fred’s letter!

* * *

**Combined Computation**

As you well know if you have read this strip before, there has of late been much interest in combined analog and digital systems because the two methods complement each other and together are much more powerful than either alone.

Under the general subject “the ABC’s of DDA’s” those attending the next meeting of the DDA Council will learn about another combination of computers which should also offer many advantages: the combination of a General-Purpose Digital Computer and a Digital Differential Analyzer as exemplified by the Bendix GPC & DDA (See ad, p. 1869 September 14). Appropriately enough, Bendix Computer Division, 5630 Arbor Vitae, Los Angeles will be host for this
GEORGIA TECH ADDS AN ANALOG COMPUTER FACILITY

- Convincing evidence that analog equipment not only broadens the scope but also increases the efficiency of a digital computer facility is again corroborated by Georgia Tech.

Engineers of the South's leading engineering and industrial research activity, the Georgia Tech Engineering Experiment Station, found an early need for analog equipment to supplement their extensive digital computer facilities (the Rich Electronic Computer Center) in the solution of physical problems. Analog techniques for real-time solution of problems involving continuous quantities are typically ten to one hundred times faster than digital. When digital machines are required for high-accuracy resolution of such problems, analog equipment can quickly spot critical areas to be given detailed examination.

Georgia Tech's Analog Computer Laboratory had another reason for existence— the training of graduate students in computing theory and technology, an area in which analog concepts are a must.

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meeting in January. Bendix will also have a clinic class on the GPC & DDA at the TIAE.

Want to be Host for a DDA Meeting?

The DDA Council considers itself a national organization, but so far the meetings have all been held on the West Coast. So they would be interested in hearing from any of you elsewhere in the country who have or are interested in Digital Differential Analyzers, especially if you would like to sponsor a meeting of the DDA Council. You can get in touch with Stan Rogers at 3023 Alcott Street, San Diego, Calif.

* * *

Saw Grace Hopper at MIT and was amused by a story she told on herself. Seems she, a renowned mathematician, couldn't balance her check book for three months straight. She sought help from her brother—an investment banker—who, after careful analysis, discovered that she had on various occasions lapsed into binary arithmetic.

Thot

(By Bill Schart, Convair-San Diego)

"The analog computer" to quote Dr. Schart, "is a bunch of morons with hoses transferring water from tank to tank. They are given instructions from the control panel on what each one will do and how fast to work.

"Every morning the morons are given a workout to see if any are missing and if all are able and willing to do the work within their job rating. This is analog checkout."

Computer Events

Southeastern Simulation Council
Date: 5 and 6 December 1956
See detailed description under "Information (Without Theory)"

Central States S/C
Date: 10 December
Time: 10:00 AM
Place: Midwest Research Institute, 425 Volker Boulevard, Kansas City 10, Missouri
Subject: "Function of Two Variables"—All-day session (i.e. until 3 or 4 PM)
Contact: Arthur C. Cotts at the Institute. No Security Clearance required!

NATIONAL S/C MEETING
New York Trade Show Bldg.
Rooms 633 and 635
Wednesday, 28 November
1956

1300—Midwestern Simulation Council Meeting. Milt Warshawsky will set the stage for a discussion of the trend in simulation equipment by describing unique features of the new simulation facility being built for Wright Air Development Center.

1445—Western Simulation Council Meeting Stan Rogers (Convair-San Diego) will put forth ideas on "Simulation and Computer Techniques to Come."

1700—Cocktail Party
No speeches, no planned entertainment—just an opportunity to enjoy tall drinks and tall tales with old friends and new.

Thursday, 29 November
1956

1400—Southeastern Simulation Council Meeting

1445—Eastern Simulation Council Meeting Program will be developed about a discussion of "Simulation of Time Delays."

1700—Business Meeting of the National Simulation Council. A chairman for the Steering Committee of the National Simulation Council must be selected and plans for the next year will be discussed. All who are interested in the Council's work are invited, but only two authorized representatives from each Council will have votes.

Each of the Councils will be responsible for arranging and conducting their regular meetings. All who are interested in the particular subject to be discussed, or in the modus operandi of the Simulation Councils in general, are urged to attend and participate.

Thursday, 29 November

Business meeting of the Eastern Simulation Council at 1545, Reeves Instrument Corporation, 215 East 91st Street, New York, preceded by a tour of the Reeves plant. There will be luncheon meeting of the ESC study groups. Tour is at 9 A.M., business meeting 10 A.M.

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November 1956—Instruments & Automation—Page 2245