Letters to the Editor

Prompt publication of brief reports of NEW ideas in measurement and instrumentation or comments on papers appearing in this Journal may be secured by addressing them to this department. No proof will be sent to the authors. Communications should not exceed 500 words in length. The Board of Editors does not hold itself responsible for the opinions expressed by the correspondents.

Oscillographic Measurements of Probability Distributions

W. F. SCHREIBER
Technicolor Motion Picture Corporation, Hollywood, California
(Received October 25, 1954)

A RECENT article[1] in this journal concerning a method for the rapid measurement of amplitude probability distributions of voltage sources prompts me to call attention to previous publications concerning similar methods. Kretzmer,[2] in his device called the *Probabiloscope*, applied the signal to be measured to the deflection plates of a cathode-ray tube and by use of an extremely ingenious photographic method obtained directly curves of brightness of the trace (probability density) *versus* deflection. Nienburg and Rogers[3] applied the signal to one set of deflection plates of a storage tube for a certain length of time and then measured the stored charge *versus* deflection. Mention should also be made of the technique of gray-wedge pulse-height analysis[4] long used in nuclear physics.

In my own work at Cruft Laboratory, Harvard University,[5] I measured the second-order probability distribution of video signals by applying the two signals in question to the vertical and horizontal deflection plates of a cathode-ray tube, respectively. This resulted in a brightness pattern proportional to the desired probability density. Recording was accomplished by translating the entire pattern in 32 steps each way (1024 readings in all) past an aperture behind which was mounted the search unit of a multiplier photometer. The translation was accomplished semi-automatically by means of solenoid-operated ratchet centering controls on the scope. In a later model, the pattern was optically focused on an aperture, and the translation was accomplished by means of solenoid-operated stepping switches and precision voltage dividers.

As for the suggestion to replace the CRT-phototube combination with a special beam deflection tube, such tubes have been successfully operated for this purpose and will be reported on at a later date.

1 L. W. Orr, Rev. Sci. Instr. 25, 9, 894 (1954).
2 E. R. Kretzmer, Bell System Tech. J. 31, 751 (1952).
3 R. E. Nienburg and T. F. Rogers, Inst. Radio Engrs. National Convention, New York City, March 19, 1951.
4 W. F. Schreiber, Convention Record of the Inst. Radio Engrs., 1953, Part 4, pp. 35–44.
5 W. F. Schreiber, Ph.D. thesis, Harvard University, 1953.

Probability Distribution Measurements with the Oscilloscope

LYMAN W. ORR
Department of Electrical Engineering, University of Michigan, Ann Arbor, Michigan
(Received November 10, 1954)

IN a recent article[1] in this journal, we discussed a simplified method of making wide-band probability distribution measurements with an oscilloscope and phototube. The primary purpose of the article was to assist other laboratories by showing that the method could be quickly and easily executed with existing equipment. However, the display oscilloscope may be replaced with an X-Y recorder, such as the Moseley Autograf thus eliminating the photographic process previously used, and at the same time making a permanent record.

The comments of William F. Schreiber prompt me to mention that to the best of our knowledge, D. F. Winter first conceived of this method prior to 1949 at M.I.T. This was referred to briefly by Knudtzon.[2] At that time, a high-precision method was being sought, without any particular wide-band requirement, and it is presumed that for this reason Winter's method was not developed more fully.

1 Lyman W. Orr, Rev. Sci. Instr. 25, 894 (1954).
2 N. Knudtzon, MIT Tech. Rept. No. 115, July 15, 1949.

Statistics of the Glass-Hurst Pulse Integrating Circuit*

JAMES F. PERKINS
Convair, Fort Worth, Texas
(Received July 9, 1954)

GLASS and Hurst[1] have devised a simple pulse integrating circuit which employs binary scalers connected so that the pulse size required to trigger a given stage is proportional to the count corresponding to that stage, e.g., 1, 2, 4, or 8. The principal virtue of this circuit seems to be its simplicity. Rather than the awkward and bulky anticoincidence circuits which would otherwise have to be used, this circuit employs, at the expense of some increase in statistical uncertainty, only discriminators at the input to each stage. Glass and Hurst have experimentally investigated the resultant increase in σ in a particular case. It is the purpose of this paper to investigate the general case.

Consider first the case of a pulse integrator using the first four stages of a scaler, such as is shown in Fig. 1. With this circuit a pulse of, say, 25 volts will trip the scale of stage 4 and also all preceding stages. Thus, a 25-volt pulse will give an output of $4\pm2\pm1$, where the choice of the signs depends on the previous history of the scaler. By use of anticoincidence circuits it would have been possible to assure that such a pulse would always produce an output count of precisely 4. The order in which pulses arrive may be assumed to be random; hence, a 25-volt pulse is equally apt to give an output count of 1, 3, 5, or 7. The standard deviation, σ_{or} (we use the subscript *or* to indicate that this is the portion of the statistical uncertainty arising from the order in which the pulses arrive) for such a case is given by:

$$\sigma_{or}^2=\langle x^2\rangle-\langle x\rangle^2$$

$$\sigma_{or}^2=\sum_1^n P_i(x_i)^2-\left(\sum_1^n P_i x_i\right)^2.$$

The values of $A_X=\sigma_{or}^2/\langle x\rangle^2$ (where $X=\langle x\rangle$) are tabulated below:

$$A_1=0\quad,$$
$$A_2=0.250,$$
$$A_4=0.312,$$
$$A_8=0.328,$$
$$A_\infty=0.333.$$

If we designate by N_4 the number of pulses which are large enough to trigger all stages up to and including the scale of 4 but no higher stage, etc., and by N the total indicated count, we have

$$N=N_1+2N_2+4N_4+8N_8,$$

$$\sigma_{or}=(\sigma_{or,1}^2+\sigma_{or,2}^2+\sigma_{or,4}^2+\sigma_{or,8}^2)^{\frac{1}{2}},$$

$$\sigma_{or}=(N_1A_1+4N_2A_2+16N_4A_4+64N_8A_8)^{\frac{1}{2}},$$

$$\sigma_{or}=(N_2+5N_4+21N_8)^{\frac{1}{2}}.$$

We designate by σ_{in} the standard deviation resulting from the random nature of the intervals between the pulses. This is just the deviation encountered in ordinary counting circuits and is given by:

$$\sigma_{in,j}^2/N_j=1.$$

The σ_{in} for each stage are independent, of course, so they combine as

$$\sigma_{in}=(\sigma_1^2+4\sigma_2^2+16\sigma_4^2+64\sigma_8^2)^{\frac{1}{2}},$$

since a count of N_j in the j register gives, on the average, a contribution of $j\cdot N_j$ to the integrated count.

Hence,

$$\sigma_{in}=(N_1+4N_2+16N_4+64N_8)^{\frac{1}{2}}.$$

In the case discussed by Glass and Hurst we find from the above equations:

$$\sigma_{or}=107,\ \sigma_{in}=190.$$

The last of these values is the same as that of Glass and Hurst, of course, since it was calculated in the same way. The calculated value of σ_{or} agrees satisfactorily with the value of 92.8 obtained by them experimentally.

The order in which pulses arrive and the intervals between pulses are statistically independent, so that

$$\sigma=(\sigma_{in}^2+\sigma_{or}^2)^{\frac{1}{2}}.$$

The ratio $\sigma/\sigma_{in}=(1+\sigma_{or}^2/\sigma_{in}^2)^{\frac{1}{2}}$ gives a measure of the additional uncertainty introduced by omission of anticoincidence circuits.

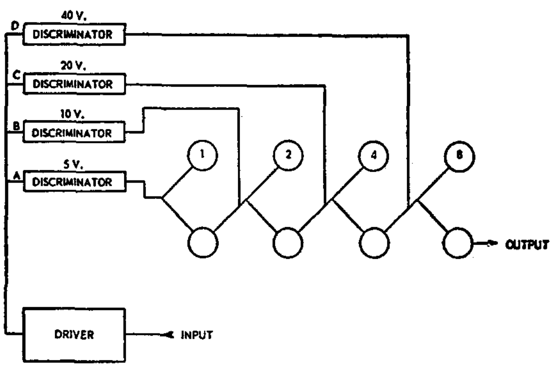

FIG. 1. A simple method of pulse integration from Glass and Hurst's paper.

In the case treated by Glass and Hurst $N_1=N_2=N_4=N_8$ and $\sigma/\sigma_{or}=1.148$. Even in the limiting, most unfavorable case we have $\sigma/\sigma_{or}=(1+A_\infty)^{\frac{1}{2}}=(4/3)^{\frac{1}{2}}=1.155$, and it would require only 1.33 times as many counts on the present circuit to get a given statistical uncertainty as it would take on a similar integrator equipped with anticoincidence circuits.

The total standard deviation σ is

$$\sigma=(\sigma_{or}^2+\sigma_{in}^2)^{\frac{1}{2}}=(N_1+5N_2+21N_4+85N_8)^{\frac{1}{2}},$$

$$\sigma/(N)^{\frac{1}{2}}=[(N_1+5N_2+21N_4+85N_8)/(N_1+2N_2+4N_4+8N_8)]^{\frac{1}{2}}.$$

The foregoing treatment concerned only a single scaler, but all of the equations apply with equal force to a case in which the output of several scalers is summed, the N's being defined as

$$N_1=M_1+M_1'+M_1''\cdots$$

$$N_2=M_2+M_2'+M_2''\cdots,\text{ etc.},$$

where the M's and M''s refer to the individual scalers. For instance, M_2 is the number of pulses just large enough to trip the scale of 2, but not the scale of 4, of the first scaler.

In the commercial model of this circuit there are two scalers used in the integrating circuit, each of which drives a scale-of-64 tandem scaler which in turn drives a mechanical register. The input connections from the discriminators to the separate stages are cabled; hence for a given spectrum shape N_4, for instance, can easily be determined simply by disconnecting all these cables except the two driving the scales-of-four. From the above equations, then, one can determine $\sigma/N^{\frac{1}{2}}$. Having performed this calibration the standard deviation for the case of a spectrum that does not differ too markedly from that used for calibration can be determined from the integrated count. It will be observed that the value of $\sigma/N^{\frac{1}{2}}$ is rather sensitive to N_8, i.e. to the shape of the high energy end of the pulse spectrum.

From the plot of the typical neutron spectrum given by Glass and Hurst, one gets approximately

$$\sigma/N^{\frac{1}{2}}=2.15,\quad \sigma/\sigma_{in}=1.11.$$

* Work performed under contract with the Wright Air Development Center of the U. S. Air Force.

[1] F. M. Glass and G. S. Hurst, Rev. Sci. Instr. 23, 67 (1952).

Laboratory and Shop Notes

BRIEF contributions in any field of instrumentation or technique within the scope of the journal can be accorded earlier publication if submitted for this section. Contributions should in general not exceed 500 words, and no proof will be shown to the authors.

Analysis of Diffraction Pattern Observed by Microscopy

SHIGETO YAMAGUCHI
Scientific Research Institute, Ltd., Hongo, Tokyo, Japan
(Received October 20, 1954)

THE double camera method in electron diffraction[1] was applied for analysis of the diffraction patterns observed by microscopy. One microscope (a) and one diffraction apparatus (b) were connected to a common terminal of a high-tension source supplying the two (see Fig. 1). In this way the electrons in the two instruments were of the same wavelength. The microdiffraction pattern in apparatus (a) and the diffraction pattern in (b) were photographed simultaneously. Throughout the present experiment, the positions of the specimens in the two instruments and the current flowing in the final projector coils in (a) were kept constant.

Figure 2 is the microdiffraction pattern of a gold leaf observed

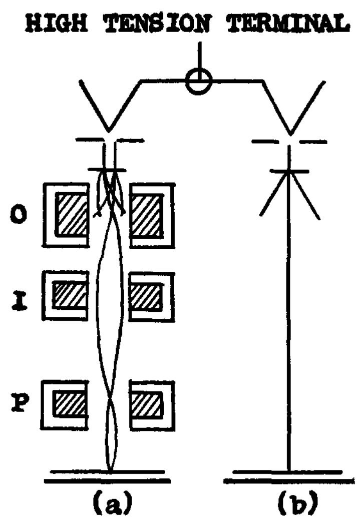

FIG. 1. Here a microscope (a) and a diffraction apparatus (b) are connected to a common terminal of a high-tension supply. O, objective. I, intermediate lens. P, final projector. The positions of the specimens in (a) and (b) and the current flowing in P are kept constant.