THE USE OF THE PROGRAMMED
DISTRIBUTION GENERATOR

D. N. SAMSKY

SEPTEMBER 1, 1967

AEC RESEARCH &
DEVELOPMENT REPORT

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PACIFIC NORTHWEST LABORATORY

RICHLAND, WASHINGTON

operated by

BATTELLE MEMORIAL INSTITUTE

for the

UNITED STATES ATOMIC ENERGY COMMISSION UNDER CONTRACT AT(45-1)-1830

PRINTED BY/FOR THE U. S. ATOMIC ENERGY COMMISSION

3 3679 00060 6337

BNWL-494

UC-37, Instruments
(TID-4500)

THE USE OF THE PROGRAMMED DISTRIBUTION GENERATOR*

By

D. W. Samsky**

Radiological Sciences Section
Environmental and Radiological Sciences Department

September 1, 1967

FIRST UNRESTRICTED
DISTRIBUTION MADE

AUG 29 '67

- * Work performed under Contract AT(45-1)-1830 between the United States Atomic Energy Commission and the Pacific Northwest Laboratory of the Battelle Memorial Institute.
- ** Present address, Booz-Allen Applied Research, Inc. Albuquerque, New Mexico.

THE USE OF THE PROGRAMMED DISTRIBUTION GENERATOR

The Programmed Distribution Generator (PDG) consists of an interface, a flexible program, and the PDP-8 analyzing system. Table 1 defines the meaning of the terms, sub-event, event, and run as used in this and other reports. It also relates the corresponding definitions used in the program and gives the operations in the P(Z) generator a physical interpretation. The operation of the PDG requires a random input pulse, an arbitrary input distribution. The input to the interface is a random pulse, 1/2 microsecond wide and 150 millivolts negative, with an average frequency from a few to 10^5 per second, corresponding to an average number of sub-events per event of from 0.001 to 30.0. Care should be taken to minimize the dead time after a pulse has passed. Usually 2 microseconds is sufficient, but for higher counting rates a dead time of 1 microsecond or less should be used.

The interface, shown logically and schematically in Appendix A, consists basically of two 12-bit registers, a clock, an inhibit circuit and break request and event complete signal generators. The registers are used as inputs to the PDP-8's data break facility. The location register is reset to 4000_8 and the value register to 6000_8 . A break request, initiated by the input pulse, transfers the contents of the value register into the memory location specified by the location register. The clock is scaled into the value register and the location register is incremented by one each time a break request has been completed. When the value register reaches 6400_8 , an event complete pulse is generated. The inhibit circuit, which stops the clock and prevents

additional break requests, is enabled by a break request or the event complete pulse and is disabled by a break request complete or a program-controlled reset pulse. In this way, input pulses have an equal probability of transferring the 400_8 different values in the value register to the PDP-8.

The input distribution to the PDG program is any function that can be stored in region 2 (to use DODAD language) in double precision. Thus a histogram of up to 400 channels and less than 1.6×10^7 counts can be used. The program is based upon the DODAD program and consisting of two nearly independent parts. The first is the PDG function generator, the second is the distribution generator. The additional commands available are summerized in Appendix B at the beginning of the program listing. A logical flow chart is included to aid in understanding the program.

The command "CP" initiates the PDG function generator. It takes the initial function in region 2, integrates it and normalizes it to a maximum value of 256 in region 1, and inverts the ordinate and abscissa in region 3. The result is the PDG function, a histogram of 256 channels with less than 3200 counts. The 3200 counts represent the 400 initial channels plus a gain factor of eight. Regions one and two should be cleared following this command.

The second part, the distribution generator, uses the PDG function and the PDG interface to generate the desired function. The command "C9" will produce a direct one to one correspondence with the original function if the average number of sub-events per event is much less than one.*

*C9 means a gain of 2^9 so that with the built-in gain of 2^3 and reduction ratio of 2^{12} , the result is the complete original value.

Commands of less than "C9" (i.e., "C8", "C7", "C6", etc.) allow the energy scale to be expanded in multiples of two. To continue a run, interrupted by a use of the rub-out key, the command "CC" should be used.

The program normally spins and tests for non-zero values in the second region. A non-zero value means that a sub-event has occurred at a time specified by its value. Successive sub-events are placed in successive channels to avoid pile up. A sub-event is analyzed by looking up the appropriate energy deposition for that sub-event and storing that value. At the end of an event the sum of the energy depositions are treated like a pulse with zero height. The resulting pulse height analysis is stored in region one. At the end of 65,536 events, one run, the average number of sub-events is printed out. The number of events per run can be modified by changing the values of "NUM" and of "CH" according to Table 2. The program may be set to take "data" continuously by changing the last statement executed before exiting: change "JMP CONTIN" (location 7265) to "JMP BGN + 3" (octal value 5311).

TABLE 1

DEFINITION OF TERMS

Program	Paper		Physical Interpretation
Event	Sub-event	- one transfer of a value to the PDP-8 via data break.	One ionizing event
Case	Event	- a set of sub-events; PHA is performed on the sum of the set.	A sum of ionizing events
Run	Run	a number of events after which an average number of sub-events per event is printed.	A pulse height spectrum

REFERENCES:

- (1) D.N. Samsky
 "A Programmed Distribution Generator"
 BNWL 494 (Annual Report for 1966)

TABLE 2

Channel (octal)	7232	7351	
<u>Number of Events Per Run in Powers of 2</u>	<u>NUM Octal Value</u>	<u>CH Octal Value</u>	<u>Approximate Running Time in Minutes</u>
13	0000	7776	1/8
14	0001	7774	1/4
15	0002	7770	1/2
16*	0003	7760	1
17	0004	7740	2
18	0005	7700	4
19	0006	7600	8
20	0007	7400	16
21	0010	7000	32
22	0011	6000	64
23	0012	4000	128

*normally set at this value.

PDG WIRING LIST

From Circuit	To MPIX	Function
D16R(IN)	Random Source	Trigger Circuit
A25U	B27U	ADD ACC-2
D17H	B22D	BRK REQ-2
D32S	C17L	DI-IN-2 bit 0
32H	18L	1
31S	19L	2
31H	20L	3
30S	21L	4
30H	22L	5
29S	23L	6
29H	24L	7
28S	25L	8
28H	26L	9
27S	27L	10
27H	28L	11
26S	1L	DI-ADD2 bit 0
26H	2L	1
25S	3L	2
25H	4L	3
24S	5L	4
24H	6L	5
23S	7L	6
23H	8L	7
22S	9L	8
22H	10L	9
21S	11L	10
21H	12L	11
MPLX	MPLX	
B13V	B13C	Ground Input to Inverter(-3V)
B13U	C13L	-3V cyc sel (one cycle)
B13U	C30L	-3V DI In-out (data IN)
C29C	C29L	+0V + ICAIN#

PDG Registers

PDG Wiring Diagram

Appendix A

Transistors are 2N3640

Diodes are 1N4

Appendix B

/THIS PROGRAM ,A BINARY ADDITION TO DODAD,
 /HAS BEEN WRITTEN TO USE DOUBLE PRECISION
 /SPHERICAL PROPORTIONAL COUNTER DATA THAT
 /HAS BEEN STORED IN REGION 2.
 /THE NEW COMMANDS ARE AS FOLLOWS:
 /CP CALCULATE THE P(Z) GENERATING FUNCTION.
 /CX START A NEW P(Z) RUN. THE
 / INTEGER X IS THE BINARY GAIN FACTOR
 / OF THE GENERATOR.
 /CC CONTINUE THE OLD P(Z) RUN.
 /CM ZERO THE M SIDE CLOCK AS IN DODAD.
 / THE COMMAND CF IS DELETED.

/DEFINTIONS

SEC=6371 /SKIP ON END OF CASE
 SRG=6372 /SET REGISTERS
 SBR=6374 /SET BREAK REQUEST

/PREVIOUSLY DEFINED TERMS

ADRSC6	=0156	/TABLE3+7
BELLS	=0577	/0207
CMAND	=0165	/CMMAND
CONST6	=0137	
CONST7	=0140	
CONTIN	=0020	
CRLF	=0050	
EQUAL	=0063	/0275
HIGH	=0124	
HOLD1	=0122	
LOW	=0125	
MASK10	=0113	/1777
MASK15	=0110	/0017
MINUS4	=0104	/7774
OUTPUT	=0162	/PNTDEC
PRINT1	=0041	
P2THOU	=0102	/2000
READ	=0024	
SPACE	=0065	/0240

/PAGE 0

		*0014	
0014	0000	INDEX3,	0
0015	0000	INDEX4,	0
0016	0000	INDEX5,	0
0017	0000	INDEX6,	0

/PAGE 2

		*0400	
0400	4024	CLOCK,	JMS READ
0401	1122		TAD HOLD1
0402	1214		TAD MPP /IS IT P(Z) GENERATOR
0403	7450		SNA
0404	5615		JMP I POZ
0405	1216		TAD MM /IS IT M CLOCK RESET
0406	7450		SNA
0407	5747		JMP I MCK
0410	1350		TAD MC /IS IT CONTINUE OLD RUN
0411	7450		SNA
0412	5751		JMP I OLD
0413	5752		JMP I NEW /START A NEW RUN
0414	7460	MPP,	7460
0415	7001	POZ,	PBN
0416	0003	MM,	0003

		*0547	
0547	1572	MCK,	1572
0550	0012	MC,	0012
0551	7316	OLD,	INT-1
0552	7306	NEW,	BGN

/PAGE 6

		*1572	
1572	6324	6324	/MCE
1573	1175	1175	/TAD CLKCM1
1574	3536	3536	/DCA I SETTING
1575	1176	1176	/TAD CLKCM2
1576	3062	3062	/DCA CLKM2
1577	5020	5020	/JMP CONTIN

		*7001		
7001	7300	PBN,	CLA CLL	
7002	3124		DCA HIGH	
7003	3125		DCA LOW	
7004	1362		TAD M400	
7005	3345		DCA COUNT	
7006	1352		TAD P1777	
7007	3014		DCA INDEX3	
7010	1353		TAD P3157	
7011	3015		DCA INDEX4	
7012	1354		TAD P3777	
7013	3016		DCA INDEX5	
7014	1355		TAD P5157	
7015	3017		DCA INDEX6	
7016	1416	CON,	TAD I INDEX5	/INTEGRATE IN DOUBLE
7017	1125		TAD LOW	/PRECISION REGION 2
7020	3125		DCA LOW	
7021	1125		TAD LOW	
7022	3414		DCA I INDEX3	
7023	7004		RAL	
7024	1417		TAD I INDEX6	
7025	1124		TAD HIGH	
7026	3124		DCA HIGH	
7027	1124		TAD HIGH	
7030	3415		DCA I INDEX4	
7031	2345		ISZ COUNT	
7032	5216		JMP CON	
7033	7100		CLL	
7034	1125		TAD LOW	
7035	7401		MOL	
7036	1124		TAD HIGH	
7037	7413		SHL	
7040	0000		0000	
7041	2345		ISZ COUNT	
7042	7420		SNL	
7043	5237		JMP --4	
7044	7010		RAR	
7045	3267		DCA DVD	
7046	1345		TAD COUNT	
7047	1357		TAD P7776	
7050	3265		DCA NROT	
7051	1362		TAD M400	
7052	3345		DCA COUNT	
7053	1352		TAD P1777	
7054	3014		DCA INDEX3	
7055	1353		TAD P3157	
7056	3015		DCA INDEX4	
7057	1352		TAD P1777	
7060	3016		DCA INDEX5	
7061	1414	NORM,	TAD I INDEX3	/NORMALIZE DATA TO A
7062	7421		MOL	/MAXIMUM OF 256 COUNTS
7063	1415		TAD I INDEX4	
7064	7413		SHL	
7065	0000	NROT,	0000	
7066	7407		DVI	
7067	0000	DVD,	0000	

7070	7200		CLA	
7071	7420		SNL	
7072	7501		MQA	
7073	7012		RTR	
7074	7012		RTR	
7075	0351		AND P777	
7076	3416		DCA I INDEX5	
7077	2345		ISZ COUNT	
7100	5261		JMP NORM	
7101	7340		CLA CLL CMA	
7102	3346		DCA PP	
7103	7201		CLA IAC	
7104	3347		DCA MP	
7105	1352		TAD P1777	
7106	3014		DCA INDEX3	
7107	1356		TAD P5777	
7110	3015		DCA INDEX4	
7111	1361		TAD M256	
7112	3344		DCA CT	
7113	1414	IX,	TAD I INDEX3	/SLOPE INVERTER
7114	1347		TAD MP	/CHANNEL <> NUMBER
7115	7450		SNA	
7116	5313		JMP IX	
7117	3350		DCA TEMP	
7120	1350		TAD TEMP	
7121	7041		CIA	
7122	3345		DCA COUNT	
7123	1350		TAD TEMP	
7124	1346		TAD PP	
7125	3346		DCA PP	
7126	1346		TAD PP	
7127	7041		CIA	
7130	3347		DCA MP	
7131	1014	IMX,	TAD INDEX3	
7132	0351		AND P777	
7133	7104		CLL RAL	
7134	7006		RTL	
7135	3415		DCA I INDEX4	
7136	2344		ISZ CT	
7137	5341		JMP .+2	
7140	5020		JMP CONTIN	/RETURN
7141	2345		ISZ COUNT	
7142	5331		JMP IMX	
7143	5313		JMP IX	
7144	0000	CT,	0	
7145	0000	COUNT,	0	
7146	0000	PP,	0	
7147	0000	MP,	0	
7150	0000	TEMP,	0	
7151	0777	P777,	0777	
7152	1777	P1777,	1777	
7153	3157	P3157,	3157	
7154	3777	P3777,	3777	
7155	5157	P5157,	5157	
7156	5777	P5777,	5777	
7157	7776	P7776,	7776	
7160	7777	P7777,	7777	
7161	7377	M256,	7377	
7162	7160	M400,	7160	

```

*7200
7200 1361 NEXT, TAD LEAST /ROTATE FOR "GAIN"
7201 7421 MQL
7202 1360 TAD MOST
7203 7413 SHL
7204 0000 RO, 0
7205 0113 AND MASK10
7206 1102 TAD P2THOU
7207 3274 DCA PLHT
7210 2674 ISZ I PLHT /PULSE HEIGHT ANALYSIS
7211 5213 JMP FIN
7212 5266 JMP OUTE
7213 1363 FIN, TAD START /SUM ON THE NUMBER OF EVENTS
7214 7161 CIA CLL CML
7215 1362 TAD R
7216 1357 TAD NLOW
7217 3357 DCA NLOW
7220 7430 SZL
7221 2356 ISZ NHIGH
7222 2355 ISZ CLOW /SUM THE NUMBER OF CASES
7223 5317 JMP INT
7224 2354 ISZ CHIGH
7225 5317 JMP INT
7226 1357 OUT, TAD NLOW /N=THE AVERAGE NUMBER OF COUNTS
7227 7421 MQL /PER CASE.
7230 1356 TAD NHIGH /NORMALLY 2+16 CASES.
7231 7417 LSR
7232 0003 NUM, 0003
7233 0275 AND P377
7234 3356 DCA NHIGH
7235 7405 MUY
7236 1750 1750
7237 3357 DCA NLOW
7240 1277 TAD MINUS3
7241 3137 DCA CONST6
7242 1300 TAD ADRSC8
7243 3140 DCA CONST7
7244 3124 DCA HIGH
7245 1304 TAD NN /PRINT N=XXX.XXX
7246 4041 JMS PRINT1
7247 1063 TAD EQUAL
7250 4041 JMS PRINT1
7251 1301 TAD NOSP
7252 3703 DCA I PDC
7253 1356 TAD NHIGH
7254 3125 DCA LOW
7255 4562 JMS I OUTPUT
7256 1305 TAD POINT
7257 4041 JMS PRINT1
7260 1357 TAD NLOW
7261 3125 DCA LOW
7262 1302 TAD YESSP
7263 3703 DCA I PDC
7264 4562 JMS I OUTPUT
7265 5020 JMP CONTIN
7266 1274 OUTE, TAD PLHT /DOUBLE PRECISION OVERFLOW
7267 1271 TAD P1160
7270 5207 JMP RO+3
7271 1160 P1160, 1160

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7272	0000	CONT1,	0
7273	0000	CONT2,	0
7274	0000	PLHT,	0
7275	0377	P377,	0377
7276	0037	P37,	0037
7277	7775	MINUS3,	7775
7300	1067	ADRSC8,	1067
7301	5600	NOSP,	5600
7302	1104	YESP,	1104
7303	1020	PDC,	1020
7304	0316	NN,	0316
7305	0256	POINT,	0256
7306	1350	BGN,	TAD CCC
7307	0110		AND MASK15
7310	3753		DCA I ROT /NUMBER OF GAIN FACTORS OF 2
7311	1351		TAD CH /NORMALLY 2+16 CASES
7312	3354		DCA CHIGH
7313	3355		DCA CLOW
7314	3356		DCA NHIGH
7315	3357		DCA NLOW
7316	4050		JMS CRLF
7317	6031	INT,	KSF /KEYBOARD BUSY?
7320	5022		JMP .+2
7321	5565		JMP I CMAND/YES:
7322	6376		SRG SBR
7323	7300		CLA CLL
7324	3360		DCA MOST
7325	3361		DCA LEAST
7326	1363		TAD START
7327	3362		DCA R
7330	1762	TEST,	TAD I R
7331	7440		SZA /DID AN EVENT HAPPEN?
7332	5036		JMP CALC /YES:
7333	6371		SEC /ARE WE DONE?
7334	5330		JMP TEST
7335	5200		JMP NEXT /YES:
7336	7100	CALC,	CLL
7337	3352		DCA T
7340	1752		TAD I T
7341	1361		TAD LEAST /UP DATE CASE
7342	3361		DCA LEAST
7343	7430		SZL
7344	2360		ISZ MOST
7345	3762		DCA I R /ZERO REGISTER
7346	2362		ISZ R
7347	5330		JMP TEST /GO ON TO NEXT EVENT
7350	0302	CCC,	0302 /"C" -1
7351	7760	CH,	7760
7352	0000	T,	0
7353	7204	ROT,	RO
7354	0000	CHIGH,	0
7355	0000	CLOW,	0
7356	0000	NHIGH,	0
7357	0000	NLOW,	0
7360	0000	MOST,	0
7361	0000	LEAST,	0
7362	0000	R,	0
7363	4000	START,	4000

ADRSC6	0156
ADRSC8	7300
BELLS	0577
BGN	7306
CALC	7336
CCC	7350
CH	7351
CHIGH	7354
CLOCK	0400
CLOW	7355
CMAND	0165
CON	7016
CONST6	0137
CONST7	0140
CONTIN	0020
CONT1	7272
CONT2	7273
COUNT	7145
CRLF	0050
CT	7144
DVD	7067
EQUAL	0063
FIN	7213
HIGH	0124
HOLD1	0122
IMX	7131
INDEX3	0014
INDEX4	0015
INDEX5	0016
INDEX6	0017
INT	7317
IX	7113
LEAST	7361
LOW	0125
MASK10	0113
MASK15	0110
MC	0550
MCK	0547
MINUS3	7277
MINUS4	0104
MM	0416
MOST	7360
MP	7147
MPP	0414
M256	7161
M400	7162
NEW	0552
NEXT	7200
NRIGH	7356
NLOW	7357
NN	7304
NORM	7061
NOSP	7301
NROT	7065
NUM	7232
OLD	0551
OUT	7226

OUTE	7266
OUTPUT	0162
PBN	7001
PDC	7303
PLHT	7274
POINT	7305
POZ	0415
PP	7146
PRINT1	0041
P1160	7271
P1777	7152
P2THOU	0102
P3157	7153
P37	7276
P377	7275
P3777	7154
P5157	7155
P5777	7156
P777	7151
P7776	7157
P7777	7160
R	7362
READ	0024
RO	7204
ROT	7353
SBR	6374
SEC	6371
SPACE	0065
SRG	6372
START	7363
T	7352
TEMP	7150
TEST	7330
YESSP	7302

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