December 22, 1958

MEMO TO: Erich Bloch

SUBJECT: Sigma Divide Simulation

As a result of consultation with Joseph Stewart and Charles Freiman, it was decided that a simulation of the Sigma Floating Point Divide would provide needed verification of theoretical conclusions. This decision was later supported by E. Bloch and specifications and a general block diagram were drawn up to serve as an outline from which a 704 program might be constructed. On or about July 21, 1958, the 704 programming group was given the responsibility for the writing and obtaining results from the program. Werner Schanzenbach was chosen as the programmer. Concurrent with this effort was a similar one by the author - since this particular program was written and debugged during of-hours and consisted, in part, of different approaches from the Schanzenbach program, it was considered a reasonable effort to pursue and was later used as a check. A full description of the Sigma Divide method is outside the scope of this report and it is assumed the reader has a general familiarity with the method. The following report is merely a brief explanation of those parts of the simulation programs that would be considered of special interest to those seeking a more complete understanding of the simulation program differences and simularities with the original Sigma Divide Scheme.

H. G. Kolsky

H. Kolsky,

Erich Bloch suggested you might
like to look at this.

F. Bielawa

The information given at the end of this report is that obtained from only a partial reduction of the available data. The original data requirements covered the information needs of both J. R. Stewart and C. Freiman and at this point, only that of interest to J. Stewart has been presented. When further arrangements can be made to discuss the data with C. Freiman, an additional report can be given on the information peculiar to his needs.

Operands

1. Dividend

   a. Generation

In the B program, use was made of an existing library sub-routine known as PE RANG. This routine generates pseudo-random numbers modulo N, by an extended "middle of the square" method. It was found that the routine was incapable of producing one of the possible full length (35 bit) numbers, namely $2^{36}-1$, and a modification was made to restore this number. Since a 48 bit dividend was required, two 35 bit random numbers were used together and were carried in two storage cells (A word contained 35 bits, B contained remaining 13 bits.)

The S program made use of similar techniques in the generation of random numbers and construction of operands. A major difference was evident, though, in the actual method of random number generation. While the library sub-routine used in B program consisted of essentially a "middle of the squares" method, it was modified by the random selection of one of 16 preset random multipliers which, during each routine cycle, operated on the previously generated random number - the S program only used the "middle of the square of the previously generated random number. It should be noted that both of the generators are assumed non-degenerate and non-cyclic for at least the first one million numbers.

While a thorough test of the randomness of either sub-routine was not attempted, a test of the library sub-routine used in the B program was made of the positional probability of each of the 35 bits of 100,000 numbers. The occurrence of a 1 in each position is listed in included print-out and generally exhibits the expected probability of 1/2. This, of course, only indicates that of n samples, approximately n/2 of them were 1's. This does not imply anything about the joint probability of two or more bits.

b. Normalization:

Normalization in the B program occurs immediately after 70 bits of dividend are formed. The entire 72 bits are shifted left until a 1 is encountered - 0's are inserted in vacated positions on right. At this point, the right most 22 positions (of the 70) are masked out which yields desired 48 bit number. Radix point is considered at the left.

Normalization in the S program is accomplished by simply placing a 1 in the left most position of the 48 bit random dividend. While this method is faster, the above more closely approximates the actual method of normalization.

2. Divisor:

a. Generation & Mask:

In the B program, the same generator as mentioned above is used to generate 70 additional bits of random divisor, right most 22 positions (of the 70) are masked out which yields required 48 bit number. Since it is desired to restrict divisors to specific ranges, the first 5 high order bits are masked and 5 new bits ranging incrementally from 10000 to 11111 are inserted. This then allows for 16 ranges of divisors with 2^{43} possible divisors in each range without repetition.

Generation and masking of the divisor in the S program is accomplished in the same manner as in B program.

b. The 3/4 divisor multiple required is obtained by adding (1/4 + 1/2) divisor. There is no overflow for maximum value. To obtain 3/2 divisor, the number obtained for 3/4 divisor is shifted left 1 position. Overflow may occur and is lost. The 3/4 divisor multiple in S program is obtained as in B program. The 3/2 divisor is obtained by shifting left one position. In this case, the overflow is retained.

3. Subtraction

a. In both the S & B programs a complement number is formed and carried as a 2's complement number. This was necessitated by the fact that each "add-complement" operation consisted essentially of a double-precision subtraction and the 704 Add-Subtract operation would, because of its inherent character of representing a number as a sign and absolute value, present logical problems when performing double precision operations.

b. Detection of Complement Result

In the B program, the radix point for the divisor and dividend are always considered to be to the left of the left most digit. The radix point of the result of an add-type operation is put in same relative position as that of operands. It is characteristic of this program to perform the add-type operation only on the digits to right of radix point. This means that add operations will involve 48 bit operands in the basic scheme and up to 50 bit operands in the Multiple scheme. The overflow bits to the left of radix point, incurred in the case of adding 3/2 x divisor are ignored during an add-type operation. In the Basic scheme, the carry out of the first position to right of radix point indicates sense of result after add operation - 0 indicates complement result; 1 indicates true. In the Multiple scheme, the status of the first position to right of radix point indicates sense of result for add operations (of any of the possible operands) - 0 indicates true result, 1 indicates complement. This latter complementation detect method is well known and was used in this program for the sake of uniform computer functioning and has been verified by successful use in the program.

In the S program, the radix point for the divisor (1X) is considered as two positions to left of highest order bit. The radix point for 3/2 and 3/4 divisor as well as that of the result of add-type operations is placed in same relative position to that of 1x divisor. Complement detection is accomplished in either scheme by means of sensing the carry out of the position left of radix point-where a 1 indicates true result and 0 indicates complement.

Rounding Procedure:

The time both programs were written it was felt that the divide operands should consist of a 48 bit divisor and a 96 bit number or actual dividend which consisted of 48 bits of original dividend and an additional 48 or 49bits which would produce a rounded quotient. It was decided that initially the divisor would be subtracted from the 48 bit original dividend and the sense of the result would be detected. If this operation produced a true result, the divisor would be placed to right of first partial remainder with no separation, forming 96 bits of actual first partial remainder. If the result was complement the divisor would be placed to right of first partial remainder with a one position separation, this position being made 0 forming 97 bits of actual first partial remainder.

Normal Cycle Operation:

It is beyond the purpose of this report to describe the exact operation of either divide method. It is sufficient to state that both programs, when executing a problem solution by means of the Basic scheme, duplicate the actual machine operations after the initial subtraction; the program continues by shifting across on similar leading bits of partial remainder (normalization) and performing on add-type operation when normalization is complete. This cycle is repeated until problem terminates. The quotient is concurrently generated and its construction is dependent on the type of normalization and the result of each add operation.

Likewise, in both programs, when executing a problem solution by means of Multiple scheme, actual machine behavior is also duplicated in that after the initial subtraction, the program continues by shifting across on similar leading bits of partial remainder (normalization) and performing an add-type operation when normalization is complete. In this case, the rules of quotient construction and divisor (multiple) selection are those illustrated in chart by J. R. Stewart dated July 28, 1958. The cycle is repeated until problem terminates.

It is of interest to note that the S program considered the Basic scheme normal cycle operation rules as a subset of the Multiple normal cycle operation set.

Termination:

The termination cycle, which is a function of the rounding operation, is handled in the same manner as actual machine termination. The rules for adjusting both quotient and remainder are derived from those stated in Notebook #3514 by J. R. Stewart (page 28). Since the Multiple scheme reverts to Basic-type cycles when 3 or less quotient bits remain to be generated, the termination rules are the same for both schemes. Both programs terminate identically.

Checking:

In order to insure proper operation of simulated divide schemes, a method for checking the problem results, i. e. the quotient, was devised for the B program. After each Basic scheme problem solution, the generated quotient was multipled by the original divisor to produce a double length product; the high order 48 bits of which should have been the original 48 bit dividend. This reconstructed dividend was then compared, bit wise, with original dividend and computer was stopped when a dis-similarity was detected. This obviously, neglected to compare the round portion of 96 bit actual dividend but it was felt that this particular check would catch all the probable errors. After a successful run through all problems in the Basic mode, the checking device was then replaced with another that essentially only compared the results, from a given set of operands, that were produced by operation in Basic and Multiple mode. Since the Basic scheme results were proven correct, they served as a standard for Multiple mode results.

The S program undertook to check results also and it is understood that much the same method was used as that given above with the exception that, additionally, the "round" portion of reconstructed actual dividend was checked.

In both programs, it was assumed that the statistical data obtained during the course of problem solutions would be accurate if the above test procedures indicated correct solutions .

Data Collection:

In the B program, data was collected for 1024 problems (a problem is defined as the generation of a 48 bit quotient from two 48 bit operands) in each of the 16 sub-groups of divisors making a total of 16, 384 problems.

The S program solved 100 problems per divisor sub-group which yielded a total of 1600 problems. The specific information obtained from both programs was fundamentally the same and is listed below.

1. Problems using the n-th loop.

Since each problem consisted of a number of iterations of the add-shift sequence, it is of interest to know how many problems of each divisor sub-group used a particular iteration during the course of each problem solution. There are 48 possible iterations a problem may take before termination and each problem that requires the use of the n-th iteration, or loop, will add 1 to the sum accumulated for that iteration. By this means, data can be acquired which indicates, of r problems, what fraction, S, used the n-th loop during the process of problem solution.

It can be seen later, that the information given by this data implies the information to be presented by data in (4). Since each data group was generated by an essentially unrelated means, the concurrence of the two provides a check on the inherent data.

2. Sum of Shifts Taken on Iteration .

Part of the loop process consists of simply normalizing (either normal or inverted) the partial remainder and, at the same time, shifting quotient bits into the partial quotient. During each loop, the number of shifts utilized in each normalization is sensed and added to the accumulated sum of shifts for that particular divisor sub group. It is important to realize that in both programs, the normalization was <u>not</u> limited and the amount of shifting was determined, in all cases except termination, by the leading bits of partial remainder. In the case of termination, normalization ceased at the point of generating the 48th (or 49th, in special case of initial subtraction yielding complement result) bit of quotient. The shifts taken up to this point in this particular loop are then added to the previous sum for that loop.

3. Sum of the $(\text{Shifts})^2$ Taken per Iteration

The data gathered for this set is essentially the same as for (1) with the exception that the sum of shift amount <u>squared</u> is accumulated for each iteration (loop) instead of only the shift amount. This data was extracted with the anticipation that it would be useful in determining the standard deviation of the average shift per loop.

4. Problems Terminating in n-th loop

Whenever a problem termination occurred, a 1 was added to the accumulated sum of previous problems that terminated in that particular loop. As mentioned before, this information is implied also in the data taken for (1), but it more clearly presents the distribution of density of termination for each particular loop.

5. Shift Amount Distribution

In order to determine what percentage of the normalization is lost by placing a restriction on the maximum allowable shift amount, data was taken, whereby, for unlimited normalization (as stated) the shift amount taken for a particular loop during a problem solution is sensed and a 1 is added to the accumulated sum of previous loops requiring a shift of that particular amount. All 48 possible sums, indicating a shift amount of at least 1 to at most 48, are extracted for each divisor sub group. The sum of each sum included in the first n sums compared to the sum of all sums indicated the percentage of cases capable of unrestricted shifting with a maximum shift limited to n.

Processed Data:

Included at the end of this section are two charts giving the computed averages for two basic parameters that are of particular interest. The first is a list of the average loops taken, by both the Basic and Multiple scheme, to terminate an average division problem. For the Multiple scheme with a shift limited to 6x, the average number of loops to terminate is <u>14.43</u>. For the same conditions, it has been found that <u>94.3</u>% of the shifts required will be a shift of 6 or less, which demonstrates that a shift limited to 6 is justified, in a theoretical sense, on the basis of its high effectiveness.

Conclusions:

Inherent in a study such as this are always a few doubts as to the usefulness of such inexact techniques to extract, more or less, exact information. The author acknowledges the need for understandable verification of the methods used and a more adequate proof of the present assumptions that the statistics drawn from the programs are valid, will be given in a later report.

Two general aspects of the simulation programs will be investigated - a more extensive analysis must be made of the random number generators in both programs to insure that the random variables are not biased (to an unreasonable degree). Another point that needs to be clarified is whether the method for obtaining the Average Loops to Termination is valid for extablishing this average for the total population of random variables - it is not unreasonable to ask if it is valid to attribute to the total population characteristics, evident in a sub group, if the sampling technique is biased. It will be the aim of further studies to uncover what bias might exist in the data gathering methods.

Frank R. Bielawa

AVERAGE LOOPS TO TERMINATION AS FUNCTION OF SHIFT LIMITATION.

MULTIPLE

	SUM OF LOOPS PER 100 PROB PER DIVISOR			
DIVISOR (LEADING BITS)	UNLIMITED SHIFT	SHIFT EQUAL TO 6 OR LESS	SHIFT EQUAL TO 5 OR LESS	SHIFT EQUAL TO 4 OR LESS
10000	1367	1447	1526	1694
10001	1367	1457	1540	1709
10010	1306	1376	1447	1629
10011	1333	1398	1466	1690
10100	1380	1464	1532	1687
10101	1315	1392	1479	1643
10110	1315	1372	1455	1622
10111	1321	1391	1473	1659
11000	1324	1409	1496	1671
11001	1326	1412	1473	1664
11010	1295	1372	1448	1633
11011	1363	1433	1497	1656
11100	1410	1475	1539	1702
11101	1435	1501	1593	1749
11110	1523	1593	1658	1817
11111	1534	1598	1647	1798

SUM, Σ	21914	23090	24289	26973
AVE. $\frac{\Sigma}{n}\times\frac{1}{100}$	13.696	14.431	15.181	16.858

BASIC

	SUM OF LOOPS PER 100 PROB, PER DIVISOR			
DIVISOR (LEADING BITS)	UNLIMITED SHIFT	SHIFT EQUAL TO 6 OR LESS	SHIFT EQUAL TO 5 OR LESS	SHIFT EQUAL TO 4 OR LESS
10000	2169	2236	2290	2404
10001	1855	1924	2000	2151
10010	1732	1786	1848	1992
10011	1679	1730	1785	1927
10100	1645	1717	1772	1904
10101	1652	1710	1761	1873
10110	1631	1689	1741	1865
10111	1667	1713	1762	1862
11000	1716	1771	1808	1913
11001	1850	1905	1946	2049
11010	1950	1984	2043	2162
11011	2124	2166	2199	2309
11100	2194	2232	2268	2359
11101	2298	2331	2368	2448
11110	2378	2417	2452	2540
11111	2450	2484	2518	2609

SUM, Σ	30490	31795	32561	34365
AVE., $\frac{\Sigma}{n}\times\frac{1}{100}$	19.369	19.872	20.351	21.478

(NOTE: ABOVE DATA TAKEN FROM SCHARZENBACH PROGRAM)

Dec. 22, 1958

(NOTE: ABOVE DATA TAKEN FROM SIMULATION PROGRAMS)

BASIC

CUMULATIVE SUM OF PROBS, USING SHIFT OF MAX AMOUNT, k (PER 100 PROBS./DIVISOR

[illegible]	k=4	R	k=5	R	k=6	R	k=∞
10000	1956	.902	2050	.945	2103	.970	2169
10001	1576	.850	1711	.922	1785	.962	1855
10010	1490	.860	1621	.936	1679	.970	1732
10011	1447	.862	1574	.937	1628	.970	1679
10100	1402	.852	1521	.925	1573	.956	1645
10101	1446	.875	1545	.935	1595	.965	1652
10110	1410	.865	1525	.935	1574	.965	1631
10111	1487	.892	1575	.945	1622	.973	1667
11000	1529	.891	1626	.948	1663	.969	1716
11001	1671	.903	1758	.950	1796	.971	1850
11010	1748	.896	1861	.954	1916	.983	1950
11011	1952	.919	2050	.965	2083	.981	2124
11100	2037	.928	2121	.967	2156	.983	2194
11101	2152	.936	2228	.970	2265	.986	2298
11110	2222	.934	2304	.969	2339	.984	2378
11111	2297	.938	2383	.973	2416	.986	2450

SUM Σ	—	14.303	—	15.176	—	15.574	—
AVE, $\frac{\Sigma}{16}$	—	.8939	—	.9485	—	.9734	—

R = RATIO

MULTIPLE

CUMULATIVE SUM OF PROBS USING SHIFT OF MAX AMOUNT, k (PER 100 PROBS / DIVISOR

k=4	R	k=5	R	k=6	R	k=∞
1065	.779	1211	.886	1288	.942	1367
1047	.766	1197	.876	1278	.935	1367
997	.763	1172	.897	1239	.909	1306
1044	.783	1204	.903	1268	.951	1333
1095	.793	1231	.892	1296	.939	1380
1011	.769	1155	.878	1240	.943	1315
941	.716	1094	.763	1174	.893	1315
1009	.764	1172	.887	1253	.949	1321
1002	.757	1155	.872	1241	.937	1324
1017	.767	1166	.879	1241	.936	1326
974	.752	1148	.886	1219	.941	1295
1089	.799	1231	.903	1294	.949	1363
1134	.804	1282	.909	1345	.954	1410
1132	.789	1278	.891	1369	.954	1435
1242	.815	1389	.912	1453	.954	1523
1286	.838	1422	.927	1470	.958	1534

—	12.454	—	14.161	—	15.084	—
—	.7784	—	.8851	—	.9428	—

PERCENTAGE OF CASES WHERE SHIFT REQUIRED IS IN SHIFT LIMITATION AS FCN OF SHIFT LIMITATION

R. Carver

DEC 22 19[illegible]

Section omitted pertains to SAP program written for 704 Computer.

100,000 [illegible].

RANDOM NUMBER GENERATO

TEST RESULTS.

		Δ
1	50006	+6
2	49942	-58
3	50316	+316
4	50276	+276
5	50031	+31
6	50168	+168
7	49959	-41
8	49809	-191
9	49811	-189
10	50270	+270
11	50324	+324
12	49964	-36
13	50130	+130
14	50133	+133
15	49639	-361
16	49971	-29
17	49913	-87
18	49964	-36
19	50459	+459
20	50071	+71
21	50018	+18
22	49969	-31
23	49938	-62
24	49839	-161
25	50258	+258
26	49746	-254
27	49793	-207
28	49810	-190
29	49696	-304
30	50231	+231
31	49865	-135
32	50062	+62
33	49825	-175
34	49884	-116
35	50172	+172

[illegible] = 50000/100000

Ray Kohler - Sept 19, [illegible].

(DVH replaced with ccs 35 to avoid dropping 1 [illegible])

B PROGRAM PRINT-OUT

```
ING BITS    DIVISOR EQUAL    16
   (1)          (2)          (3)          (4)          (5)        [MULTIPLE       (1)          (2)          (3)          (4)                 (5)
E]1024         2252         7752            0            0         SCHEME]     1024         2252         7752            0                   0
  1024         2232         7614            0         9466                     1024         3741        16377            0                 951
  1024         2346         8658            0         5694                     1024         3844        17400            0  .2847         2996
  1024         2394         8622            0         2965                     1024         3832        17322            0  .6018         4480
  1024         2334         8152            0         1487                     1024         3850        17172            0  .7924         2560
  1024         2344         8142            0          841                     1024         3805        16731            0  .8851         1327
  1024         2463         9011            0          561                     1024         3831        17351            0  .9433          766
  1024         2320         8176            0          275                     1024         3853        17255            0  .9702          373
  1024         2286         7948            0          181                     1024         3889        17811            3  .9859          217
  1024         2324         7904            0           69                     1021         3760        16568           22  .9939           97
  1024         2414         9058            1           33                      999         3666        16066           67                  49
  1023         2292         7850            1           26                      932         3209        13251          151                  26
  1022         2317         8069            7            9                      781         2330         8510          260                   9
  1015         2339         8125           11            6                      521         1463         5263          251                   6
  1004         2287         7975           21            3                      270          602         1784          175                   5
   983         2162         7260           38            0                       95          183          473           67                   0
   945         2081         7119           54            1                       28           43           85           26                   1
   891         2024         6794           88            1                        2            2            2            2                   1
   803         1688         5436          108            1                        0            0            0            0                   1
   695         1479         4833          111            0                        0            0            0            0                   0
   584         1170         3376          118            0                        0            0            0            0                   0
   466          940         2698          108            0                        0            0            0            0                   0
   358          657         1713          109            0                        0            0            0            0                   0
   249  [illegible]         1379          108            0                        0            0            0            0                   0
   141          227          477           63            0                        0            0            0            0                   0
    78          139          339           36            0                        0            0            0            0                   0
    42           71          153           14            0                        0            0            0            0                   0
    28           44          104           13            0                        0            0            0            0                   0
    15           20           32            7            0                        0            0            0            0                   0
     8           19           16            6            0                        0            0            0            0                   0
     2            5           13            0            0                        0            0            0            0                   0
     2            2            2            1            0                        0            0            0            0                   0
     1            1            1            1            0                        0            0            0            0                   0
     0            0            0            0            0                        0            0            0            0                   0
     0            0            0            0            0                        0            0            0            0                   0
     0            0            0            0            0                        0            0            0            0                   0
     0            0            0            0            0                        0            0            0            0                   0
     0            0            0            0            0                        0            0            0            0                   0
     0            0            0            0            0                        0            0            0            0                   0
     0            0            0            0            0                        0            0            0            0                   0
     0            0            0            0            0                        0            0            0            0                   0
     0            0            0            0            0                        0            0            0            0                   0
     0            0            0            0            0                        0            0            0            0                   0
     0            0            0            0            0                        0            0            0            0                   0
     0            0            0            0            0                        0            0            0            0                   0
     0            0            0            0            0                        0            0            0            0                   0
     0            0            0            0            0                        0            0            0            0                   0
```

```
ING BITS  DIVISOR EQUAL     17

 1024    2516    9126      0      0        1024    2516    9126      0      0
 1024    2585    9727      0   6463        1024    3925   18091      0    834
 1024    2728   10498      0   5008        1024    3802   16752      0   3469
 1024    2704   10186      0   2675        1024    3800   16526      0   3393
 1024    2704   10152      0   2107        1024    3839   17083      0   2867
 1024    2709   10593      0   1370        1024    3932   18222      0   1692
 1024    2700   10306      0    649        1024    3800   16748      0    770
 1024    2753   10823      0    314        1024    3813   16637      0    397
 1024    2760   10580      0    138        1024    3881   17671      5    172
 1024    2738   10420      0     68        1019    3686   15828     36     86
 1024    2719   10261      4     28         983    3588   15764     84     38
 1020    2626    9788      4     15         899    3080   12626    161     14
 1016    2661   10219     17      5         738    2301    8781    228     11
  999    2550    9312     40      5         510    1426    5156    252      5
  959    2418    8836     55      1         258     606    1984    155      1
  904    2279    8333    125      1         103     183     423     79      0
  779    1922    6776    128      1          24      40      86     22      2
  651    1498    4838    156      0           2       5      17      2      0
  495    1109    3603    153      1           0       0       0      0      1
  342     746    2268    126      0           0       0       0      0      0
  216     437    1279    104      0           0       0       0      0      0
  112     205     537     57      0           0       0       0      0      0
   55      97     219     31      0           0       0       0      0      0
   24      42      94     16      0           0       0       0      0      0
    8      10      16      4      0           0       0       0      0      0
    4       6      12      3      0           0       0       0      0      0
    1       1       1      1      0           0       0       0      0      0
    0       0       0      0      0           0       0       0      0      0
    0       0       0      0      0           0       0       0      0      0
    0       0       0      0      0           0       0       0      0      0
    0       0       0      0      0           0       0       0      0      0
    0       0       0      0      0           0       0       0      0      0
    0       0       0      0      0           0       0       0      0      0
    0       0       0      0      0           0       0       0      0      0
    0       0       0      0      0           0       0       0      0      0
    0       0       0      0      0           0       0       0      0      0
    0       0       0      0      0           0       0       0      0      0
    0       0       0      0      0           0       0       0      0      0
    0       0       0      0      0           0       0       0      0      0
    0       0       0      0      0           0       0       0      0      0
    0       0       0      0      0           0       0       0      0      0
    0       0       0      0      0           0       0       0      0      0
    0       0       0      0      0           0       0       0      0      0
    0       0       0      0      0           0       0       0      0      0
    0       0       0      0      0           0       0       0      0      0
    0       0       0      0      0           0       0       0      0      0
    0       0       0      0      0
```

```
ING BITS   DIVISOR EQUAL    18

 1024     2617      9463        0        0          1024     2617      9463        0        0
 1024     2921     11363        0     4756          1024     3904     17248        0      766
 1024     2912     11140        0     4691          1024     3967     17475        0     1756
 1024     2901     11257        0     3182          1024     3996     17908        0     4533
 1024     2910     11424        0     2542          1024     3981     17787        0     3141
 1024     2771     10321        0     1273          1024     4052     18380        0     1572
 1024     2973     11863        0      608          1024     4006     18126        0      749
 1024     2924     11562        0      292          1024     4066     18710        1      366
 1024     2923     11517        0      144          1023     4048     18724        6      177
 1024     2964     11724        3       67          1017     3920     17020       27       73
 1021     2865     10967        5       27           990     3755     16517      112       42
 1016     2789     10519        9       19           878     3080     12690      238       21
 1007     2881     11421       20        6           640     1857      6651      296        9
  987     2756     10698       67        3           344      827      2657      236        5
  920     2454      8862      133        2           108      197       479       89        2
  787     1983      6777      161        0            19       25        43       17        0
  626     1564      5378      184        0             2        2         2        2        0
  442     1039      3181      155        0             0        0         0        0        0
  287      588      1642      125        1             0        0         0        0        1
  162      362      1050       82        0             0        0         0        0        0
   80      140       318       49        0             0        0         0        0        0
   31       54       120       25        0             0        0         0        0        0
    6        8        12        5        0             0        0         0        0        0
    1        1         1        1        0             0        0         0        0        0
    0        0         0        0        0             0        0         0        0        0
    0        0         0        0        0             0        0         0        0        0
    0        0         0        0        0             0        0         0        0        0
    0        0         0        0        0             0        0         0        0        0
    0        0         0        0        0             0        0         0        0        0
    0        0         0        0        0             0        0         0        0        0
    0        0         0        0        0             0        0         0        0        0
    0        0         0        0        0             0        0         0        0        0
    0        0         0        0        0             0        0         0        0        0
    0        0         0        0        0             0        0         0        0        0
    0        0         0        0        0             0        0         0        0        0
    0        0         0        0        0             0        0         0        0        0
    0        0         0        0        0             0        0         0        0        0
    0        0         0        0        0             0        0         0        0        0
    0        0         0        0        0             0        0         0        0        0
    0        0         0        0        0             0        0         0        0        0
    0        0         0        0        0             0        0         0        0        0
    0        0         0        0        0             0        0         0        0        0
    0        0         0        0        0             0        0         0        0        0
    0        0         0        0        0             0        0         0        0        0
    0        0         0        0        0             0        0         0        0        0
    0        0         0        0        0             0        0         0        0        0
```

```
ING BITS   DIVISOR EQUAL      19

 1024     2676     9666      0      0          1024     2676     9666      0      0
 1024     3095    12181      0   3556          1024     3943    17605      0    672
 1024     3076    12274      0   4001          1024     3972    17860      0   1697
 1024     3083    12091      0   4398          1024     3932    17338      0   5047
 1024     3002    11704      0   2495          1024     3941    17235      0   3082
 1024     3073    11997      0   1172          1024     3917    17391      0   1464
 1024     3010    11628      0    561          1024     4039    18461      0    683
 1024     3103    12293      0    321          1024     3929    17165      1    362
 1024     3126    12590      0    120          1023     4007    17885     10    179
 1024     3089    12309      3     64          1013     3908    17112     27     79
 1021     3059    11861      7     25           986     3666    15668    101     31
 1014     3069    12081     16     14           885     3034    12046    199     17
  998     2836    10496     33      8           686     2117     7959    307      8
  965     2820    10626    112      5           379      963     3097    240      7
  853     2237     7575    160      0           139      274      700    115      2
  693     1804     6046    194      2            24       32       52     22      2
  499     1232     3972    211      1             2        2        2      2      1
  286      625     1761    162      0             0        0        0      0      0
  126      255      699     91      0             0        0        0      0      0
   35       67      175     27      0             0        0        0      0      0
    8       11       17      5      0             0        0        0      0      0
    3        4        6      3      0             0        0        0      0      0
    0        0        0      0      0             0        0        0      0      0
    0        0        0      0      0             0        0        0      0      0
    0        0        0      0      0             0        0        0      0      0
    0        0        0      0      0             0        0        0      0      0
    0        0        0      0      0             0        0        0      0      0
    0        0        0      0      0             0        0        0      0      0
    0        0        0      0      0             0        0        0      0      0
    0        0        0      0      0             0        0        0      0      0
    0        0        0      0      0             0        0        0      0      0
    0        0        0      0      0             0        0        0      0      0
    0        0        0      0      0             0        0        0      0      0
    0        0        0      0      0             0        0        0      0      0
    0        0        0      0      0             0        0        0      0      0
    0        0        0      0      0             0        0        0      0      0
    0        0        0      0      0             0        0        0      0      0
    0        0        0      0      0             0        0        0      0      0
    0        0        0      0      0             0        0        0      0      0
    0        0        0      0      0             0        0        0      0      0
    0        0        0      0      0             0        0        0      0      0
    0        0        0      0      0             0        0        0      0      0
    0        0        0      0      0             0        0        0      0      0
    0        0        0      0      0             0        0        0      0      0
    0        0        0      0      0             0        0        0      0      0
    0        0        0      0      0             0        0        0      0      0
    0        0        0      0      0             0        0        0      0      0
```

```
ING BITS  DIVISOR EQUAL     20

  1024      2878     10850         0         0           1024      2878     10850         0         0
  1024      3117     12095         0      3149           1024      3821     16471         0       620
  1024      3015     11415         0      4111           1024      3748     16126         0      3120
  1024      3006     11516         0      4691           1024      3831     17259         0      4814
  1024      3125     12621         0      2313           1024      3762     16452         0      2574
  1024      3201     13247         0      1195           1024      3817     17031         0      1456
  1024      3077     12171         0       581           1024      3823     16965         0       702
  1024      3153     12743         0       261           1024      3813     17021         1       340
  1024      3129     12543         1       131           1023      3739     16377         7       152
  1023      3008     11436         3        71           1016      3602     14864        30        88
  1020      3050     12060         2        29            966      3479     14399        62        42
  1018      3017     11711        22        16            924      3050     12106       170        18
   990      2926     10942        48        11            754      2350      8946       214        13
   948      2757     10157        97         5            540      1507      5093       217         6
   851      2407      8849       184         2            323       790      2474       182         1
   667      1068      5376       220         1            141       322       956        97         1
   447      1077      3247       208         2             44        80       186        38         2
   239       535      1549       126         1              6        12        28         4         1
   113       231       601        87         0              2         2         2         2         1
    26        38        68        21         0              0         0         0         0         0
     5         8        14         4         0              0         0         0         0         0
     1         1         1         1         0              0         0         0         0         0
     0         0         0         0         0              0         0         0         0         0
     0         0         0         0         0              0         0         0         0         0
     0         0         0         0         0              0         0         0         0         0
     0         0         0         0         0              0         0         0         0         0
     0         0         0         0         0              0         0         0         0         0
     0         0         0         0         0              0         0         0         0         0
     0         0         0         0         0              0         0         0         0         0
     0         0         0         0         0              0         0         0         0         0
     0         0         0         0         0              0         0         0         0         0
     0         0         0         0         0              0         0         0         0         0
     0         0         0         0         0              0         0         0         0         0
     0         0         0         0         0              0         0         0         0         0
     0         0         0         0         0              0         0         0         0         0
     0         0         0         0         0              0         0         0         0         0
     0         0         0         0         0              0         0         0         0         0
     0         0         0         0         0              0         0         0         0         0
     0         0         0         0         0              0         0         0         0         0
     0         0         0         0         0              0         0         0         0         0
     0         0         0         0         0              0         0         0         0         0
     0         0         0         0         0              0         0         0         0         0
     0         0         0         0         0              0         0         0         0         0
     0         0         0         0         0              0         0         0         0         0
     0         0         0         0         0              0         0         0         0         0
     0         0         0         0         0              0         0         0         0         0
```

```
ING BITS   DIVISOR EQUAL    21

 1024     2882    10490      0      0          1024    2882    10490      0      0
 1024     3104    11926      0   2247          1024    4019    18249      0    474
 1024     3073    11713      0   5581          1024    3954    18030      0   2511
 1024     2971    11055      0   4495          1024    3948    17696      0   4504
 1024     3083    11685      0   2238          1024    3918    17598      0   2757
 1024     3063    11695      0   1111          1024    3956    17962      0   1528
 1024     3057    11451      0    524          1024    3988    18366      1    794
 1024     3055    11613      0    251          1023    3871    17155      1    395
 1024     2990    11110      0    142          1022    3983    18263      7    197
 1024     3143    12453      2     50          1015    3894    17474     23    102
 1022     3091    11893      4     29           992    3652    15710    106     34
 1018     3015    11253     25     12           886    3034    12284    211     20
  993     2926    10910     35      9           675    2057     7555    306     11
  958     2815    10439     85      0           369     953     3125    226      2
  873     2367     8075    181      1           143     302      828    111      2
  692     1826     5958    213      2            32      59      153     26      1
  479     1147     3435    201      1             6       7        9      5      2
  278      614     1684    168      0             1       1        1      1      0
  110      200      486     84      0             0       0        0      0      0
   26       49      117     22      0             0       0        0      0      0
    4        7       19      4      0             0       0        0      0      0
    0        0        0      0      0             0       0        0      0      0
    0        0        0      0      0             0       0        0      0      0
    0        0        0      0      0             0       0        0      0      0
    0        0        0      0      0             0       0        0      0      0
    0        0        0      0      0             0       0        0      0      0
    0        0        0      0      0             0       0        0      0      0
    0        0        0      0      0             0       0        0      0      0
    0        0        0      0      0             0       0        0      0      0
    0        0        0      0      0             0       0        0      0      0
    0        0        0      0      0             0       0        0      0      0
    0        0        0      0      0             0       0        0      0      0
    0        0        0      0      0             0       0        0      0      0
    0        0        0      0      0             0       0        0      0      0
    0        0        0      0      0             0       0        0      0      0
    0        0        0      0      0             0       0        0      0      0
    0        0        0      0      0             0       0        0      0      0
    0        0        0      0      0             0       0        0      0      0
    0        0        0      0      0             0       0        0      0      0
    0        0        0      0      0             0       0        0      0      0
    0        0        0      0      0             0       0        0      0      0
    0        0        0      0      0             0       0        0      0      0
    0        0        0      0      0             0       0        0      0      0
    0        0        0      0      0             0       0        0      0      0
    0        0        0      0      0             0       0        0      0      0
    0        0        0      0      0             0       0        0      0      0
```

```
ING BITS & DIVISOR EQUAL     22

  1024     2981    10795        0        0              1024     2981    10795        0        0
  1024     2964    10750        0     1426              1024     3988    18338        0      379
  1024     2996    10798        0     6811              1024     4098    19216        0     2304
  1024     3049    11675        0     4409              1024     4086    19216        0     4103
  1024     3122    12012        0     2153              1024     4056    18864        0     2895
  1024     3069    11595        0     1051              1024     4050    18456        0     1675
  1024     3058    11360        0      500              1024     4037    18781        1      881
  1024     3033    11235        0      213              1023     4036    18722        1      384
  1024     3009    11017        0      106              1022     4031    18485       10      189
  1024     3043    11229        2       45              1012     3971    18041       33       63
  1022     3049    11195        8       32               979     3646    15896      115       45
  1014     3056    11244       14       10               864     3063    12849      269       21
  1000     2968    10916       34        7               595     1803     6637      331       15
   966     2785     9961       87        5               264      611     1791      207        6
   879     2360     7908      178        2                57       94      194       52        5
   701     1843     5783      203        1                 5        6        8        5        1
   498     1217     3633      209        2                 0        0        0        0        2
   289      650     1812      171        1                 0        0        0        0        1
   118      228      550       80        0                 0        0        0        0        0
    38       61      121       32        0                 0        0        0        0        0
     6       11       23        4        0                 0        0        0        0        0
     2        4        8        1        0                 0        0        0        0        0
     1        1        1        1        0                 0        0        0        0        0
     0        0        0        0        0                 0        0        0        0        0
     0        0        0        0        0                 0        0        0        0        0
     0        0        0        0        0                 0        0        0        0        0
     0        0        0        0        0                 0        0        0        0        0
     0        0        0        0        0                 0        0        0        0        0
     0        0        0        0        0                 0        0        0        0        0
     0        0        0        0        0                 0        0        0        0        0
     0        0        0        0        0                 0        0        0        0        0
     0        0        0        0        0                 0        0        0        0        0
     0        0        0        0        0                 0        0        0        0        0
     0        0        0        0        0                 0        0        0        0        0
     0        0        0        0        0                 0        0        0        0        0
     0        0        0        0        0                 0        0        0        0        0
     0        0        0        0        0                 0        0        0        0        0
     0        0        0        0        0                 0        0        0        0        0
     0        0        0        0        0                 0        0        0        0        0
     0        0        0        0        0                 0        0        0        0        0
     0        0        0        0        0                 0        0        0        0        0
     0        0        0        0        0                 0        0        0        0        0
     0        0        0        0        0                 0        0        0        0        0
     0        0        0        0        0                 0        0        0        0        0
     0        0        0        0        0                 0        0        0        0        0
     0        0        0        0        0                 0        0        0        0        0
     0        0        0        0        0                 0        0        0        0        0
```

```
ING BITS   DIVISOR EQUAL    23

  1024      3069     11479        0        0          1024      3069     11479        0        0
  1024      3071     11415        0      732          1024      3940     18354        0      322
  1024      3096     11962        0     7795          1024      3950     17968        0     3046
  1024      3095     11463        0     4217          1024      3979     18079        0     3675
  1024      3000     10734        0     1975          1024      3931     17767        0     2921
  1024      3041     11071        0     1015          1024      4086     19470        1     1666
  1024      3112     11906        0      462          1023      4011     18791        0      796
  1024      3125     12069        0      239          1023      3897     17599        1      411
  1024      3129     11719        2      127          1022      4081     19577        5      198
  1022      3031     11161        1       69          1017      3888     17508       44      100
  1021      3027     10985        5       28           973      3559     15243      100       48
  1016      3090     11694       23       10           873      2961     11933      233       25
   993      2689     10229       43        7           640      1945      7165      288       12
   950      2676      9074       98        2           352       918      2996      225        3
   852      2261      7293      153        1           127       327      1059       99        1
   699      1827      5751      225        1            28        62       184       24        1
   474      1122      3228      203        0             4        10        30        2        0
   271       618      1706      151        1             2         2         2        2        1
   120       248       632       80        1             0         0         0        0        1
    40        75       177       31        0             0         0         0        0        0
     9        14        26        9        0             0         0         0        0        0
     0         0         0        0        0             0         0         0        0        0
     0         0         0        0        1             0         0         0        0        0
     0         0         0        0        0             0         0         0        0        0
     0         0         0        0        0             0         0         0        0        1
     0         0         0        0        0             0         0         0        0        0
     0         0         0        0        0             0         0         0        0        0
     0         0         0        0        0             0         0         0        0        0
     0         0         0        0        0             0         0         0        0        0
     0         0         0        0        0             0         0         0        0        0
     0         0         0        0        0             0         0         0        0        0
     0         0         0        0        0             0         0         0        0        0
     0         0         0        0        0             0         0         0        0        0
     0         0         0        0        0             0         0         0        0        0
     0         0         0        0        0             0         0         0        0        0
     0         0         0        0        0             0         0         0        0        0
     0         0         0        0        0             0         0         0        0        0
     0         0         0        0        0             0         0         0        0        0
     0         0         0        0        0             0         0         0        0        0
     0         0         0        0        0             0         0         0        0        0
     0         0         0        0        0             0         0         0        0        0
     0         0         0        0        0             0         0         0        0        0
     0         0         0        0        0             0         0         0        0        0
     0         0         0        0        0             0         0         0        0        0
     0         0         0        0        0             0         0         0        0        0
     0         0         0        0        0             0         0         0        0        0
     0         0         0        0        0             0         0         0        0        0
```

```
ING BITS   DIVISOR EQUAL    24

 1024    2982    10538      0      0            1024    2982    10538      0      0
 1024    3077    11613      0   1358            1024    3904    17598      0    331
 1024    2965    10711      0   8151            1024    3966    18210      0   3214
 1024    2998    10854      0   4020            1024    3944    18070      0   3636
 1024    2982    11158      0   1959            1024    3859    17065      0   3022
 1024    2959    10685      0    957            1024    3965    18171      0   1628
 1024    2908    10346      0    479            1024    3969    18351      0    792
 1024    2978    10894      0    227            1024    3790    16474      1    398
 1024    2917    10423      0     99            1023    3928    17782      4    193
 1024    2934    10504      1     56            1019    3961    18307     35     87
 1023    2898     9988      5     27             984    3640    15870     99     41
 1018    2903    10381     19     14             885    3115    13077    204     24
  999    2851     9975     36      3             681    2148     8248    276      7
  963    2696     9362     90      4             405    1070     3512    253      6
  873    2315     7759    140      1             152     351     1057    113      1
  733    1867     6017    165      2              39      76      226     35      2
  568    1397     4215    184      1               4       4        4      4      2
  384     877     2471    143      0               0       0        0      0      0
  241     527     1497    107      0               0       0        0      0      0
  134     299      875     56      0               0       0        0      0      0
   78     156      374     35      0               0       0        0      0      0
   43      79      179     15      0               0       0        0      0      0
   28      50      120     12      0               0       0        0      0      0
   16      29       63      7      0               0       0        0      0      0
    9      17       35      5      0               0       0        0      0      0
    4       6       10      2      0               0       0        0      0      0
    2       2        2      1      0               0       0        0      0      0
    1       2        4      0      0               0       0        0      0      0
    1       1        1      1      0               0       0        0      0      0
    0       0        0      0      0               0       0        0      0      0
    0       0        0      0      0               0       0        0      0      0
    0       0        0      0      0               0       0        0      0      0
    0       0        0      0      0               0       0        0      0      0
    0       0        0      0      0               0       0        0      0      0
    0       0        0      0      0               0       0        0      0      0
    0       0        0      0      0               0       0        0      0      0
    0       0        0      0      0               0       0        0      0      0
    0       0        0      0      0               0       0        0      0      0
    0       0        0      0      0               0       0        0      0      0
    0       0        0      0      0               0       0        0      0      0
    0       0        0      0      0               0       0        0      0      0
    0       0        0      0      0               0       0        0      0      0
    0       0        0      0      0               0       0        0      0      0
    0       0        0      0      0               0       0        0      0      0
    0       0        0      0      0               0       0        0      0      0
    0       0        0      0      0               0       0        0      0      0
    0       0        0      0      0
```

```
ING BITS [illegible] DIVISOR EQUAL     25

 1024      2927     10643        0        0            1024      2927     10643        0        0
 1024      2708      9498        0     3279            1024      3984     18252        0      436
 1024      2742      9760        0     7710            1024      3976     18318        0     2567
 1024      2738      9708        0     3934            1024      4000     18244        0     4265
 1024      2735      9531        0     1871            1024      3968     17834        0     2847
 1024      2711      9419        0      922            1024      3958     18180        0     1639
 1024      2722      9358        0      461            1024      3972     18108        0      801
 1024      2759      9605        0      209            1024      3962     17762        0      379
 1024      2788      9950        0      102            1024      3852     16824        9      192
 1024      2720      9070        0       51            1015      3975     18275       31       83
 1024      2833     10035        1       30             984      3624     15566       99       47
 1023      2818     10202        9       14             885      3172     13666      216       28
 1014      2672      9370       28        9             669      2046      7754      300       15
  986      2626      9182       62        4             369       960      3194      237        7
  924      2357      7705       80        0             132       293       859      103        1
  844      2073      6537      128        0              29        54       138       24        0
  716      1788      5816      136        1               5         6         8        5        1
  580      1366      4186      125        0               0         0         0        0        0
  455      1022      3010      128        0               0         0         0        0        0
  327       702      1992      110        0               0         0         0        0        0
  217       440      1136       93        0               0         0         0        0        0
  124       245       635       59        0               0         0         0        0        0
   65       133       343       30        0               0         0         0        0        0
   35        67       169       21        0               0         0         0        0        0
   14        25        51        8        0               0         0         0        0        0
    6         9        15        4        0               0         0         0        0        0
    2         2         2        1        0               0         0         0        0        0
    1         1         1        1        0               0         0         0        0        0
    0         0         0        0        0               0         0         0        0        0
    0         0         0        0        0               0         0         0        0        0
    0         0         0        0        0               0         0         0        0        0
    0         0         0        0        0               0         0         0        0        0
    0         0         0        0        0               0         0         0        0        0
    0         0         0        0        0               0         0         0        0        0
    0         0         0        0        0               0         0         0        0        0
    0         0         0        0        0               0         0         0        0        0
    0         0         0        0        0               0         0         0        0        0
    0         0         0        0        0               0         0         0        0        0
    0         0         0        0        0               0         0         0        0        0
    0         0         0        0        0               0         0         0        0        0
    0         0         0        0        0               0         0         0        0        0
    0         0         0        0        0               0         0         0        0        0
    0         0         0        0        0               0         0         0        0        0
    0         0         0        0        0               0         0         0        0        0
    0         0         0        0        0               0         0         0        0        0
    0         0         0        0        0               0         0         0        0        0
    0         0         0        0        0               0         0         0        0        0
```

```
ING BITS  DIVISOR EQUAL     26

 1024     2976    11374       0       0           1024    2976    11374       0       0
 1024     2568     8566       0    5160           1024    4099    18805       0     534
 1024     2556     8602       0    7513           1024    4024    18288       0    1490
 1024     2572     8634       0    3782           1024    3975    17565       0    5183
 1024     2544     8618       0    1689           1024    3996    17904       0    2927
 1024     2584     9024       0     931           1024    4045    18537       0    1584
 1024     2510     8336       0     421           1024    4026    18202       0     723
 1024     2503     8367       0     198           1024    4005    17885       1     381
 1024     2461     8179       0     116           1023    3996    17752       8     194
 1024     2613     9195       2      49           1015    3940    17416      33      69
 1022     2495     8265       1      19            982    3768    16826     107      31
 1021     2505     8223       4      16            875    3047    12485     244      29
 1017     2494     8260       9       7            631    1853     6669     307      12
 1008     2561     8943      20       5            324     810     2516     215       5
  988     2459     8287      45       0            109     208      498      93       0
  943     2259     7335      89       1             16      19       27      16       3
  854     2085     6957      99       1              0       0        0       0       1
  755     1696     5004     132       1              0       0        0       0       0
  623     1342     3850     133       0              0       0        0       0       0
  490     1061     2993     125       0              0       0        0       0       1
  365      797     2233     127       0              0       0        0       0       0
  238      485     1327      90       0              0       0        0       0       0
  148      281      709      56       0              0       0        0       0       0
   92      176      436      38       0              0       0        0       0       0
   54       97      235      25       0              0       0        0       0       0
   29       63      201      18       0              0       0        0       0       0
   11       18       38       6       0              0       0        0       0       0
    5       11       29       3       0              0       0        0       0       0
    2        5       13       0       0              0       0        0       0       0
    2        6       18       1       0              0       0        0       0       0
    1        2        4       0       0              0       0        0       0       0
    1        2        4       1       0              0       0        0       0       0
    0        0        0       0       0              0       0        0       0       0
    0        0        0       0       0              0       0        0       0       0
    0        0        0       0       0              0       0        0       0       0
    0        0        0       0       0              0       0        0       0       0
    0        0        0       0       0              0       0        0       0       0
    0        0        0       0       0              0       0        0       0       0
    0        0        0       0       0              0       0        0       0       0
    0        0        0       0       0              0       0        0       0       0
    0        0        0       0       0              0       0        0       0       0
    0        0        0       0       0              0       0        0       0       0
    0        0        0       0       0              0       0        0       0       0
    0        0        0       0       0              0       0        0       0       0
    0        0        0       0       0              0       0        0       0       0
    0        0        0       0       0              0       0        0       0       0
    0        0        0       0       0              0       0        0       0       0
```

```
ING BITS   DIVISOR EQUAL     27

  1024      2858     10582         0         0              1024      2858     10582         0         0
  1024      2551      8873         0      6506              1024      4091     18529         0       658
  1024      2494      8326         0      7132              1024      4042     18436         0      1422
  1024      2578      9310         0      3613              1024      4034     18194         0      5573
  1024      2533      8593         0      1770              1024      3904     16796         0      2955
  1024      2529      8597         0       859              1024      3955     17437         0      1466
  1024      2463      8271         0       445              1024      3927     17273         0       726
  1024      2459      8521         0       214              1024      3936     17170         3       339
  1024      2385      7605         1        88              1021      3914     17384         6       156
  1023      2474      8408         1        48              1015      3845     16585        41        73
  1022      2409      7555         2        28               974      3643     15611        80        41
  1020      2433      8143         9         8               894      3035     12101       219        14
  1011      2436      7984         8         4               675      2009      7167       274        10
  1003      2437      8223        19         4               401      1064      3532       222         4
   984      2332      7684        50         2               179       406      1198       115         2
   934      2106      6624        71         1                64       129       337        40         2
   863      1886      5652        70         1              . 24        35        65        21         1
   793      1764      5330       109         0                 3         5        11         2         0
   684      1453      4207       113         1                 1         1         1         1         1
   571      1176      3176        99         0                 0         0         0         0         0
   472       968      2614        99         0                 0         0         0         0         0
   373       741      2009       100         0                 0         0         0         0         0
   273       546      1476        86         0                 0         0         0         0         0
   187       349       853        68         0                 0         0         0         0         0
   119       207       430        50         0                 0         0         0         0         0
    69       108       212        19         0                 0         0         0         0         0
    50        82       190        21         0                 0         0         0         0         0
    29        41        73        15         0                 0         0         0         0         0
    14        22        40         3         0                 0         0         0         0         0
    11        12        14         8         0                 0         0         0         0         0
     3         6        14         3         0                 0         0         0         0         0
     0         0         0         0         0                 0         0         0         0         0
     0         0         0         0         0                 0         0         0         0         0
     0         0         0         0         0                 0         0         0         0         0
     0         0         0         0         0                 0         0         0         0         0
     0         0         0         0         0                 0         0         0         0         0
     0         0         0         0         0                 0         0         0         0         0
     0         0         0         0         0                 0         0         0         0         0
     0         0         0         0         0                 0         0         0         0         0
     0         0         0         0         0                 0         0         0         0         0
     0         0         0         0         0                 0         0         0         0         0
     0         0         0         0         0                 0         0         0         0         0
     0         0         0         0         0                 0         0         0         0         0
     0         0         0         0         0                 0         0         0         0         0
     0         0         0         0         0                 0         0         0         0         0
     0         0         0         0         0                                     0         0         0
     0         0         0         0         0                                     0         0         0
```

```
ING BITS & DIVISOR EQUAL     28

  1024    2777    9923     0     0        1024   2777    9923     0     0
  1024    2393    7925     0  8032        1024   3920   17354     0   718
  1024    2325    7261     0  6953        1024   3884   16920     0  2310
  1024    2366    7738     0  3491        1024   3915   17445     0  4879
  1024    2365    7855     0  1760        1024   3897   17341     0  2938
  1024    2273    7027     0   827        1024   3900   17420     0  1485
  1024    2362    7736     0   381        1024   3852   16968     0   724
  1024    2410    8288     0   195        1024   3958   17934     0   351
  1024    2354    7794     0    98        1024   3800   16108     5   169
  1024    2297    7411     1    49        1019   3946   18062    15    85
  1023    2236    6954     0    25        1004   3608   14944    94    50  x~
  1023    2356    7740     3     8         910   3095   12539   177    15
  1020    2325    7521     4     5         733   2261    8475   257     8
  1016    2372    7958    14     3         476   1288    4478   229     3
  1002    2269    7047    31     1         247    588    1820   147     2
   971    2199    7013    33     1         100    179     413    73     2
   938    2098    6618    58     0          27     46     100    22     0  x3
   880    1864    5432    75     0           5      9      21     3     0
   805    1639    4495   108     0           2      5      17     2     0
   697    1456    4164   111     0           0      0       0     0     0
   586    1155    3187   120     0           0      0       0     0     0
   466     875    2155    93     0           0      0       0     0     0
   373     719    1893    86     0           0      0       0     0     0
   287     549    1441    89     0           0      0       0     0     0
   198     358     868    69     0           0      0       0     0     0
   129     226     564    51     0           0      0       0     0     0
    78     143     365    34     0           0      0       0     0     0
    44      69     133    14     0           0      0       0     0     0
    30      59     139    12     0           0      0       0     0     0
    18      32      70    14     0           0      0       0     0     0
     4       6      10     3     0           0      0       0     0     0
     1       1       1     1     0           0      0       0     0     0
     0       0       0     0     0           0      0       0     0     0
     0       0       0     0     0           0      0       0     0     0
     0       0       0     0     0           0      0       0     0     0
     0       0       0     0     0           0      0       0     0     0
     0       0       0     0     0           0      0       0     0     0
     0       0       0     0     0           0      0       0     0     0
     0       0       0     0     0           0      0       0     0     0
     0       0       0     0     0           0      0       0     0     0
     0       0       0     0     0           0      0       0     0     0
     0       0       0     0     0           0      0       0     0     0
     0       0       0     0     0           0      0       0     0     0
     0       0       0     0     0           0      0       0     0     0
     0       0       0     0     0           0      0       0     0     0
     0       0       0     0     0           0      0       0     0     0
```

```
ING BITS [illegible] DIVISOR EQUAL    29

  1024      2659      9877       0        0                1024      2659      9877        0        0
  1024      2215      7049       0     9722                1024      3656     15574        0      912
  1024      2179      6667       0     6699                1024      3801     16903        0     3727
  1024      2509      7815       0     3435                1024      3602     17112        0     3858
  1024      2190      6754       0     1674                1024      3785     16869        0     2912
  1024      2222      7074       0      761                1024      3735     16067        0     1498
  1024      2210      6852       0      399_               1024      3607     15795        0      765_
  1024      2213      7789       0      172                1024      3746     16400        1      357
  1024      2209      6449       0       83                1023      3739     16409        2      181
  1024      2230      7062       0       36                1021      3686     15592       13       64
  1024      2154      6458       0       15                1008      3438     14252       54       33
  1024      2257      7161       1       12                 954      3252     13054      136       17
  1023      2154      6820       1        4_                818      2654     10454      196        4_
  1022      2229      6818      12        5                 622      1755      6169      220        9
  1010      2144      6474      14        5                 402      1006      3306      204        7
   998      2159      6723      25        0                 198       396      1054      117        0
   971      2046      6162      40        0                  61       128       266       59        0
   931      1869      5161      47        0                  22        33        75       19        0
   864      1796      5154      70        0_                  3         3         3        3        0_
   814      1646      4556      99        0                   0         0         0        0        0
   715      1441      3697      89        0                   0         0         0        0        0
   626      1257      3479     104        0                   0         0         0        0        0
   522       994      2724     141        0                   0         0         0        0        0
   381       690      1650      95        0                   0         0         0        0        0
   286       520      1212      74        0                   0         0         0        0        0
   212       358       770      63        0                   0         0         0        0        0
   149       245       509      53        0                   0         0         0        0        0
    90       150       344      40        0                   0         0         0        0        0
    50        70       126      34        0                   0         0         0        0        0
    22        30        50      14        0                   0         0         0        0        0
     6        12        26       5        0                   0         0         0        0        0
     3         4         9       0        0                   0         0         0        0        0
     3         6        14       2        0                   0         0         0        0        0
     1         1         1       0        0                   0         0         0        0        0
     1         2         4       1        0                   0         0         0        0        0
     0         0         0       0        0                   0         0         0        0        0
     0         0         0       0        0                   0         0         0        0        0
     0         0         0       0        0                   0         0         0        0        0
     0         0         0       0        0                   0         0         0        0        0
     0         0         0       0        0                   0         0         0        0        0
     0         0         0       0        0                   0         0         0        0        0
     0         0         0       0                            0         0         0        0        0
     0         0         0       0                            0         0         0        0        0
     0         0         0       0                            0         0         0        0        0
     0         0         0       0        0                   0         0         0        0
     0         0         0       0        0                   0         0         0        0
     0         0         0       0        0                   0         0         0        0
```

```
ING BITS  DIVISOR EQUAL    30

 1024    2541    9725      0       0             1024    2541    9725      0       0
 1024    2143    6725      0   10968             1024    3654   15542      0     944
 1024    2112    6314      0    6628             1024    3584   15224      0    4361
 1024    2194    6944      0    3213             1024    3576   15198      0    4150
 1024    2177    6857      0    1537             1024    3599   15377      0    2645
 1024    2146    6618      0     763             1024    3635   15289      0    1412
 1024    2183    6675      0     393             1024    3605   15445      0     653
 1024    2128    6358      0     181             1024    3573   15071      0     346
 1024    2153    6577      0      90             1024    3544   14742      2     181
 1024    2209    6823      0      48             1022    3568   14850     17      70
 1024    2110    6322      1      26             1005    3489   14377     42      45
 1023    2205    7117      2       8              963    3306   13506     95      18
 1021    2153    6679      3       3              868    2779   10919    154       8
 1018    2118    6712      4       3              714    2044    7240    205       6
 1014    2096    6246      8       1              509    1369    4729    199       2
 1006    2019    5727     19       0              310     717    2109    153       0
  987    2048    6234     28       0              157     323     913    104       1
  959    1967    5953     42       0               53      97     239     31       0
  917    1832    5050     75       0               22      33      65     19       0
  842    1633    4351     76       0                3       4       6      3       0
  766    1438    3870     81       0                0       0       0      0       0
  685    1275    3365    100       0                0       0       0      0       0
  585    1110    2954    103       0                0       0       0      0       0
  482     868    2146     96       0                0       0       0      0       0
  386     696    1786     88       0                0       0       0      0       0
  296     506    1170     75       0                0       0       0      0       0
  225     362     812     65       0                0       0       0      0       0
  150     246     488     50       0                0       0       0      0       0
  126     181     397     44       0                0       0       0      0       0
   64     107     235     33       0                0       0       0      0       0
   31      46      92     16       0                0       0       0      0       0
   15      24      50      8       0                0       0       0      0       0
    7       9      15      5       0                0       0       0      0       0
    2       4       8      1       0                0       0       0      0       0
    1       1       1      1       0                0       0       0      0       0
    0       0       0      0       0                0       0       0      0       0
    0       0       0      0       0                0       0       0      0       0
    0       0       0      0       0                0       0       0      0       0
    0       0       0      0       0                0       0       0      0       0
    0       0       0      0       0                0       0       0      0       0
    0       0       0      0       0                0       0       0      0       0
    0       0       0      0       0                0       0       0      0       0
    0       0       0      0       0                0       0       0      0       0
    0       0       0      0       0                0       0       0      0       0
    0       0       0      0       0                0       0       0      0       0
    0       0       0      0       0                0       0       0      0       0
```

```
INC BITS   DIVISOR EQUAL     31

  1024      2240      7[illegible]        0      0               1024     2240      7784       0       0
  1024      2030      5890        0  12163               1024     3592     14804       0    1072
  1024      2052      6154        0   6364               1024     3550     14524       0    3995
  1024      2036      5764        0   3149               1024     3512     14260       0    4915
  1024      2103      6603        0   1506               1024     3621     15301       0    2529
  1024      2054      6074        0    772               1024     3571     14681       0    1310
  1024      2150      6506        0    373               1024     3537     14521       0     658
  1024      2047      6001        0    174               1024     3548     14558       0     308
  1024      2022      5834        0     81               1024     3551     14963       2     147
  1024      2099      6435        0     40               1022     3620     15308      10      70  x2
  1024      2155      6925        0     21               1012     3558     14904      18      35
  1024      2111      6259        0      8                994     3259     12533      75      15
  1024      2088      6258        1      3                919     2945     11387     129       7
  1023      2089      6371        1      3                790     2314      8220     211       5
  1022      2135      6619        6      1                579     1558      5434     247       0
  1016      2015      5953       11      1                332      769      2409     192       3  x3
  1005      2049      6305       16      0                140      253       611      89       1
   989      1949      5639       34      0                 51       91       217      36       0
   955      1870      5332       43      0                 13       17        37      11       0
   912      1763      4989       55      0                  2        2         2       2       0
   857      1650      4546       61      0                  0        0         0       0       0
   796      1482      3894       85      0                  0        0         0       0       0
   711      1335      3535      125      0                  0        0         0       0       0
   586      1100      2968      112      0                  0        0         0       0       0
   474       816      1894      125      0                  0        0         0       0       0
   349       596      1386       93      0                  0        0         0       0       0
   256       402       850       81      0                  0        0         0       0       0
   175       284       598       60      0                  0        0         0       0       0
   115       195       425       49      0                  0        0         0       0       0
    66       102       216       33      0                  0        0         0       0       0
    33        52       110       18      0                  0        0         0       0       0
    15        20        36        9      0                  0        0         0       0       0
     6        10        20        3      0                  0        0         0       0       0
     3         4         6        0      0                  0        0         0       0       0
     3         3         3        3      0                  0        0         0       0       0
     0         0         0        0      0                  0        0         0       0       0
     0         0         0        0      0                  0        0         0       0       0
     0         0         0        0      0                  0        0         0       0       0
     0         0         0        0      0                  0        0         0       0       0
     0         0         0        0      0                  0        0         0       0       0
     0         0         0        0      0                  0        0         0       0       0
     0         0         0        0      0                  0        0         0       0
     0         0         0        0      0                  0        0         0
     0         0         0        0      0                  0        0         0
     0         0         0        0      0                  0                  0       0
               0                  0      0                  0        0         0       0
                                  0      0                  0                  0       0
```