Unclassified

97

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

LINCOLN LABORATORY

NASA
N63

AP-

(Apol

ATION PRODUCTS

This document has
Information Office,
Administration, and
lic release. Furth
in whole or in part
ment shall not be
approval of Lincoln

med
etts I
al Ae

d

ABSTRACT

21725

A program has been written in the SHARE 709 system (SOS) for the IBM 7090 computer to calculate all intermodulation products up to and including sixth order for any number of input frequencies and bandwidths consistent with core storage limitations. Interfering products are written out using OUTRAN as they are calculated and detected.

PROGRAM OUTLINE

Purpose

The purpose of the program is to calculate all intermodulation products up to and including sixth order for any number of transmitting frequencies and receiver bandwidths and to detect and write out interfering products, i.e., those falling within the receiver bandwidths.

Restrictions

A. IB monitor SOS must be used. Program transfers to monitor (location 160_8) when finished.

B. Input frequencies must be fixed-point (decimal) integers up to four significant figures. (Program may be modified to go to eight significant figures.)

C. If the maximum order of product desired is less than six, two instructions should be inserted just after the total for that section is written out, i.e., just ahead of the section to compute products of the next higher order. They are, simply,

```
WEFA    3
TRA     112
```

Method

Denote by f_{j_i} any one of a set of N transmitter frequencies $f_1, f_2, \ldots, f_N$. Then we compute the Pth order intermodulation products by means of the formula

$$F_P = f_{j_1} + \sum_{i=2}^{P} (\pm f_{j_i}) ,$$

where $1 \leq j_i \leq j_{i+1} \leq N$ for $i = 1, 2, \ldots, P$. The double sign of f_{j_i} is intended to indicate that a value of F_P is computed using first $(+f_{j_i})$ and then $(-f_{j_i})$ while all other terms in the sum are held fixed. There is a separate section of the program for each value of P. Note that the f_{i_j} may be arranged in any desired order in the set $f_1, \ldots, f_N$.

Two examples should make this formulation more meaningful and should also serve to illustrate the method used by the program in covering all possible combinations without repetitions.

(1) Let N = 2, P = 3. Then the following sums are formed in the order indicated:

$$f_1 \pm f_1 \pm f_1$$
$$f_1 \pm f_1 \pm f_2$$
$$f_1 \pm f_2 \pm f_2$$
$$f_2 \pm f_2 \pm f_2$$

(2) Let T = 3, N = 3. We have

$f_1 \pm f_1 \pm f_1$	$f_1 \pm f_2 \pm f_3$	$f_2 \pm f_3 \pm f_3$
$f_1 \pm f_1 \pm f_2$	$f_1 \pm f_3 \pm f_3$	$f_3 \pm f_3 \pm f_3$
$f_1 \pm f_1 \pm f_3$	$f_2 \pm f_2 \pm f_2$	
$f_1 \pm f_2 \pm f_2$	$f_2 \pm f_2 \pm f_3$	

The sign-changing procedure for a given set of P frequency values can be illustrated by considering the case $f_1 \pm f_2 \pm f_3 \pm f_4$. Computed in the order indicated are

(1)	$f_1 + f_2 + f_3 + f_4$	(5)	$f_1 - f_2 + f_3 + f_4$
(2)	$f_1 + f_2 + f_3 - f_4$	(6)	$f_1 - f_2 + f_3 - f_4$
(3)	$f_1 + f_2 - f_3 + f_4$	(7)	$f_1 - f_2 - f_3 + f_4$
(4)	$f_1 + f_2 - f_3 - f_4$	(8)	$f_1 - f_2 - f_3 - f_4$

Two tests must be met by a value of F_P in order that it be printed out as an interfering intermodulation product.

(a) F_P must fall within one of the receiver bandwidths.

(b) F_P must be non-redundant (in a sense which will now be defined).

We define a redundancy to be the occurrence for some P of a value of F which reduces trivially to a case which has already resulted at some lower value of P, e.g., $f_1 + f_2 + f_3 + f_4 - f_4$, fifth order, is the same as $f_1 + f_2 + f_3$, third order.

Usage

A. Data Input - Output

Data are entered by means of ALTER card as follows:

Location	Operation	Variable Field
FREQ	DEC	$f_1, f_2, f_3, \ldots, f_N$
CHEK	DEC	$L_{1h}, L_{1\ell}, L_{2h}, L_{2\ell}, \ldots, L_{Rh}, L_{R\ell}$
N	EQU	n_1
CF	EQU	$2n_2$
MAXP	EQU	n_3
L1	BCI	, title

Here

$f_1, \ldots, f_N$ are the transmitter frequencies presented in any order whatever. Note that the values used on the FREQ card are ten times the actual transmitter values, where the latter are assumed to be given to no more than one decimal place.

L_{ih}, $L_{i\ell}$ are the upper and lower limits of the ith receiver bandwidth. Note that the upper limit must precede the lower limit in each pair.

n_1 = total number of transmitter frequencies

n_2 = number of receiver frequency bands.

n_3 = maximum order of intermodulation product to be calculated.

Output is written on logical tape A-3. Values of component frequencies which appear are scaled to ten times their actual value, just as they were for input.

B. Space Requirements

Lower memory contains monitor and OUTRAN! Program begins at 16000_{10} and requires 639_{10} locations plus FREQ, CHEK.

C. Error Halts

Standard OUTRAN error halts.

D. Program Deck

SOS column binary squoze deck with modification package as described in A.

E. Timing

To calculate and check one product

second order, 0.31 milliseconds

third order, 0.37 milliseconds

fourth order, 0.44 milliseconds

fifth order, 0.51 milliseconds

sixth order, 0.59 milliseconds

The above times do not include redundancy testing or outputting.

Sample running time. To calculate products for single sets of N = 18 transmitter frequencies and two receiver frequency bands (CF = 4) and to write out 180 resultant intermodulation products through fourth order required a total time of 6.2 minutes. For the same set of inputs, approximately 15 minutes were required to compute and output all interfering products through sixth order.

HARVEY GRO 11/Ø8/62

```
                ORG     16ØØØ
     B          EQU     A-2
     C          EQU     A-3
     D          EQU     A-4
     E          EQU     A-5
     F          EQU     A-6
     CF         EQU     Ø
     N          EQU     Ø
     MAXP       EQU     Ø
     FREQ       BSS     1,0
     CHEK       BSS     1,0
     L1         BSS     1Ø,0
*** INITIALIZATION FOR ORDER N ***
     SETUP      LXA     P,1
          +1    TXI     *+1,1,1
          +2    SXA     P,1
          +3    SXA     IN2,1
          +4    SXA     ALS,1
          +5    CLA     I1
     ALS        ALS     Ø,1
          +1    STO     TERM2,1
          +2    TIX     ALS-1,1,1
          +3    TRA     1,4
*** COMPUTE ONE SUM ***
     C3         LXA     P,1
          +1    PXD
          +2    ADD     A,1
          +3    TIX     *-1,1,1
          +4    SSP
          +5    STO     PROD
          +6    TRA     COMP
*** TEST TO SEE IF ALL SIGN COMB. USED FOR THIS SET OF F'S***
*** EACH C(TERM2,1)=1 ***
     IN3        LXA     P,1
          +1    PXD
          +2    ADD     TERM2,1
          +3    TIX     *-1,1,1
          +4    SUB     P
          +5    TZE     1,4
     IN1        LXA     P,1
     C2         CLA     TERM2,1
          +1    PAX     ,2
          +2    TNX     C1,2,1
          +3    PXA     ,2
          +4    STO     TERM2,1
          +5    TIX     C2,1,1
          +6    TRA     C3
* CHANGE SIGN OF TERM.*
     C1         CLA     A,1
          +1    CHS
          +2    STO     A,1
* RESET REG IN TERM2 BLOCK.*
          +3    CLA     I1
     IN2        ALS     Ø,1
```

```
      +1  STO    TERM2,1
      +2  TIX    C2,1,1
      +3  TRA    C3
P         PZE
I1                1
A         BES    MAXP,0
TERM2     BES    MAXP,0
PROD      BSS    1,0
TOTAL     DEC       0
N1        DEC       1
M         PZE    N
UNIT      OCT    1203
L2        BCI    3,INPUT FREQUENCIES
L3        BCI    8,INTERMODULATION PRODUCTS          PRODUCED BY
L4        BCI     ,            THESE COMPONENT FREQUENCIES
L5        BCI    5,TOTAL SECOND ORDER PRODUCTS =
L6        BCI    5,TOTAL THIRD ORDER PRODUCTS =
L7        BCI    5,TOTAL FOURTH ORDER PRODUCTS =
L8        BCI    5,TOTAL FIFTH ORDER PRODUCTS =
L9        BCI    3,CHECK FREQUENCIES
L10       BCI    5,TOTAL SIXTH ORDER PRODUCTS =
*     BRING UP NEW VALUES OF FREQUENCY.
BUA       SXD    IRA,4
      +1  LXA    IRA,4
      +2  CLA    FREQ+N,4
      +3  STO    A-1
      +4  SXA    IRA,4
      +5  LXD    IRA,4
      +6  TRA    1,4
IRA       PZE
MA        PZE    N
BUB       SXD    IRB,4
      +1  LXA    IRB,4
      +2  CLA    FREQ+N,4
      +3  STO    B
      +4  SXA    IRB,4
      +5  LXD    IRB,4
      +6  TRA    1,4
IRB       PZE
MB        PZE    N
BUC       SXD    IRC,4
      +1  LXA    IRC,4
      +2  CLA    FREQ+N,4
      +3  STO    C
      +4  SXA    IRC,4
      +5  LXD    IRC,4
      +6  TRA    1,4
IRC       PZE
MC        PZE    N
BUD       SXD    IRD,4
      +1  LXA    IRD,4
      +2  CLA    FREQ+N,4
      +3  STO    D
      +4  SXA    IRD,4
```

```
109          +5  LXD     IRD,4
110          +6  TRA     1,4
111     IRD      PZE
112     DUE      SXD     IRE,4
113          +1  LXA     IRE,4
114          +2  CLA     FREQ+N,4
115          +3  STO     F
116          +4  SXA     IRE,4
117          +5  LXD     IRE,4
118          +6  TRA     1,4
119     IRE      PZE
120     DUF      SXD     IRF,4
121          +1  LXA     IRF,4
122          +2  CLA     FREQ+N,4
123          +3  STO     F
124          +4  SXA     IRF,4
125          +5  LXD     IRF,4
126          +6  TRA     1,4
127     IRF      PZE
128*       TEST PRODUCT FOR INTERFERENCE.
129     COMP     AXT     CF,2
130     LOOP     CAS     CHEK+CF,2
131          +1  TRA     *+5
132          +2  TRA     REDN
133          +3  CAS     CHEK+CF+1,2
134          +4  TRA     REDN
135          +5  TRA     REDN
136          +6  TIX     LOOP,2,2
137          +7  TRA     INS
138*       TEST INTERFERING PRODUCT FOR REDUNDANCY.
139     REDN     LXA     P,3
140          +1  TXI     *+1,3,-1
141     RI       CLA     A-1,1
142          +1  ADD     A,2
143          +2  TZE     INS
144          +3  TIX     RI,2,1
145          +4  TNX     OWT6,1,1
146          +5  SXA     *+1,1
147          +6  AXT     0,2
148          +7  TRA     RI
149     CON      CCT     2330000000000
150     N10F     DEC        10.0
151*       UPDATE TOTAL,OUTPUT INTERFERING PRODUCT.
152     OWT6     CLA     TOTAL
153          +1  ADD     N1
154          +2  STO     TOTAL
155          +3  CLA     PROD
156          +4  FRA     CON
157          +5  FAD     CON
158          +6  FDH     N10F
159          +7  STO     PROD
160              CBLANK  132,0,1
             +8  STL     22
161              CFLFIX  PROD,0,29,4,1
```

```
            +11  STL     22
162              OINT     A-1,0,70,6
            +16  STL     22
163              OINT     B,0,80,6
            +20  STL     22
164              OINT     C,0,90,6
            +24  STL     22
165              OINT     D,0,100,6
            +28  STL     22
166              OINT     E,0,110,6
            +32  STL     22
167              OINT     F,0,120,6
            +36  STL     22
168              OSCRIB   UNIT,0,22,1
            +40  STL     22
169              OREADY
            +44  STL     22
170         +46  TRA     IN3
171*        PRINT INITIAL DATA
172              OUTRAN
        START    STL     22
173              OBLANK   132,0,1
             +2  STL     22
174              OSPACE   2,0,0,1
             +5  STL     22
175              OBCW     L1,0,20,10
             +9  STL     22
176              OSCRIB   UNIT,0,13,1
            +13  STL     22
177              OBLANK   132,0,1
            +17  STL     22
178              OSPACE   2,0,0,1
            +20  STL     22
179              OBCW     L2,0,20,3
            +24  STL     22
180              OSCRIB   UNIT,0,7,1
            +28  STL     22
181              OREADY
            +32  STL     22
182         +34  AXT     N,1
183              OBLANK   132,0,1
        LOOP1    STL     22
184              OSPACE   2,0,0,1
             +3  STL     22
185              OINT     FREQ+N,1,29,6
             +7  STL     22
186              OSCRIB   UNIT,0,7,1
            +11  STL     22
187         +15  TIX     LOOP1,1,1
188         +16  AXT     CF,1
189              OBLANK   132,0,1
            +17  STL     22
190              OSPACE   2,0,0,1
            +20  STL     22
```

```
                 OBCW     L9,Ø,2Ø,3
          +24    STL      22
                 OSCRIB   UNIT,Ø,2Ø,1
          +28    STL      22
                 OREADY
          +32    STL      22
                 OBLANK   132,Ø,1
      LOOP2      STL      22
                 OSPACE   2,Ø,Ø,1
           -3    STL      22
                 OINT     CHEK+CF,1,29,6
           +7    STL      22
                 OSCRIB   UNIT,Ø,2Ø,1
          +11    STL      22
          +15    TIX      LOOP2,1,1
                 OREADY
          +16    STL      22
                 OBLANK   132,Ø,1
          +18    STL      22
                 OSPACE   2,Ø,Ø,1
          +21    STL      22
                 OBCW     L3,Ø,2Ø,8
          +25    STL      22
                 OBCW     L4,Ø,75,9
          +29    STL      22
                 OSCRIB   UNIT,Ø,2Ø,1
          +33    STL      22
                 OREADY
          +37    STL      22
          +39    AXT      MAXP,1
          +4Ø    STZ      A,1
          +41    TIX      *-1,1,1
          +42    CLA      II
          +43    STO      P
          +44    TSX      SETUP,4
                 OZERO    1
          +45    STL      22
*       CALCULATE SECOND ORDER PRODUCTS.
*       CALCULATE A+B,A-B
          +48    AXT      N,1
          +49    SXA      IRA,1
          +5Ø    SXA      IRB,1
      LP1        TSX      BUA,4
           +1    TSX      BUB,4
           +2    TSX      C3,4
           +3    LXA      P,1
           +4    TSX      ALS-1,4
           +5    LXA      IRB,1
           +6    TNX      *+3,1,1
           +7    SXA      IRB,1
           +8    TRA      LP1
           +9    CLA      MB
          +1Ø    SUB      NI
          +11    STO      MB
```

```
230        +12  STA     IRB
231        +13  LXA     IRA,1
232        +14  TXI     *+1,1,-1
233        +15  SXA     IRA,1
234        +16  TXH     LP1,1,0
235*      PRINT TOTAL FOR THIS ORDER.
236             OZERO
           +17  STL     22
237             OBLANK  132,0,1
           +20  STL     22
238             OBCW     L5,0,20,5
           +23  STL     22
239             OINT     TOTAL,0,60,5
           +27  STL     22
240             OSCRIB  UNIT,0,20,1
           +31  STL     22
241             CREADY
           +35  STL     22
242        +37  STZ     TOTAL
243        +38  TSX     SETUP,4
244             OZERO    1
           +39  STL     22
245*      CALCULATE THIRD ORDER PRODUCTS.
246        +42  AXT     N,1
247        +43  SXA     IRA,1
248        +44  SXA     IRB,1
249        +45  SXA     IRC,1
250     LP3     TSX     BUA,4
251         +1  TSX     BUB,4
252         +2  TSX     BUC,4
253         +3  TSX     C3,4
254         +4  LXA     P,1
255         +5  TSX     ALS-1,4
256         +6  LXA     IRC,1
257         +7  TNX     *+3,1,1
258         +8  SXA     IRC,1
259         +9  TRA     LP3
260        +10  LXA     IRB,1
261        +11  TNX     *+4,1,1
262        +12  SXA     IRC,1
263        +13  SXA     IRB,1
264        +14  TRA     LP3
265        +15  LXA     IRA,1
266        +16  TXI     *+1,1,-1
267        +17  SXA     IRA,1
268        +18  SXA     IRB,1
269        +19  SXA     IRC,1
270        +20  TXH     LP3,1,0
271             OZERO
           +21  STL     22
272             OBLANK  132,0,1
           +24  STL     22
273             OBCW     L6,0,20,5
           +27  STL     22
```

```
                OINT    TOTAL,0,60,5
          +31   STL     22
                OSCRIB  UNIT,0,20,1
          +35   STL     22
                OREADY
          +39   STL     22
          +41   STZ     TOTAL
          +42   TSX     SETUP,4
                OZERO   1
          +43   STL     22
*       CALCULATE FOURTH ORDER PRODUCTS.
          +46   AXT     N,1
          +47   SXA     IRA,1
          +48   SXA     IRB,1
          +49   SXA     IRC,1
          +50   SXA     IRD,1
     LP4        TSX     BUA,4
           +1   TSX     BUB,4
           +2   TSX     BUC,4
           +3   TSX     BUD,4
           +4   TSX     C3,4
           +5   LXA     P,1
           +6   TSX     ALS-1,4
           +7   LXA     IRD,1
           +8   TNX     *+3,1,1
           +9   SXA     IRD,1
          +10   TRA     LP4
          +11   LXA     IRC,1
          +12   TNX     *+4,1,1
          +13   SXA     IRD,1
          +14   SXA     IRC,1
          +15   TRA     LP4
          +16   LXA     IRB,1
          +17   TNX     *+5,1,1
          +18   SXA     IRD,1
          +19   SXA     IRC,1
          +20   SXA     IRB,1
          +21   TRA     LP4
          +22   LXA     IRA,1
          +23   TXI     *+1,1,-1
          +24   SXA     IRD,1
          +25   SXA     IRC,1
          +26   SXA     IRB,1
          +27   SXA     IRA,1
          +28   TXH     LP4,1,0
                OZERO
          +29   STL     22
                OBLANK  132,0,1
          +32   STL     22
                OBCW    L7,0,20,5
          +35   STL     22
                OINT    TOTAL,0,60,5
          +39   STL     22
                OSCRIB  UNIT,0,20,1
```

```
          +43  STL     22
320            CREADY
          +47  STL     22
321       +49  STZ     TOTAL
322       +50  TSX     SETUP,4
323            CZERO   1
          +51  STL     22
324*     CALCULATE FIFTH ORDER PRODUCTS.
325       +54  AXT     N,1
326       +55  SXA     IRA,1
327       +56  SXA     IRB,1
328       +57  SXA     IRC,1
329       +58  SXA     IRD,1
330       +59  SXA     IRE,1
331    LP5     TSX     BUA,4
332        +1  TSX     BUB,4
333        +2  TSX     BUC,4
334        +3  TSX     BUD,4
335        +4  TSX     BUE,4
336        +5  TSX     C3,4
337        +6  LXA     P,1
338        +7  TSX     ALS-1,4
339        +8  LXA     IRE,1
340        +9  TNX     *+3,1,1
341       +10  SXA     IRE,1
342       +11  TRA     LP5
343       +12  LXA     IRD,1
344       +13  TNX     *+4,1,1
345       +14  SXA     IRE,1
346       +15  SXA     IRD,1
347       +16  TRA     LP5
348       +17  LXA     IRC,1
349       +18  TNX     *+5,1,1
350       +19  SXA     IRE,1
351       +20  SXA     IRD,1
352       +21  SXA     IRC,1
353       +22  TRA     LP5
354       +23  LXA     IRB,1
355       +24  TNX     *+6,1,1
356       +25  SXA     IRE,1
357       +26  SXA     IRD,1
358       +27  SXA     IRC,1
359       +28  SXA     IRB,1
360       +29  TRA     LP5
361       +30  LXA     IRA,1
362       +31  TXI     *+1,1,-1
363       +32  SXA     IRE,1
364       +33  SXA     IRD,1
365       +34  SXA     IRC,1
366       +35  SXA     IRB,1
367       +36  SXA     IRA,1
368       +37  TXH     LP5,1,0
369            CZERO
          +38  STL     22
```

```
370              CBLANK  132,0,1
            +41  STL     22
371              CBCW    L8,0,20,5
            +44  STL     22
372              OINT    TOTAL,0,60,5
            +48  STL     22
373              OSCRIB  UNIT,0,20,1
            +52  STL     22
374              CREADY
            +56  STL     22
375         +58  STZ     TOTAL
376         +59  TSX     SETUP,4
377              OZERO   1
            +60  STL     22
378=        CALCULATE SIXTH ORDER PRODUCTS
379         +63  AXT     N,1
380         +64  SXA     IRA,1
381         +65  SXA     IRB,1
382         +66  SXA     IRC,1
383         +67  SXA     IRD,1
384         +68  SXA     IRE,1
385         +69  SXA     IRF,1
386     LP6      TSX     BUA,4
387          +1  TSX     BUB,4
388          +2  TSX     BUC,4
389          +3  TSX     BUD,4
390          +4  TSX     BUE,4
391          +5  TSX     BUF,4
392          +6  TSX     C3,4
393          +7  LXA     P,1
394          +8  TSX     ALS-1,4
395          +9  LXA     IRF,1
396         +10  TNX     *+3,1,1
397         +11  SXA     IRF,1
398         +12  TRA     LP6
399         +13  LXA     IRE,1
400         +14  TNX     *+4,1,1
401         +15  SXA     IRF,1
402         +16  SXA     IRE,1
403         +17  TRA     LP6
404         +18  LXA     IRD,1
405         +19  TNX     *+5,1,1
406         +20  SXA     IRF,1
407         +21  SXA     IRE,1
408         +22  SXA     IRD,1
409         +23  TRA     LP6
410         +24  LXA     IRC,1
411         +25  TNX     *+6,1,1
412         +26  SXA     IRF,1
413         +27  SXA     IRE,1
414         +28  SXA     IRD,1
415         +29  SXA     IRC,1
416         +30  TRA     LP6
417         +31  LXA     IRB,1
```

```
418        +32  TNX     *+7,1,1
419        +33  SXA     IRF,1
420        +34  SXA     IRE,1
421        +35  SXA     IRD,1
422        +36  SXA     IRC,1
423        +37  SXA     IRB,1
424        +38  TRA     LP6
425        +39  LXA     IRA,1
426        +40  TXI     *+1,1,-1
427        +41  SXA     IRF,1
428        +42  SXA     IRE,1
429        +43  SXA     IRD,1
430        +44  SXA     IRC,1
431        +45  SXA     IRB,1
432        +46  SXA     IRA,1
433        +47  TXH     LP6,1,0
434             OBLANK   132,0,1
           +48  STL     22
435             OBCW     L10,0,20,5
           +51  STL     22
436             OINT     TOTAL,0,60,5
           +55  STL     22
437             OSCRIB   UNIT,0,20,1
           +59  STL     22
438             OREADY
           +63  STL     22
439        +65  STZ     TOTAL
440        +66  WEFA    3
441        +67  TRA     112
442             END     START
```

HARVEY GRO 11/08/62

CHEK	0001	IRD	0003	LOOP1	0004	N10F	
COMP	0003	IRE	0003	LOOP2	0005	OWT6	
CON	0003	IRF	0003	LP1	0005	P	
D	0001	L1	0001	LP3	0006	PROD	
E	0001	L10	0002	LP4	0007	R1	
F	0001	L2	0002	LP5	0008	REDN	
FREQ	0001	L3	0002	LP6	0009	SETUP	
I1	0002	L4	0002	M	*0002	START	
IN1	*0001	L5	0002	MA	*0002	TERM2	
IN2	0001	L6	0002	MAXP	0001	TOTAL	
IN3	0001	L7	0002	MB	0002	UNIT	
IRA	0002	L8	0002	MC	*0002		
IRB	0002	L9	0002	N	0001		
IRC	0002	LOOP	0003	N1	0002		
A	0002						
ALS	0001						
B	0001						
BUA	0002						
BUB	0002						
BUC	0002						
BUD	0002						
BUE	0003						
BUF	0003						
C	0001						
C 1	0001						
C 2	0001						
C 3	0001						
CF	0001						

DISTRIBUTION LIST

Director's Office

C. F. J. Overhage
W. H. Radford
H. W. Fitzpatrick
J. A. Kessler

Division 2

A. Armenti
J. A. Arnow
T. C. Bartee
F. Belvin
R. N. Davis
S. H. Dodd
R. G. Enticknap
O. V. Fortier
F. E. Heart
D. A. Koniver
M. S. Macrakis
A. J. Morency
B. J. Moriarty
J. F. Nolan
H. C. Peterson
W. G. Schmidt
F. C. Schweppe
H. Sherman
J. Slesers
C. R. Wieser
J. M. Winett
D. Wiggert
P. E. Wood
H. E. Ziemann
Group 25 File

Division 4

J. G. Barry
J. A. Bosco
G. F. Dalrymple
J. C. Fielding
J. Freedman
A. A. Galvin
B. S. Goldstein
W. F. Higgins
B. H. Labitt
W. W. Ward

Division 5

R. T. Mitchell

Division 7

J. F. Hutzenlaub
S. H. Wright

MIT, Instrumentation Laboratory

M. Trageser (2)

Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena 3, California

P. Goodwin, Telecommunications Div. (2)

J. J. Freeman Associates
8416 Georgia Avenue
Silver Spring, Maryland

Dr. J. J. Freeman

George C. Marshall Space Flight Center
Astrionics Division
Instrumentation Development Branch
Huntsville, Alabama

Mr. O. A. Hoberg

George C. Marshall Space Flight Center
Aeroballistics Division
Flight Evaluation Branch
Huntsville, Alabama

Dr. F. A. Speer

North American Aviation
Space and Information Systems Division
12214 Lakewood Boulevard
Downey, California

D. S. Levine (6)
NAA Sub-group 419-77

J. W. Small
Apollo Program Management Office, D/402

NASA Headquarters (Attn: Code T)
400 Maryland Avenue, S. W.
Washington 25, D. C.

R. D. Briskman
C. R. Morrison

NASA - Langley Research Center
Hampton, Virginia

C. J. Donlon (2)
J. E. Stitt

NASA - Manned Spacecraft Center
P. O. Box 1536
Houston 1, Texas

Apollo Project Office
D. R. Broome
E. L. Chicoine
D. Fielder (5)
M. R. Franklin
G. Gibson
D. W. Gilbert
G. B. Graves
J. Heberlig (2)
M. Jenkins
H. C. Kyle
L. Leopold
MSC Files (3)
M. F. Matthews
H. E. Meily (Lincoln Laboratory Representative)
L. E. Packham
R. O. Piland
J. A. Roberts
R. Sawyer
T. Skopinski
P. Vavra
W. Williams

Scientific and Technical Information Facility (2)
Attn: NASA Representative (S-AK/RKT)
P. O. Box 5700
Bethesda, Maryland

NASA - Flight Research Center
Box 273
Edwards, California

K. C. Sanderson
FRC Files

NASA - Pre-Launch Operations
Hangar S
Cape Canaveral, Florida

J. Moser
J. Williams

NASA Headquarters
801 Nineteenth Street, N. W.
Washington 25, D. C.

W. E. Miller
Office Manned Space Flight
Space Flight Operations

M. J. Krasnican (Attn: Code MS)

J. Turnock

M. Mullen, Librarian (6)
Department 675-1, Mail Station 817
Philco Western Development Laboratory
3875 Fabian Way
Palo Alto, California

Goddard Space Flight Center
Greenbelt, Maryland

Dr. H. J. Goett, Director

Mr. J. T. Mengel, Ass't. Director
Tracking and Data Systems Directorate

Mr. C. A. Schroeder, Chief (8)
Tracking Systems Division

Dr. R. J. Coates, Assoc. Chief
Tracking Systems Division

Dr. J. W. Siry, Chief
Theory and Analysis Staff
Tracking Systems Division

Mr. J. J. Fleming, Chief (4)
Data Systems Division

Mr. F. J. Friel, Jr., Chief (4)
Operations Division

Mr. N. R. Heller, Chief (4)
Direct Data Division

Mr. O. Covington
Deputy Ass't. Director of Operations