LINE INTERFEROMETER PROGRAM

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Third Edition

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FOREWARD

Considerable effort has been made to make this document accurate. It is inevitable that mistakes will remain, therefore please advise the authors of any discrepancies.

The Program is very flexible and its design has followed the requirements of the line interferometer so far. There are many hidden features (e.g., tracking planets) and additions are readily made, so if you have a need not met by the program, again, consult the authors.

Efforts will be made to keep the documentation up-to-date.

15 January 1972

MCHW

CHM

PREFACE TO THIRD EDITION

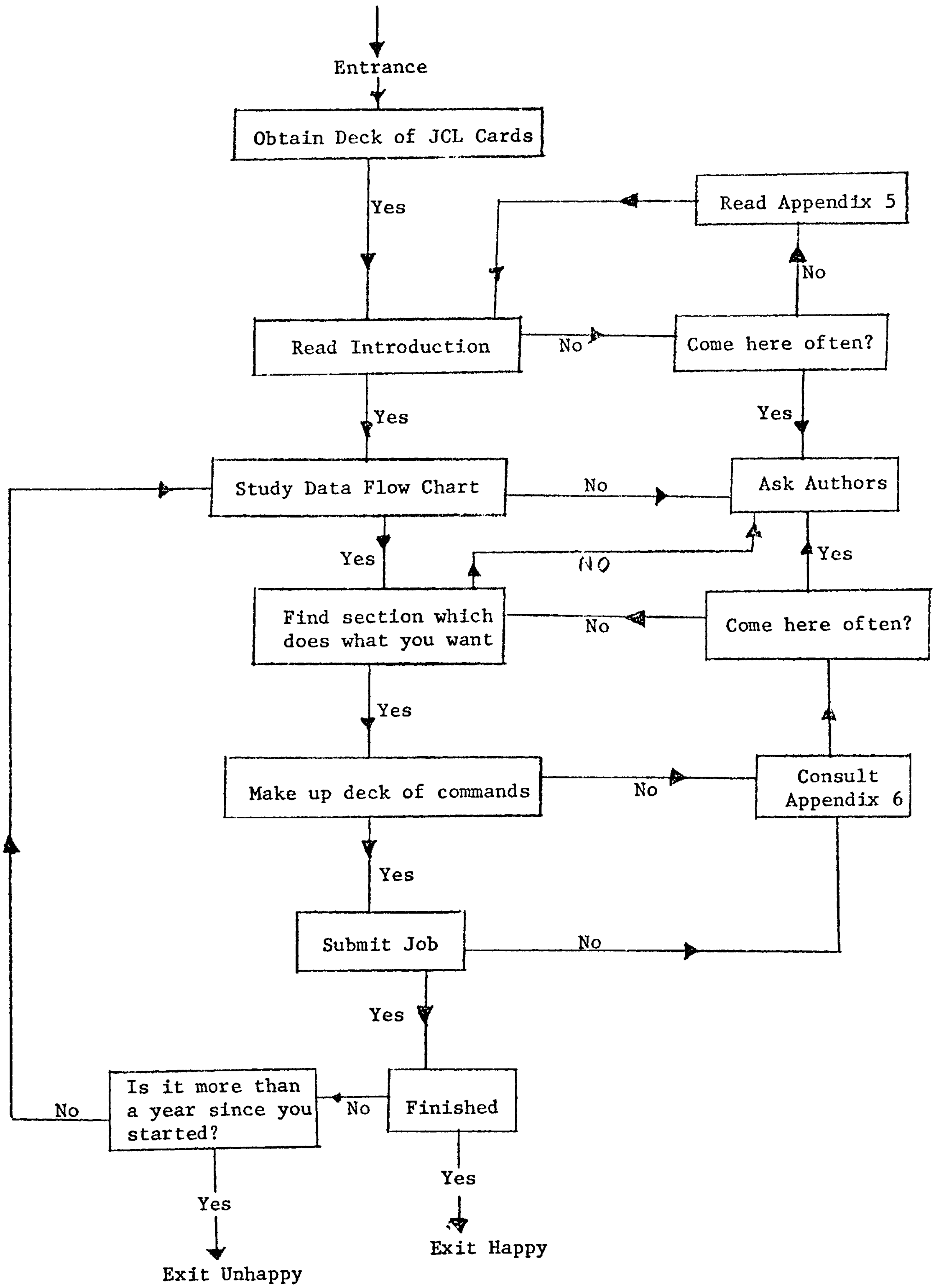
A small number of additions and improvements have been made to the program and this edition updates and replaces the second edition. Three private disk packs are now in use and can be allocated to major users of the system. A small scratch data file "FREQS" is also available. Maps (HI or polarized S and X band) stored on disk through the program can be displayed on the printer, on the "ARDS" display or CalComp, or punched out on cards for input to other programs. Maps can also be "cleaned" and re-stored on disk.

Mel Wright

May 1972

CONTENTS

APPENDIX


Entrance
Obtain Deck of JCL Cards
Yes
Read Appendix 5
No
Read Introduction
No
Come here often?
Yes
Yes
Study Data Flow Chart
No
Ask Authors
Yes
NO
Yes
Find section which does what you want
No
Come here often?
Yes
Make up deck of commands
No
Consult Appendix 6
Yes
Submit Job
No
Yes
Is it more than a year since you started?
No
No
Finished
Yes
Yes
Exit Unhappy
Exit Happy

USERS GUIDE

1. INTRODUCTION

a) Purpose and Compatability

The Line interferometer program is designed to reduce and display data from the NRAO line interferometer. Many of the reduction programs have been re-coded from the Dual-Frequency system with particular attention to simplifying the input. The 360 program described here is separate from the Dual Frequency system, but users of the latter will be familiar with many of the job steps. Compatability with Dual Frequency data format has been maintained so that either Line or Dual Frequency data may be reduced using this program. In particular this program provides an automatic way of inverting, mapping and displaying polarized data.

b) Language

The program is a collection of Fortran and IBM - Assembler subroutines called by a Forth program. Essentially the Forth program provides a flexible language for defining operations and the program is directed by punching Verbs and Parameters in free format input. The program is compiled in an overlay structure so that one standard deck together with the Forth directives suffices for all use of the system.

c) The aim of this documentation is to provide a description of the program and a users' guide allowing him to use and extend the present program with his own subroutines.

The following sections provide a description of the Program and examples of its use to reduce the data.

d) Data Flow

1. The data from the telescope is recorded on 7-track tape data records.

2. The 7-track telescope tapes may be transferred to an "Observer" or "Back-up" 9-track tape in the original data format by a separate program, which rejects and gives advice of wrong length records, etc. No reformatting is done by this program which only serves to store the data on 9-track tape and release the 7-track tape.

3. Either 7-track telescope tape or 9-track observer tape may be loaded onto disk and converted into a catalogued disk data set. The data is reformatted at this time into 512 word records with the line data scaled into 16 bit words by the "GAIN" settings. Error messages are generated at the time the data is reformatted.

4. The data is catalogued, and can be accessed by Source and by Scan number.

5. The data can be inspected, edited and calibrated on the disk.

6. The data may be written out and reloaded from 9-track tape for storage at anytime.

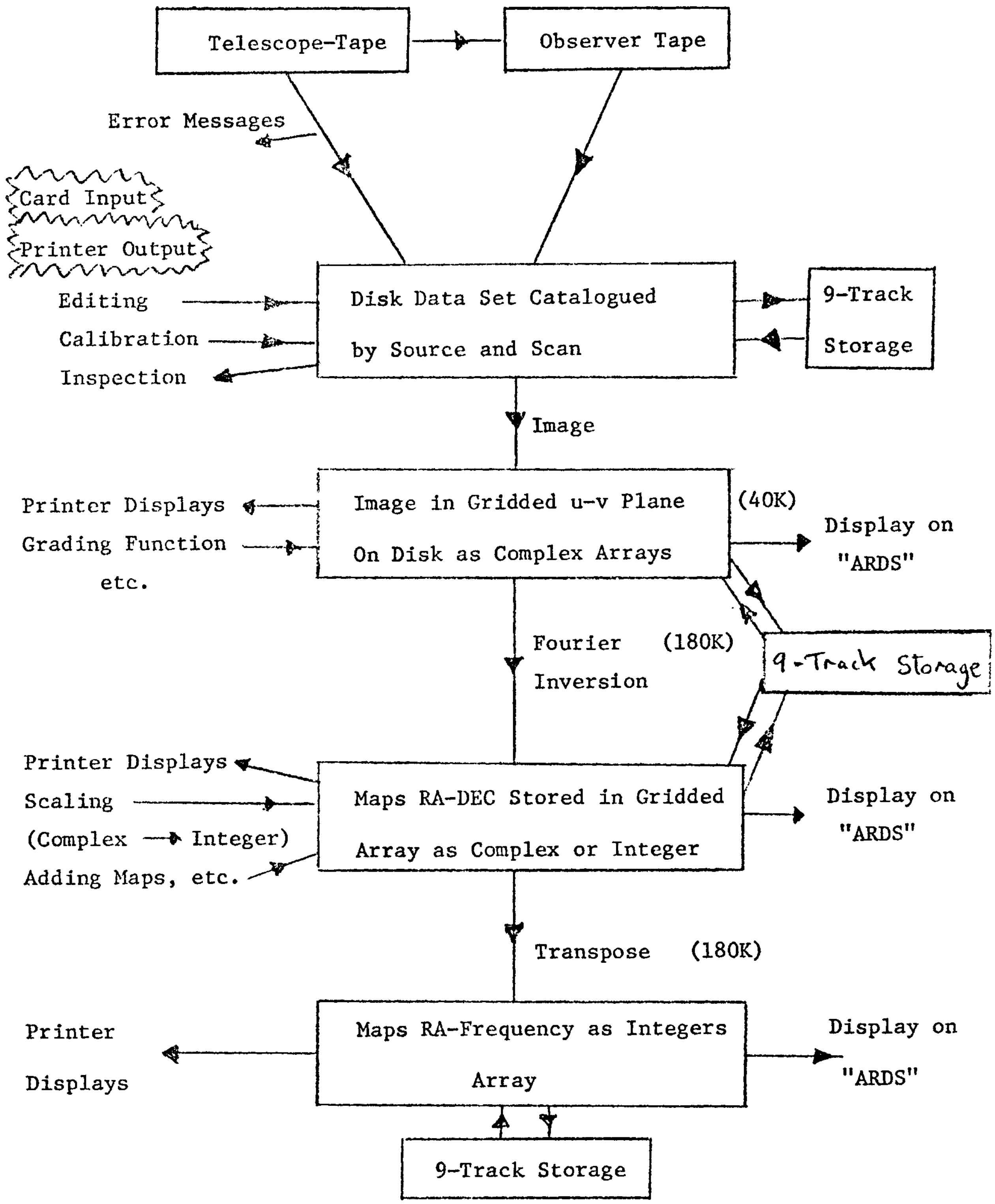
7. Any continuum or averaged frequency channel(s) may be imaged into a gridded u-v plane which is also stored on disk.

8. The u-v planes may be Fourier inverted in-core in a 180K job "BIG".

9. A sequence of maps at an equal frequency intervals may be transposed into space-frequency maps.

10. Either RA-DEC or RA-frequency maps may be displayed as printed maps or on the ARDS display as profiles or contours.

11. Maps can be stored on 9-track tape.


Telescope-Tape
Observer Tape
Error Messages
Card Input
Printer Output
Editing
Calibration
Inspection
Disk Data Set Catalogued by Source and Scan
9-Track Storage
Image
Printer Displays
Grading Function
etc.
Image in Gridded u-v Plane On Disk as Complex Arrays
(40K)
Display on "ARDS"
Fourier Inversion
(180K)
9-Track Storage
Printer Displays
Scaling
(Complex → Integer)
Adding Maps, etc.
Maps RA-DEC Stored in Gridded Array as Complex or Integer
Display on "ARDS"
Transpose
(180K)
Printer Displays
Maps RA-Frequency as Integers Array
Display on "ARDS"
9-Track Storage

2. ORGANIZATION OF PROGRAM

a) Forth

This is the users interface with the program and provides a flexible free-format language for directing subroutine calls within the program.

Two types of words may be distinguised in the use of Forth.

1) Verbs cause some action - usually a subroutine call

2) Nouns set parameters to make choices and do not need repeating unless reset.

The user directs the program by typing a string of nouns to set parametric input followed by a verb to cause the action to take place. A fuller description of the Forth program is contained in Appendix 1 and a dictionary of Forth words is given in Appendix 2.

b) Interface

The Forth is interfaced to the subroutines

i) through a Fortran main routine "INTER" which makes calls to the subroutines.

ii) through a common area "USER" which contains all the parameters which are set by Forth Nouns to be used by the subroutines.

c) Subroutines

The subroutines are written in Fortran or Assembler and are compiled in a hierachical overlay structure. Additional subroutines may be easily added by the user and directions for doing this are contained in Appendix 3.

d) Data Flow

The data from the telescope consists of head records and data records which are recorded on 7 track tape, which is the starting point for this program. The 7 track tape is converted into a catalogued disk data set of constant length (512x16 bit integer) records and all disk access is handled by the routine "FREQS" through a common area "PRIME". FREQS is used to read and write records and index the data by scan # and by source name.

Display, calibration, and editing may all be performed from the disk data set without transfer to tape, but the data may be dumped or transferred to tape at anytime.

e) Mapping

A source may be arrayed into a gridded u-v plane inverted to obtain a map of the sky in any frequency channel (frequency channels can be combined). These maps are also stored on disk and a subroutine "ROWS" transfers the data through a common area "PLANE". In order to obtain a frequency spectra at a point in the sky, the required frequency channels must be separately inverted, stored and re-displayed as a spectra.

f) Disk Layout

The Forth Program, Index by Scan, Index by Source name, Data and Maps all reside on disk. The layout is shown in appendix 5. The user must himself allocate blocks 110 to 159 to hold the indices for given sources, before a tape can be loaded.

3. LOADING A TELESCOPE TAPE

The line data is contained in a double precision word to avoid analogue gain setting for the correlator. This is converted to single precision (16 bits) at the time the telescope is loaded onto disk.

The user must:

i) Allocate disk space to catalogue the sources on disk

* (ii) Provide a digital gain setting to prevent overflow with strong sources.)

TAPES LOAD	load in program for tape I/O
ERASE-SOURCE	
160 DEFINE AVAIL	initialize source index
0 DEFINE EVERYTHING	

110 GAINS 0202* INCLUDE 3C48	disk blocks 110 through 159 are used
111 GAINS 0202 INCLUDE 3C48-1	to hold source index
112 GAINS 0000 INCLUDE P0237-23	assign blocks to hold index for
etc.	sources included
159 GAINS 0000 INCLUDE M33	

FLUSH	terminate index
TELESCOPE-TAPE†	reads the sources above onto disk, reformats data and monitors ADC and discontinuities in data

†A JCL card is required for the telescope tape.

* "GAINS" are dummy numbers except for Data before March 1972 where the gains are used in reducing line data to 16 bits for baselines 1-2, 1-3, 1-4, 2-3 respectively 0 ≡ x 1., 2 ≡ x 0.1, 3 ≡ 0.01
See also Section 7.

4. DATA DISPLAY

Data may be accessed by source and by scan number. Printed numbers or plots can be obtained for the different receivers or correlators.

LIST_SCANS
HEADER
BASELINES
LOOK
DELAYS
SPECTRAL_DENSITY
PROFS
DISPLAY
PROFILES
DUMP
MONITOR

A) Printed Output

FOR 3C48 LIST_SCANS	lists scans in the index for 3C48 (1 line per scan)
FOR 3C309.1 DUMP 3024 A_SCAN	prints out every word of SCAN 3024 (6 lines)
FOR EVERYTHING CONTINUUM VECTOR LOOK 3000 3024 SCANS	prints amplitude and phase of continuum channels (1 line per record)

FOR NGC2403 RX_SUMS VECTOR LOOK 3000 3024 SCANS	prints added line channels for NGC2403 from scan 3000 to 3024 (1 line per record)
FOR EVERYTHING AVERAGE BROAD_BAND COMPLEX LOOK 3124 3135 SCANS	prints the scan-average as real and imaginary for both continuum and rx-sums

B) Plotted Output

FOR EVERYTHING CONTINUUM AMPL(PHASE) MONITOR 3000 3123 SCANS	a printed plot of the continuum channels amplitude (phase)

C) Line-data

AMPL(PHASE)	select amplitude (or phase) to be plotted
0 30000 Scale	The range given in "scale" is divided into 20 equal intervals printed as 0, blank, 1, blank, 2, -------, 9, blank.
RX-AB SPECTRAL-DENSITY	a matrix printout of 96 frequencies as above

D) Other displays driven by SCANS are

PROFS	a plot of scan averaged amplitude and phase (1/2 page per scan)
DISPLAY	a printed or plotted display of chosen frequencies

Examples are:

1) {RX-C / RX-AB / RX-CD} COMPLEX LOOK 1010 1050 SCANS — "complex" gives real and imaginary

2) {CONTINUUM / RX-SUMS / BROAD-BAND} {VECTOR / COMPLEX} LOOK 1100 A-SCAN — "vector" gives amplitude and phase pairs "continuum" or "line-sum" channels.

3) {RX-AB / RX-CD} PROFS 1030 1400 SCANS

4) {PLOT / PRINT} {REAL / IMAG / AMPL / PHASE / COMPLEX / VECTOR} {CONTINUUM / LINE-SUM / RX-AB FREQ 10, 15, 16, 17, 20,} DISPLAY 1034 A-SCAN

If several types of display are required for the same scan range typing may be avoided by defining: ":GO 1010 1050 SCANS;". This defines "GO" as "1010 1050 SCANS" so that the above might become for example:

:GO 1010 1050 SCANS;

RX-AB

CONTINUUM

VECTOR

LOOK GO

FREQ 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, PLOT DISPLAY GO

RX-AB and VECTOR do not need re-defining as they have not been changed.

E) Profiles down the page may be obtained for selected scans through

SCAN-LIST 10, 100, 1000, 1001, 1002,

PRINT PLOT	REAL IMAG AMP PHASE COMPLEX VECTOR	PROFILES

For any of the above the integrating period may be set by:

1 INT = a single record, default value unless re-set by user

AVERAGE is defined as : 120 INT = namely a scan-average.

F) Other displays are:

HEADER 1010 1050 SCANS a print out of header information

BASELINES 1010 1050 SCANS prints out baselines

WATER 1010 1050 SCANS water vapor receiver

DELAYS prints three amplitudes and phases versus delays in binary. A correlator list is also required thus:

```
CONTINUUM              )
RX-SUMS                }   DELAYS 1015  1050 SCANS
RX-CD FREQ 10, 11, 12, )
```

DUMP 1010 1050 SCANS the whole record is dumped in decimal

HEX-DUMP defined as:

```
:HEX-DUMP  20K = DUMP;
```

gives a hex instead of decimal dump.

5. CALIBRATION

Five calibrations are envisaged:

i) interferometer baseline

ii) observing-frequency dependent instrumental phase

iii) instrumental phase

iv) shape of the IF passband

v) instrumental gain

i) Baseline Calibration

BASES LOAD	load program
5 VARIABLES	
CONTINUUM	use continuum channels

CAL	3C48	100	200	SCANS	selects the sources to be used as baseline calibrations
CAL	3C309.1	150	300	SCANS	
CAL	3C418	170	270	SCANS	

SOLVE — performs a single least squares iteration to the phase of the continuum data to improve the 5 variables;phase center, Bx, By, Bz, K

ii) Combined Fit

A combined baseline and phase-frequency fit may be made by:

6 VARIABLES	
RX_SUMS	use added line channels

CAL	3C48	500	1700	SCANS	sources to be used as calibrators
CAL	3C209.1	550	750	SCANS	
CAL	3C295	600	755	SCANS	

SOLVE performs a least squares iteration to the phase of the continuum or line-sum channels to improve ϕ_o, Bx, By, Bz, K, $d\phi/df$.

These calibrating programs print out the best fitting parameters, their rms deviation, and a correlation matrix of the variables. Inspection of the data as a phase-time plot can be obtained before and after the data has been corrected. The corrections are stored and may be applied directly:

BASE_COR	500	1000	SCANS	applies the stored baseline corrections to all bandwidths
"n" BANDWIDTH				
BASE_COR	600	700	SCANS	corrects the data for bandwidth "n" 1≡10 MHz thru 9≡39 KHz n=0 is default value

An initial guess may, and should, be entered if there exists a lobe ambiguity in the baseline or phase-frequency parameters. Otherwise the least squares solution may find a false minimum. For this reason it is a good idea to observe a calibrator at a number of frequencies as a cross-check.

0	0	0	0	0	0	B12
0	0	0	0	0	1413	B13
0	0	0	0	0	-121	B23
0	0	0	0	0	0	B14
	BASE_COR	100	1000	SCANS		

} corrects all B/W's for initial values of all 6 variables, ϕo, ΔBx, ΔBy, ΔBz, ΔK, $d\phi/df$. units : millilobes, $\lambda/1000$ and millilobes per MHz

iii) Instrumental Phase

A phase centre is calculated in the baseline fitting program, but the instrumental phase may be computed between jumps by:

1 VARIABLE

CAL	3C295	100	300	SCANS
CAL	3C48	100	300	SCANS
CAL	3C309.1	100	300	SCANS

} determine instrumental phase from these calibrators

SOLVE

BASE_COR 100 300 SCANS correct all B/W's

iv) IF Passband

PASS-BAND 144 A-SCAN	generates the shape of the scan averaged spectrum for scan 144 and stores its complex reciprocal on disk.
RX-AB EDIT-BAND 145 147 SCANS	multiplies the given range of scans by the stored reciprocals. Application of the calibrator to itself yields a corrected pass-band of constant amplitude and constant phase. A range of (-4, 4) is allowed in amplitude and the digital precision is limited to one part in 2^{12}. The average phase across the pass-band is preserved through this correction.

v) Gain Calibration

To inspect for system gain variations (actually system noise temperature variations if ALC is used):

1) Store the calibrator fluxes (in mfu)

e.g. for 3C48

15600 STORE-FLUX 1000 9000 SCANS

for 3C147

22500 STORE-FLUX 1000 9000 SCANS

2) The reciprocal gains i.e.,

1000/(count per mfu)

can be printed out using:

FOR EVERYTHING (AVERAGE) BROADBAND

RECIPROCAL-GAINS 1000 9000 SCANS

3) These are the numbers to be used in MULT-AMPL if you wish to correct for temporal gain variations.

6. EDITING

Editing is provided by two subroutines "Edit" and "Phase" each with several entry points. Edit provides for Editing directly. Phase corrects for baseline, position, clock, atmospheric and observing frequency changes.

A) Direct Editing

FETCH
STORE
DELETE
MULT_AMPL
ADD_PHASE
EDIT_BAND

Examples

EDITS LOAD	load program
4 FETCH 144 A_SCAN	print word 4 of every record in scan 144
50 INTO 4 STORE DATA 144 A_SCAN	store the value 50 into word 4 of data records
RX_A DELETE 140 150 SCANS	flags line receiver bad
COR_1 DELETE 140 A_SCAN	flags continuum bad
RX_AB 500 MULT_AMPL 144 170 SCANS	multiplies data by 500/1000
RX_AB 50 ADD_PHASE 144 170 SCANS	add 50 degrees of phase to RX_AB

B) Phase Corrections

CLOCK_COR
POSITION_COR
PHASE_COR

Examples

FOR EVERYTHING

PHASE_COR 140 5260 SCANS	corrects for atmospheric phase effects
10 CLOCK_COR 5260 5400 SCANS	adds the given correction (ms) to the clock
FOR 3C286 130 40 POSITION_COR 500 5000 SCANS	Adds corrections 130 x 1/100 secs of time in RA, 40 x 1/10 secs arc in DEC to position of 3C286. Decimal points may be inserted without effect so the position changes may also be written 1.30 4.0. Trailing zeros must be present.

7. TAPE TRANSFER

TAPES LOAD			load program
TELESCOPE-TAPE*			transfers the data to a catalogued disk data set
500	2700	OBSERVER-TAPE*	transfers back-up tape of data to disk
500	2700	WRITE-NINE	writes a scan sequential 9 track tape from disk for scans 500 2700
500	2700	LOAD-NINE	loads the 9 track tape (written by above)
500	2700	1 BAND-WIDTH	as LOAD-NINE but loads only the 10 MHz Bandwidth data (2 ≡ 5 MHz, ..., 9 ≡ 39 kHz,)
500	2700	COPY-NINE	copies 9 track tapes
500	7000	TAPE-INDEX	list of scans on tape in given range

The whole disk-file may be dumped onto tape and re-loaded through two separate programs. "DUMP" and "LOAD" (See Appendix 7).

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* Data taken before March 1972

It is necessary to remember which baselines are attached to which correlator inputs and prefix these commands by "# NU = ". Cases allowed for at present are:

2 receiver mode

4 NU = channels 1-192 BL12, channels 193-384 BL23

5 NU = channels 1-192 BL13, channels 193-384 BL23

3/4 receiver mode

6 NU = channels 1-96 BL12, channels 97-192 BL13,
channels 193-288 BL23, channels 289-384 autocorrelator

The Gains to be applied to the line data must also be inserted. See Section 3.

8. MAPPING

The mapping process has two stages:

1) Imaging the data for the desired source, correlators and baselines into a gridded u-v plane.

2) Fourier inverting the u-v plane to obtain a map of the brightness distribution in the x-y plane.

The Fourier inversion may be performed in the usual 90K job using disk storage but is better performed in a separate 180K job which also provides for storing the maps as integers.

A) 90K Mapping

DIMENSION RESOLUTION LINE_FREQ IMAGE MAP READMAP TRANSFORM	ONE-FREQ PLANE

Examples

MAPS LOAD	load program
127 DIMENSION	128 x 128 array (this is the default value)
30 30 RESOLUTION	3" arc per cell in sky
3000 ARRAY =	starting address for map on disk (128 blocks per map)
RX-SUMS	
1 9 ONE-FREQ	u-v plane to be made from $\frac{1}{9}\sum_1^9 \text{freq}_i$. Produces real map (imaginary part zero). Amplitude and phase in u-v plane are meaningful.

RX-SUMS	frequencies 1 thru 9 added together
1 9 LINE_FREQ	and end up in Real map, 10 thru 18 in Imaginary. "Amplitude" and "phase" in u-v plane are not valid.
500 27000 IMAGE NGC2403	image the given scan range into a gridded u-v plane
0 100 SCALE AMPL MAP	a printed plot of "1" thru "9" ranging over the previous set scale
PHASE / REAL / IMAG PLANE	a 2 digit display of left half plane
TRANSFORM	inverts the data and puts it back into block 3000
0 10000 SCALE	re-set scale
44 76 45 77 OUTER_AREA 50 70 60 70 INNER_AREA	set area displayed below
REAL READ_MAP	freqs. 1-9
IMAG READ_MAP	freqs. 10-19

Readmap is a 4 digit printout and also gives the sums and averages over the inner and outer areas specified.

B) Map Operations

BEAM
MOVE_MAP
MULT_MAP
ADD_MAP
DIVIDE_MAP

Examples

3000 INTO 3128 MOVE_MAP	enables one to preserve the u-v plane
3000 INTO 3128 ADD_MAP	adds 1st map into 2nd
3000 INTO 1328 MULT_MAP	multiplies 1st map into 2nd
3000 INTO 1328 DIVIDE_MAP	divides 1st map into 2nd
10 LOW = 3000 INTO 3128 BEAM	creates a u-v plane which when transformed gives the beam offset 10 cells in RA from the map center

C) 180 Mapping

Uses the large partition to invert already stored u-v planes.

```
UV
GET
SQUEEZE
TRANSFORM
MAP
SECOND MAP
PUT
TRANSPOSE
```

Examples

UV 3000 GET	move u-v plane into core
TRANSFORM	invert
1000 1000 SQUEEZE	condense to integer maps (÷ 1000)
MAP	1 digit printout of real map
4000 PUT	store integer map
SECOND MAP	imaginary map printout
4032 PUT	store integer map (32 blocks per map)

BEAM, in 180K mapping pgm, adds 1000 into imaginary part before "TRANSFORM".

can be used for a real map to give the beam shape in the imaginary (or second) map.

The integer maps stored by the 180K program take 32 blocks each (for a 128 x 128 map). These maps can be used as input for an iterative souce subtraction program "CLEANF" which stores the cleaned maps back onto disk in a new location. (For details ask for separate memo.)

9. DUAL FREQUENCY DATA

The program has been designed to handle dual frequency data. Either 7 track telescope tapes or 9 track calibrated or uncalibrated tapes may be loaded onto disk and all the baseline fitting and display programs are available by specifying the appropriate correlators.

A) Loading Tapes

```
                    TAPES LOAD
              -include sources, etc.-
                3 NU = TELESCOPE-TAPE          loads 7 track
   or           500  28000  DUAL-FREQ          loads 9 track

         S-BAND  RR
         VECTOR LOOK 500 28000 SCANS
```

-displays S-band RR data, etc.

B) Mapping

```
                  MAPS LOAD
                127   DIMENSION
          10     10   RESOLUTION        1 x 1 arc cell size in sky
           0    100   SCALE
               3000   ARRAY =
          X-BAND   RR
          RR or LL or RL
          500 28000 IMAGE 3C20
```

"RL" automatically gives RL and LR* in u-v plane for polarized data.

```
          AMPL MAP                  give intensity of polarization
          PHASE MAP                 and 2x for polarized map
```

The polarized maps may be transformed and operated on as for line data. Note that the amplitude and phase of a polarized map are the intensity and twice the position angle of the polarization.

LOW-RR

LOW-LL — are defined to give maps from the 2-3 baseline only.

LOW-RL

Dual frequency maps may be inverted and cleaned through the 180K program as for 21 cm maps.

APPENDIX 1

THE H-LINE FORTH LANGUAGE

The Forth language is a dictionary search for character sequences or "words" broken by spaces. Certain character sequences define basic machine operations and the Language is built up by defining other character sequences in terms of already defined words. The language is self-compiling and definitions may be mixed together with executable words.

The Forth used in this program is a particular application of the language to the IBM 360/50. In this application the Forth is interfaced with Fortran and is able to set parameters in the Fortran common area "/USER/" and to make subroutine calls from the Fortran main program. The parameters in common may all be directly set (for example: "45 THETA =") but are mostly combined into more mnemonic definitions. (For example, "RR" sets up the number and a list of the correlator positions for the RR data.) The subroutine calls are made by other words; the verbs of the language which cause actions to take place.

The program is run off-line by submitting a card deck of directives which starts:

```
          E LOAD
       H-LINE  LOAD
              |
              |— Displays
              |
              |— MAPS LOAD ————————— mapping
              |
              |— TAPES LOAD ———————— tape 1/0
              |
```

```
|
|—— EDITS LOAD ——————————— editing
|
|—— BASES LOAD ——————————— baseline fitting
|
|—— OPTIONAL LOAD ———————— extras
```

MAPS, TAPES, EDITS, BASES overlay each other

The current definitions may be inspected at anytime by:

E LOAD

CARDS LOAD

20 40 SHOW

Definitions may be added or changed (caution) by the user

": WORD OTHER WORDS;"

defines "WORD" AS "OTHER WORDS."

APPENDIX 2

H-LINE FORTH DICTIONARY

a) Common "/USER/"

Common "/USER/"	USE
THETA	rotation of array
F1	starting frequency
NF	number of frequencies
DF	interval between frequencies
RES (4)	Δ_x, Δ_y, Δ_u, Δ_v
NS	count of items in List
LIST (38)	Lists of scans and frequencies
LOW	Lower Limit
HIGH	Upper Limit
INT	number of records integrated
C	correlator posiiton
SCAN	scan #
RECORD	record #
NU	frequency
P	polarization
SOURCE	used in disk index
ARRAY	starting block # for map
K	used for real, imag, etc.
ARG (3)	multiply used for parameter passing
Y-DIM	used in retangular FT
K1	entry point in "INTER"
NR	# of repitions of "SCANS" loop
ENTRY	entry point in subroutines

b) Words used to set parameters

INCLUDE	create a source index on disk
GAINS	set scaling factor for data transfer
DEFINE	a define file statement
AVAIL	a define file statement
INNER-AREA	inner area for readmap
OUTER-AREA	outer area for readmap
A-RECORD	sets record number
DATA	data records chosen by SCANS
HEAD	head record only chosen by SCANS
EVERY	every record chosen by SCANS
REAL	real part of data
IMAG	imaginary part of data
AMPL	amplitude of data
PHASE	phase of data
COMPLEX	real and imaginary of data
VECTOR	amplitude and phase of data
RX-A	frequency channels 1-48
RX-B	frequency channels 49-96
RX-C	frequency channels 97-144
RX-D	frequency channels 145-192
RX-AB	frequency channels 1-96
RX-CD	frequency channels 97-192
RX-ABCD	frequency channels 1-192
RESOLUTION	sets Δ_x, Δ_y, Δ_u, Δ_v for mapping
BASELINES	printout baselines

LOOK	printout given frequency list
HEADER	printout header
FREQ	list frequencies
SCAN-LIST	list scans
DUMP	prints whole record
PASS-BAND	store spectral pass-band or disk
WATER	printout water vapour rxs
DISPLAY	display frequency list
SPECTRA	averaged amplitude and phase
SPECTRAL-DENSITY	a matrix plot out
MULTIPLY	multiply and add phase to data
MULT-AMP	multiply data
ADD-PHASE	modify phase of data
PHASE-COR	apply atmospheric phase corrections
BASE-COR	apply baseline ocrrections
POSITION-COR	apply ΔRA, ΔDEC corrections
GRADING-FUNCTION	specify half widths of
PRIMARY BEAM	specify half widths of
INTO	dummie word
VARIABLES	no. of variables in baseline calibration
BANDWIDTH	bandwidth of data to be used in above

c) Words used to cause actions

FLUSH	moves included sources to disk
MAP	a printed contour map
READ-MAP	a numerical printout of map
ERASE-SOURCE	erase disk source indices
ERASE-ARRAY	zero array on disk
SCANS	a loop through scan #s
A-SCAN	a single scan
TRANSFORM	an FFT routine using disk access
TELESCOPE-TAPE	load 7 track tape onto disk
OBSERVER-TAPE	load 9 track observer tape
DUAL-FREQ	load dual frequency data onto disk
LOAD-NINE	load 9 track tape onto disk
WRITE-NINE	write a 9 track tape
COPY-NINE	copy a 9 track tape
TAPE-INDEX	index a 9 track tape
BEAM	make BEAM of array
ADD-MAP	add arrays together
IMAGE	make a gridded u-v plane
GENERATE	make a specified map
CAL	use source as calibrator

APPENDIX 3

To Add A Fortran Subroutine To H-Line

1) Code the subroutine accepting all input through common /USER/. Compile it as a member of "MOORE·MODS".
2) Recompile subroutine "INTER" with a call to your subroutine.
3) Add your subroutine to an overlay statement with similar subroutines in the "LINK-EDIT" deck.
4) Add a Fortran definition of your subroutine to the "FORTH" deck, and/or a suitably memonic definition in the "FORTH" definitions.

APPENDIX 4

H-LINE RECORD FORMAT

Word	Content (units)	Unused fields
1	integer 1 (identifies header)	
2	scan no. (0 - 32767)	
3		360: no. of data records
4	Greenwich sidereal days since 2424832	
5-6	LST 116: BCD $(.1^s)$ 360: integer $(.1^s)$	
7-10	source name (8 ANSI letters, even parity)	
11-12	RA (rev) 116: 30-place fraction 360: REAL*4	
13-14	Dec (rev) "	
15	return code: 0 1 2 3 4 5 6	
16	start LST (	start LST (10^s)
17		stop LST (10^s)
18		mode
19		system
20		observer (2 ANSI letters)
21		operator "
22		
23	no. of phase corrections applied	
24		
25	" clock "	
26	" position "	
27		85-1 Dec (1/4 rev, 15-place
28		HA fraction)
29-30		85-2 "
31-32		85-3 "
33-34	line-of-sight standard-of-rest velocity (c) 116: 30-place fraction 360: REAL*4	
35-36	synthesizer frequency (Hz, integer)	
37-38	Z_{12} baseline (1/1024 cycle) 116: integer 360: REAL*4	
39-40	Z_{13} "	
41-42	Z_{23}	
43-44	Z_{14}	
45-46	X_{12}	
47-48	X_{13}	
49-50	X_{23}	
51-52	X_{14}	
53-54	Y_{12}	
55-56	Y_{13}	
57-58	Y_{23}	
59-60	Y_{14}	
61-62	k_{12}	
63-64	k_{13}	
65-66	k_{23}	
67-68	k_{14}	

69	source scaling divisor
70-100	
101-512	

Word	Content (units)	Unused fields
1	integer 2 identifies data	
2	scan no. (must match header)	
3		
4		sidereal day
5-6	LST 116: BCD ($.1^s$) 360: integer ($.1^s$)	
7	mode: 1 S-band 2 X-band 4 mixed	
8	receiver baselines (see word format)	
9	no. of distinct baselines	
10	correlator gains (see word formats)	
11	if selection "	
12	computer control "	
13	lock "	
14	range "	
15	faults "	
16	85-1 delay (us, 10-place fraction)	
17	85-2 "	
18	85-3 "	
19-20	local oscillator (Hz, integer)	
21-22	integration time (3.2 us, integer)	
23-24	signal power, channels 1-48	
25-26	" 49-92	
27-28	" 93-144	
29-30	" 145-192	
31-38	signal + noise power "	
39-54	correlator words 1572-1587	
39-42	bandwidth code, channels 1-48, etc.	
43	mode	
44	noise tube state	
45	gain modulator code	
46	switches *	
47	switching rate code	
48	clipper test	
49	digital test	
50		
51-54	local oscillator, channels 1-48, BCD (10 Hz)	

55	1-2 continuum, real	
56	imaginary	
57	baseline #1	116: offset
58	RMS: 0 or negative - ignore data	
59-62	1-3 " (#2)	
63-66	2-3 " (#3)	
67-70	1-4 " (#4)	

<u>360 format</u>

71-74	first receiver, real
	imaginary
	baseline
	RMS
75-78	second "
79-82	third "
83-86	fourth
87	
88	
	A/D channels 24-63
89	85-1 R if monitor
90	" L "
91-92	85-2 "
93-94	85-3 "
95-96	42' "
97-104	" sync detector
105	microwave I phase
106	" Q "
107	
108	temperature (°C)
109	dew point (°C)
110	barometric pressure (mm)
111	cable pressure (?)
112	85-1 water vapor (?/K)
113	85-2 "
114	85-3 "
115	
116-118	" box temperature (?)
119-125	
126	42' water vapor (?/K)
127-128	
129-130	channel 1, real
	imaginary
131-132	channel 2 "
133-512	channels 3-192

<u>116 format</u>

71-72	first, real
73-74	imaginary
75-76	$(2^{-7} * RMS)^2$
77-82	second "
83-88	third "
89-94	fourth "
95-134	A/D channels 24-63
135-150	correlator words 1588-1603
150-256	
257-258	channel 1, real
259-260	imaginary
261-264	channel 2 "
265-1024	channels 3-192

Word formats

Word	Use	Bit	Use		
8	receiver baselines	1-4	RX-A		
		5-8	B		
		9-12	C		
		13-16	D		
10	correlator gains	1-2	1-2 RR	00	multiplied by 1.
		3-4	LL	~~01~~	~~undefined~~
		5-8	1-3	10	multiplied by .1
		9-12	1-4	11	" .01
		13-16	2-3		
11	if selected	1-3	85-1	001	XR-SL
		4-6	2	010	XR-XL
		7-9	3	100	SR-SL
		10	water vapor cal on		
12	computer control	1	85-1		
		2	2		
		3	3		
		4	85-1 receiver		
		5	2 "		
		6	3		
		7	85-1 delay		
		8	2 "		
		9	3		
		10	1-2 correlator gain		
		11	1-3 "		
		12	polarization and focus motors		
		13	1-4 correlator gain		
		14	2-3 "		
		15	2-4		
		16	3-4		
13	lock	10	42'	out of lock	
		11	master lo	"	
		12	85-1 lo	"	
		13	2 "		
		14	3		
		15			
		16	42' lo	"	

14	range	1	85-1 lo phase unlocked
		2	2 "
		3	3 "
		4	42' "
		5	
		6	master lo out of range
		7	if level "
		8	
		9	85-1 R if level "
		10	L "
		11-12	2 "
		13-14	3 "
		15-16	42' "
15	faults	1	85-1 box temperature out of range
		2	2 "
		3	3 "
		4	
		5	85-1 SR receiver fault
		6	SL "
		7	XR "
		8	XL "
		9-12	85-2 "
		13-16	3 "

APPENDIX 5

Disk Layout

Block	Content
0	Empty
1	Empty
2 – 99	Forth program
100	Name index
101	Calibrations
102 – 109	Scan index
110 – 159	Source index
160 –	Scans
– 4095	Maps

APPENDIX 6

COMPLETE EXAMPLES

i) Loading Program — E LOAD

H-LINE LOAD

TAPES LOAD

ii) Creating the disk index of sources

ERASE-SOURCE

160	DEFINE	AVAIL		
0	DEFINE	EVERYTHING		
110	GAINS	0202	INCLUDE	3C48
110	GAINS	0202	INCLUDE	3C48-1
111	GAINS	0000	INCLUDE	3C13
112	GAINS	0000	INCLUDE	NGC_2403
113	GAINS	0203	INCLUDE	CAS-A

FLUSH

iii) Loading a telescope tape

TELESCOPE-TAPE (+ JCL card)

iv) Inspecting the data on disk for a range of scans

: GO 2500 3000 SCANS;		Output
FOR EVERYTHING		For all sources
DISK-INDEX	GO	2 lines per scan
BASELINES	GO	5 lines per scan
DELAYS	GO	1 line per record
WATER	GO	1 line per record
SYSTEM	GO	1 line per record

```
      0     30000     SCALE

AMPL   RX-CD   SPECTRAL-DENSITY   GO       1 line per record

RX-AB  FREQ  20, 21, 22, 23, 24, 30, 31, 32, 33, 34,

PRINT VECTOR DISPLAY   GO                  1 line per record

FOR 3C48                                   for 3C48 only

AMPL MONITOR   GO                          1 line per record
```

Write data to a nine track tape

```
   2500  3000  WRITE-NINE    (+JCL Card)
```

v) Editing Data

```
               EDITS LOAD FOR 3C48    ("EDITS" overlays "TAPES")

   DELETE   RX-AB    13    A-RECORD   200   A-SCAN

   FOR EVERYTHING

   DELETE   COR-1    300   3100       SCANS
```

vi) Correcting for Atmospheric phase, clock corrections, Error in position of 3C48.

```
PHASE-COR      2500     3000     SCANS

10 CLOCK-COR   2500     2700     SCANS

5 CLOCK-COR    2701     2800     SCANS

-5 CLOCK-COR   2801     3000     SCANS

FOR 3C48       0        100      POSITION-COR

               100      2000     SCANS
```

vii) Initial correction to baseline

```
    BASES LOAD

      0   0   0   0   0     10   B12

      0   0   0   0   0   -100   B13

      0   0   0   0   0      0   B13

      0   0   0   0   0      0   B14

    BASE-COR    1000    2000    SCANS
```

viii) Finding a least squares solution

: GO 1000 2000 SCANS ;

CONTINUUM

4 VARIABLES

CAL 3C48 GO

CAL 3C309.1 GO

CAL 3C286 GO

CAL P0237-23 GO

CAL P1055+01 GO

SOLVE

BASE_COR GO

ix) Inspect amplitude of continuum

CONTINUUM AMPL MONITOR 2500 3000 SCANS

x) Correction for system gain change

EDITS LOAD FOR EVERYTHING

RL-AB 1.20 MULT-AMPL 2500 2700 SCANS

COR-1 1.20 MULT-AMPL 2500 2700 SCANS

xi) Inspect phase of continuum

CONTINUUM PHASE MONITOR 2500 3000 SCANS

xii) Detailed phase fitting - suppose that this is just a phase jump occured in scan 2700 and that we are in mode 6.

COR-1 15 ADD-PHASE 2500 2700 SCANS

RX-AB 15 ADD-PHASE 2500 2700 SCANS

COR-2 -60 ADD-PHASE 2500 2700 SCANS

RX-CD -60 ADD-PHASE 2500 2700 SCANS

COR-2 -20 ADD-PHASE 2700 3000 SCANS

RX-AB -20 ADD-PHASE 2700 3000 SCANS

COR-2 +40 ADD-PHASE 2700 3000 SCANS

RX-CD +40 ADD-PHASE 2700 3000 SCANS

xiii) Passband Correction

Using scan 2500 as the reference up to scan 2900 and scan 2900 thereafter

FOR EVERYTHING

PASS-BAND 2500 A-SCAN

RX-AB EDIT-BAND 2500 2899 SCANS

RX-CD EDIT-BAND 2500 2899 SCANS

PASS-BAND 2900 A-SCAN

RX-AB EDIT-BAND 2900 3000 SCANS

RX-CD EDIT-BAND 2900 3000 SCANS

xiv) Look at some corrected visibility spectra

FOR EVERYTHING

RX-AB PROFS 2700 2750 SCANS

RX-CD PROFS 2700 2750 SCANS

Write corrected data to a nine track tape

TAPES LOAD

2500 3000 WRITE-NINE (+JCL Card)

xv) Image a source into the (u,v) plane

a) for the continuum

MAPS LOAD

CONTINUUM 40

3000 ARRAY =

127 DIMENSION

20 20 RESOLUTION

2500 3000 IMAGE NGC2403

0 100 SCALE

AMPL MAP

PHASE MAP

b) For a single frequency channel (#13 also get 14 as bonus)

13 1 LINE-FREQ

3128 ARRAY =

2500 3000 IMAGE NGC2403

xvi) <u>Make a beam from continuum</u>

3000 into 3256 BEAM

xvii) <u>Transform all this</u>

3000 ARRAY=

TRANSFORM

REAL MAP

3128 ARRAY=

TRANSFORM

REAL MAP

IMAG MAP

3256 ARRAY =

TRANSFORM

REAL MAP

xviiii) <u>correct for shape of primary beam</u>

3384 ARRAY=

13 13 PRIMARY BEAM GENERATE

3384 INTO 3000 MULTIPLY-MAP

3384 INTO 3126 MULTIPLY-MAP

3384 INTO 3256 MULTIPLY-MAP

xx) <u>Display corrected data</u>

3000 ARRAY= REAL MAP

3128 ARRAY= REAL MAP

3256 ARRAY = REAL MAP

APPENDIX 7

DUMP / LOAD

DUMP is a program to copy a FORTH disk data-set onto tape. Blocks are read from disk, blocked 10 to a record, and written sequentially onto tape. DUMP verifies completion of each data card by listing it after processing it.

You must modify 3 cards in the sample deck below:

FT01F001 DD card for disk
FT02F001 DD card for tape (but don't change the DCB parameters)
one card for each set of blocks to be dumped - first and last block (inclusive) in 2I6 format.

This deck will dump blocks 1-99 and 4000-4096:

```
//GO.FT01F001 DD DSNAME=MOORE.DISK,DISP=SHR
//GO.FT02F001 DD UNIT=2400,DCB=(RECFM=FB,LRECL=1024,BLKSIZE=10240),
// DISP=(NEW,KEEP),DSNAME=X,VOLUME=SER=1379,LABEL=2
//SYSIN DD  *
9-TRACK
     1    99
  4000  4096
```

You may dump onto a 7-track tape for processing at Tucson. The first input card specifies the longer 7-track records (which are no longer blocked). Here is the deck above:

```
//GO.FT01F001 DD DSNAME=MOORE.DISK,DISP=SHR
//GO.FT02F001 DD UNIT=TAPE7,DCB=(RECFM=F,BLKSIZE=1536,DEN=2),
// DISP=(NEW,KEEP),LABEL=(,BLP),VOLUME=SER=FOR-2
//SYSIN DD *
7-TRACK
     1    99
  4000  4096
```

Load is a program to copy a dump tape back onto a FORTH disk data-set. You may change the block addresses on disk, but you must account for all the blocks read (sequentially) from tape. FT01F001 and FT02F001 have the same meanings (disk and tape, respectively) though the content of FT02F002 is different.

This deck will re-load the tape dumped above into blocks 1-50 and 5000-5049, ignoring original blocks 51-99 and 4050-4096.

```
//GO.FT01F001 DD DSNAME=MOORE.DISK,DISP=SHR
//GO.FT02F002 DD UNIT=2400,DSNAME=X,VOLUME=SER=1379,LABEL=2,DISP=OLD
//SYSIN DD *
    1   50
 5000 5049
```

STORE 7

program to store 7-track tape

```
//HLINE6   JOB (173,C,6,7,14),WRITE,MSGLEVEL=1,CLASS=B
//STORE7   EXEC  PGM=STORE7
//STEPLIB   DD  DSN=MOORE.JOBS,DISP=SHR
//FT04F001 DD DSN=BACK-UP,DISP=MOD,UNIT=TAPE,
// VOL=(,RETAIN,SER=2491),
//     DCB=(RECFM=VSB,LRECL=2052,BLKSIZE=4108)
//FT06F001  DD  SYSOUT=A
//DDP116  DD  UNIT=TAPE7,DSN=INTERF.DDP116,DCB=(,DEN=1),DISP=OLD,
// LABEL=(2,BLP),VOL=SER=0500
//INDEX  EXEC  PGM=TAPEINDX
//SYSPRINT  DD  SYSOUT=A
//TAPE  DD  UNIT=TAPE,DISP=(OLD,KEEP),LABEL=(,BLP),
//     VOL=SER=2491
```

Sample Output of Store 7.

```
HASP-II JOB STATISTICS --      13 CARDS READ --        78 LINES PRINTE

EOF
NO. HDRS=     134
NO. DATA=     897
NO. A/D=        0
NO. MSG=        0
NO. POINTING=       0

NO. 100 WORD DATA RECORDS=       0
NO. 1024 WORD DATA RECORDS=    897
```

(HDRS + DATA) → 1031 records total = 516 blocks

Sample Output of Tape Index pgm.

```
VOL12491   0                                     NRAO

HDR1BACK-UP              2491   00010001        71270 000000000000

HDR2V0410802052330HLINE6   /STORE7        R

---------------------------------------------------------------------

            2875 BLOCKS

---------------------------------------------------------------------

EOF1BACK-UP              2491   00010001        72013 000000002875

EOF2V0410802052330HLINE6   /STORE7        R

---------------------------------------------------------------------

---------------------------------------------------------------------
```

Tape index is used as a check on Store7
516 blocks should have been added to Tape 2491

LIST 9

```
//    EXEC  PGM=LIST9
//STEPLIB  DD  DSN=MOORE.JOBS,DISP=SHR
//FT03F001  DD  DSN=BACK-UP,DISP=OLD,UNIT=TAPE,
//    VOL=SER=2482
//FT06F001  DD  SYSOUT=A
//*  READS SCAN RANGE (I5,1X,I5)
//FT05F001  DD  *
 2735 2825
```

This program reads an observer tape, viz. the un-re-formatted data on 9-track tape.

It lists out the continuum channels for the given scan range.

Listing available if anyone ~~whant~~ wants to make it do something else.

LIST7

```
//LIST76   JOB (173,0,6,7,14),WRITE,MSGLEVEL=1,CLASS=B
//   EXEC   PGM=LIST7
//STEPLIB   DD   DSN=MCCPE.JOBS,DISP=SHR
//FT06F001   DD   SYSOUT=A
//DDP116   DD   UNIT=TAPE7,DSN=INTERF.DDP116,DCB=(,DEN=1),DISP=OLD,
// LABEL=(2,BLP),VOL=SER=0500
```

Lists Errors on a 7-track

telescope tape - Odd length records etc

APPENDIX 8

JOB CONTROL CARDS

```
//HLINE JOB (234,P,6,4,3),NINETR,MSGLEVEL=1,CLASS=C
// EXEC PGM=HLINE,COND=EVEN,ACCT=G
//STEPLIB DD DSNAME=MOORE.JOBS,DISP=OLD
//   FT03F001  DD  DSN=BACK-UP,DISP=OLD,UNIT=TAPE,
// VOL=SER=2491,DCB=BUFNO=1
//FT04F001 DD DSN=CAS-A,DISP=(MOD,PASS),UNIT=TAPE,
// VOL=SER=1675,DCB=(RECFM=VSB,LRECL=1028,BLKSIZE=2060)
//FT06F001 DD SYSOUT=A
//DISK DD DSNAME=MOORE.FREQS,DISP=OLD
//READER DD *
70 CYL
E LOAD  H-LINE LOAD
TAPES LOAD
ERASE-SOURCE   160 DEFINE AVAIL   0 DEFINE EVERYTHING
110 GAINS 2223 INCLUDE CASA-A
111 GAINS 2223 INCLUDE CASA-B
112 GAINS 2223 INCLUDE CASA-C
113 GAINS 2223 INCLUDE CASA-D
114 GAINS 2223 INCLUDE CASA-E
FLUSH
5 NU =
7830 8311 OBSERVER-TAPE
FIND AVAIL
EDITS LOAD
:SYSTEM BROAD-BAND 5 NS= VECTOR LOOK:
: GO 7830 8311 SCANS :
FOR EVERYTHING
COR-1 -PHASE GO
COR-3 -PHASE GO
RX-AB -PHASE GO
SYSTEM GO
TAPES LOAD
7830 8311 WRITE-NINE
DISCARD
GOODBY
```

This job reads Observer Tape 2491

Transfers Data for included sources to disk

Edits and prints out data for inspection

Transfers Edited data to Tape 1675

```
//HLINE JOB (234,P,6,4,3),CASCAL,MSGLEVEL=1,CLASS=C
// EXEC PGM=HLINE,COND=EVEN,ACCT=G
//STEPLIB DD DSNAME=MOORE.JOBS,DISP=SHR
//FT03F001 DD DSN=CAS-A,DISP=(OLD,KEEP),UNIT=TAPE,
// VOL=SER=1675,DCB=(RECFM=VSB,LRECL=1028,BLKSIZE=2060)
//FT06F001 DD SYSOUT=A
//DISK DD DSNAME=MOORE.FREQS,DISP=SHR
//READER DD *
70 CYL
E LOAD
H-LINE LOAD
TAPES LOAD
ERASE-SOURCE   150 DEFINE AVAIL   0 DEFINE EVERYTHING
110 GAINS 2223 INCLUDE CASA-A
FLUSH ←  7830  8311  LOAD-NINE
:SYSTEM BROAD-BAND 5 NS= VECTOR LOOK:
: GO 7830 8311 SCANS :
FOR CASA-A  SYSTEM GO
RX-AB PROFS GO
RX-CD PROFS GO
DISCARD  GOODBY
```

This job reads a nine track tape (written by H-LINE)

Transfers data for included source to disk

Prints out selected broad band channels (amplitude and phase)

Prints out spectral profiles on both receivers

```
//FREQ  JOB (203,D,1,1,1),WRIGHT,MSGLEVEL=1,CLASS=O
// EXEC PGM=HLINE,COND=EVEN,ACCT=G
//STEPLIB DD DSNAME=MOORE.JOBS,DISP=SHR
//DISK DD DSNAME=MOORE.DISK,DISP=SHR,VOL=PRIVATE
//FT06F001 DD SYSOUT=A
//READER DD *
E LOAD
H-LINE LOAD
MAPS LOAD
127 127 DIMENSION
3 3 RESOLUTION
40 50 40 50 INNER-AREA
45 75 45 75 OUTER-AREA
0 100 SCALE
: LOW-RR 1 P= 0 F1= FREQ 61, ;  : LOW-RL  3 P= 0 F1= FREQ 85, ;
S-BAND
RR
15000 ARRAY =
1000 30000 IMAGE 3C20
AMPL READ-MAP
RL
15128 ARRAY =
1000 30000 IMAGE 3C20
PHASE READ-MAP
X-BAND
LOW-RR
15256 ARRAY =
1000 30000 IMAGE 3C20
AMPL READ-MAP
LOW-RL
15384 ARRAY =
1000 30000 IMAGE 3C20
PHASE READ-MAP
1 1 RESOLUTION
RR
15512 ARRAY =
1000 30000 IMAGE 3C20
AMPL READ-MAP
RL
15640 ARRAY =
1000 30000 IMAGE 3C20
PHASE READ-MAP
S-BAND
RR
15768 ARRAY =
1000 30000 IMAGE 3C20
AMPL READ-MAP
PHASE READ-MAP
FLUSH GOODBY
```

This job is using the private disk pack onto which data from the Dual Frequency system has already been loaded.

u-v planes for S and X Band are being made for both RR and polarized (RL) data.

The definition of LOW-RR and LOW-RL is allowing the selection of the 2-3 baseline only for a X-BAND low resolution map.

```
//BIG JJB (199,D,7,5,14),MOORE,CLASS=C,MSGLEVEL=(1,1)
//LINK EXEC PGM=IEWL,PARM='LET,MAP,LIST',ACCT=L
//SYSLIB DD DSNAME=SYS1.FORTLIB,DISP=SHR
// DD DSNAME=SYS1.GPSLMOD,DISP=SHR
//SYSUT1 DD UNIT=2314,SPACE=(CYL,(2,2))
//SYSPRINT DD SYSOUT=A,DCB=(RECFM=FBA,LRECL=121,BLKSIZE=3509)
//MODS DD DSNAME=MOORE.MODS,DISP=SHR
//JOBS DD DSNAME=MOORE.JOBS,DISP=SHR
//SYSLMOD DD DSNAME=&&TEMP(MAIN),DISP=(NEW,PASS),
// UNIT=DISK,SPACE=(CYL,(3,2,1))
//SYSLIN DD *
 INCLUDE JOBS(FORTHF)
 ENTRY BEGIN
 INCLUDE MODS(INTER,DAIO)
 INCLUDE MODS(EXPI,MOVE)
 INCLUDE MODS(MAPS)
// EXEC PGM=*.LINK.SYSLMOD,COND=EVEN,ACCT=G
//FT06F001 DD SYSOUT=A
//DISK DD DSNAME=MOORE.DISK,DISP=SHR
//READER DD *
E LOAD  H-LINE LOAD
12 FORTRAN CALL    : CALL  ENTRY=  CALL:
: SIZE  DUP DIM=  Y-DIM= :
: GET  ARRAY=  1 CALL:       : PUT  ARRAY=  2 CALL:
: MAP  11 CALL:
: TRANSPOSE  3 CALL:
9 FORTRAN QUAD-SWAP
: QUAD-SWAP   QUAD-SWAP 5 CALL:
: TRANSFORM  4 CALL QUAD-SWAP:   : SQUEEZE  6 CALL:
: SECOND  7 CALL:    : BEAM  8 CALL:
: ZERO  9 CALL:    : GAUSSIAN  FREQ , , , , ,  10 CALL:
: NORMALIZE  12 CALL:
ARG 1( CONSTANT BYTES
0 LOW=  1000 HIGH=
: MAP  NORMALIZE MAP:
: SQUEEZE  LOW=  HIGH=  6 CALL :
: PICK   NF=  DIM@ 2/ 2+ + ARG=  13 CALL:
3 BYTES=  127 SIZE
: UV 8 BYTES = 127 SIZE :
UV
15000 GET
BEAM
TRANSFORM
1000 1000 SQUEEZE
MAP
16000 PUT
SECOND MAP
16032 PUT
UV
15128 GET
TRANSFORM
1000 1000 SQUEEZE
MAP
16064 PUT
SECOND MAP
16096 PUT
```

This is the 180 K version for doing a 128 x 128 Fourier transform in core. The arrays being transformed are those of 3C20 data previously made. A beam may be made at the same time as an RR or RL inversion.

THE END

THE END