NATIONAL RADIO ASTRONOMY OBSERVATORY
Green Bank, West Virginia

TELESCOPE CONTROL USER STANDARDS MEMO NO. 24

SINGLE DISH FITS TAPE

Betty Stobie and Lorrie Morgan

Issued:

January 9, 1987

National Radio Astronomy Observatory
Charlottesville, Virginia

October 21, 1986

To: Single Dish Users

From: Betty Stobie, Lorrie Morgan

Subject: Single Dish FITS tape

Since the last User's Meeting the NRAO's Single Dish Programmers have been working very hard to develop a complete and descriptive format for a single dish FITS tape. The advantages of using the FITS format are many: Most users are already familiar with the basic concept of a FITS tape, it is completely self-documenting, and the ASCII representation can be digested by any computer that the astronomer has at his home institution.

The first thing that had to be accomplished was to build a vocabulary of keywords that would describe various parameters that applied to single dish data. Once that was done, it was important to decide exactly how the data were going to be represented on tape. Should it be in binary or ASCII? If the data would be in ASCII, how could they be incorporated into the FITS format without violating fundamental rules of the structure of a FITS tape? The final decision was that the FITS Tables extention would be perfect. Single Dish header parameters would be represented in the table's header, and the data would comprise the actual table in ASCII. Various FITS Tables keywords would describe in great detail the format of the table and how a computer program could read it.

The next problem to overcome was that it was highly unlikely that our new keywords would be approved by the FITS International Standards Committee. So we came up with the SINGLDSH card. The only difference between a standard FITS card and the SINGLDSH card is in which column the keyword begins. In the standard FITS card, the keyword begins in column 1. However, in the SINGLDSH card, the word SINGLDSH begins in column 1, and the keyword begins in column 19. Columns 10 – 16 will contain a qualifier that is more for documentation purposes than anything else. This qualifier will describe whether the data parameter is a GENERAL single dish parameter, or whether it really only applies to one telescope. The qualifier for the 12 – Meter telescope is NRAO–12M, and for the Green Bank telescopes is NRAO–GB. (Please see the attached example of how this is implemented.)

Attached to this memo are the following: First you will find a summary of the keywords that appear on SINGLDSH cards. For each parameter there is a short definition of that single dish data parameter, followed by its FITS keyword, followed by the units of that parameter, followed by a small note. This summary does not include standard AIPS keywords, as those are already defined in previous FITS documents. Following the summary is a glossary which describes in more detail the SINGLDSH card parameters. An example of a single dish FITS tape is the last section of this package.

Should be SINGLDSH= ? or analogous to COMMENT?

Summary of SINGLDSH Card Keywords

Basic Information

Length of Header	HEADLEN	Bytes	
Length of Data	DATALEN	Bytes	
Scan Number	SCAN		
Observer Initials	OBSID		C*8
Observer Name	OBSERVER		C*16
Telescope Descriptor	TELESCOP		C*8
Project Identification	PROJID		C*8
Source Name	OBJECT		C*16
Type of Data and Observing Mode	OBSMODE		C*8
Frontend Descriptor	FRONTEND		C*8
Backend Descriptor	BACKEND		C*8
Data Precision of Spectrum	PRECIS		C*8

Pointing Parameters

Total Az/RA Pointing Correction	XPOINT	Arcsec	
Total El/Dec Pointing Correction	YPOINT	Arcsec	
User Az/RA Pointing Correction	UXPNT	Arcsec	
User El/Dec Pointing Correction	UYPNT	Arcsec	
Pointing Constants (4)	PTCON		12M only
Receiver Box or Secondary Orientation	ORIENT	Deg	
Radial Focus	RFOCUS	M	
North-South Focus	VFOCUS	M	
East-West Focus	HFOCUS	M	
R.A. Pointing Coefficients (3)	RAPT		GB only
Dec Pointing Coefficients (4)	DECPT		GB only
Level Pointing Coefficients (4)	LEVPT		GB only
Extra Pointing Coefficients (10)	EXPT		GB only

Observing Parameters

Universal Time Date	UTDATE		YYYY.MMDD
Universal Time	HOURUT	Hours	
LST	HOURLST	Hours	
Number of Receivers	NORCVR		
Number of Switching Variables	NOSWVAR		
Number of Phases per Cycle	NOPHASE		
Length of Cycle	CYCLLEN	Sec	
Sample Period	SAMPRAT	Sec	

Positions			
Epoch	EPOCH	Years	
Commanded Source X	XSOURCE	Deg	
Commanded Source Y	YSOURCE	Deg	
Commanded Reference X	XREF	Deg	
Commanded Reference Y	YREF	Deg	
Commanded Epoch Right Ascension	EPOCRA	Deg	
Commanded Epoch Declination	EPOCDEC	Deg	
Commanded Galactic Longitiude	GALLONG	Deg	
Commanded Galactic Latitude	GALLAT	Deg	
Commanded Azimuth	AZ	Deg	
Commanded Elevation	EL	Deg	
Indicated X Position	INDX	Deg	
Indicated Y Position	INDY	Deg	
Descriptive Origin(3)	DESORG	Deg	
Coordinate System Code	COORDCD		C*8

Environment			
Ambient Temperature	TAMB	Deg C	
Pressure	PRESURE	mm Hg	
Relative Humidity	HUMIDTY	%	
Index of Refraction	REFRAC		
Dew Point	DEWPT	Deg C	
MM H2O	MMH2O	mm	

Map Parameters			
Map Scanning Angle	SCANANG	Deg	
X Position at Map Reference Position Zero	XZERO	Deg	
Y Position at Map Reference Position Zero	YZERO	Deg	
Delta X or X Rate	DELTAXR	Arcsec or Arcsec/sec	
Delta Y or Y Rate	DELTAYR	Arcsec or Arcsec/sec	
Number of Grid Points	NOPTS		
Number of X Grid Points	NOXPTS		
Number of Y Grid Points	NOYPTS		
Starting X Grid Cell Number	XCELLO		
Starting Y Grid Cell Number	YCELLO		
XY Reference Frame Code	FRAME		

Data Parameters

Beam Fullwidth at Half Maximum	BFWHM	Arcsec	
Off Scan Number	OFFSCAN		
Bad Channel Value	BADCHV		
Velocity Correction	RVSYS	M/Sec	
Velocity with respect to Reference	VELOCTY	M/Sec	
Velocity Definition and Reference	VELDEF		C*8
Type of Calibration	TYPECAL		C*8

Engineering Parameters

Antenna Aperture Efficiency	APPEFF		
Antenna Beam Efficiency [ETA(MB)]	BEAMEFF		
Antenna Gain	ANTGAIN		
ETAL Rear Spillover & Scattering Efficiency	ETAL		
ETAFSS Forward Spillover & Scattering Eff	ETAFSS		

Telescope Dependent Parameters -- Green Bank (Qualifier will be NRAO-GB)

L1	L1	Hz	
L1F1	L1F1	Hz	
L1F2	L1F2	Hz	
L2	L2	Hz	
L2F1	L2F1	Hz	
L2F2	L2F2	Hz	
LA	LA	Hz	
LB	LB	Hz	
LC	LC	Hz	
LD	LD	Hz	
Level Correction	LEVCORR		
Pointing Fudge(2)	PTFUDGE		
Center Frequency Formula (4)	CFFORM		C*32

Phase Block: Repeated for the Number of Switching Variables (NOSWVAR)

Switching Variable	SWVAR		
Variable Value	VARVAL		
Variable Descriptor	VARDES		C*8
Phase Table	PHASTB		C*8

Telescope Dependent Parameters -- 12M (Qualifier will be NRAO-12M)

Synthesizer Frequency	SYNFREQ	Hz	
LO Factor	LOFACT	Hz	
Harmonic	HARMONC	Hz	
LO IF	LO IF	Hz	
First IF	FIRSTIF	Hz	
Reference Azimuth Offset	RAZOFF	Arcsec	
Reference Elevation Offset	RELOFF	Arcsec	
Beam Throw	BMTHROW	Arcsec	
Beam Orientation	BMORENT	Deg	
Baseline Offset	BASEOFF	Deg	
Observing Tolerance	OBSTOL	Arcsec	
Sideband	SIDEBAND		

Receiver Descriptor Block : Repeated for Number of Receivers (NORCVR) times.

Receiver Number	RCVR		
Observed Frequency	OBSFREQ	Hz	
Rest Frequency or Total Power Calibration	RSTFREQ	Hz	
Frequency Resolution or SP Calibration	FREQRES	Hz	
Bandwidth	BW	Hz	
Receiver Temperature	TRX	K	
Calibration Temperature	TCAL	K	
Source System Temperature	STSYS	K	
Reference System Temperature	RTSYS	K	
Source Temperature	TSOURCE	K	
RMS of Mean	TRMS		
Reference Point Number	REFPT		
X Value at the Reference Point	XO		
Delta X	DELTAX		
Total Integration Time	INTTIME	Sec	
Number of Integrations or channels	NOINT		
Starting Point Number	SPN		
H2O Opacity	TAUH2O		
H2O Temperature	TH2O	K	
O2 Opacity	TAUO2		
O2 Temperature	TO2	K	
Polarization	POLARIZ		C*8
RHO	RHO	Deg	
THETA	THETA	Deg	

Single Dish FITS Format Glossary

Basic Information

These parameters are used to identify the block of data with a particular Observer/Project/Telescope.

Scan Number - SCAN
: A number assigned at the telescope to be associated with this scan.
If this scan is not averaged but is exported as individual records, then the record number is appended after the decimal point. A maximum of 9999 records are allowed.
For example, record number one of scan 500 would be 500.0001 .

Observer Initials - OBSID
: A data ID used to segregate each observer's data.

Observer Name - OBSERVER
: Name of the primary Observer.

Telescope Descriptor - TELESCOP
: A field of eight characters to describe where the data are taken.

NRAO12M	NRAO42M	NRAO93M
MPI100M	IRAM30M	NRO45M
PMO14M	OSO20M	MASS14M
UTX5M	UK-D15M	IRAM15M

Project Identification - PROJID
: The program ID associated with the proposal as it appears on the telescope schedule.

Source Name - OBJECT
: As provided by the observer.

Type of Data and Observing Mode - OBSMODE
: Field of 8 characters where four describe the type of data and four describe the observing mode.

Type of Data	Observing Mode	
LINE	PSSW	PLSW
CONT	FQSW	SHSW
FSAM	BMSW	LDSW
PULS	TLPW	

Frontend Descriptor - FRNTEND
: A field of 8 characters to describe the receiver used.
Typical NRAO frontends are:

2C3MMSIS	140CASS	2.7-1.2M
2C3MMSHM	21CM 4CH	1.2-0.6M
2MM	11CM3CH	100-30CM
.8MM	6/25 6CM	25-20 CM
BOLOMETR	23-17CM	6/2525CM
	15-0.6CM	

Backend Descriptor - BACKEND
A field of 8 characters to describe the backend used.
Typical NRAO backends are:

DIGITAL	STD A/D	FABRITEK
384ACIII	1024ACIV	1536HYSP
.03MHZFB	.1MHZ FB	.25MHZFB
.5MHZ FB	1.MHZ FB	2.MHZ FB

Data Precision of the Spectrum - PRECIS
The specification of the nuber of bits and data type used to represent the data. It may be one of the following:
L*1 I*2 I*4 R*4 R*8 R*16 C*8 C*16

Pointing Parameters

This group of parameters refers to the telescope pointing, both those offsets and terms provided by the observer and those computed by the online program.

Total Az/RA Pointing Correction - XPOINT
The total pointing correction applied in the X (horizontal) direction.

Total El/Dec Pointing Correction - YPOINT
The total pointing correction applied in the Y (vertical) direction.

User Az/RA Pointing Correction - UXPNT
Additional X pointing correction supplied by the observer.

User El/Dec Pointing Correction - UYPNT
Additional Y pointing correction supplied by the observer.

Pointing Constants and Coefficients - PTCON, RAPT, DECPT, LEVPT, EXPT
Constants to describe a secondary pointing correction.
At the 12M these are AO, C, BO and ELO in the expressions below:
Delta Az = AO * COS(EL) + C
Delta El = BO * COS(EL) + ELO
At the 42M these constants refer to the PVAL's.

Receiver or Secondary Orientation - ORIENT
Rotation or polarization angle orientation of the receiver or reflector at the prime focus.

Radial Focus - RFOCUS
Radial focus position.

North-South Focus - VFOCUS
Vertical focus offset.

East-West Focus - HFOCUS
Horizontal focus offset.

Observing Parameters

A group of parameters that characterize the when and how of the observations.

Universal Time Date - UTDATE
Universal Time - HOURUT
LST - HOURLST
Date and time at the start of the observation.

Number of Receivers - NORCVR
The number of independent polarizations or channels of this frontend. When receiver channels refer to different positions in the sky, they are expressed as separate scans.

The following parameters are defined as a very general description of observations made with one ore more of the observing variables being switched. For example, in beam-switched observations one variable, sky position, is switched (via subreflector motion or a comparision of two feed horns). One could also imagine beam switching at the same time that polarization was switched -- in this case 2 variables are switched. IF "phase" of a switched variable is used to describe one state of the switch, then a 2-position subreflector nutation, for example, would be a switch with "2 phases" per cycle. Similarly, if one switches between a center frequency and 2 offset frequencies, then this switch has "3 phases" per cycle and so forth.

Number of Switching Variables - NOSWVAR
A simple count of the number of variables being switched.

Number of Phases per Cycle - CYCLLEN
A count of the number of different states of the switched variables.

Sample Period - SAMPRAT
The time required to complete a single sample. A sample may be composed of multiple cycles. Also known as the SAMPLE RATE.

Positions

For each scan the telescope is given, or computes following the observer's instructions, a position at a particular epoch. The right ascension of that position is "Epoch Right Ascension" and the declination is "Epoch Declination". At the time of the observation, however, the telescope is directed to a position corresponding to horizontal coordinate "xcoord", which may be either RA(date) or AZ(date), and corresponding to vertical coordinated "ycoord", which may be DEC(date) or EL(date). The actual position that the telescope points to differs from "xcoord" and "ycoord" by whatever are the current pointing offsets. This position, i.e., the position at which the telescope actually points, is the "indicated" position described by horizontal coordinate "indicated x telescope position" and vertical telescope coordinate "indicated y telescope position". Finally, using RA(epoch) one calculates the Galactic coordinates "longitude and latitude". For all observations the above

parameters have meaning and are computed. If the observer wishes to define his own coordinate system relative to one of the standard coordinate systems defined above, he does so with the descriptive coordinate array.

Epoch - EPOCH
As specified by the observer.

Commanded Source Xcoord - XSOURCE
Horizontal coordinate of source or position in the coordinate system specified by the observer.

Commanded Source Ycoord - YSOURCE
Vertical coordinate of source or position in the coordinate system specified by the observer.

Commanded Reference Xcoord - XREF
Horizontal coordinate of the reference position in the coordinate system specified by the observer.

Commanded Reference Ycoord - YREF
Vertical coordinate of the reference position in the coordinate system specified by the observer.

Epoch Right Ascension - EPOCRA
RA at "Epoch" of the source or position specfied.

Epoch Declination - EPOCDEC
Dec at "Epoch" of the source or position specified.

Commanded Galactic Longitude - GALLONG
Longitude of the source or position specified.

Commanded Galactic Latitude - GALLAT
Latitude of source or position specified.

Commanded Azimuth - AZ
Azimuth of the source or position specified.

Commanded Elevation - EL
Elevation of the source or position specified.

Indicated Xcoord - INDX
Horizontal telescope coordinate of the position actually observed, i.e. position measured by horizontal encoder.

Indicated Ycoord - INDY
Vertical telescope coordinate of the position actually observed, i.e., position measured by vertical encoder.

Descriptive Origin(3) - DESORG
An orthogonal 2-dimensional coordinate system defined by the observer by means of
a. - horizontal position
b. - vertical position
c. - position angle describing the orientation on the sky, of the "horizontal axis".

Coordinate System Code - COORDCD
An 8 character string indicating in which coordinate system the observations are commanded:
Galactic - GALACTIC
1950 RA, Dec - 1950RADC
Epoch RA, Dec - EPOCRADC
Mean RA, Dec at start of scan - MEANRADC
Apparent RA, Dec - APPRADC
Apparent HA, Dec - APPHADC
1950 Ecliptic - 1950ECL
Epoch Ecliptic - EPOCECL
Mean Ecliptic at start of scan - MEANECL
Apparent Ecliptic - APPECL
Azimuth, Elevation - AZEL
User defined coordinate system - USERDEF
2000 RA, Dec - 2000RADC
Indicated RA, Dec - INDRADC

Environment

The environment parameters define the external physical conditions affecting the telescope.

Ambient Temperature - TAMB
Pressure - PRESURE
Relative Humidity - HUMIDTY
Index of Refraction - REFRAC
Dew Point DEWPT
MM H2O - MMH2O

Map Parameters

The purpose here is to store an entire map as a single entity. The map is understood to be rectangular with dimensions "xpoints" by "ypoints" where these parameters simply count the number of map cells along the two orthogonal axes of the rectangular map. The orientation on the sky of the rectangle is defined by "map scanning angle", with this angle referring to the orientation of the horizontal, x, axis. A reference point for the map on the sky is specified by means of the horizontal and vertical telescope coordinates "xposition at zero" and "yposition at zero", respectively. The reference point need not be the center of the rectangle and, in fact, need not even be within the region mapped. The rectangle to be mapped is fully described by the parameters "starting xcell" and "starting ycell", together with the total number of points to be sampled in each coordinate "xpoint" and "ypoint", respectively.

For example, suppose we wish to construct a square map with 41 points on a side centered on the reference position. In this case,

```
Starting xcell     :  XCELLO = -20
Starting ycell     :  YCELLO = -20
Number of xpoints  :  NOXPTS = 41
Number of ypoints  :  NOYPTS = 41
```

On the other hand, suppose we wish to make the same map near, but not including, that same reference position. Then, perhaps

```
Starting xcell     :  XCELLO = 20
Starting ycell     :  YCELLO = -61
Number of xpoints  :  NOXPTS = 41
Number of ypoints  :  NOYPTS = 41
```

and the region from (x,y) = (20,-61) to (x,y) = (61,-20) will be mapped.

Map Scanning Angle - SCANANG
: Orientation on the sky in the reference frame specified by "XY Reference Frame Code" of the rectangle to be mapped. It is not the angle through the rectangle that the telescope is driven. This provides an alternate capability to that of using descriptive coordinates.

X position at Zero - XZERO
: Horizontal telescope coordinate at the map reference position. Together with "Y position at Zero", this defines the cell (X,Y) = (0,0) at the map reference position.

Y position at Zero - YZERO
: Vertical telescope coordinate at the map reference position.

Delta X or X Rate - DELTAXR
: The cell size or distance (in minutes of arc/minutes of time) between cells on the x axis.

Delta Y or Y Rate - DELTAYR
: The cell size or distance between cells on the y axis.

Number of X points - NOXPTS
: Map sample points along the "x-edge" of the rectangle.

Number of Y points - NOYPTS
: Map sample points along the "y-edge" of the rectangle.

Number of Points - NOPTS
: Total number of cells in the map. This should be (x*y).

Starting X cell - XCELLO
: Cell number. May be positive, negative or zero. It is used to define the position of the rectangle to be mapped with respect to the reference position which, by definition is (x,y) = (0,0).

Starting Y cell - YCELLO
Cell number as above.

XY Reference Frame Code - FRAME
An eight character code which states whether the grid is polar (POLR) or cartesian (CART) and whether items 3 and 4 refer to STEP sizes or SCANning rates.

Observing Parameters

Beam Full Width at Half Maximum - BFWHM
Telescope main beamwidth at the observing frequency.

Off Scan Number - OFFSCAN
Scan number of the last designated total power off scan.

Bad Channel Value - BADCHV
The antenna temperature to be assigned to those filterbank channels that are noted as defective.

Velocity with respect to the Reference - VELOCTY
The source velocity specified by the observer relative to the velocity reference frame.

Velocity Definition and Reference - VELDEF
An eight character field to describe the velocity system.
The velocity definition may be:

RADI	OPTL	RELV

The velocity reference may be:

LSR	HELO	EART	BARI	OBS

Engineering Parameters

This is an area for describing the physical aspects of the telescope.

Antenna Aperture Efficiency - APPEFF
The ratio of total power observed to the total power incident on the telescope.

Antenna Beam Efficiency - BEAMEFF
The fraction of the beam lying in a diffraction limited main beam.

Antenna Gain - ANTGAIN

ETAL -
Rear Spillover and Scattering Efficiency

ETAFSS -
Forward Spillover and Scattering Efficiency

Telescope Dependent Parameters

This is an area words reserved for those parameters that are unique to a given telescope.

For the Green Bank telescopes they are:
the LO values - L1, L1F1, L1F2, L2, L2F1, L2F2, LA, LB, LC, LD ,
the level correction, the pointing fudge(2), and the center frequency formula(4).

For the 12M telescope they are:
synthesizer frequency, LO Factor, Harmonic LOIF, first IF, reference azimuth offset, reference elevation offset, beam throw, beam orientation, baseline offset, sideband and observing tolerance.

Phase Block

This block describes what variables are switched in the scan. For instance, a scan may be position switched, beam switched, frequency switched, load switched, focus switched, polarization switched, or any combination of the above or simply a measure of total power. The variable value is value of one switch state. For example, to switch high and low about a center frequency requires three variable values. A total power observation requires one value.

Associated with each variable value is a variable descriptor of eight characters and a 32 bit phase table which reflects when that particular state is on with a one and when it is off with a 0. These three parameters are repeated for as many times as there are switching states. Also note that the phases appear in the description of the spectrum in the same order as they appear here.

This Switching Variable - SWVAR

Variable Value - VARVAL
The value of a single switch state.

Variable Descriptor - VARDES
An 8 character descriptor of the switching variable.

Phase Table - PHASTB
A bit-map description of when each switch state is on and off. An integration can have a maximum of 32 states.

An example of a phase block is shown below:
An observation is made by switching the telescope position and the focus. There are five switching states. The table would look like
Variable Values - 0, +30, -30, +54, -54
Variable Descriptors - POSN ON, POSN HI, POSN LO, FOCUS HI, FOCUS LO
Phase Table - 0 0 1 1 1 1 0 0
1 1 0 0 0 0 0 0
0 0 0 0 0 0 1 1
1 0 1 0 1 0 1 0
0 1 0 1 0 1 0 1

Descriptor Block for each Receiver Channel

Certain parameters vary with an individual receiver channel. When multiple polarizations are used, this block must be repeated for each channel.

This receiver number - RCVR

Observed Frequency - OBSFREQ
The center frequency of the observation.

Rest Frequency/Total Power Calibration - RSTFREQ
In the spectral line observation the rest frequency of the observation or in the continuum observation the total power calibration.

Frequency Resolution/Switched Power Calibration - FREQRES
In the spectral line observation the frequency spacing of the spectral line backend or in the continuum observation the switched power calibration.

Bandwidth - BW
The total bandwidth in MHz of this receiver channel.

Receiver Temperature - TRX
The receiver temperature measured for a given channel.

Calibration Temperature - TCAL
The value of the noise tube diode or other calibration temperature used to calibrate the data.

Source System Temperature - STSYS
The system temperature measured on source.

Reference System Temperature - RTSYS
The system temperature measured on reference.

Source Temperature - TSOURCE
Source temperature computed for a series of on-off samples.

RMS -
RMS value about the mean source temperature.

Reference Point Number - REFPT
The position in the spectral line device for which the observer enters a freqency and/or velocity. It is usually the first or center channel.

X value at the Reference Point - XO
Value of the x-axis at the reference point.

Delta X - DELTAX
The step size along the x-axis.

Total Integration Time - INTTIME
The total integration time for this receiver channel.

Number of Integrations or Channels - NOINT
The number of data points for this receiver channel.

Starting Point Number - SPN
The starting point location of this receiver channel in the data area.

H2O Opacity - TAUH2O
The opacity of water as computed by a model.

H2O Temperature - TH2O
The temperature of water.

O2 Opacity - TAUO2
The opacity of oxygen as computed by a model.

O2 Temperature - TO2
The temperature of oxygen.

Polarization Description - POLARIZ
An eight character field to describe the type of polarization and the angle. The type may be RC, LC or LIN. The angle can be expressed to the nearest tenth of a degree.

```
      0........1.........2.........3.........4.........5.........6.........7.........8
      12345678901234567890123456789012345678901234567890123456789012345678901234567890

1: 1  SIMPLE  =                    T                  / Standard FITS format
1: 2  BITPIX  =                    8                  / Character information
1: 3  NAXIS   =                    0                  / No image data array present
1: 4  EXTEND  =                    T                  / There may be standard extent
1: 5
1: 6  DATE    = '09/18/86'                            / Date tape written
1: 7  ORIGIN  = 'TUCVAX  '                            / Site which wrote this tape
1: 8
1: 9  COMMENT  This is a FITS tape of Tucson
1:10  COMMENT  Spectral Line data.  It is written
1:11  COMMENT  using the FITS Tables Extension
1:12  COMMENT  format.  The first 2880-byte record
1:13  COMMENT  is the main FITS header.  Following
1:14  COMMENT  the main header is a table for each
1:15  COMMENT  scan.  Each table contains one or more
1:16  COMMENT  header records followed by one or more
1:17  COMMENT  data records.
1:18
1:19
1:20  COMMENT  General Single Dish parameters have
1:21  COMMENT  the GENERAL qualifier.  Telescope
1:22  COMMENT  dependent parameters have a qualifier
1:23  COMMENT  which indicates the telescope.
1:24  COMMENT  In a SINGLDSH card, the qualifier
1:25  COMMENT  starts in column 10, the keyword in
1:26  COMMENT  column 19, and the "=" in column 27.
1:27  END
1:28
1:29
1:30
1:31
1:32
1:33
1:34
1:35
1:36

      0........1.........2.........3.........4.........5.........6.........7.........8
      12345678901234567890123456789012345678901234567890123456789012345678901234567890

2: 1  XTENSION= 'TABLE   '                            / Standard table
2: 2  BITPIX  =                   16                  / 16-bits per "pixel"
2: 3  NAXIS   =                    2                  / Simple 2-D matrix
2: 4  NAXIS1  =                    8                  / # chars in field
2: 5  NAXIS2  =                    8                  / # fields in data table
2: 6  PCOUNT  =                    0                  / No "random" parameters
2: 7  GCOUNT  =                    1                  / Only one group
2: 8  TFIELDS =                    1                  / # columns in data table
2: 9  TBCOL1  =                    1                  / Starting column
2:10  TFORM1  = 'I8      '                            / Format of data entry
2:11  TTYPE1  = 'CH-TEMP '                            / Heading for column 1
2:12  TUNIT1  = 'K       '                            / Units of data for column 1
2:13  TSCAL1  =                 0.15                  / Real=(Data/TSCAL1)+TZERO1
2:14  TZERO1  =                -.25                   / Zero offset
2:15  SINGLDSH GENERAL  HEADLEN =  1024.0000          / Length of header in bytes
```

```
2:16  SINGLDSH GENERAL  DATALEN =  32.000000          / Length of data in bytes
2:17  SINGLDSH GENERAL  SCAN    =  8702.0000          / Scan number
2:18  SINGLDSH GENERAL  OBSID   = 'DEH WS  '          / Observer & Operator Initials
2:19  SINGLDSH GENERAL  OBSERVER= 'HOGG              '/ Observer Name
2:20  SINGLDSH GENERAL  TELESCOP= 'NRAO 12M'          / Telescope
2:21  SINGLDSH GENERAL  PROJID  = 'TEST    '          / Project ID
2:22  SINGLDSH GENERAL  OBJECT  = 'VENUS             '/ Source Name
2:23  SINGLDSH GENERAL  OBSMODE = 'CONTBMSW'          / Type of data & observing mode
2:24  SINGLDSH GENERAL  FRNTEND = '2C3MMSHM'          / Front End
2:25  SINGLDSH GENERAL  BACKEND = 'STD A/D '          / Back End
2:26  SINGLDSH GENERAL  PRECIS  = 'R*4     '          / Data precision
2:27  SINGLDSH GENERAL  XPOINT  = 0.00000000E+00      / Az/RA Pointing Corr (Arcsec)
2:28  SINGLDSH GENERAL  YPOINT  = 0.00000000E+00      / El/Dec Pointing Corr (Arcsec)
2:29  SINGLDSH GENERAL  UXPNT   =  6.7977800          / User Az/RA Correction (Arcsec)
2:30  SINGLDSH GENERAL  UYPNT   = -32.752941          / User El/Dec Correction(Arcsec)
2:31  SINGLDSH GENERAL  PTCON1  = 0.00000000E+00      / Pointing constant - PVLS
2:32  SINGLDSH GENERAL  PTCON2  = 0.00000000E+00      / Pointing constant - PVLS
2:33  SINGLDSH GENERAL  PTCON3  =  41500000.          / Pointing constant - PVLS
2:34  SINGLDSH GENERAL  PTCON4  = 0.00000000E+00      / Pointing constant - PVLS
2:35  SINGLDSH GENERAL  ORIENT  = 0.00000000E+00      / Rcvr Box or Sec Orient (Deg)
2:36  SINGLDSH GENERAL  UTDATE  =  1986.0914          / Universal Time Date(YYYY.MMDD)

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3: 1  SINGLDSH GENERAL  HOURUT  =  1.6625977         / Universal Time (hours)
3: 2  SINGLDSH GENERAL  HOURLST =  17.738038         / LST (hours)
3: 3  SINGLDSH GENERAL  NORCVR  =  1.2000000         / Number of Receivers
3: 4  SINGLDSH GENERAL  NOSWVAR = 0.00000000E+00     / Number of Switching Variables
3: 5  SINGLDSH GENERAL  NOPHASE = 0.00000000E+00     / Number of Phases per Cycle
3: 6  SINGLDSH GENERAL  CYCLLEN = 0.00000000E+00     / Length of cycle (Sec)
3: 7  SINGLDSH GENERAL  SAMPRAT =  5.0000000         / Sample Period (Sec)
3: 8  SINGLDSH GENERAL  EPOCH   =  1950.0000         / Epoch of observation (Years)
3: 9  SINGLDSH GENERAL  XSOURCE =  211.82739         / Comm. Source RA (Deg)
3:10  SINGLDSH GENERAL  YSOURCE = -17.182789         / Comm. Source Dec (Deg)
3:11  SINGLDSH GENERAL  XREF    = 0.00000000E+00     / Comm. Reference RA (Deg)
3:12  SINGLDSH GENERAL  YREF    = 0.00000000E+00     / Comm. Reference Dec (Deg)
3:13  SINGLDSH GENERAL  EPOCRA  =  211.82739         / Comm. Epoch RA (Deg)
3:14  SINGLDSH GENERAL  EPOCDEC = -17.182789         / Comm. Epoch Dec (Deg)
3:15  SINGLDSH GENERAL  GALLONG = 0.00000000E+00     / Comm. Galactic Longitude (Deg)
3:16  SINGLDSH GENERAL  GALLAT  = 0.00000000E+00     / Comm. Galactic Latitude (Deg)
3:17  SINGLDSH GENERAL  AZ      =  234.86573         / Comm. Azimuth (Deg)
3:18  SINGLDSH GENERAL  EL      =  18.501036         / Comm. Elevation (Deg)
3:19  SINGLDSH GENERAL  INDX    = 0.00000000E+00     / Indicated X Position (Deg)
3:20  SINGLDSH GENERAL  INDY    = 0.00000000E+00     / Indicated Y Position (Deg)
3:21  SINGLDSH GENERAL  DESORG  = 0.00000000E+00     / Descriptive origin
3:22  SINGLDSH GENERAL  DESORG  = 0.00000000E+00     / Descriptive origin
3:23  SINGLDSH GENERAL  DESORG  = 0.00000000E+00     / Descriptive origin
3:24  SINGLDSH GENERAL  COORDCD = '1950RADC'         / Coordinate system code
3:25  SINGLDSH GENERAL  TAMB    =  19.209999         / Ambient Temp (Deg C)
3:26  SINGLDSH GENERAL  SCANANG = 0.00000000E+00     / Map scanning angle (Deg)
3:27  SINGLDSH GENERAL  XZERO   = 0.00000000E+00     / X Pos at Map Ref Pos Zero(Deg)
3:28  SINGLDSH GENERAL  YZERO   = 0.00000000E+00     / Y Pos at Map Ref Pos Zero(Deg)
3:29  SINGLDSH GENERAL  DELTAXR = 0.00000000E+00     / Delta X or X Rate (Arcsec)
3:30  SINGLDSH GENERAL  DELTAYR = 0.00000000E+00     / Delta Y or Y Rate (Arcsec)
3:31  SINGLDSH GENERAL  NOPTS   = 0.00000000E+00     / Number of Grid Points
3:32  SINGLDSH GENERAL  NOXPTS  = 0.00000000E+00     / Number of X Grid Points
3:33  SINGLDSH GENERAL  NOYPTS  = 0.00000000E+00     / Number of Y Grid Points
3:34  SINGLDSH GENERAL  XCELLO  = 0.00000000E+00     / Starting X Cell Grid Number
3:35  SINGLDSH GENERAL  YCELLO  = 0.00000000E+00     / Starting Y Cell Grid Number
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 3:36  SINGLDSH GENERAL  FRAME   = '        '           / XY Reference Frame Code

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 4: 1  SINGLDSH GENERAL  BFWHM   =  35.000000          / Beam Fwdth at Half Max(Arcsec)
 4: 2  SINGLDSH GENERAL  OFFSCAN = 0.00000000E+00      / Off-Scan number
 4: 3  SINGLDSH GENERAL  BADCHV  =  2.0000000          / Bad channel value
 4: 4  SINGLDSH GENERAL  RVSYS   = 0.00000000E+00      / Velocity Correction (M/S)
 4: 5  SINGLDSH GENERAL  VELOCTY = 0.00000000E+00      / Velocity wrt Reference (M/S)
 4: 6  SINGLDSH GENERAL  VELDEF  = '        '          / Velocity Def and Ref
 4: 7  SINGLDSH GENERAL  TYPECAL = 'NOISE TU'          / Type of Calibration
 4: 8  SINGLDSH GENERAL  APPEFF  = 0.44999999          / Antenna Aperture Efficiency
 4: 9  SINGLDSH NRAO-12M SYNFREQ = 0.19476300E+10      / Synthesizer Frequency (Hz)
 4:10  SINGLDSH NRAO-12M LOFACT  = 0.00000000E+00      / LO Factor (Hz)
 4:11  SINGLDSH NRAO-12M HARMONC =  45000000.          / Harmonic (Hz)
 4:12  SINGLDSH NRAO-12M LOIF    = 0.10000000E+09      / LO IF (Hz)
 4:13  SINGLDSH NRAO-12M FIRSTIF = 0.15000000E+10      / First IF (Hz)
 4:14  SINGLDSH NRAO-12M RAZOFF  = -232.97845          / Ref Az Offset (Arcsec)
 4:15  SINGLDSH NRAO-12M RELOFF  = -32.752941          / Ref El Offset (Arcsec)
 4:16  SINGLDSH NRAO-12M BMTHROW =  1.5000000          / Beam Throw (Arcsec)
 4:17  SINGLDSH NRAO-12M BMORENT = 0.00000000E+00      / Beam Orientation (Deg)
 4:18  SINGLDSH NRAO-12M BASEOFF =  26.080000          / Baseline Offset (Deg)
 4:19  SINGLDSH NRAO-12M OBSTOL  =  5.0000000          / Observing Tolerance (Arcsec)
 4:20  SINGLDSH NRAO-12M SIDBAND = 0.00000000E+00      / Sideband
 4:21  HISTORY
 4:22  SINGLDSH GENERAL  RCVR    =  1.0000000          / This receiver number
 4:23  SINGLDSH GENERAL  OBSFREQ = 0.86243350E+11      / Observed Frequency (Hz)
 4:24  SINGLDSH GENERAL  RSTFREQ = 0.92000000E+09      / Rst Freq or TP Cal (Hz)
 4:25  SINGLDSH GENERAL  FREQRES = 0.70200000E+09      / Freq Res or SP Cal (Hz)
 4:26  SINGLDSH GENERAL  BW      = 0.60000000E+09      / Band Width (Hz)
 4:27  SINGLDSH GENERAL  TRX     = 0.00000000E+00      / Receiver Temp (K)
 4:28  SINGLDSH GENERAL  TCAL    =  8.0000000          / Calibration Temp (K)
 4:29  SINGLDSH GENERAL  STSYS   =  310.00000          / Signal System Temp (K)
 4:30  SINGLDSH GENERAL  RTSYS   = 0.00000000E+00      / Ref System Temp (K)
 4:31  SINGLDSH GENERAL  TSOURCE =  21.547501          / Source Temp (K)
 4:32  SINGLDSH GENERAL  TRMS    = 0.17749977          / RMS of Mean
 4:33  SINGLDSH GENERAL  REFPT   =  1.0000000          / Ref Point Number
 4:34  SINGLDSH GENERAL  X0      =  1.0000000          / Velocity at Ref Point (M/S)
 4:35  SINGLDSH GENERAL  DELTAX  =  1.0000000          / Delta X
 4:36  SINGLDSH GENERAL  INTTIME =  5.0000000          / Total Integration Time (Sec)

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 5: 1  SINGLDSH GENERAL  NOINT   =  8.0000000          / # Integrations or channels
 5: 2  SINGLDSH GENERAL  SPN     =  1.0000000          / Starting point number
 5: 3  SINGLDSH GENERAL  TAUH2O  = 0.50000001E-01      / H2O Opacity
 5: 4  SINGLDSH GENERAL  TH2O    = 0.00000000E+00      / H2O Temp (K)
 5: 5  SINGLDSH GENERAL  TAUO2   = 0.00000000E+00      / O2 Opacity
 5: 6  SINGLDSH GENERAL  TO2     = 0.00000000E+00      / O2 Temp (K)
 5: 7  SINGLDSH GENERAL  POLARIZ = '        '          / Polarization
 5: 8  END
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 6: 1       710    32767    32767      488        0    31700    31893      310        0        0
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