

TIMED - IDI

DEFINITION STUDY FINAL REPORT

NASA-CR-196198

IONOSPHERIC DYNAMICS INSTRUMENT INVESTIGATION

**FOR THE TIMED MISSION
CONTRACT NO. NAS5-32571**

UNIVERSITY OF TEXAS AT DALLAS

**PRINCIPAL INVESTIGATOR
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DYNAMICS INSTRUMENT INVESTIGATION
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DEFINITION STUDY FINAL REPORT	1
TABLE OF CONTENTS	2
INVESTIGATOR TEAM	3
ORGANIZATION CHART	4
CO-INVESTIGATORS RESPONSIBILITIES	5
SCIENCE QUESTIONS	6
BASIC PHYSICAL PRINCIPLES	7
REQUIRED MEASUREMENTS	8
MEASUREMENT CAPABILITIES I	9
MEASUREMENT CAPABILITIES II	10
MEASUREMENT APPROACH I	11
MEASUREMENT APPROACH II	12
MEASUREMENT STRATEGY	13
SCIENCE PARAMETER EXTRACTION I	14
SCIENCE PARAMETER EXTRACTION II	15
SCIENCE PARAMETER EXTRACTION III	16
DESCOPE OPTIONS	17
SCIENCE IMPACT OF THE FUTURE DESCOPE OPTIONS - I	18
SCIENCE IMPACT OF THE FUTURE DESCOPE OPTIONS - II	19
RPA SENSOR CROSS-SECTION	20
PLASMA PLATE SENSOR CROSS-SECTION	21
IDM SENSOR CROSS-SECTION	22
ION TRAP SENSOR CROSS-SECTION	23
INSTRUMENT OUTLINE - IDI FOR TIMED	24
DESIGN DESCRIPTION - I	25
DESIGN DESCRIPTION - II	26
DESIGN DESCRIPTION - III	27
FUNCTIONAL DIAGRAM	28
MICROPROCESSOR CONTROL TASKS	29
FLIGHT SOFTWARE	30
ON-BOARD SIGNAL PROCESSING - I	31
ON-BOARD SIGNAL PROCESSING - II	32
ON-BOARD SIGNAL PROCESSING - III	33
IDI GROUNDING BIAS DIAGRAM	34
SPACECRAFT RESOURCES	35
POWER BREAKDOWN	36
MASS BREAKDOWN	37
SPACECRAFT REQUIREMENTS	38
VEHICLE POTENTIAL	39
S/C POINTING AND ATTITUDE	40
MOUNTING AND FOV	41
TECHNOLOGY RISK AREAS	42
INSTRUMENT ACQUISITION	43
FACILITIES AND EQUIPMENT	44
RELIABILITY AND QUALITY ASSURANCE	45
EEE PARTS	46
ENVIRONMENTAL TESTING (T&E)	47
INSTRUMENT CALIBRATION	48
IDI GSE	49
GSE SOFTWARE	50
IDI STIMULUS	51
IDI TEST CONFIGURATIONS	52
DATA CENTER INTERACTIONS	53
UTD PHASE C/D SCHEDULE	54
PHASE C/D BUDGET - \$K -	55
APPENDIX	56

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RQA (ACTING)

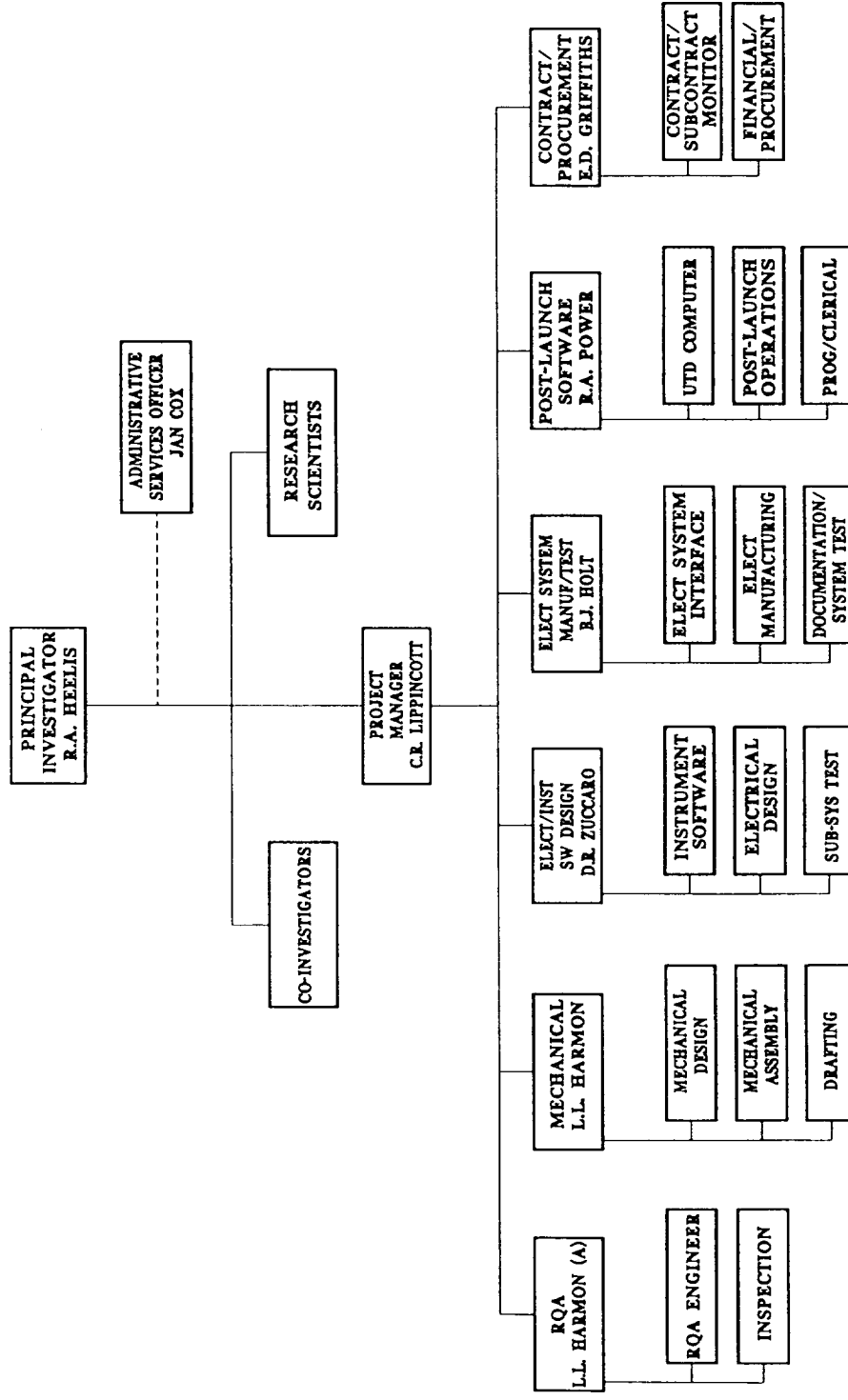
**LARRY HARMON
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CONTRACT

**DAN GRIFFITHS
UTD - X2853**

ORGANIZATION CHART

UTD CENTER FOR SPACE SCIENCES IDI PROJECT ORGANIZATION



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CO-INVESTIGATORS RESPONSIBILITIES

W. B. HANSON - UTD

- PARTICIPATE IN DESIGN OF DATA ACQUISITION ALGORITHMS AND OPERATION OF PLASMA PLATE TO DERIVE THE APERTURE PLANE POTENTIAL
- ASSIST IN DEVELOPMENT OF DATA QUALITY FLAGS
- PARTICIPATE IN THE DATA REDUCTION AND ANALYSIS, PARTICULARLY IN THE AREA OF LOW LATITUDE ELECTRODYNAMICS

M. C. KELLEY - CORNELL UNIVERSITY

- PARTICIPATE IN DESIGN OF DATA ACQUISITION ALGORITHMS FOR THE DIGITAL SIGNAL PROCESSING
- ASSIST IN THE REDUCTION AND INTERPRETATION OF THE DATA FROM ON-BOARD FFT'S
- RESPONSIBLE FOR COORDINATING DATA ACQUISITION BETWEEN THE TIMED PAYLOAD AND GROUND RADAR FACILITIES
- PARTICIPATE IN JOINT ANALYSIS AND INTERPRETATION OF THE COORDINATED DATA

H. C. YEH - NATIONAL CENTRAL UNIVERSITY

- COORDINATE DATA ACQUISITION ACTIVITIES OF PACIFIC GROUND BASED OBSERVATORIES WITH OPERATION OF TIMED PAYLOAD
- PARTICIPATE IN THE ANALYSIS AND INTERPRETATION OF THE JOINTLY COLLECTED DATA SETS AS THEY APPLY TO THE RESPONSE OF THE ITM SYSTEM TO INTERNALLY GENERATED ELECTRIC FIELDS

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SCIENCE QUESTIONS

- **WHAT IS THE RESPONSE OF THE ITM REGION TO JOULE HEATING AT HIGH LATITUDES?**
- **HOW EFFECTIVE IS AURORAL ZONE HEATING IN THE PRODUCTION OF DISTURBANCE MOTIONS AND DYNAMOS AT MIDDLE LATITUDES?**
- **WHAT IS THE RELATIONSHIP BETWEEN GLOBAL SCALE MOTIONS IN THE NEUTRAL ATMOSPHERE ABOVE 120 km AND THE EXB DRIFT MOTION OF THE CHARGED PLASMA?**
- **HOW ARE PLASMA STRUCTURES FORMED AND HOW DOES THEIR EVOLUTION DEPEND ON LARGER SCALE MOTIONS OF THE NEUTRAL ATMOSPHERE?**

BASIC PHYSICAL PRINCIPLES

- **ELECTRIC FIELDS APPLIED EXTERNALLY AND PRODUCED BY GRADIENTS IN NEUTRAL WIND DRIVEN CURRENTS**
- **ELECTRIC FIELD MEASURED FROM ION DRIFT VELOCITY VECTOR AND $E = -V \times B$**
- **ELECTRIC FIELD MAPS ALONG MAGNETIC FIELD LINES IN KNOWN WAY**
- **NEUTRAL WIND DRIVEN CURRENTS DEPEND UPON WIND VECTOR AND CONDUCTIVITY**
- **NEUTRAL WINDS TO BE MEASURED AS A FUNCTION OF ALTITUDE**
- **CONDUCTIVITY CAN BE ESTIMATED FROM IONOSPHERIC MODELS AND KNOWLEDGE OF THE SOLAR EUV AND PARTICLE PRECIPITATION**
- **SOLAR EUV OBTAINED BY MEASUREMENT OR F10.7 RADIO FLUX**
- **PARTICLE PRECIPITATION FROM MODELS NORMALIZED IN LOCATION BY ION DRIFT MEASUREMENTS, AND IN MAGNITUDE BY IMAGING OR SECONDARY ELECTRON MEASUREMENTS OF RPA**

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REQUIRED MEASUREMENTS

PRIMARY - IDI MEASURED

- ION TEMPERATURE
- TOTAL ION CONCENTRATION
- ION DRIFT VELOCITY
- ION CONCENTRATION AND VELOCITY STRUCTURES

PRIMARY - OTHER INSTRUMENTS

- MAJOR NEUTRAL ATMOSPHERE CONSTITUENTS
>120 km
- NEUTRAL ATMOSPHERE TEMPERATURE
>120 km
- NEUTRAL GAS VELOCITY
>120 km

SECONDARY

- AIRLGOW IMAGING

TIMED - IDI

MEASUREMENT CAPABILITIES I

PARAMETER	DYNAMIC RANGE	ABSOLUTE ACCURACY	SENSITIVITY	SPATIAL RESOLUTION
ION VELOCITY RAM COMPONENT	±4 km/s	±20 m/s	20 m/s **	4 km
ION VELOCITY HORIZONTAL COMPONENT	±4 km/s	±4 m/s (0.03 deg*)	1.5 m/s	250 m
ION VELOCITY VERTICAL COMPONENT	±4 km/s	±4 m/s (0.03 deg*)	1.5 m/s	250 m
ION TEMPERATURE	100 to 10000 K	±3%	30 K **	4 km
MAJOR ION CONSTITUENT CONCENTRATION	10 to 106 cm ⁻³	±5%	1cm ⁻³	4 km
TOTAL ION CONCENTRATION	10 to 106 cm ⁻³	±5%	ΔN/N 0.1%	250 m
DENSITY AND VELOCITY POWER SPECTRA	0 to -70 DB 0 to 1 kHz	±10% (TBD)	TBD	8 km

* ASSUMED ATTITUDE DETERMINATION ERROR.

**SENSITIVITY IS ESTIMATED FROM CAPABILITIES OF LEAST-SQUARES ALGORITHM AND EXPECTED INSTRUMENT NOISE LEVELS.

UTD
8/26/94

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MEASUREMENT CAPABILITIES II

- ALL MEASUREMENTS MADE IN-SITU AT SPACECRAFT ALTITUDE
- MEASUREMENTS CAN BE MADE UNDER ALL CONDITIONS AND IN ALL LOCATIONS WHEN SENSORS FACE THE RAM DIRECTION
- ELECTRIC FIELD DERIVED FROM $E = -V \times B$ ASSUMING MODEL B-FIELD
- ELECTRIC FIELD CAN BE EVALUATED AT ALL LOCATIONS ALONG B-FIELD THROUGH SATELLITE LOCATION
- ELECTRIC FIELD MEASURED AT ALL ALTITUDES AND LATITUDES OUTSIDE THE MAGNETIC FLUX TUBE WITH APEX HEIGHT = 400 km. THIS FLUX TUBE CROSSES 100 km AT ABOUT 12 DEGREES LATITUDE.

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MEASUREMENT APPROACH I

- **RPA**
 - **MEASURES RAM ENERGY AND TEMPERATURE FROM LOCATION AND SHAPE OF I-V CHARACTERISTIC**
- **IDM**
 - **MEASURES HORIZONTAL AND VERTICAL ION ARRIVAL ANGLES FROM ASYMMETRY IN CURRENT COLLECTION**
- **IT**
 - **MEASURES SATURATION ION CURRENT DIRECTLY**

- RPA MEASURES RAM ENERGY FOR GIVEN MASS
$$E_R^M = 1/2 mV^2 + q\psi$$
- ORIGINAL PROPOSAL
MEASURE E_R^M FOR TWO MASSES TO SEPARATE V FROM ψ
- ADOPTED APPROACH
USE RPA PLASMA PLATE (RPA/PP) TO INDEPENDENTLY MEASURE ψ
- ABILITY TO SWEEP MASS ANALYZER FOR ION MASS SPECTROMETRY IS LOST
- ABILITY TO OBTAIN T_e FROM PLASMA PLATE IS GAINED
- MEASUREMENT APPROACH AND DEFINITION STUDY ASSUMED RPA/PP IMPLEMENTATION

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MEASUREMENT STRATEGY

- 100% DUTY CYCLE DESIRABLE
- INSTRUMENT OPERATIONAL ONLY WHEN FACING RAM DIRECTION
- INSTRUMENT TO FUNCTION SIMULTANEOUSLY WITH NEUTRAL WIND AND WAVE MEASUREMENTS
- NO SUSCEPTIBILITY TO SUN ANGLE
- OPERATION DURING CONTROLLED S/C MANEUVERS IS DESIRABLE

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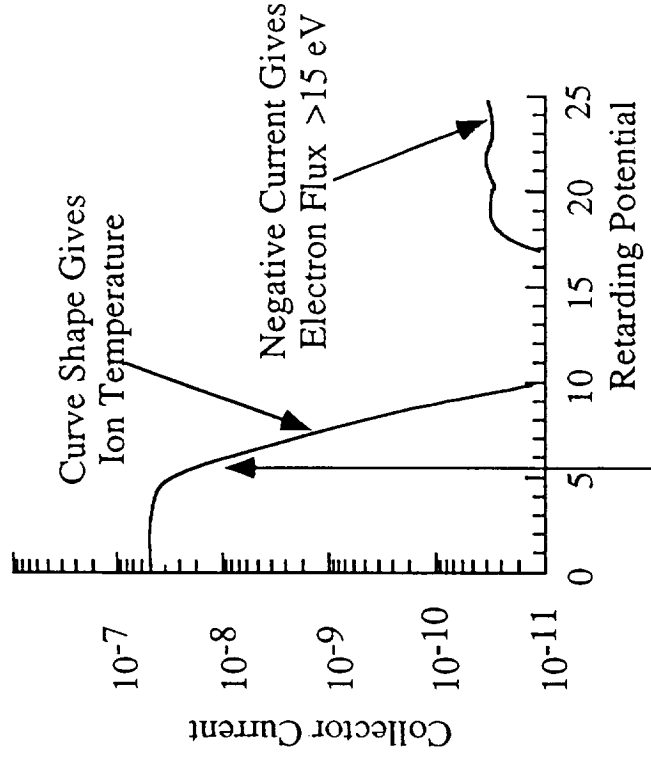
SCIENCE PARAMETER EXTRACTION I

• RETARDING POTENTIAL ANALYZER

- RAM ENERGY HAS COMPONENTS FROM DRIFT $\frac{1}{2} mV^2$ AND POTENTIAL $q\psi$
- SEPARATION REQUIRES KNOWLEDGE OF RAM ENERGY FROM TWO MASSES OR INDEPENDENT MEASURE OF ψ
- ORIGINAL APPROACH UTILIZES MASS SPECTROMETER FOR RAM ENERGY FROM TWO MASSES
- PRESENT APPROACH UTILIZES PLASMA PLATE TO MEASURE ψ

• MEASURES THERMAL ION ENERGY DISTRIBUTION ALONG SENSOR LOOK DIRECTION

- PLATEAU CURRENTS GIVE MAJOR ION CONCENTRATIONS
- CURVE SHAPE GIVES T_i
- CURVE LOCATION GIVES RAM ENERGY



Half Power Point Gives
Total Ram Energy

$$\Phi(P) = \frac{n}{2} V_r \left[1 + \operatorname{erf} \beta f + \frac{1}{\sqrt{\pi} \beta V_r} \exp(-\beta^2 f^2) \right]$$

$$P = q(R_v + \psi_s) \quad f = V_r - (2P/m)^{1/2}$$

$$V_r = -(\vec{V}_d + \vec{V}_s) \cdot \hat{n} \quad \beta = (m/2kT)^{1/2}$$

$\hat{n}$ = unit normal in look direction of sensor

- PLASMA PLATE

- ELECTRON CURRENT INCREASES EXPONENTIALLY IN RETARDING REGION
- DEPARTS FROM EXPONENTIAL FOR POSITIVE PLATE VOLTAGES > PLASMA POTENTIAL
- DETECTION OF THIS LOCATION PROVIDES PLATE POTENTIAL

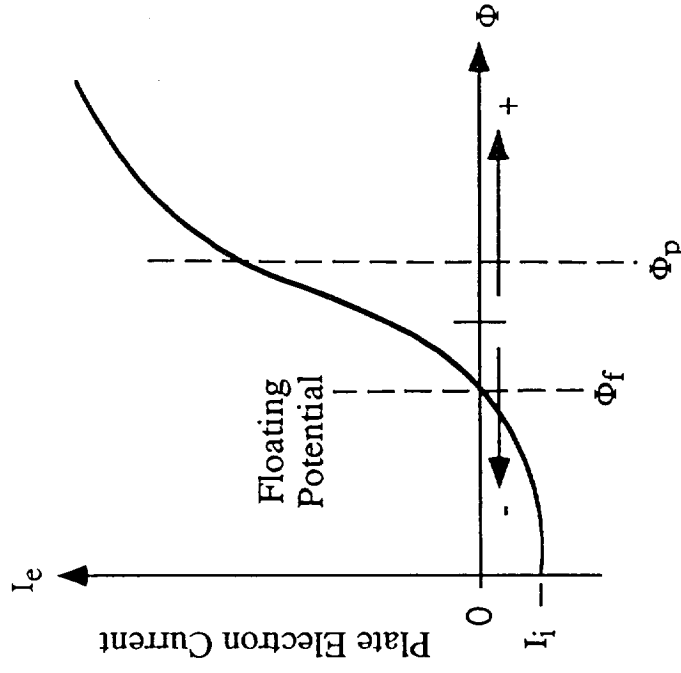


Plate potential at which current
departs from logarithmic increase
locates plasma potential
with respect to plate

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SCIENCE PARAMETER EXTRACTION III

- ION DRIFT METER
 - SIMULTANEOUSLY MEASURES TWO MUTUALLY PERPENDICULAR ION ARRIVAL ANGLES WRT SENSOR LOOK DIRECTION
 - CROSS TRACK HORIZONTAL AND VERTICAL DRIFTS OBTAINED FROM ANGLES AND RAM VELOCITY WRT SENSOR
- ION TRAP
 - MEASURES SATURATION ION CURRENT
 - ION FLUX DOMINATED BY S/C RAM VELOCITY
 - CURRENT DIRECTLY PROPORTIONAL TO TOTAL ION CONCENTRATION

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DESCOPE OPTIONS

- PRESENTLY ADOPTED/NEW BASELINE
 - REMOVED MAGNETIC MASS ANALYZER
 - ADDED PLASMA PLATE TO RPA
 - ONLY SCIENCE IMPACT IS LOSS OF PRESUMABLY REDUNDANT ION MASS SPECTROMETRY DATA
 - ABILITY TO OBTAIN Te FROM PP IS GAINED
- FUTURE OPTIONS
 - REMOVE FFT CAPABILITY
(SAVES 0.5 WATT, 0.45 LB., \$100K)
 - REMOVE ONE ION DRIFT METER SENSOR
(SAVES 0.3 WATT, 1.32 LBS., \$50K)

The primary science objectives for IDI are related to studying the global response of the ITM to energy inputs from the magnetosphere and to understanding the ways in which electric fields are internally generated by neutral atmosphere motions in the lower thermosphere and mesosphere.

The energy inputs from magnetospheric fields contain an input at large spatial scales that can be quite easily characterized from measurements made with temporal resolution of 1 second. An important but not well studied energy input also arises from much smaller spatial scales requiring temporal sampling rates exceeding 20 Hz.

At low and mid latitudes the electric fields are generated by neutral atmosphere motions and temporal resolution on time scales of a second will adequately describe the global field and allow its relationship to neutral wind motion to be established. However, the redistribution of current systems and the electrodynamics associated with plasma structures requires temporal sampling rates at the highest possible frequencies.

The removal of one IDM sensor would require that the remaining sensor be operated with the axis alternating at a rate of 4 Hz or so. This would provide vector measurements of the velocity over a period of about 0.5 seconds. While adequate for describing the large scale electrodynamics, there would be no capability to observe small scale features associated with plasma structures at high or low latitudes without sacrificing the vector measurement.

While potentially interesting and new science could be achieved from these data, it is unlikely that this smaller scale structure will dominate over the large scale features that are essential for understanding the system response.

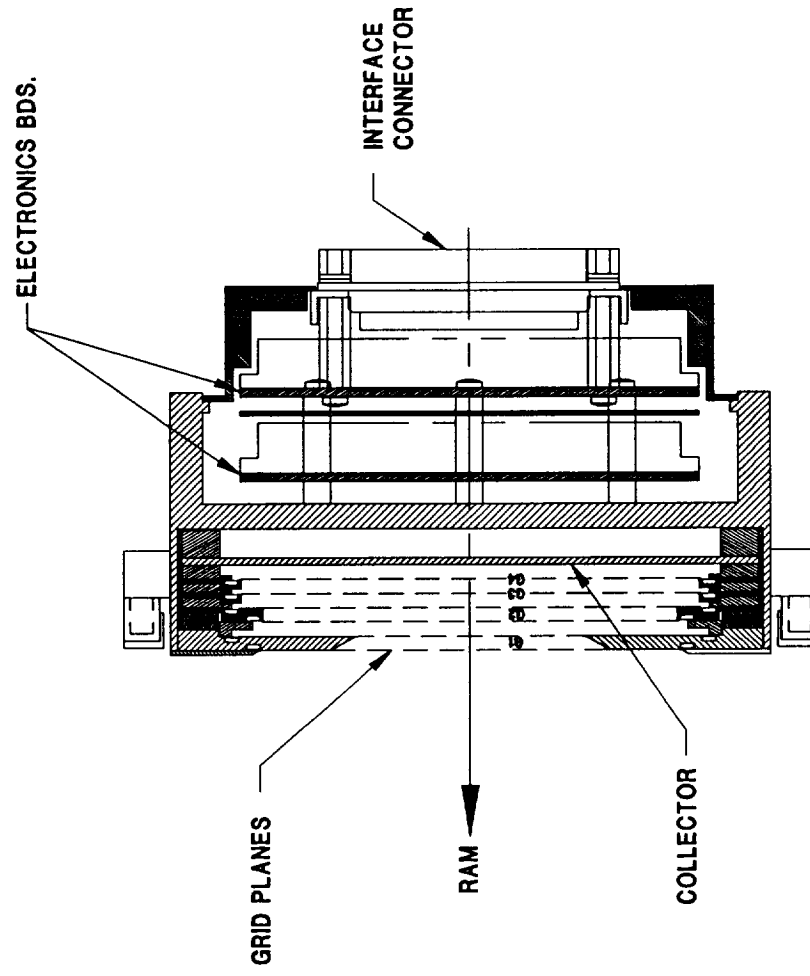
SCIENCE IMPACT OF FUTURE DESCOPE OPTIONS - II

The removal of the FFT signal processing will not allow any specification of the energy input to the system at small spatial scales and would render impossible a diagnosis of small scale plasma structures. It would not compromise the major science goals that will be addressed by IDI, but the impact of a new and potentially interesting energy source would remain uninvestigated.

Deletion of one IDM sensor would not seriously compromise the ability of the IDI to record the high latitude, large scale energy input to the system or to diagnose the large scale internally generated electric fields. However, this investigation could not be performed on a full-time basis without losing the ability to investigate a new and potentially interesting energy source from smaller scale features at high latitudes and from small scale plasma structures at low and middle latitudes.

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RPA SENSOR CROSS-SECTION

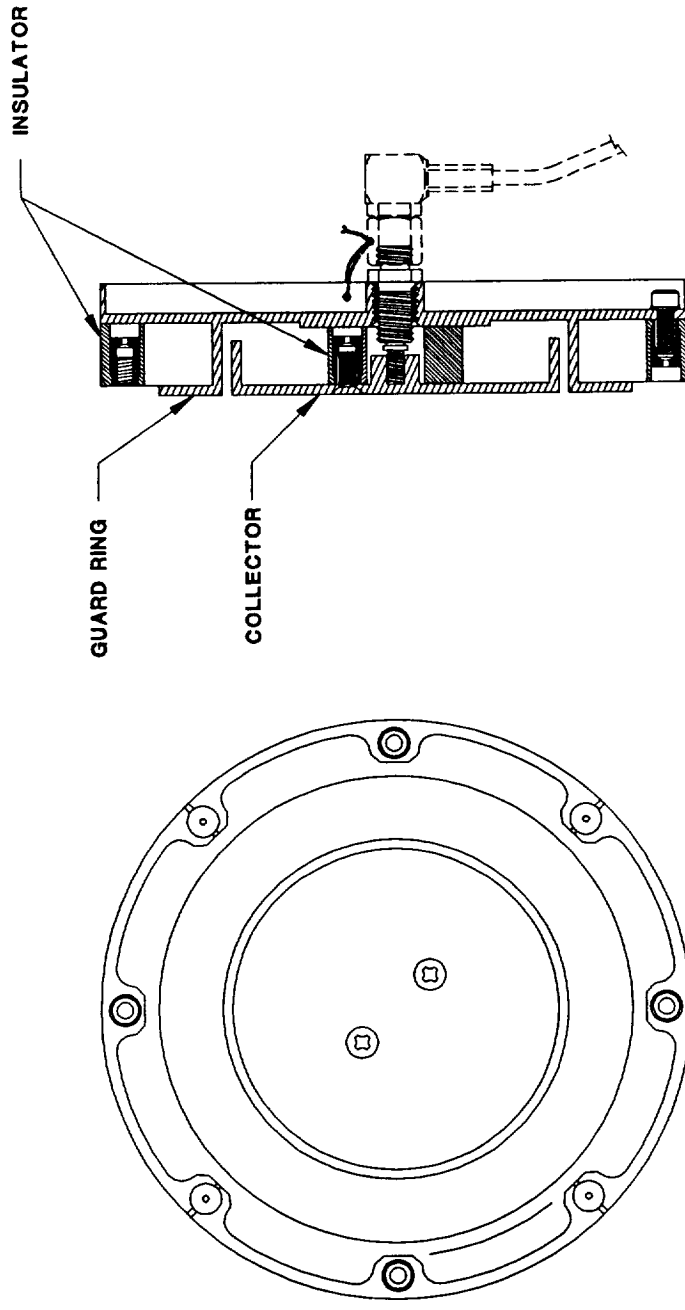


GRID DESCRIPTION
G1- DUAL APERTURE
G2- DUAL RETARDING
G3- SUPPRESSOR
G4- SHIELD

9K099910

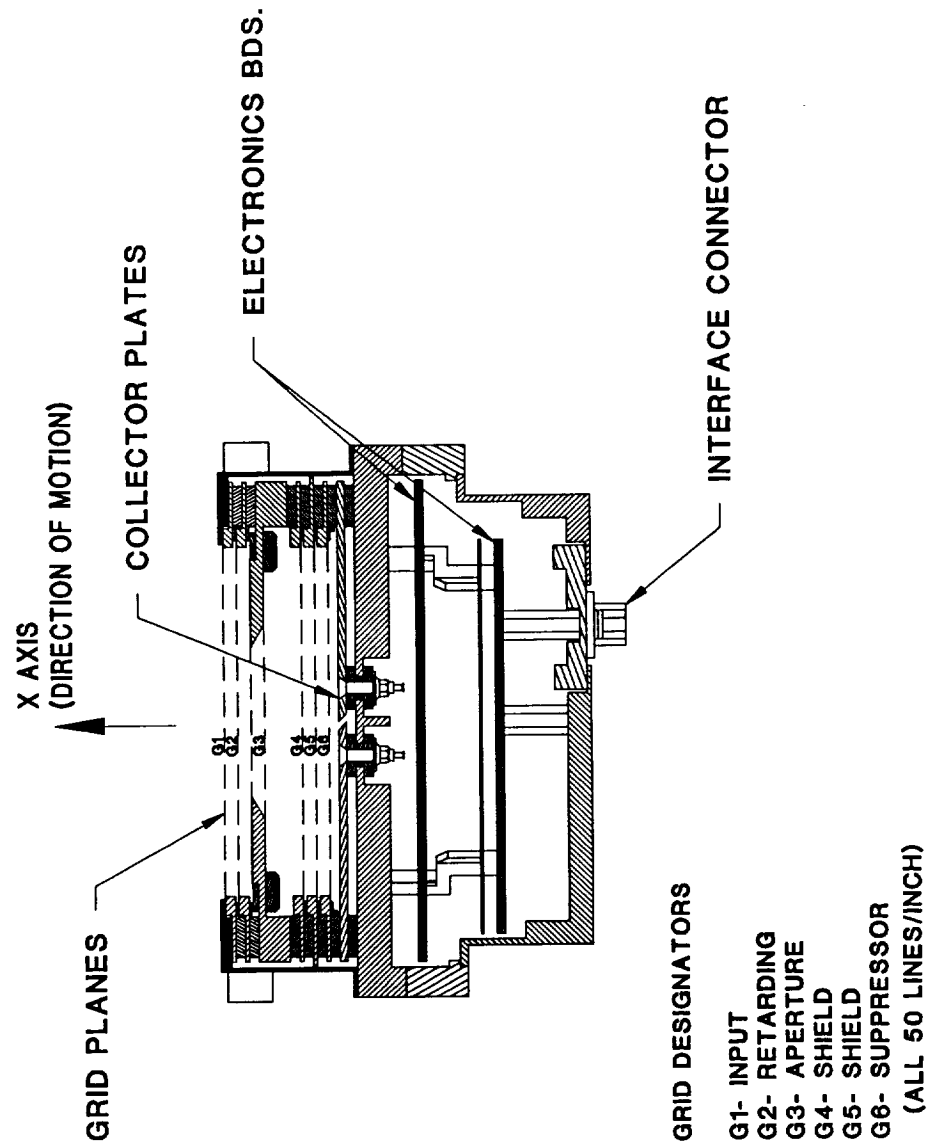
TIMED-IDI

PLASMA PLATE SENSOR CROSS-SECTION



TIMED-IDI

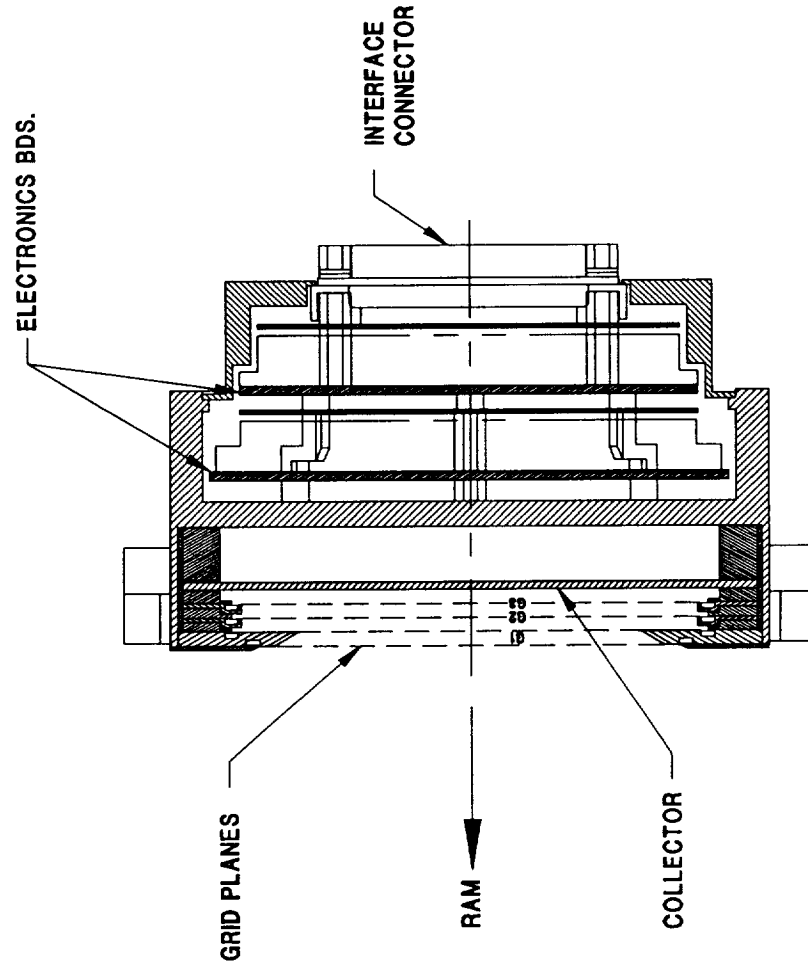
IDM SENSOR CROSS-SECTION



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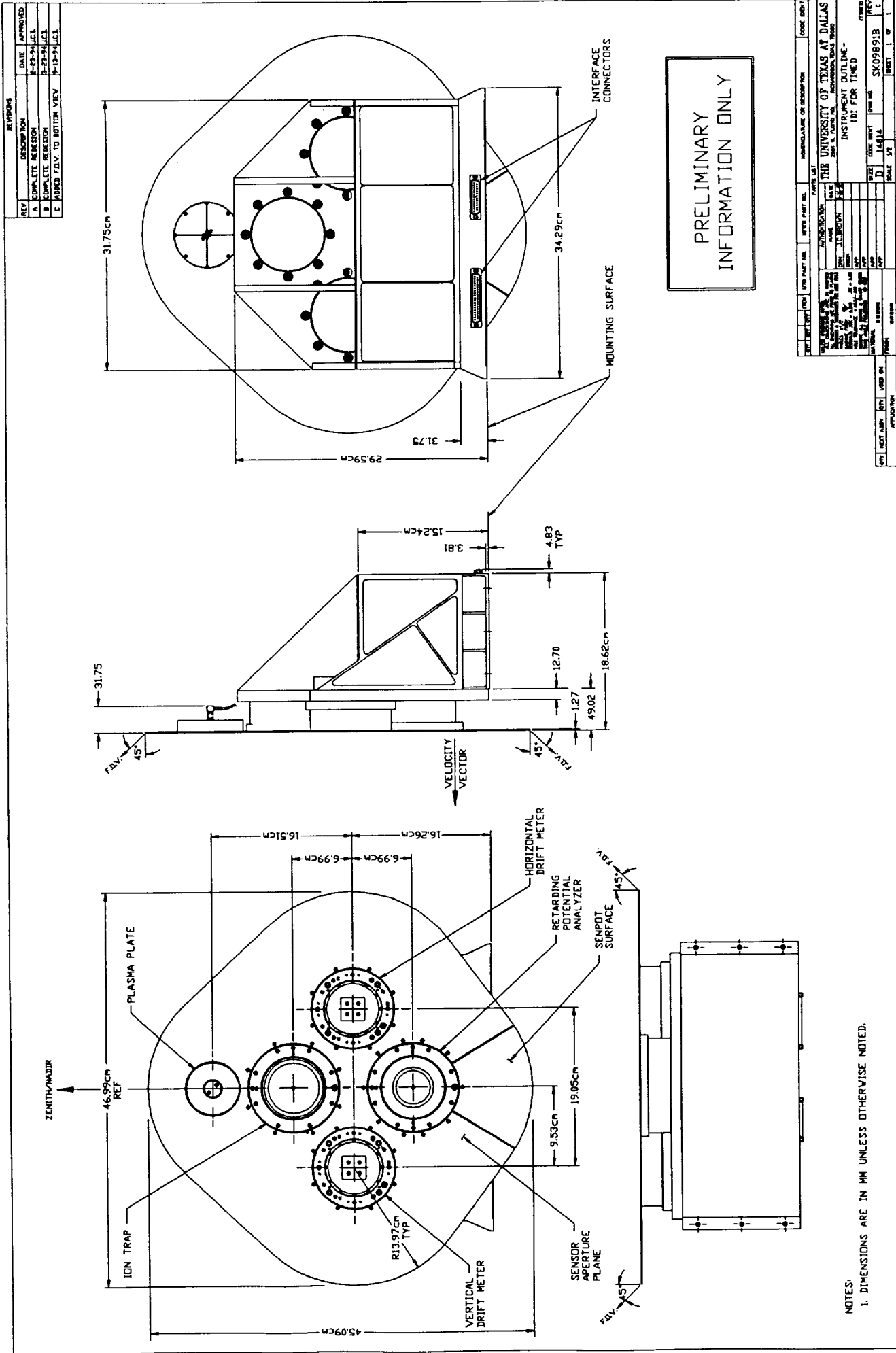
ION TRAP SENSOR CROSS-SECTION



GRID DESCRIPTION
G1- DUAL APERTURE
G2- SUPPRESSOR
G3- SHIELD
(ALL 50 LINES/INCH)

8K099510

REVISIONS		
REV	DESCRIPTION	DATE
A	COMPLETE REVISION	8-22-94 JLS
B	COMPLETE REVISION	8-22-94 JLS
C	ADDED FAV. TO BOTTOM VIEW	8-12-94 JLS



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DESIGN DESCRIPTION - I

- **IDI SENSORS INTEGRATED INTO A SINGLE PACKAGE**
- **SENSOR POTENTIAL (SENPOT) CONTROL -5V TO +15V WRT S/C GROUND**
- **MICROPROCESSOR CONTROL VIA PARALLEL I/O PORTS**
- **DEDICATED FFT SLAVE PROCESSOR**
- **MIL-STD-1553B**
- **SERIAL TIME CODE AND PERIODIC FIDUCIAL PULSE REQUIRED FOR DATA TIME TAGGING**
- **ELECTRICAL SCHEMATICS - SEE APPENDIX**

RPA

- LINEAR ELECTROMETER, 8 RANGES
- 64 SAMPLES/SEC
- 10 BIT ELECTROMETER CONVERSION + 3 RANGE BITS PER SAMPLE
- 256 DISCRETE RV LEVELS AVAILABLE, 8 BIT D/A, 0-25.5V, 0.1V/STEP
- ONE OF FOUR RV FORMATS SELECTED BY GROUND COMMAND
- RV FORMATS DEFINED BY LOOK-UP TABLES IN DPU ROM/RAM

IT

- LOG ELECTROMETER, 12 BIT CONVERSIONS, 32 SAMPLES/SEC

PP

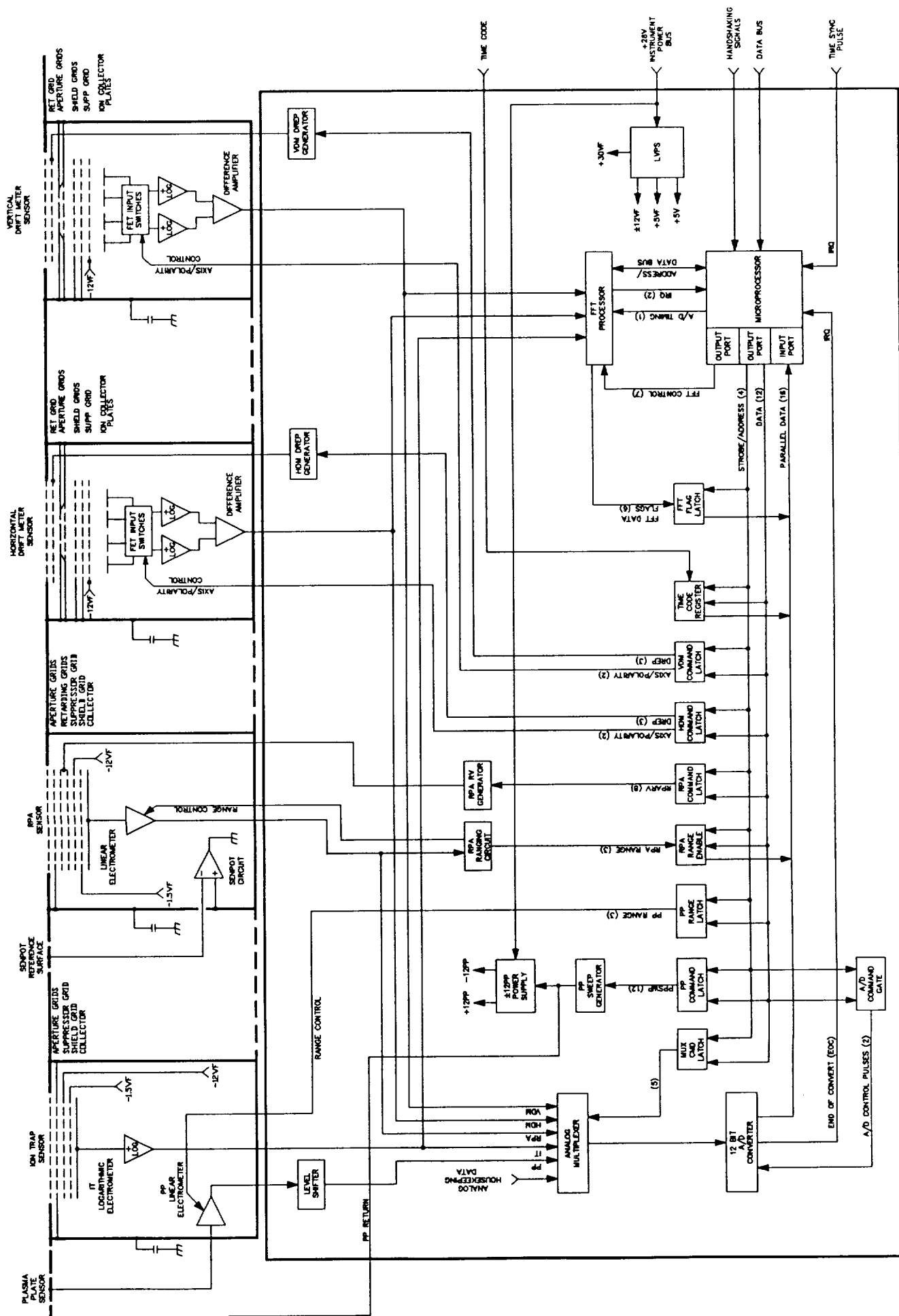
- OPERATION CONTROLLED BY DPU PP ALGORITHM
- LINEAR ELECTROMETER, 8 RANGES
- 4096 AVAILABLE SWEEP POINTS, +10V TO -10V, 12 BIT D/A
- 32 ELECTROMETER SAMPLES/SWEEP AT 64 SAMPLES/SEC RATE
- 12 BIT ELECTROMETER CONVERSIONS
- SWEEP FROM V_{START} TO $V_{\text{START}} + 31 (\Delta V)$, ΔV TYPICALLY $< 0.1 \text{ V}$
- SWEEP ΔV FIXED BY GROUND COMMAND, V_{START} COMPUTED FROM PREVIOUS SWEEP
- ELECTROMETER RANGE SET AT BEGINNING OF EACH SWEEP, THEN LOCKED
- TELEMETER V_{START} (12 BITS) FOR EACH SWEEP
- 32 POINT SWEEP DURING ALTERNATE 1/2 SEC PERIODS

VDM

- 12 BIT CONVERSIONS OF DIFFERENCE AMPLIFIER OUTPUT, $\pm 4 \text{ Km/SEC FULL SCALE}$, 32 SAMPLES/SEC

HDM

- SAME AS VDM



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MICROPROCESSOR CONTROL TASKS

- **ANALOG DATA MULTIPLEXING CONTROL**
- **A/D CONVERTER CONTROL**
- **SET PP SWEEP/ELECTROMETER RANGE**
- **SET RPA RETARDING VOLTAGE/ELECTROMETER RANGE**
- **SET HDM H⁺ REPELLER VOLTAGE, HDM AXIS/COLLECTOR SELECTION**
- **SET VDM H⁺ REPELLER VOLTAGE, VDM AXIS/COLLECTOR SELECTION**
- **CONTROL FFT SLAVE PROCESSOR**
- **PERFORM 1553B INTERFACE HOST PROCESSOR FUNCTIONS**

- COLLECT DATA SAMPLES FROM SENSORS IN FIXED SEQUENCE
- OUTPUT PARALLEL CONTROL WORD TO EACH SENSOR IMMEDIATELY AFTER EACH SAMPLE
- CONTROL FFT SLAVE PROCESSOR/PERFORM FFT OUTPUT DATA SELECTION
- SENSOR CONTROL PRIMARILY FROM LOOK-UP TABLES
- AMPLIFIER RANGE SETTINGS DETERMINED BY ALGORITHM
- RECEIVE AND IMPLEMENT SERIAL MODE COMMANDS
- TIME TAG AND PACKETIZE DATA
- SERVICE 1553B INTERFACE
- 80C86 ASSEMBLY LANGUAGE CODE

The use of on-board processing to perform spectral analysis allows information from data taken at high temporal resolution to be sent to the ground with only modest telemetry allocations. The IDI uses the Raytheon TMC2310 dedicated FFT processor to perform fast fourier transforms (FFT) and to produce the magnitude squared of the resulting complex numbers.

Data is stored as a time series of 1024 points that are gathered in 1 second. There will be 3 such blocks of 1024 points originating respectively from the VDM, the HDM, and the IT. Thus the effective sample rates for each parameter will be about one KHz. The FFT function will produce 512 complex numbers from each 1024 point data set that represent the decomposition of each time series into sine waves with known amplitudes and frequencies. The magnitude squared function applied to these complex numbers will provide the power spectral density in 512 equally spaced frequency bins extending to 512 Hz. The input data will be digitized with 12 bit accuracy providing a sensitivity of 0.28% in $\Delta N/N$ and 2 m s^{-1} in ion drift velocity. The FFT and magnitude squared operations are performed with 16 bit precision and automatic scaling within 19 bits. Following these operations a representation of the power spectrum will be constructed to be sent to the ground along with 3 bits designating the automatic scaling shifts that were applied to all the points.

A representation of the spectrum will be obtained by using the 80C86 DPU to sum the spectral densities over fixed point ranges. Note that the low frequency end of the spectrum, up to 16 Hz, will overlap directly with that obtainable on the ground from the directly sampled IDM and IT outputs. Thus the point ranges to represent the 512 point power spectrum will be chosen to provide better frequency resolution at high frequencies by sacrificing some resolution at lower frequencies. Figure 1 shows the results of a rather simple algorithm that divides the point ranges into 19 intervals as shown in Table 1.

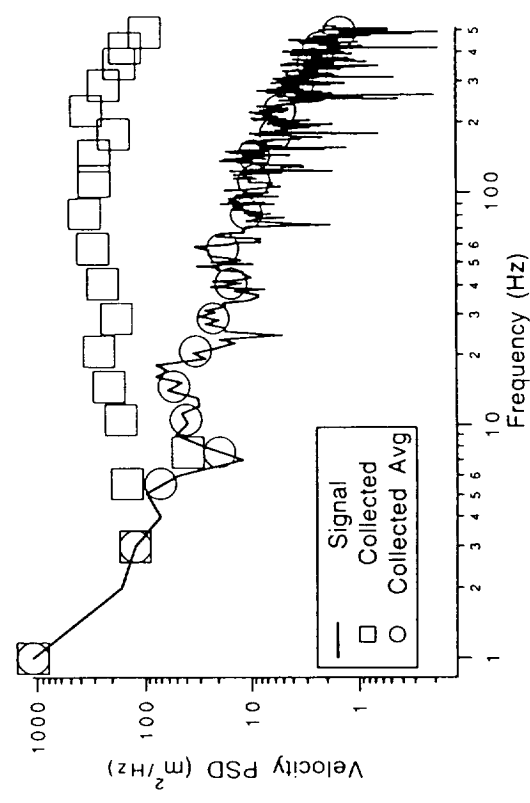


Figure 1. Representation of on-board derived power spectrum and average representation sent to the ground

Bin Number	Start Point	End Point	No of Points
1	1	1	1
2	3	3	1
3	5	6	2
4	7	8	2
5	9	12	4
6	13	16	4
7	17	24	8
8	25	32	8
9	33	48	16
10	49	64	16
11	65	96	32
12	97	128	32
13	129	160	32
14	161	192	32
15	193	256	64
16	257	320	64
17	321	384	64
18	385	448	64
19	449	512	64

Table 1. Bin Ranges for average representation of power spectrum

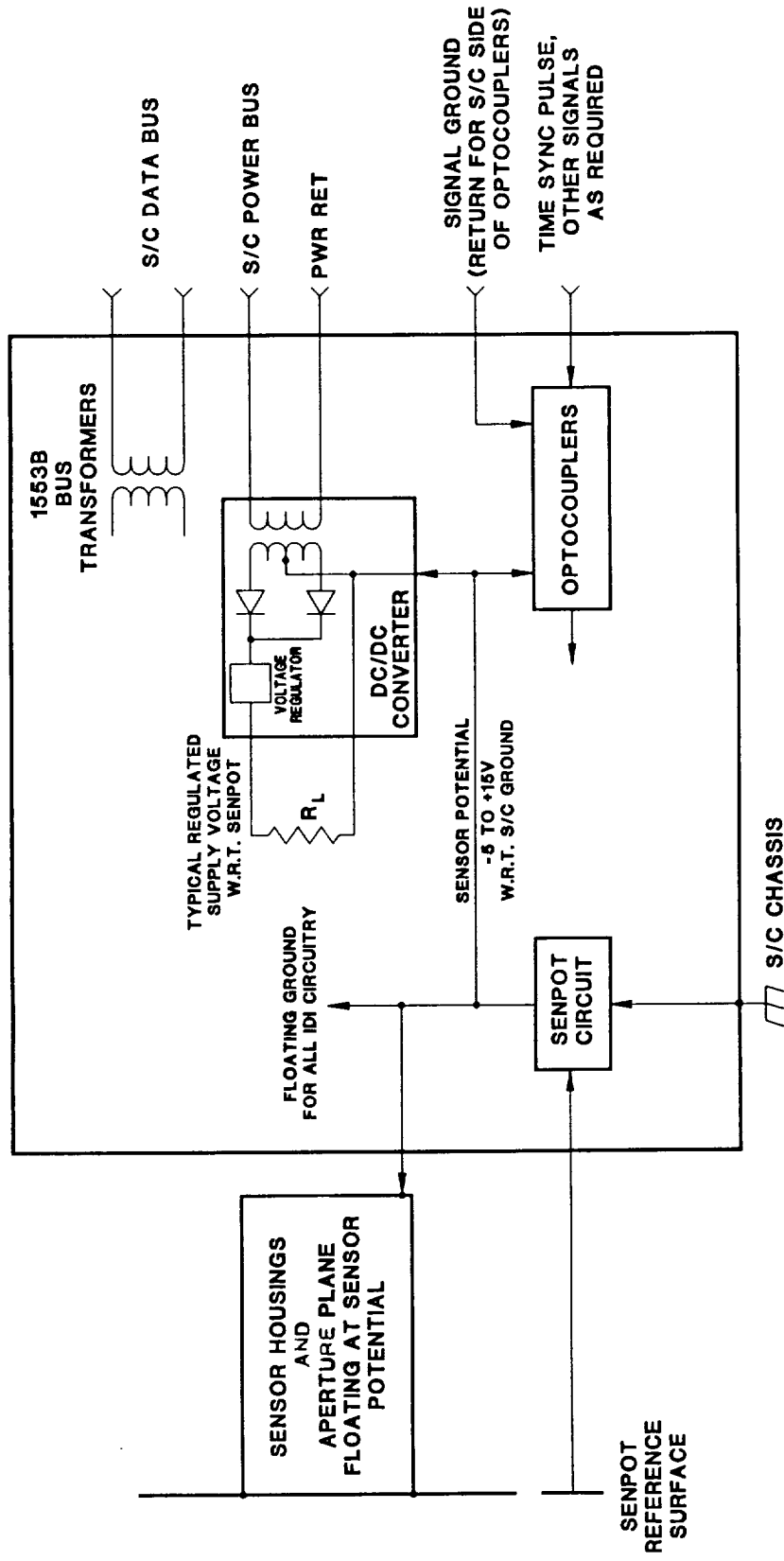
Shown in the figure is a solid trace denoting the signal as it appears after the magnitude squared operation. These data then have the rather simple accumulation shown in the table applied to collect them into 19 bins. The magnitude of the signal in each bin is shown by the open squares. These data are sent to the ground, where from the known bin widths the outputs can be corrected to retrieve an average representation of the spectrum. These corrected outputs are shown by the open circles. It can be seen immediately that plotted on a log-log scale the reduced data set can easily be used to derive the spectral characteristics of the original data set.

The rather sparse data at lower frequencies will be augmented by that obtained from the direct sampling of the VDM, HDM and IT and will also allow an additional normalization to be applied to the spectral output. Presently we anticipate that the data will be taken in 1 second and processed in 1 second. Thus the spectral densities from the three signals will be output once every 2 seconds and will apply to a 1 second (~8 km) section of the ionosphere.

Options to take the 1024 data points in a smaller time period, thus allowing diagnosis at higher frequencies over smaller sections of the ionosphere, or to perform the data acquisition and processing over periods of less than 2 seconds, will be evaluated and implemented if they are consistent with the available resources. Also note that the accumulation algorithm can be changed by changing the start points and bin widths in the table above.

TIMED-IDI

IDI GROUNDING/BIAS DIAGRAM



NOTES:

1. ALL IDI CIRCUITRY IS FLOATING AT THE SENSOR POTENTIAL (SENPOT).
2. DC ISOLATION FROM S/C GROUND IS PROVIDED BY TRANSFORMERS AND OPTOCOUPERS.
3. THE IDI BOX MOUNTING SURFACE AND ALL EXTERIOR SURFACES EXCEPT FOR THE APERTURE PLANE AND CYLINDRICAL SENSOR HOUSINGS ARE AT S/C CHASSIS GROUND.

UTD

8/28/94

DSR-34

SPACECRAFT RESOURCES

(ORIGINAL PROPOSAL)

(7.8 Kg)

MASS - 7.55 kg

(7.5 W)

POWER - 6.5 WATTS

(3360 bps)

TM - 2928 bps + PACKET OVERHEAD

RPA	-	832 bps
IT	-	384 bps
PP	-	384 bps
HDM	-	384 bps
VDM	-	384 bps
FFT	-	480 bps
HK	-	80 bps

PACKET OVERHEAD - TBD

THERMAL CONTROL

OPERATING	-	0°C TO +50°C
NON-OPERATING	-	-20°C TO +60°C

TIMED - IDI

POWER BREAKDOWN

<u>CIRCUIT</u>	<u>POWER (mW)</u>
IDM-V	226
IDM-H	226
IT	74
RPA	204
SHARED CIRCUITS (SENPO, FILTERS, A/D, TEMP SENSORS, ETC.)	649
FFT PROCESSOR	500
DPU & S/C INTERFACE	2308
POWER SUPPLIES	<u>2210</u>
TOTAL	6.5W

MASS BREAKDOWN

<u>ELEMENT</u>	<u>MASS (Kg.)</u>
RPA SENSOR	0.61
ION TRAP SENSOR	0.55
DRIFT SENSOR (H)	0.60
DRIFT SENSOR (V)	0.60
ELECTRONICS	1.23
STRUCTURE	2.38
APERTURE PLANE/PP	0.51
WIRE, CONN & MISC	<u>1.07</u>
TOTAL	7.55 Kg

NO CONTINGENCY IS CARRIED BY UTD IN THE ABOVE ESTIMATE

TIMED - IDI

SPACECRAFT REQUIREMENTS

- **IDI MOST FORWARD MOUNTED INSTRUMENT**
- **SOLAR ARRAY ELECTRICALLY INSULATED FROM AMBIENT PLASMA
SOLAR-CELL INTERCONNECTS INSULATED**
- **MAXIMIZE SPACECRAFT CONDUCTING AREA ON RAM-FACING SURFACE
SPACECRAFT STRUCTURE, THERMAL BLANKET, ETC**
- **MINIMIZE EXPOSED POSITIVE POTENTIAL SURFACES
LESS THAN 1% OF RAM CONDUCTING AREA**
- **KNOWLEDGE OF MAGNETIC FIELD AT SENSOR FACE
MINIMIZE TO ORDER 0.05G (10% EARTH'S FIELD)**
- **INCLINATION $\geq 70^\circ$ REQUIRED FOR ACCESS TO HIGH ALTITUDES**
- **IDI FULLY FUNCTIONAL AT ALTITUDES BELOW 900 km**
- **POSITION ACCURACY: TO ± 1 KM (POSTMISSION)**
- **UNIVERSAL TIME: TO 1 MSEC. (POSTMISSION)**

TIMED - IDI

VEHICLE POTENTIAL

- ELECTRONS CAN BE COLLECTED BY ALL CONDUCTING SURFACES
- IONS CAN BE COLLECTED BY RAM FACING CONDUCTING SURFACE AND OTHER SURFACES WITH LARGE NEGATIVE POTENTIAL
- NET CURRENT TO S/C WILL BE ZERO
- WITH NO POTENTIALS EXPOSED TO THE PLASMA, S/C WILL ASSUME A SMALL NEGATIVE POTENTIAL WRT PLASMA
- EXPOSED NEGATIVE POTENTIALS HAVE RELATIVELY SMALL EFFECT BECAUSE IONS ARE “STIFF” AND HAVE LOW MOBILITY
- EXPOSED POSITIVE POTENTIALS HAVE LITTLE EFFECT ON THE S/C POTENTIAL PROVIDED THAT:

$$A_i \geq 100 A_p$$

WHERE:

A_p IS AREA OF POSITIVE POTENTIAL

A_i IS RAM FACING CONDUCTING AREA

- IF THIS CONDITION IS NOT SATISFIED THEN THE S/C WILL MOVE NEGATIVE WRT PLASMA TO RETARD ELECTRONS

TIMED - IDI

S/C POINTING AND ATTITUDE

- S/C RAM AXIS IN ORBIT PLANE
- S/C AXIS PERPENDICULAR TO RAM IN ORBIT PLANE AND ALONG RADIUS VECTOR
- JITTER - 0.25°, FOR FREQUENCY GREATER THAN 1HZ
- STABILITY - LESS THAN 0.25°/MIN OVER PERIODS OF GREATER THAN 30 MINS
- DESIRABLE ATTITUDE KNOWLEDGE (POST-FLIGHT):
 - INERTIAL ATTITUDE OF S/C AXES KNOWN TO WITHIN 0.03°

TIMED - IDI

MOUNTING AND FOV

- THE IDI SENSOR APERTURES FACE ALONG AND ARE ALIGNED WITH THE S/C VELOCITY VECTOR
- A FIRST SURFACE MIRROR (APPROX. 2.5 CM DIA.) IS TEMPORARILY ATTACHED TO THE PRIMARY DRIFT SENSOR TO MEASURE IDI ALIGNMENT IN PITCH AND YAW AXES
- ROLL AXIS ALIGNMENT IS CONTROLLED BY THE INSTRUMENT/SPACECRAFT MOUNTING SURFACE AND IS NOT MEASURED ON THE S/C
- PLACEMENT - WITHIN 0.5° OF S/C RAM AXIS
- KNOWLEDGE - 0.1°
- IDI MOUNTS TO A FLAT S/C SURFACE WITH SIX M5 BOLTS
- THE INSTRUMENT APERTURE PLANE OVERHANGS (INTERSECTS WITH) THE MOUNTING PLANE (SEE INSTRUMENT OUTLINE)
- IDI SHOULD BE THE MOST FORWARD MOUNTED INSTRUMENT AND SHOULD HAVE AN UNOBSTRUCTED CONICAL FOV OF 45° HALF ANGLE CENTERED AROUND THE VELOCITY VECTOR AND ORIGINATING AT THE EDGE OF THE INSTRUMENT APERTURE PLANE

- RAYTHEON TMC2310 FFT PROCESSOR
 - NO UTD FLIGHT HISTORY
 - MIL-STD-883 VERSION AVAILABLE
 - RAD/TESTING OF ANOTHER PART USING SAME MANUFACTURING PROCESS SHOWS TOTAL DOSE >50 KRADS
 - DSP IMPLEMENTATION FOR FALLBACK OPTION
- ACTEL FIELD PROGRAMMABLE GATE ARRAY (FPGA)
 - NO UTD FLIGHT HISTORY
 - MIL-STD-883 AND DESC SMD VERSIONS AVAILABLE
 - EVIDENCE OF ACCEPTABLE TOTAL DOSE TOLERANCE
 - EXTENSIVE RELIABILITY TESTING PERFORMED
 - CD4000 SERIES CMOS FOR FALLBACK OPTION
- UTD CONSENSUS
 - LOW RISK

- INSTRUMENT DESIGN/FABRICATION/TEST AT UTD
 - PRIMARILY UTILIZING IN-HOUSE FACILITIES
 - EXPERIENCED SPACE SCIENCE TEAM
 - NO MAJOR SUBCONTRACTORS
- SOME MECHANICAL FABRICATION PERFORMED BY OUTSIDE MACHINE SHOPS
 - QA BY UTD
- FULL INSTITUTIONAL SUPPORT AS INDICATED BY PAST SUCCESSFUL MISSIONS
- PERSONNEL RESOURCES CAN BE SUPPLEMENTED BY LOCAL AEROSPACE INDUSTRY
- ALL MAJOR REQUIRED FACILITIES/EQUIPMENT IN PLACE
- NO MAJOR NEW TECHNOLOGY ITEMS/DEVELOPMENT HARDWARE
- ENVIRONMENTAL TESTING AT APL OR GSFC

TIMED - IDI

FACILITIES AND EQUIPMENT

- **CAD/CAM DRAFTING AND MACHINE SHOP**
- **PCB FABRICATION AND ASSEMBLY AREAS**
- **CONTROLLED ACCESS ASSEMBLY AND TEST AREAS**
- **LAMINAR FLOW BENCHES**
- **OIL FREE VACUUM TEST CHAMBERS**
- **ELECTRONIC TEST AND CHECKOUT EQUIPMENT**
- **CUSTOM DESIGNED ION/ELECTRON SOURCES FOR SENSOR TEST**
- **COMPUTATIONAL FACILITIES**
 - **DEDICATED VAX CLUSTER**
 - **LOCAL CONVEX SUPERCOMPUTERS**
 - **REGIONAL CRAY X/MP SUPERCOMPUTER**

TIMED - IDI

RELIABILITY AND QUALITY ASSURANCE

- IDI BUDGET BASED ON INFORMALLY-DOCUMENTED ANALYSES (WHERE REQUIRED)
- UTD PLAN USED ON PREVIOUS SUCCESSFUL NASA AND DOD PROGRAMS
- PLAN OVERVIEW
 - MANAGEMENT
 - DRAWING/SPECIFICATION CONTROL
 - IDENTIFICATION AND TRACEABILITY
 - CONFIGURATION MANAGEMENT
 - DOCUMENT CHANGE CONTROL
 - CLASS D DOCUMENTATION
 - PROCUREMENT REQUIREMENTS
 - PROCUREMENT REQUIREMENTS CONTROL
 - NONCONFORMANCE CONTROL
 - ALERT INFORMATION
 - AUDITS/REVIEWS
 - FABRICATION/WORKMANSHIP CONTROL
 - INSPECTIONS AND TESTS
 - EEE PARTS CONTROL
 - TRAINING/CERTIFICATION
 - SELECTION
 - NSPAR'S
 - CLASS C PARTS
 - PCB
 - PARTS LIST
 - MATERIALS AND PROCESSES CONTROL
 - MATERIALS LISTS
 - MRB

TIMED - IDI

EEE PARTS

- PARTS BUDGET BASED ON GSFC-409-402, PAR FOR THE TIMED INSTRUMENTS, JUNE 11, 1993, CLASS C
- HIGHEST GRADE PART AVAILABLE CONSISTENT WITH BUDGET AND DELIVERY WILL BE USED (MIN BUY QTY, ETC.)
- PARTS FROM A QPL OR QML MANUFACTURER COMPLIANT TO MIL-STD-883C, STANDARD MILITARY DRAWING, OR THE SUPPLIER'S IN-HOUSE HI-REL PROCESSING FLOW ARE ACCEPTABLE
 - EXAMPLES:

CD4XXXBKMSR	HARRIS IN-HOUSE RAD-HARD CLASS S EQUIVALENT CMOS
MP7545 UD/883	MIL-STD-883 LEVEL B COMPLIANT
2N4117A-2	INTERFET JFET WITH OPTION 2 PROCESS FLOW (JANTXV EQUIVALENT)
- NO ROUTINE DPA, QCI, OR ADDITIONAL SCREENING

TIMED - IDI

ENVIRONMENTAL TESTING (T&E)

- UTD PREFERS T & E AT APL OR GSFC
- SUPPORTED BY UTD PERSONNEL AND GSE
- POSSIBLE TESTS
 - MASS PROPERTIES
 - VIBRATION
 - EMI/EMC
 - MAGNETIC MEASUREMENTS
 - THERMAL/VACUUM
 - ACOUSTICS (TEST MODEL ONLY)

TIMED - IDI

INSTRUMENT CALIBRATION

- **GROUND**
 - **ELECTROMETER AND SWEEP VOLTAGE CALIBRATIONS TRACEABLE TO NBS**
- **ON-ORBIT**
 - **IDI HAS NO REQUIREMENTS FOR SPACECRAFT MANEUVERS**
 - **IN HIGH INCLINATION IONOSPHERIC COROTATION PROVIDES KNOWN VARIATION IN ION ARRIVAL ANGLE AROUND THE SATELLITE ORBIT OF ABOUT 7 DEGREES IN HALF AN ORBIT**
 - **CONTROLLED ROTATION OF SPACECRAFT ABOUT "PITCH" OR "YAW" AXIS WOULD PROVIDE ADDITIONAL CALIBRATION SIGNAL**
 - **ROTATION RATES OF 6 DEGREES PER SECOND (1 rpm) OR SLOWER ARE USEFUL**

TIMED - IDI

IDI GSE

BCE - BENCH CHECKOUT UNIT

- EMULATES ALL S/C ELECTRICAL INTERFACES TO IDI
- CONNECTS TO PC/AT COMPUTER FOR DATA ANALYSIS/DISPLAY/BENCH TEST

SU - STIMULATION UNIT

- SMALL, BATTERY-POWERED, SENSOR STIMULATION

STE - SPECIAL TEST EQUIPMENT

- PC/AT COMPUTER WITH COMMAND/DATA INTERFACE TO S/C GSE
- SOFTWARE FOR RETRIEVING IDI DATA PACKETS, AUTOMATED TESTS, DATA ANALYSIS/DISPLAY

TIMED - IDI

GSE SOFTWARE

- MENU-DRIVEN INSTRUMENT COMMANDS/TEST SETUP
- INSTRUMENT DATA RETRIEVAL/STORAGE
- CRT AND HARD COPY FORMATTED DATA DISPLAY
- PATTERNED AFTER EXISTING DMSP GSE SOFTWARE (CODED IN "C")

TIMED - IDI

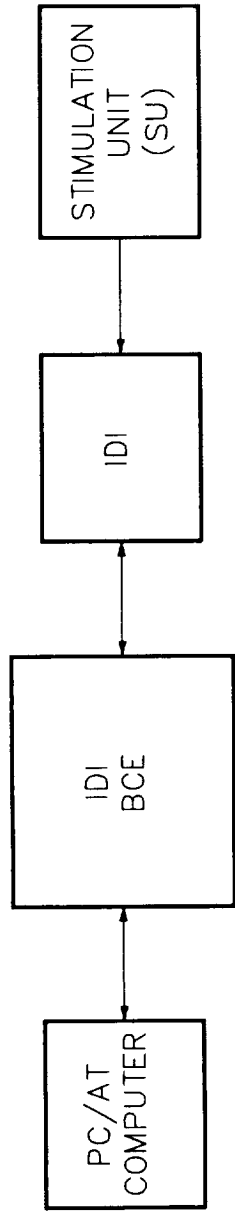
IDI STIMULUS

The IDI Stimulation unit (SU) is a small, battery-powered unit that is used to inject test currents into the sensors via test probes that screw into the sensor face. The SU case will be grounded if it is remotely located (within 3 or 4 feet of the sensor aperture plane) or connected to aperture potential (SENPOT) if the SU is attached to the sensor face. A 9-pin Cannon-D connector, accessible from in front of the aperture plane, will be used to provide buffered synchronization signals to the SU. No other connections to the SU are required.

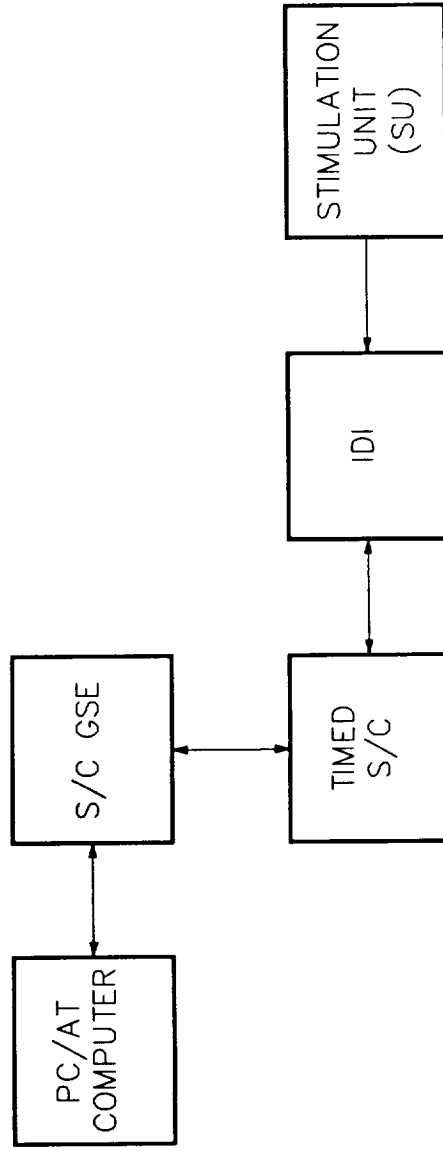
The SU will be used only during a few designated tests after S/C integration; e.g., at initial integration, after S/C environmental testing, etc. It will not be used during S/C thermal vacuum tests. Functional and aliveness tests without stimulation will be used at other times.

TIMED-IDI

IDI TEST CONFIGURATIONS



IDI BENCH TEST CONFIGURATION



IDI TEST CONFIGURATION
AFTER S/C INTEGRATION

TIMED - IDI

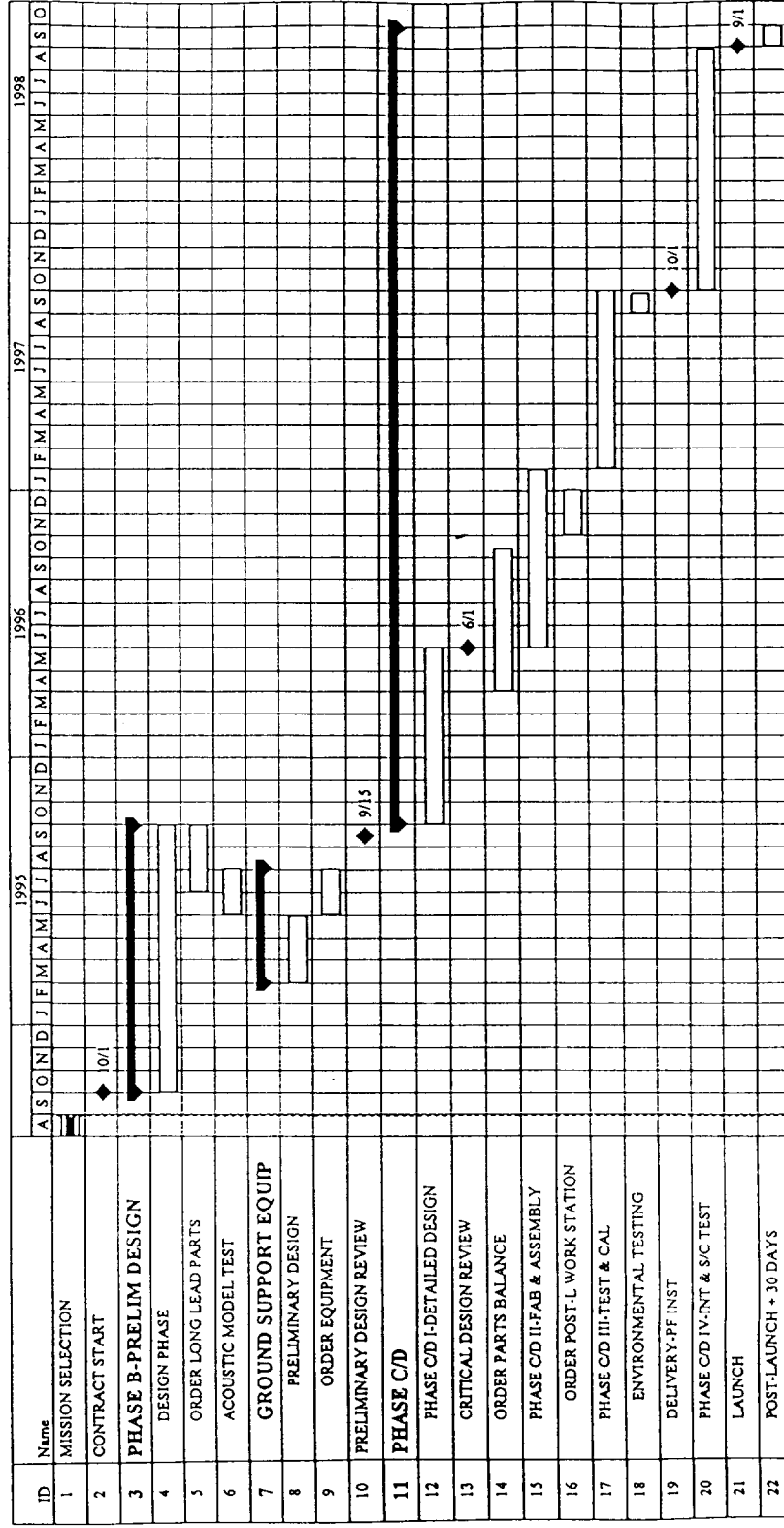
DATA CENTER INTERACTIONS

- DATA CENTER PROVIDES
 - TIME ORDERED DATA PACKETS
 - TIME TAGGED ORBIT/ATTITUDE DATA
- INVESTIGATOR SUPPLIES
 - LEVEL 0 SOFTWARE
IDI TELEMETRY PACKETS
 - LEVEL 1 SOFTWARE
ELECTROMETER OUTPUTS CORRECTED FOR SENSITIVITY
 - LEVEL 2
GEOPHYSICAL DATA
 - LEVEL 3
GLOBAL BIN AVERAGES
 - LEVEL 4
DERIVED HIGH LATITUDE CONVECTION PATTERN
- QUALITY FLAGS ON LEVEL 2 DATA AND ABOVE
- INTERACTIVE INTERFACE TO DATA CATALOGS FOR LEVEL 2 AND ABOVE
- DATA ACCESS FROM CD ROMS AND HARD DISK

TIMED - IDI

UTD PHASE C/D SCHEDULE

TIMED UTD/IDI SCHEDULE



TIMED - IDI

PHASE B/C/D BUDGET
-\$K -

• ORIGINAL PROPOSAL	
FIRST UNIT	- 2,414
SECOND UNIT	- 610
CONTINGENCY	- 0

TOTAL	3,024 (FY92\$)

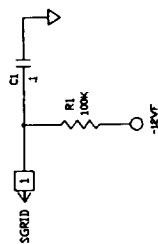
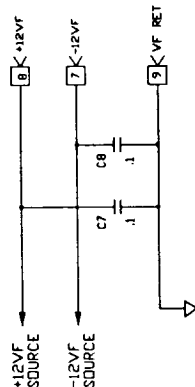
• CURRENT PLAN					
IDI	FY95	FY96	FY97	FY98	TOTAL
- 1 P/F UNIT	626	648	630	170	2,074
- FY 94\$					
- REPLACE RPMA WITH RPA/PP					
- 3 YEAR C/D					
- CLASS D DOCUMENTATION					
- NO CONTINGENCY					

SCHEMATICS

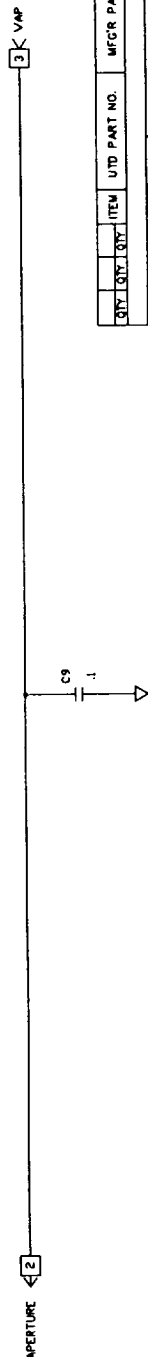
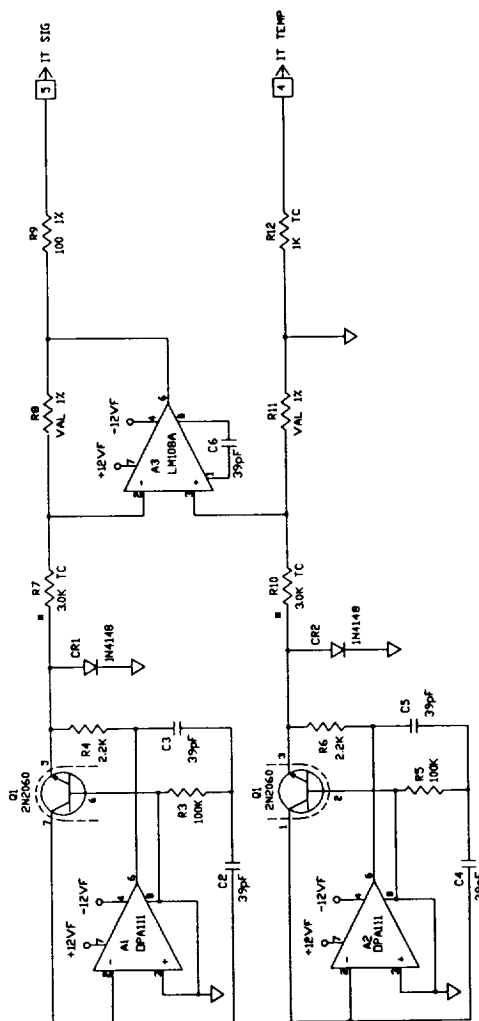
1. HDM ELECTROMETER
2. HDM AMPLIFIER
3. ION TRAP LOG ELECTROMETER
4. TIMED PP ELECTROMETER
5. TIMED RPA ELECTROMETER
6. TIMED SENPOT CIRCUIT
7. DIGITAL/ANALOG BOARD
8. TIMED DATA SEL A/D
9. OUTPUT DATA BOARD
10. TIMED TIME CODE MUX
11. TIMED RPA AMPLIFIER
12. TIMED PPE AMPLIFIER
13. LOW PASS FILTERS
14. HOUSEKEEPING DATA SELECT
15. DIGITAL DECODE BOARD
16. VDM ELECTROMETER
17. VDM AMPLIFIER
18. IDI POWER SUPPLIES
19. FFT BOARD
20. MPU BOARD
21. 1553B CIRCUIT

REVISIONS

REV	DESCRIPTION	DATE	APPROVED



COLLECTOR
PLATE
INPUT



FILE IT-1S

QTY	QTY	ITEM	UTD PART NO.	MFGR PART NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT

QTY	QTY	ITEM	UTD PART NO.	MFGR PART NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT

QTY	QTY	ITEM	UTD PART NO.	MFGR PART NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT

QTY	QTY	ITEM	UTD PART NO.	MFGR PART NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT

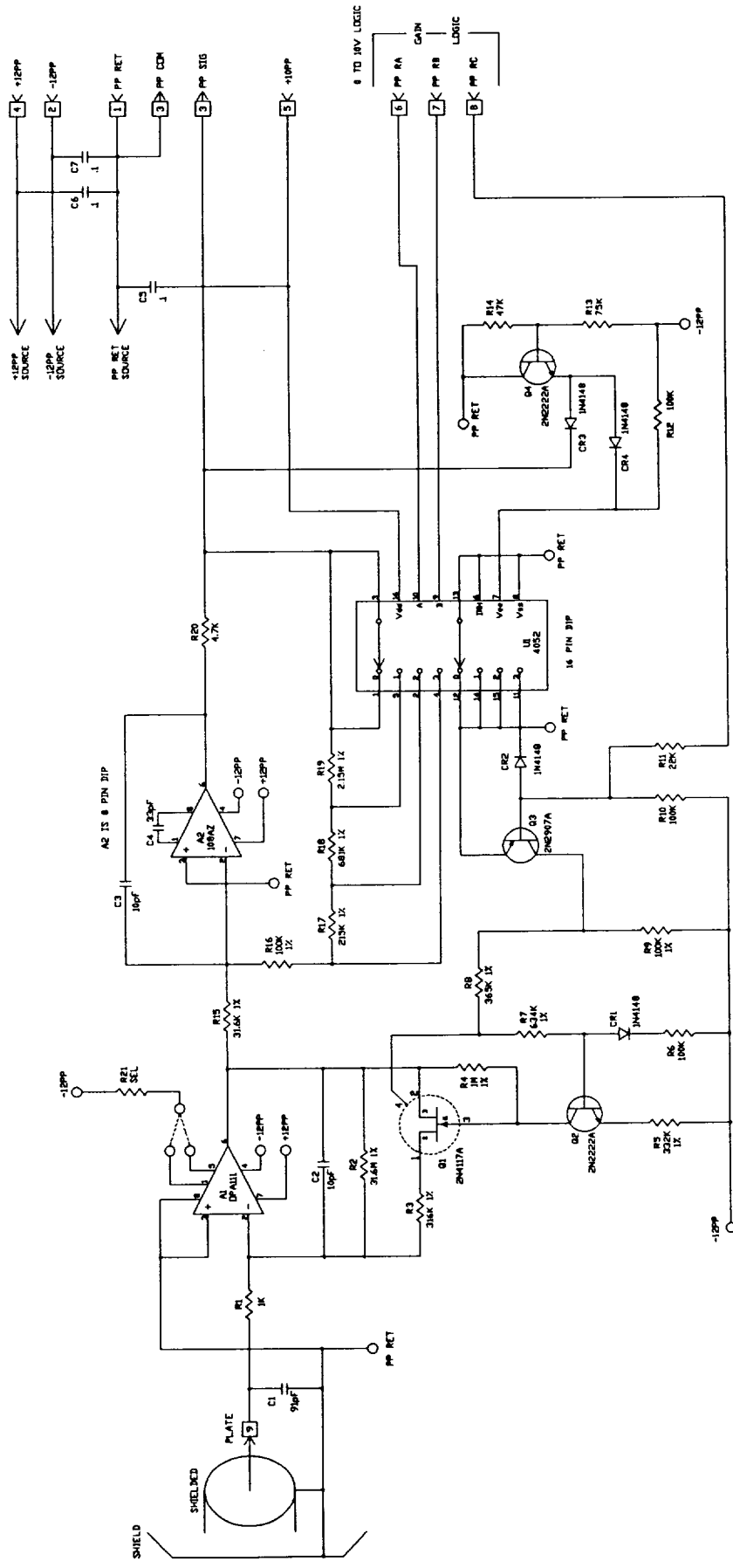
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QTY	QTY	ITEM	UTD PART NO.	MFGR PART NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT

NOTES:
1. = DENOTES TEMPERATURE COMPENSATION RESISTOR
2. MATCH R11 AND R15 TO WITHIN ONE OHM IF POSSIBLE

THE UNIVERSITY OF TEXAS AT DALLAS
2801 N. FLOYD RD. RICHARDSON, TEXAS 75080
SCHEMATIC
ION TRAP LOG ELECTROMETER
CATIMEDIT-1S
SIZE CODE IDENT DWG NO.
C 14014
SCALE
SHEET 1 OF 1

REVISIONS		
REV	DESCRIPTION	DATE
A	GENERAL REVISION FROM EM	04/28/93
		APPROVED
		DRZ



GAIN LOGIC		
C	B	A
0	0	0
0	0	1
0	1	0
0	1	1
1	0	0
1	0	1
1	1	0
1	1	1

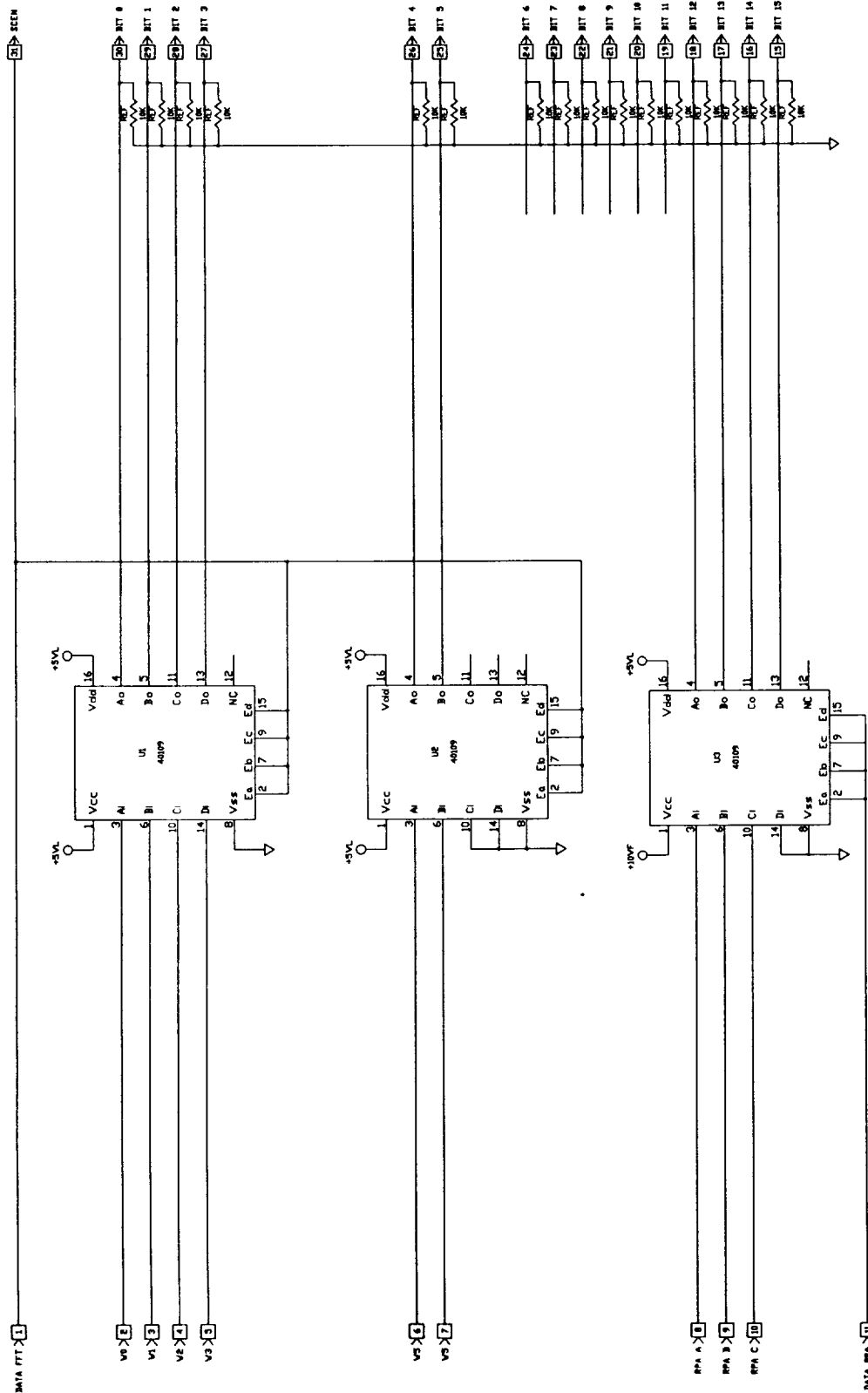
FILE: PPES

QTY	QTY	ITEM	UTD PART NO.	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT
PARTS LIST						
UNLESS OTHERWISE NOTED:						
ALL DIMENSIONS ARE IN INCHES						
DIMENSIONS ARE UNLESS OTHERWISE SPECIFIED						
MACHINE FINISH						
DECIMALS: .XX = 0.010						
REMOVE ALL BURRS & SHARP EDGES						
TYPED ANGLE PRODUCTION						
MATERIAL						
FINISH						
QTY NEXT ASSY QTY USED ON APPLICATION						

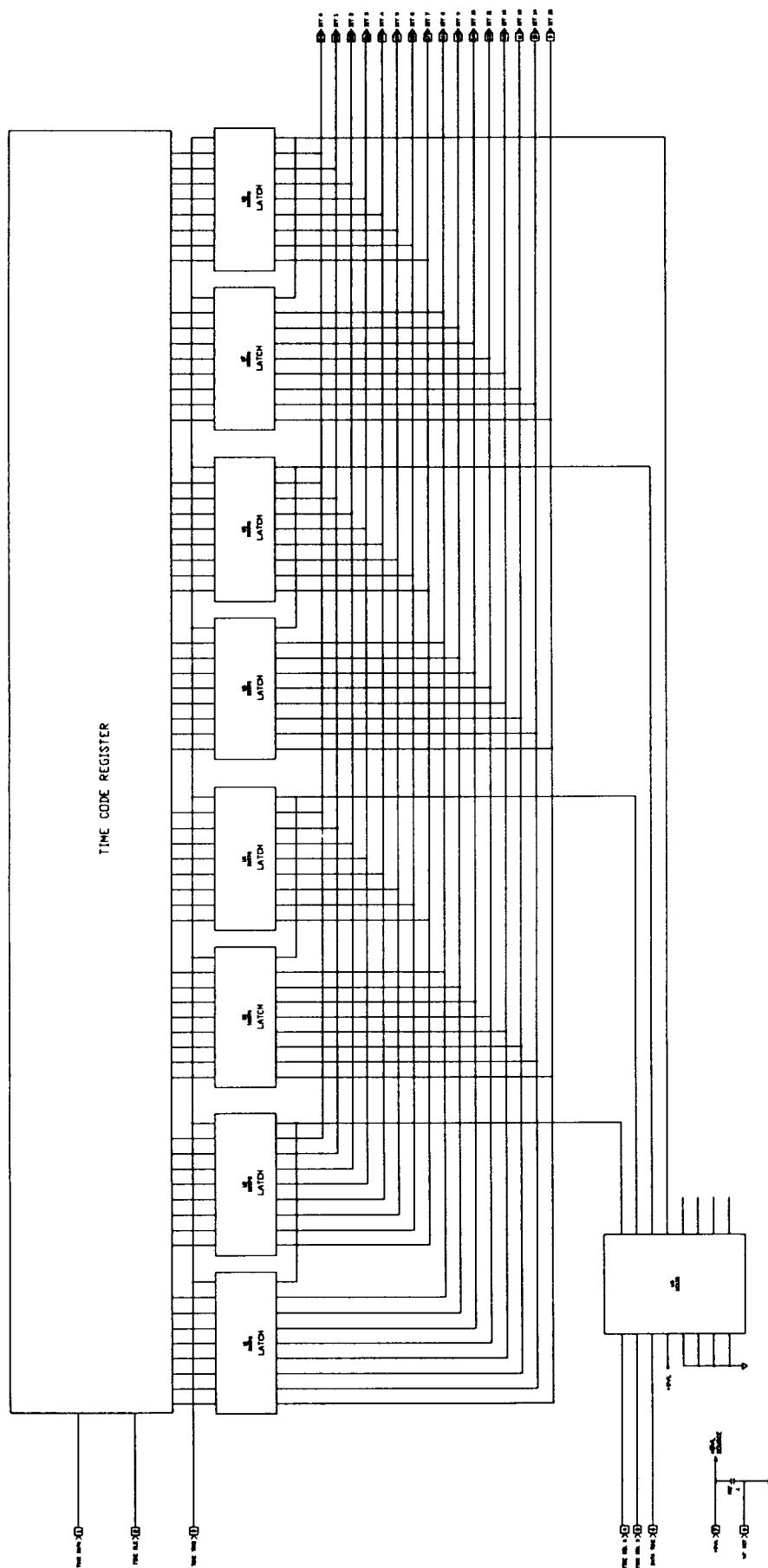
QTY	QTY	ITEM	UTD PART NO.	MFG PART NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT
PARTS LIST						
UNLESS OTHERWISE NOTED:						
ALL DIMENSIONS ARE IN INCHES						
DIMENSIONS ARE UNLESS OTHERWISE SPECIFIED						
MACHINE FINISH						
DECIMALS: .XX = 0.010						
REMOVE ALL BURRS & SHARP EDGES						
TYPED ANGLE PRODUCTION						
MATERIAL						
FINISH						
QTY NEXT ASSY QTY USED ON APPLICATION						

THE UNIVERSITY OF TEXAS AT DALLAS
2601 N. FLOYD RD. RICHARDSON, TEXAS 75080

SCHEMATIC
TIMED PP ELECTROMETER
C14614
SCALE
SHEET 1 OF 1



QTY	QTY	QTY	ITEM	UTD PART NO.	WFCR PART NO.	PARTS LIST	NOMENCLATURE OR DESCRIPTION	CODE IDENT	
							THE UNIVERSITY OF TEXAS AT DALLAS 2601 N. FLOYD RD. RICHARDSON, TEXAS 75080 SCHEMATIC OUTPUT DATA BOARD TIMED		
JUSTICE SYSTEMS WORKS ALL DIMENSIONS ARE IN INCHES ALL DIMENSIONS & TOLERANCES PER MILS ANGLES ± 1/2° FINISHES: DECIMALS - .001 XX - .02 XXXX - .05 REMOVAL BURN & SMOOTH ROUGH MATERIAL PROCESSING MATERIAL FINISH									
AUTHENTICATION									
NAME DATE									
DRN RL BICKEL 02/02/94									
DSGN RL BICKEL 01/27/94									
APP									
APP									
APP							SIZE CODE IDENT DWG NO.	REV	
APP							C 14614	TIMED	
							SCALE	SHEET 1 OF 1	

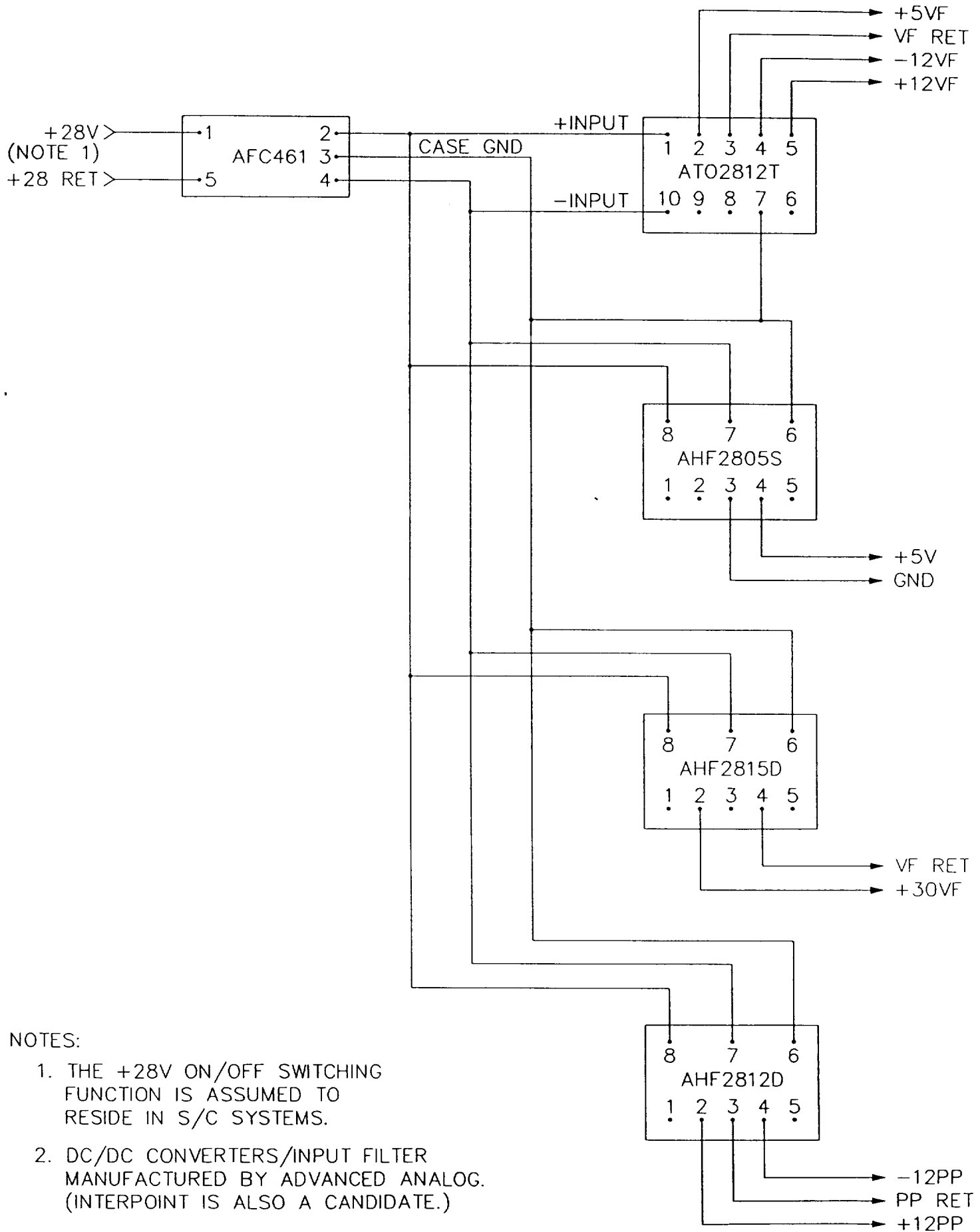


REVISIONS			
REV	DESCRIPTION	DATE	APPROVED

FILE: TEP-17S

QTY	QTY	ITEM	UTD PART NO.	MFGR PART NO.	PARTS LIST		NOMENCLATURE OR DESCRIPTION	CODE IDENT
UNLESS OTHERWISE NOTED: ALL DIMENSIONS ARE IN INCHES DIMENSIONS & TOLERANCES FOR HOLES AND TAPS ANGLES $\pm 1/2^\circ$ FRACTIONS IN PARENTHESIS DECIMALS .XX = 0.02 REMOVE ALL BURRS & SHARP EDGES INGRESS PROTECTION 			AUTENTICATION		THE UNIVERSITY OF TEXAS AT DALLAS 2601 N. FLOID RD. RICHARDSON, TEXAS 75080			
			NAME	DATE				
			DRN RL BICKEL	32/02/94				
			DSGN RL BICKEL	32/02/94	SCHEMATIC			
			APP		TIMED TIME CODE MUX			
			APP		TIMED			
			APP		SIZE	CODE IDENT	DWG NO.	REV
			APP		C	14614		
			APP		SCALE	SHEET 1 OF 1		
QTY	NEXT ASSY	QTY	USED ON					
A BOUT 1/4" DIA								

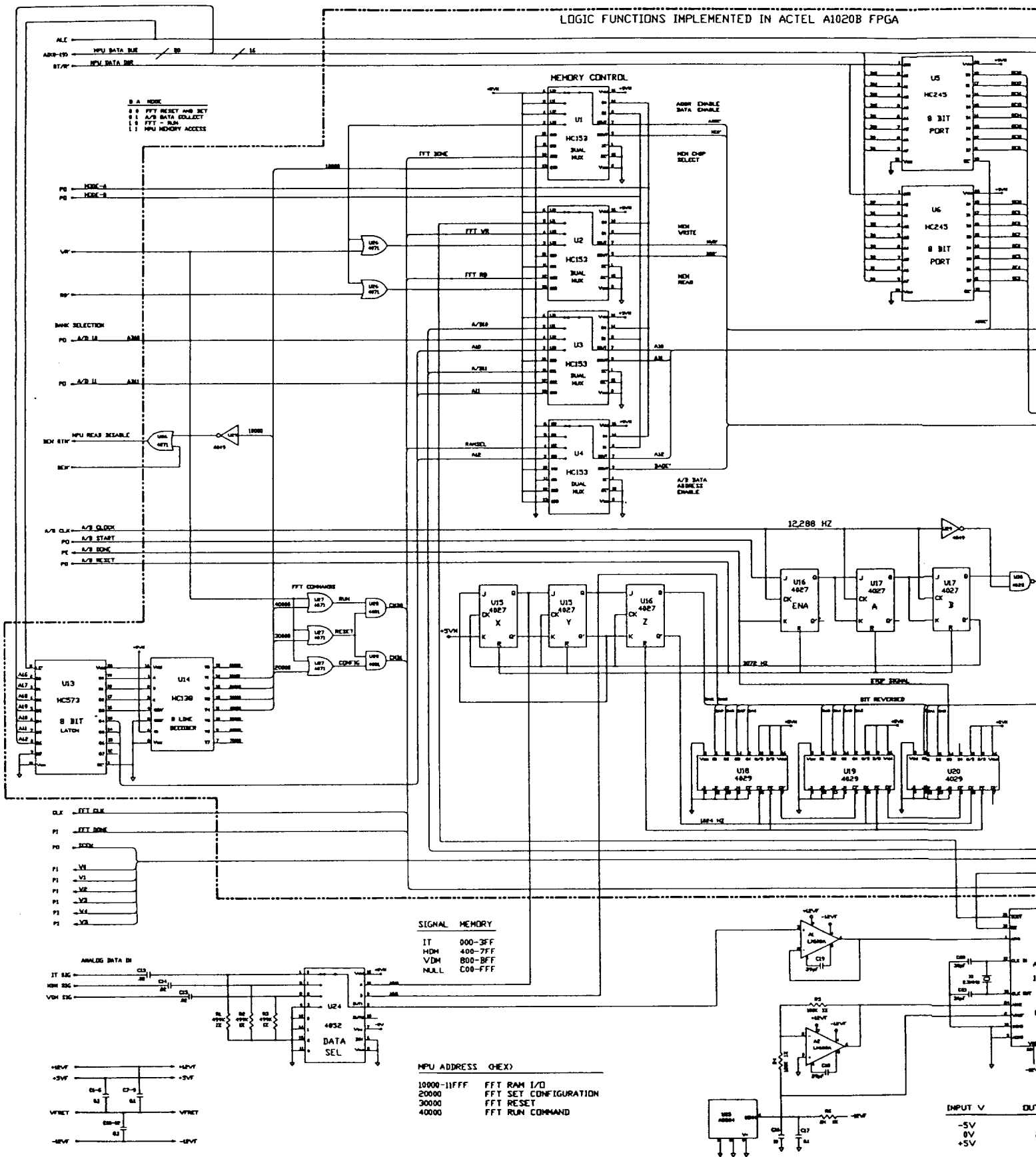
IDI POWER SUPPLIES

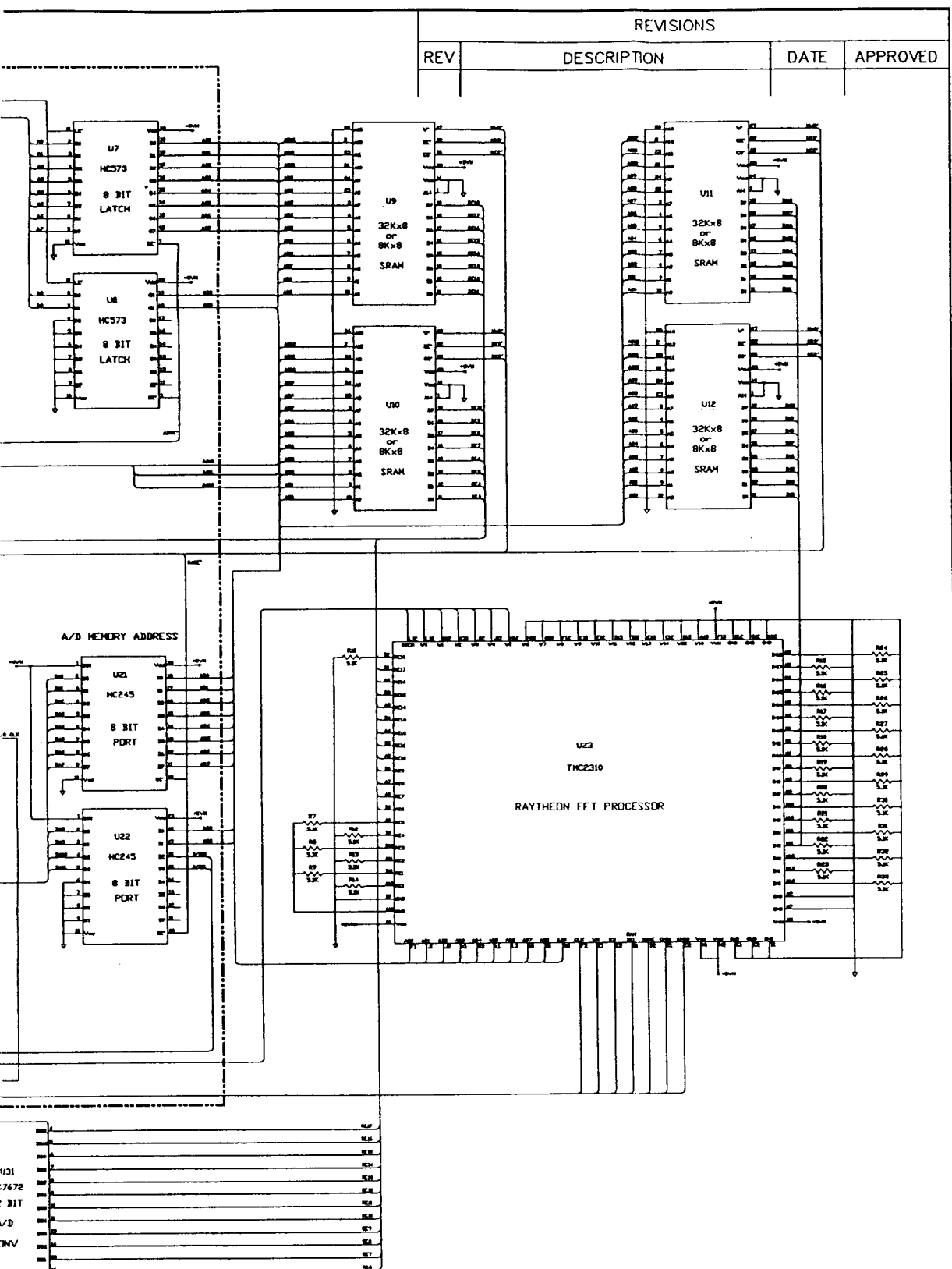


NOTES:

1. THE +28V ON/OFF SWITCHING FUNCTION IS ASSUMED TO RESIDE IN S/C SYSTEMS.
2. DC/DC CONVERTERS/INPUT FILTER MANUFACTURED BY ADVANCED ANALOG. (INTERPOINT IS ALSO A CANDIDATE.)

LOGIC FUNCTIONS IMPLEMENTED IN ACTEL A1020B FPGA

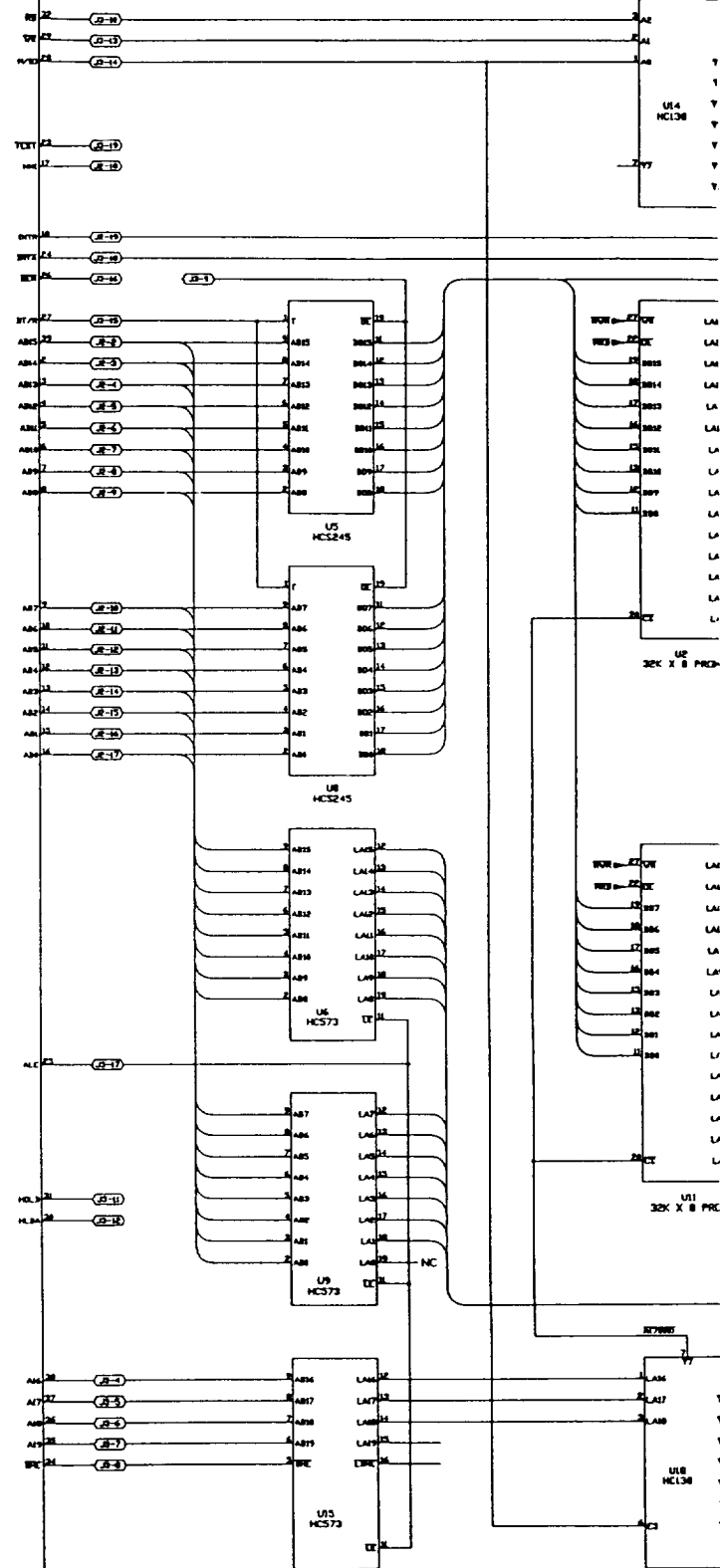
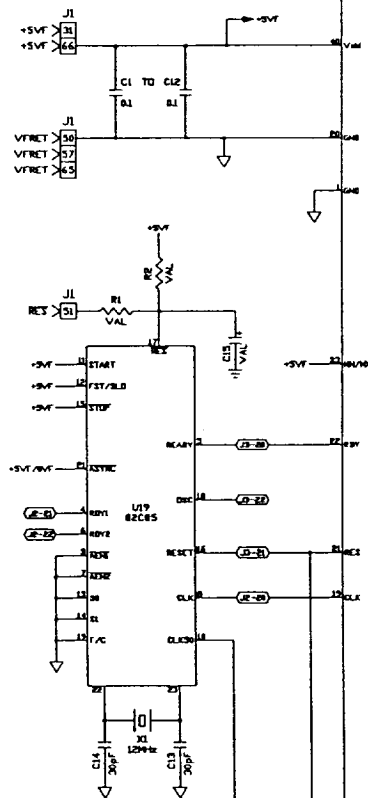




FILE: FFT1S

QTY	QTY	QTY	ITEM	UTD PART NO.	MFG'R PART NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT
PARTS LIST							
UNLESS OTHERWISE NOTED: ALL DIMENSIONS ARE IN INCHES DIMENSIONS & TOLERANCES PER ANSI Y14.5 ANGLES ±1/2° MACHINE FINISH 63 DECIMALS: .XXX = ±.010 .XX = ±.02 REMOVE ALL BURRS & SHARP EDGES THIRD ANGLE PROJECTION				AUTHENTICATION		THE UNIVERSITY OF TEXAS AT DALLAS 2601 N. FLOYD RD. RICHARDSON, TEXAS 75080	
				NAME		DATE	
				DRN RL BICKEL		02/17/94	
				DSGN RL BICKEL		01/07/94	
				APP			
				APP			
MATERIAL				APP		SIZE CODE IDENT DWG NO.	
FINISH				APP		C 14614 137-509	
				SCALE		SHEET 1 OF 1	

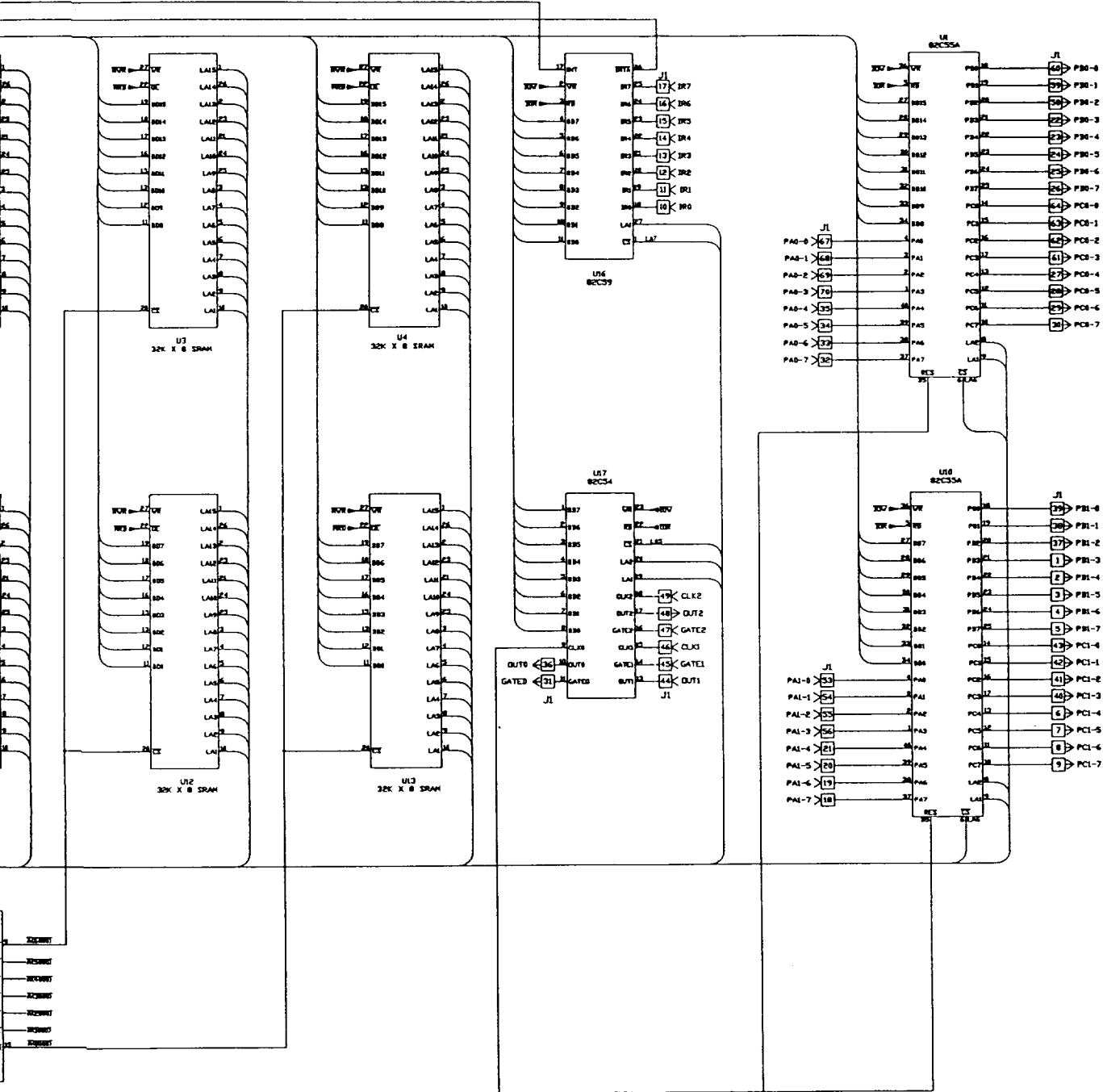
f



NOTES:

1. $XX \triangleright \boxed{XX}$ AND $\boxed{XX} \triangleright XX$ INDICATES J1 CONNECTOR
2. $\boxed{XX-XX}$ INDICATES J2 AND J3 CONNECTORS

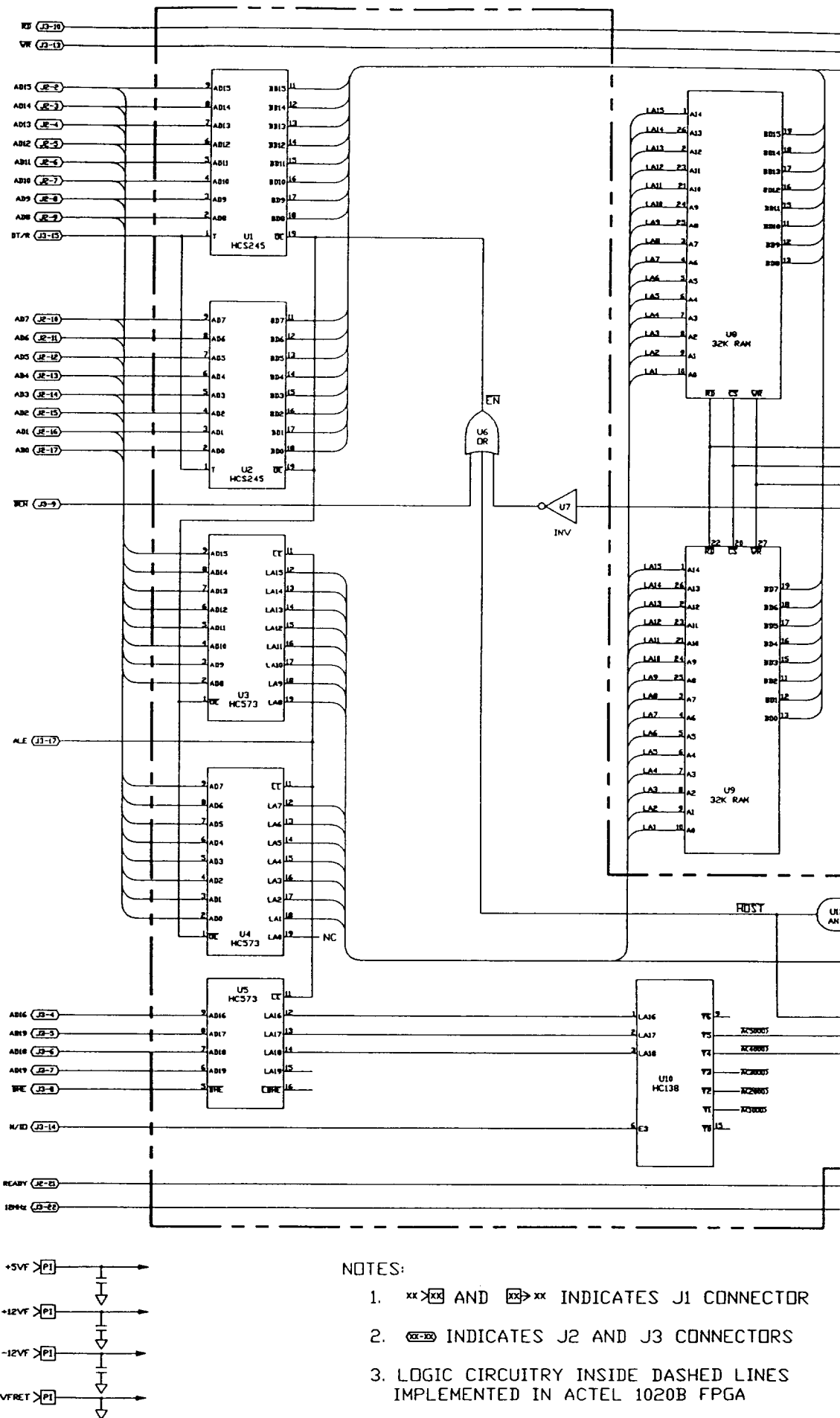
REVISIONS			
REV	DESCRIPTION	DATE	APPROVED

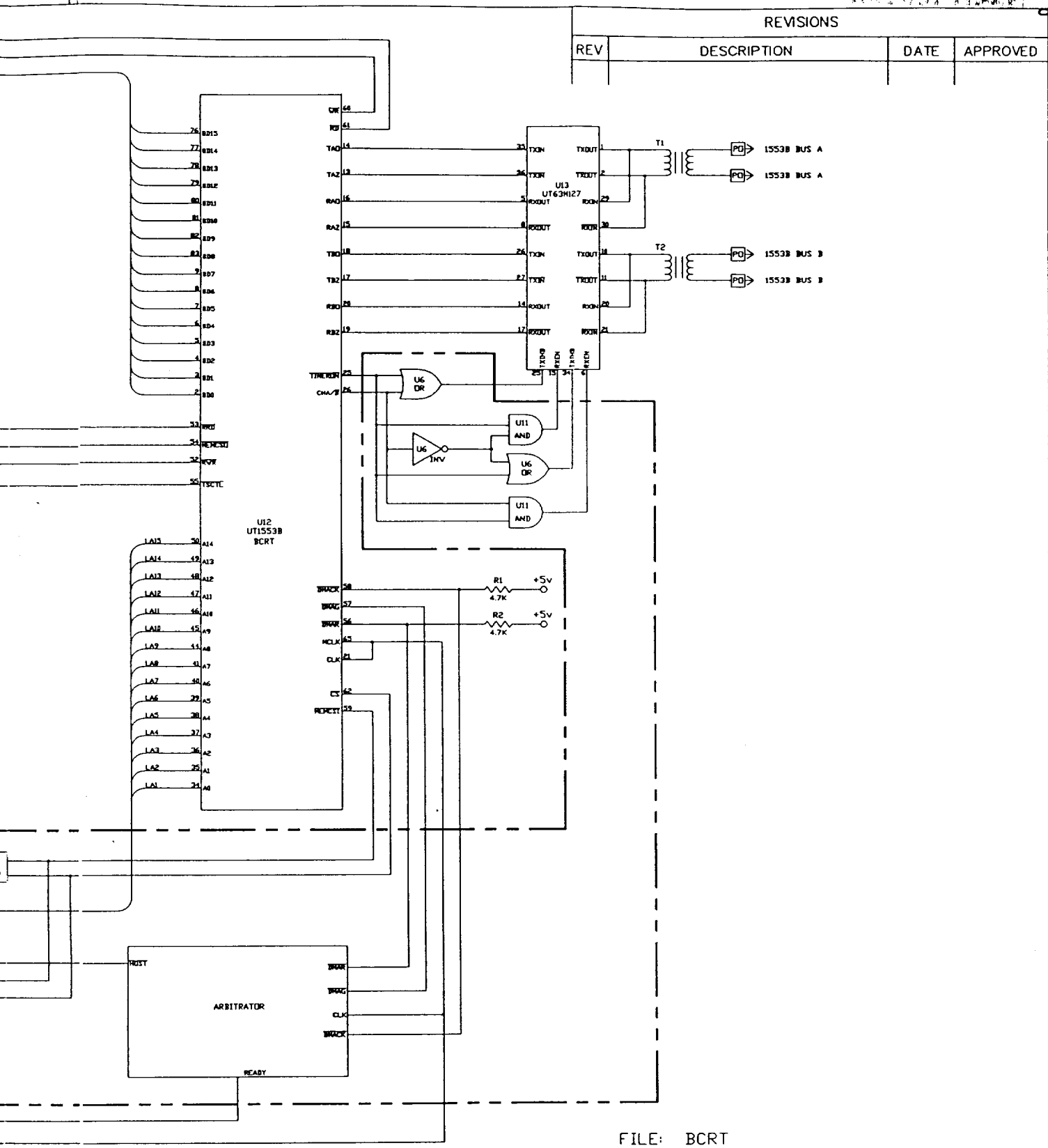


QTY	QTY	QTY	ITEM	UTD PART NO.	MFG'R PART NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT
PARTS LIST							
UNLESS OTHERWISE NOTED: ALL DIMENSIONS ARE IN INCHES DIMENSIONS & TOLERANCES PER ANSI Y14.5 ANGLES $\pm 1/2^\circ$ MACHINE FINISH DECIMALS: .XXX = $\pm .010$.XX = $\pm .02$ REMOVE ALL BURRS & SHARP EDGES THIRD ANGLE PROJECTION				AUTHENTICATION		THE UNIVERSITY OF TEXAS AT DALLAS 2601 N. FLOYD RD. RICHARDSON, TEXAS 75080	
				NAME		DATE	
				DRN J C BROWN		3-31-94	
				DSGN D. ZUCCARO		3-31-94	
				APP			
				APP			
				APP			
				APP			
MATERIAL *****				SIZE		CODE IDENT	DWG NO.
FINISH *****				C		14614	137-505
				SCALE			SHEET 1 OF 1

QTY	NEXT ASSY	QTY	USED ON

APPLICATION





FILE: BCRT

QTY			ITEM	UTD PART NO.	MFG'R PART NO.	NOMENCLATURE OR DESCRIPTION			CODE IDENT	
PARTS LIST										
UNLESS OTHERWISE NOTED: ALL DIMENSIONS ARE IN INCHES DIMENSIONS & TOLERANCES PER ANSI Y14.5 ANGLES ±1/2° MACHINE FINISH DECIMALS: .XXX = ±.010 .XX = ±.02 REMOVE ALL BURRS & SHARP EDGES THIRD ANGLE PROJECTION 				AUTHENTICATION		THE UNIVERSITY OF TEXAS AT DALLAS 2601 N. FLOYD RD. RICHARDSON, TEXAS 75080				
				NAME						DATE
				DRN SUDHIR W.		08-11-94	SCHEMATIC 1553B CIRCUIT (TIMED)			
				DSGN SUDHIR W.		08-11-94				
				APP						
				APP						
				APP						
MATERIAL				PCB		SIZE		CODE IDENT	DWG NO.	REV
*****						C		14614	137-513	*
FINISH						SCALE		SHEET 1 OF 1		

QTY	NEX	ASSY	QTY	USED ON
APPLICATION				