AD-A175 439 CONTROL ELECTRONICS FOR AN ION MASS FILTER IN THE LOWER IONOSPHERE PAYLOA..(U) NORTHEASTERN UNIV BOSTON MASS ELECTRONICS RESEARCH LAB R SUKYS ET AL. 30 SEP 85 1/1

UNCLASSIFIED AFGL-TR-86-0170 F19628-81-C-0162 F/G 14/2 NL

END
DATE
FILMED
2-87

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

AD-A175 439

AFGL-TR-86-0170

CONTROL ELECTRONICS FOR AN ION MASS FILTER IN THE LOWER IONOSPHERE PAYLOAD DEVELOPMENT PROGRAM

by

Raimundas Sukys
J. Spencer Rochefort

NORTHEASTERN UNIVERSITY
360 Huntington Avenue
Boston, Massachusetts 02115

30 September 1985

FINAL REPORT
15 September 1981 - 30 September 1985

Approved for public release: distribution unlimited.

Prepared for

AIR FORCE GEOPHYSICS LABORATORY
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
HANSCOM AFB, MASSACHUSETTS 01731

"This technical report has been reviewed and is approved for publication."

(Signature)
Alan Bailey
Contract Manager

(Signature)
John Rasmussen
Branch Chief

FOR THE COMMANDER

(Signature)
Robert Skrivanek
Division Director

This report has been reviewed by the ESD Public Affairs Office (PA) and is releasable to the National Technical Information Service (NTIS).

Qualified requestors may obtain additional copies from the Defense Technical Information Center. All others should apply to the National Technical Information Service.

If your address has changed, or if you wish to be removed from the mailing list, or if the addressee is no longer employed by your organization, please notify AFGL/DAA, Hanscom AFB, MA 01731. This will assist us in maintaining a current mailing list.

Do not return copies of this report unless contractural obligations or notices on a specific document requires that it be returned.

DISCLAIMER NOTICE

THIS DOCUMENT IS BEST QUALITY PRACTICABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION: Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT: Approved for public release; distribution unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S): AFGL-TR-86-0170
6a. NAME OF PERFORMING ORGANIZATION: Northeastern University Electronics Research Lab. — 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION: Air Force Geophysics Laboratory
6c. ADDRESS (City, State and ZIP Code): 360 Huntington Avenue, Boston, MA 02115	7b. ADDRESS (City, State and ZIP Code): Hanscom Air Force Base, Bedford, MA 01731
8a. NAME OF FUNDING/SPONSORING ORGANIZATION: Air Force Geophysics Lab. — 8b. OFFICE SYMBOL (If applicable): LI	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER: F19628-81-C-0162
8c. ADDRESS (City, State and ZIP Code): Hanscom Air Force Base, Bedford, MA 01731	10. SOURCE OF FUNDING NOS.

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT NO.
61102F	2310	G3	AW

11. TITLE (Include Security Classification) Control Electronics for an Ion Mass Filter in the Lower Ionosphere Payload Development Program

12. PERSONAL AUTHOR(S) R. Sukys, J.S. Rochefort

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Yr., Mo., Day)	15. PAGE COUNT
Final Report	FROM 9/15/81 TO 9/30/85	1985 September 30	90

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB. GR.	Ion Mass Spectrometer, Control Circuits.

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

This report describes a control and data transmission system for a switchable negative/positive ion mass filter. The system was developed for small diameter rocket applications. A Superarcus rocket could place the mass spectrometer system in the 40 to 60 km range for measurements.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT: UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS ☐	21. ABSTRACT SECURITY CLASSIFICATION: Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL: Alan D. Bailey	22b. TELEPHONE NUMBER (Include Area Code): 617-377-2525 — 22c. OFFICE SYMBOL: AFGL/LID

DD FORM 1473, 83 APR — EDITION OF 1 JAN 73 IS OBSOLETE

TABLE OF CONTENTS

TABLE OF ILLUSTRATIONS

INTRODUCTION

The contract F19628-81-C-0162 was written for the design, fabrication, modification and testing of prototype research instrument systems for ongoing AFGL measurement programs. Field engineering and technical support during flight systems checks at various field sites and test ranges was also required.

During the life of the contract the emphasis was placed on the design and development of specialized control electronics for ion mass spectrometers. Some work was also done on thermosonde/radiosonde systems for the measurement of the optical atmospheric turbulance. Most of the electronic systems were developed to control airborne instruments. Although a few subsystems were fabricated to control instruments flown on satellites and the shuttle, balloon and sounding rocket applications predominated.

A typical control system for a mass filter included a microprocessor or a microcontroller to manage pre-programmed commands, control parameters and data. Digital to analog interface circuits converted the control parameters into the basic analog signals necessary for the operation of a quadrupole ion mass filter. From these base signals the bias voltages and the quadrupole excitation was generated. For that purpose various amplifier configurations and high voltage supplies were employed. An oscillator whose amplitude could be varied with a great degree of precision over a wide range provided the ac excitation component for the quadrupole mass filter. The spectral data collected by electron multiplier devices, either in a current or a pulse mode, were conditioned by logarithmic current-to-voltage converters or pulse counters respectively. In either case, the data was converted into a PCM bit stream for transmission through a telemetry link. Various monitor and data identification signals were included to facilitate data reduction and interpretation. The control system was powered by a multiple output power converter tailored to the needs of the system.

Variations of the basic approach accommodated special requirements. Electron beam ionization generators and control circuits were added to the instruments intended to measure neutral constituents. Instruments capable of switching between positive and negative ion measurements during a flight were built. Circuits to control the potential difference between the vehicle and the instrument were provided when needed. The PCM data subsystems were omitted from a few of the mass spectrometers.

Ground support equipment was also provided. The support equipment consisted mainly of control consoles for laboratory tests and launch operations. Included among the ground support equipment were units designed to interface with a control and data processing computer used to direct the operation of a balloon-borne instrument system during a flight. These units provided a partial real time data processing that reduced the burden placed on the computer freeing it for a more efficient incoming data analysis necessary for the interaction between the ground based scientist and the airborne instrument. A command interface between the computer and the transmitting equipment of the ground station was also provided by the units.

Some of the development work has been described in Scientific Reports 1, 2 and 3 issued under this contract and listed in the publications section. Other tasks and services rendered were reported only in the Quarterly Status reports or were communicated to the contract monitor as drawings, descriptions, specifications and operating instructions.

This final report describes a control system for a switchable ion mass filter designed as a part of the Lower Ionosphere Payload Development (LIPD) project. The system provided the necessary control functions and bias voltages for a miniature cryogenically pumped ion mass filter intended to make measurements in the 40 to 60 kilometer altitude range. The control circuits included a complete PCM data system. The development has been carried through an operational breadboard stage ready to be tested with the mass filter.

I. LIPD OVERVIEW

The objective of the Lower Ionosphere Payload Development (LIPD) project was to design a lightweight cryogenically pumped Ion Mass Spectrometer for the exploration of the ionosphere at the altitude between 40 and 70 kilometers. The instrument was to be carried on a 11.4cm diameter Superarcus rocket fired from a portable launcher. The Ion Mass Spectrometer, a nosecone ejection mechanism, a battery and the telemetry was to be packaged into a 100cm long payload including a 53cm ogival nosecone and weighing less than 9 kilograms.

The development of the control unit for the positive/negative ion quadrupole mass filter capable of detecting ions up to 150 atomic mass units was assigned to this contract. Telemetry and the mechanical design including payload packaging and integration were the responsibility of the contracts F19628-83-C-0037 and F19628-81-C-0029 respectively. To conserve weight and space, the mass filter control unit also provided the timing signals for the nosecone ejection and formatted the mass filter data and the payload monitor signals into a PCM data stream ready to modulate an FM transmitter. A 200 milliwatt S-band FM transmitter and a stripline band antenna satisfied the TLM requirements. A single lithium battery pack was chosen to provide power to the whole payload. The mass filter, cryogenic pump and the ion/electron detection devices were the responsibility of AFGL.

The design of the mass filter control unit was based on an eight-bit microcontroller with a built in EEPROM. The operating system program was stored in the EEPROM. Flight and/or the test parameters to control the filter were stored in an EEPROM accessible from the outside through the communications port of the microcontroller. A block of 16 eight-bit instructions defined up to three atomic mass units through which the mass filter could be stepped while maintaining the same offsets, biases and the ratio between the ac and the dc components of the quadrupole excitation signal. A total of 126 such blocks were available for the definition of a flight program that could be repeated indefinitely.

Two twelve-bit DAC's were employed to generate the quadrupole excitation control signal and to set the ratio between the ac and the dc components of the excitation. A domain of one atomic mass unit was defined by twenty-seven levels of the control signal. Offset control for the excitation signals was provided by three 8-bit DAC's receiving their inputs from the mass filter control program. Two of the signals were primarily intended to eliminate the offset voltages of the power amplifiers producing the two dc components of the quadrupole excitation. The third signal controlled the offset of the ac component. Four bipolar digitally controlled bias signals generated by 8-bit DAC's and two fixed high voltage supplies to bias the ion detectors completed the list of signals required by the mass filter.

The mass spectrometer dwelled 10ms at each selected atomic mass unit. The data in a form of a pulse count was collected during the last 9ms of the dwell time. The first millisecond was allotted for the stabilization of the quadrupole excitation after the selection. A sixteen-bit counter was used. The data collection process and the PCM telemetry were synchronized. The ion data collected during a PCM frame was transmitted together with the support data during the following frame. Each frame consisted of 20 eight-bit words, MSB first. The word assignments within a frame are tabulated in Appendix A. Data, atomic mass unit identification and the ratio information were transmitted as two consecutive 8-bit words, the most significant byte first. The remaining words carried other support and monitor data. Analog monitor signals were converted into the digital form by an 8-channel data aquisition system. The 16kbps PCM data stream was converted into the Bi-phase Level form for transmission through the FM link.

The ac excitation for the quadrupole was generated by an oscillator whose frequency was determined primarily by a resonant circuit consisting of the secondary winding of the output transformer and the capacitance of the quadrupole. The generator was able to produce an output signal that ranged from 2.5 volts to 450 volts peak at 2.3MHz into a 94pF capacitive load. This amplitude range exceeded the quadrupole requirements to detect ions between 10 and 150 atomic mass units.

An oscillator-driven, non-saturating, dc-to-dc converter provided ±110, ±15, and +5 volt outputs to meet circuit requirements. The converter operated at a nominal 25kHz frequency and required between 0.6 and 1 A at 28 volts. The two current limits occurred when the filter was set to process ions at the two extreme atomic mass units of 10 and 150 respectively. Battery voltage to the converter was pre-regulated at +20 volts.

The instrument could be armed in a preparation area before being transported to the launcher. Applying an arming pulse through a small connector in the skin of the payload latched a relay that connected the battery to the pullaway circuits only. Power to the control circuits and the transmitter remained blocked as long as an external connection carrying approximately 1mA of current from the payload battery to the pullaway circuits was in place. Upon launch the external connection was broken. At that time power became available to the transmitter and to the control circuits. The ac exciter and the HV supplies were activated after a pre-programmed time interval during the flight when the nosecone of the vehicle had been ejected and the mass spectrometer had been exposed to the atmosphere.

II. CIRCUITS

In this chapter a brief description of the circuits in the mass filter control unit is presented. The descriptions include, where appropriate, the function of an individual component and its relationship to other components during the execution of a control task. Whenever possible, a block of circuits contributing to the execution of a given control function or functions are presented together in a single circuit diagram.

A. Digital Circuits

The circuits generating and/or responding to digital commands and intended for packaging as a functional unit are shown in Figure 1. The design of the control unit was based on an INTEL 8751 (U1) microcontroller (uC). The micro-controller operated at 6.144MHz and contained the operating system program in its internal EPROM. The mass filter control program and the timing information was stored in the EEPROM (U2). Multiplexed bus structure was used to address and to transfer data to and from the other integrated circuits. The microcontroller ports zero and two were used for that purpose.

The EEPROM was the only component connected to the bus that required an external address latch. U4 latched the lower byte of the address for the PROM.

The serial I/O port of the microcontroller was utilized in a *full-duplex configuration* to communicate with external devices in an asynchronious mode. Through this port the EEPROM could be programmed and the other devices connected to the bus could be accessed. The remainder of the I/O pins were used to generate individual discrete commands to control other circuits in the payload or to provide the chip select and control functions for other integrated components on the bus. To augment the available microcontroller I/O pins for the chip control functions a 3 to 8 line decoder (U3) was used.

A watchdog circuit was employed to guard against a program crash. The circuit consisted of a counter (1/2 of U13) driven by a 16kHz input and the NAND gates U15X. A pulse generated at Y7 of U3 under the software control of the microcontroller cleared the counter (pin 12 of U13) every 500us. The pulse propagated through U15C and the RC network. Failure to clear the counter produced a positive enabling pulse at pin 8 of U13 and 62.5us later a pulse of the same duration at 10U13. That latter pulse passed through the coincidence gates to the reset pin of the microcontroller. Since the most likely period of time for a noise induced program crash could be anticipated to be during the lift-off, the watchdog circuit could restore the system to a proper operation with a minimum loss of the data window. The reset at power-on was generated by the RC circuit at pin 5 of U15B.

The analog signals to control the quadrupole excitation were generated by 12-bit A/D converters. The converter U16 generated the ac excitation control signal while the U17 established the ratio between the ac and the dc components of the excitation. Each atomic mass unit domain was resolved into 27 levels differing one from the other by 1 significant bit. The converter output covered a nominal range from zero to +10 volts. The -10V reference for the converter was derived from the monolytic source U21.

To generate the four bias signals a quad 8 bit A/D converter U19 was used. Same type of a converter (U18) generated three dc signals to compensate for excitation amplifier offset voltages or to introduce, if needed, some offsets into the excitation signals. To eliminate possible loading problems while operating over a wide range of temperatures, separate reference sources (U22 and U23) were provided for each converter.

The ion spectral data appearing in the form of pulses was accumulated during a 9ms period for each atomic mass unit in the 16-bit binary counter U8 and U9. The counters had the tri-state output capability and, therefore, could be connected directly to the bus. The count was transfered into the PCM data stream every 10ms and, at that time, the counters were also cleared. The various analog monitor signals were converted into an 8-bit digital data by the 8 channel data acquisition component U20. The converter received its 256kHz clock from a crystal oscillator U12.

The 16kHz PCM clock was also derived from the same crystal oscillator through a 4 bit binary scaler (1/2 U13) and the U15D gate. The formatting of the PCM frame was under firmware control. A frame consisted of twenty 8-bit words. The words were loaded into the parallel-to-serial shift register U6 by the microcontroller. The microcontroller was interrupted to load a new word every 500us by a timing signal generated at pin 9 of U13. The same interrupt was also used to control the scan rate of the mass filter. The timing for the nosecone ejection and for the activation of the HV supplies and the ac exciter was based on the accumulated count of the interrupts.

The nosecone ejection commands were transmitted through U5. Four descrete commands were provided. Each line was capable to sink 200mA at 28 volts and was intended to drive a relay. To insure that all lines were in the high impedance state during the power-on interval, the same reset signal used to initialize the microcontroller was employed to clear the relay driver. Only after the reset pulse to the microcontroller had been removed, the clear signal was allowed to decay to zero. The transient suppressor line shown in the figure was connected to the relay power source.

B. The Amplifiers

The circuits used to condition and to amplify the dc signals generated by the digital to analog converters are shown in Figures 2 and 3. The exciter control signals were processed by the circuits of Figure 2 while the bias signals were converted to the required polarity and then amplified to the desired levels by the circuits of Figure 3.

The ac exciter control signal was buffered by the unity gain inverting amplifier A_{31} before being passed on to the ac excitation generating circuits. The signal from the multiplying DAC, that controlled the ratio between the ac and the dc components of the quadrupole excitation, was processed by the amplifier circuits A_{21}, A_{22}, A_1 and A_2. These circuits produced the positive and the negative dc components of the excitation. The two dc signals were very closely matched in magnitude. A common quadrupole bias Q_B was also added to the dc signals through the high voltage amplifiers A_1 and A_2. The offset voltages of the amplifiers could be digitally nulled. The bipolar offset control signals were introduced at the inverting inputs of the amplifiers A_{21}, A_{22} and A_{31}. The first two signals were primarily intended to cancel the dc offsets of the output amplifiers A_1 and A_2. The third signal could be used to manipulate the dc offset requirements of the ac exciter circuits.

One of the four similar bias voltage amplifiers is shown in Figure 3. The unipolar signal generated by an 8 bit DAC was offset and amplified to produce a bipolar signal between -30 and +50 volts with proper choice of R25. (Using 100K as illustrated produces an output bias range of $\pm$50V when the DAC output ranges from 0 to 10V.) MOSFET's were used to boost the operational amplifier outputs to the desired levels. The common supply voltages to all four bias amplifiers were derived from the $\pm$110 volts required by the dc excitation amplifiers.

C. The AC Exciter

The circuits generating the ac component of the quadrupole excitation signal are shown in Figure 4. The opposite phase signals for the two sets of the quadrupole electrodes were obtained from the secondary windings of the oscillator transformer. The free running oscillator design frequency of 2.3MHz was primarily set by the resonant circuit consisting of the output inductance of the windings and a capacitive load. The major contributor to the load capacitance was the quadrupole itself. Additional loading was introduced by the capacitive divider (C5, C7) and C_{TRIM} used to balance the output amplitude at the two windings. The signal to control the amplitude of the oscillator was obtained from the capacitive divider. It was clamped by the circuit of C4, CR7 and CR8. The diode CR8 provided some offset and temperature compensation. The clamped signal was filtered, inverted, attenuated and summed at pin 2 of A1 with the exciter control signal. The output of the amplifier provided the drive for Q_1 which in turn controlled the series pass transistor Q_2. This power transistor supplied the collector voltage for the two oscillator drivers Q_3 and Q_4. The dc base drive was also derived from the collector voltage, while the ac feedback signal to the base was obtained through the capicitors C9 and C10 from the feedback windings of the transformer. The transformer was wound on a phenolic toroid 2.4 cm high with the outside diameter of 5cm and an inside diameter of 3.8cm. Amplitude control of the oscillator output could be maintained from a minimum of 2.5 to a maximum of 450 peak volts at a power supply voltage of 22 volts. The current requirements varied between 100 to 500 mA at the two output extremes.

The power to the oscillator could be cut-off by pulling the gate of Q_1 to a ground potential. This circuit was utilized by the digital control subsystem during the initial stages of flight. The oscillator was turned on after the nosecone was ejected. In addition, two protective circuits were introduced into the exciter to interrupt power to the oscillator to prevent damage when a danger to the driver transistors was sensed. One of the protection circuits A3A monitored the oscillator current. When the current exceeded 1A the power was periodically interrupted until the current was reduced. This protection was primarily intended to avoid long periods of a high power dissipation in the transistors when the circuit was accidentally prevented from oscillation. The other circuit (A2A) was tripped by a temperature sensor CR1 when the oscillator base plate temperature exceeded approximately 80°C. The oscillator was activated again when the temperature dropped below 50°C. Amplifier circuits A2B and A3B provided temperature and ac excitation amplitude monitor signals.

D. HV Bias Circuits

The high voltage circuits to bias the Channel Electron Multipliers (CEM) are shown in Figure 5. The two CEM devices, one to measure the positive ions, the other for the negative ion data, were biased by separate HV supplies. The supplies whose outputs were proportional to the input voltages were operated at their maximum output of 3,000 volts. The required input power at 12 volts was derived from the preregulated power supply voltage of 20 volts by the operational amplifier A6X and the two MOSFET's Q_{17} and Q_{18}. The power to the HV supplies could be interrupted by the same circuit (Q_{19}) which controlled the power flow to the ac exciter. Therefore, the HV supplies and the ac exciter were always activated at the same time. Power to the selected supply was switched through a relay which was under the digital circuit control.

The outputs of the HV supplies were connected to the CEM's through two 1M resistors and a capacitor providing some additional filtering of the output ripple. The status of the two outputs were monitored through a 100M resistors terminated by diodes for safety and circuit protection.

A single charge amplifier A2, AMMP-TECH A-101, mounted on the standard PC-11 test board was used to amplify the incoming spectral data. The same relay, which activated the selected HV power supply also switched the amplifier to the appropriate CEM device. Separate ac neutralization circuits were used for the data originating at the two CEM's. The neutralizing signal was derived from the two ac excitation components of the quadrupole. The potentiometer and the centertapped variable capacitor provided the amplitude and the phase control for the neutralizing signals to cancel the interferring ac signal appearing at the input of the amplifier.

E. Support Circuits

Figure 6 is a collection of the various monitor, communications interface and power control circuits.

The arming and power control circuit is shown in the upper left corner of the drawing. The latching relay connected the flight battery to the series pass transistor Q_2 which blocked the power to the rest of the control circuits as long as R_{27} and R_{28} were connected together. When in this configuration, the current drain from the battery was a nominal 2mA. The transistor Q_1 was saturated, Q_3 and Q_2 were cut-off. When the connection between the two resistors was broken Q_1 became cut-off and the pass transistor Q_2 supplied power to the control circuits. Thus, the payload could be armed before the installation into the launcher provided a short between R_{27} and R_{28} was maintained. Closure of the relay could be verified by a voltage measurement. The active OFF circuit was chosen to insure that upon launch the broken safety connection between the two resistors could short to the vehicle without upsetting the operation of the control electronics.

The group of circuits in the lower right part of the drawing are the communications interface circuits. They include the circuits (U1, U2A) to convert the NRZ PCM data into a bi-phase signal suitable to modulate an FM transmitter. The deviation of the transmitter could be adjusted by selecting the resistor R. A monitor output to observe and to use the PCM data stream in the laboratory was also provided (U2B)

The interface circuits to control the operation of the mass spectrometer in the laboratory environment are shown in the lower part of that section. The U2C and U2D circuits were used to interface the microcontroller communications ports with a laboratory control unit. The circuit associated with Q_5 was used to indicate to the microcontroller whether a laboratory test or a flight program was being run. The rest of the circuits shown in the Figure were the various monitors. A_{11} and A_{12} converted the HV monitor currents into the voltage signals suitable for the A to D converter. The absolute value circuit A_{23}, A_{24} and A_{14} monitored the combined bias voltages. Both dc components of the quadrupole excitation signal were monitored as a combined signal by A_{21} and A_{22}. The common bias component Q_B was subtracted in the monitor circuit from the $\pm$DC voltages.The other two circuits (MON 5 and MON 6) were used to monitor the battery voltage and the $\pm$15 volt supply respectively.

F. The Power Supply

The power supply is shown in Figure 7. It was based on a non-saturating squarewave driven transformer design. The pot core transformer was driven by the power MOSFET's Q_1 and Q_2 at approximately 25kHz. The low impedence gate drivers Q_5 to Q_8 received their symetrical base signals from the FF U2 which was clocked by a 50kHz signal generated by U1.

The battery power to the converter was pre-regulated at 20 volts by VR1. VR2 provided the required +15 volts to the circuits directly from the pre-regulated power. All other voltages were derived from the transformer outputs and regulated by the circuits shown.

III. FIRMWARE

The operating system was stored in the EPROM of the microcontroller. Exclusive of the initialization process, the firmware provided three distinct modes of operation. The first mode controlled the payload in the beginning of the flight. At that time the primary task of the microcontroller was to provide the timing for the ejection of the nosecone and the activation of the HV and ac exciter circuits. When that task was completed, the microcontroller entered the data gathering mode. In that mode it provided control signals for the mass filter and formatted the PCM data. The third mode, intended for laboratory use, was command oriented. An external control source could access and modify the existing mass filter control firmware stored in an EEPROM. Also, various other control circuits could be directly accessed. Data read-out could be requested and the operation could be transferred into the data gathering mode. Only the timing functions to eject the nosecone and to automatically activate the HV and the exciter circuits were not accessable for safety reasons.

All communications to the microcontroller from the external source were initiated with a command code. The command was followed by either an address code or a data code or both. The instructions were transmitted at 1200 bits per second using an asynchronious mode. A start bit and one stop bit with no parity were used.

The command codes were 8-bit binary numbers with a ONE in the MSB position. The MSB was used to differentiate between a command and the address or data codes. The addresses and data were transmitted as 8-bit ASCII characters representing the hexadecimal numbers 0 through F. Each character thus defined four binary bits of an address or a data word in the same order of significance as received.

All transmissions to the microcontroller were immediately echoed back for verification. The end of transmission code initiated the execution of the just received command. When a command requested data to be sent back to the external control source, that data was transmitted in the binary code only. All communications from the microcontroller, except for the echo of an "ESCAPE" were followed by the end of transmission code. The command codes and the accessible memory locations are listed in Appendix B.

Upon launch, when the control unit became active, the microcontroller proceeded through an initialization process which included activity to prevent a premature ejection of the nosecone. The externally introduced FLIGHT OR TEST flag was checked. When in the flight mode the microcontroller established a counter and loaded it with the first timing byte stored in the EEPROM. The interrupts from the PCM circuits served as clock pulses to decrement the counter. When the contents of the counter were reduced to zero the second byte was loaded. When the count once again reached zero, a command was generated to eject the nosecone and to remove the seal from the orifice of the mass spectrometer. The primary command was followed by a backup command a short interval later. After an additional delay the HV supplies and the quadrupole exciter circuits were activated.

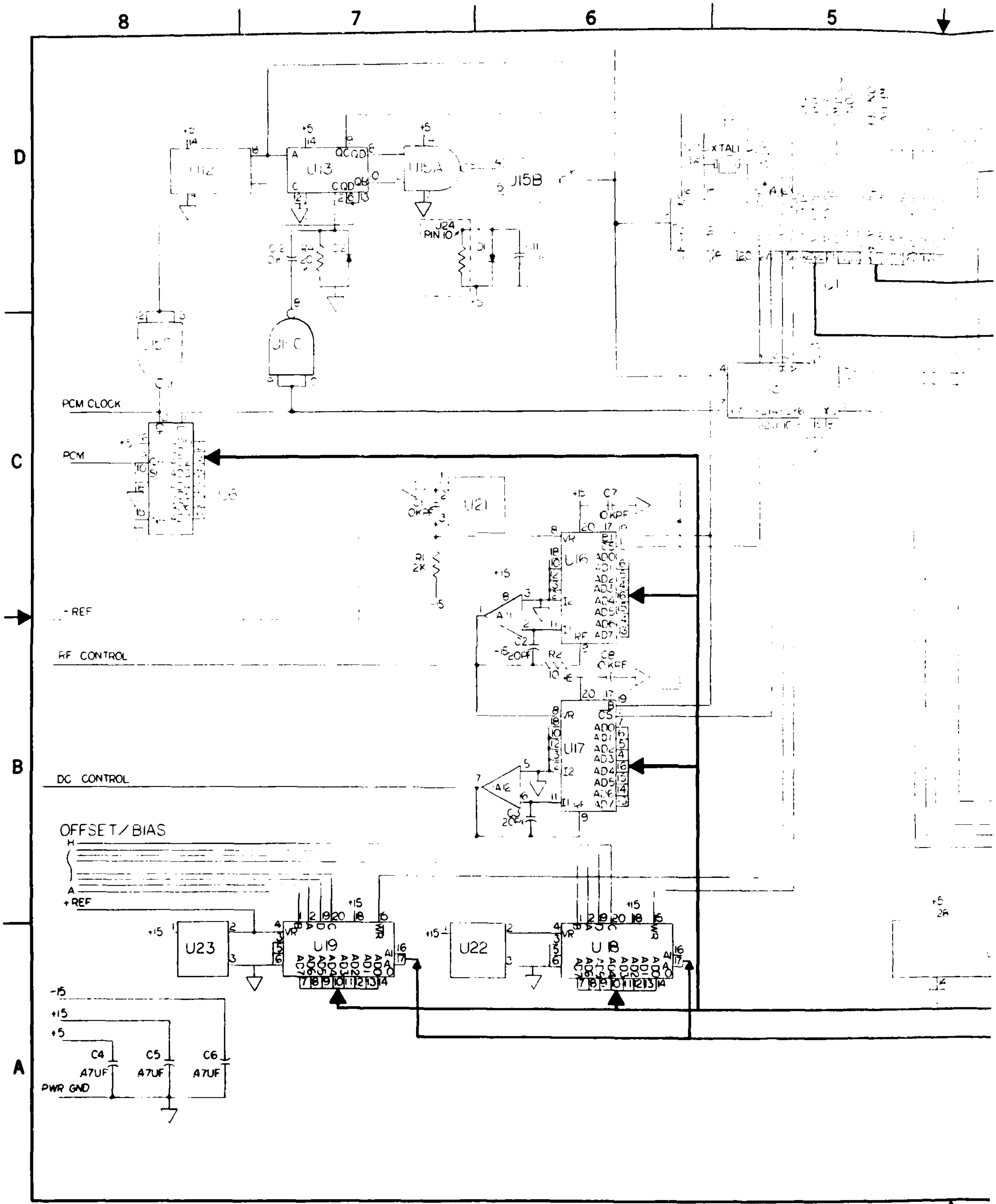
The codes specifying the flight time to nosecone ejection and the other events were stored in the EEPROM.

The binary code specifying the elapsed time between events was determined by taking the required number of seconds and multiplying that number by 10. The longest time interval to be specified was the time between the launch and the primary command to remove the nosecone. Therefore, two address locations in the EEPROM were assigned to time the primary command. The times for the back-up command and the command to activate the mass filter control circuits were referenced to the primary command. The number of seconds specified in the second byte were added to the time specified by the first byte. Thus, these two timed commands required only one memory location for each code.

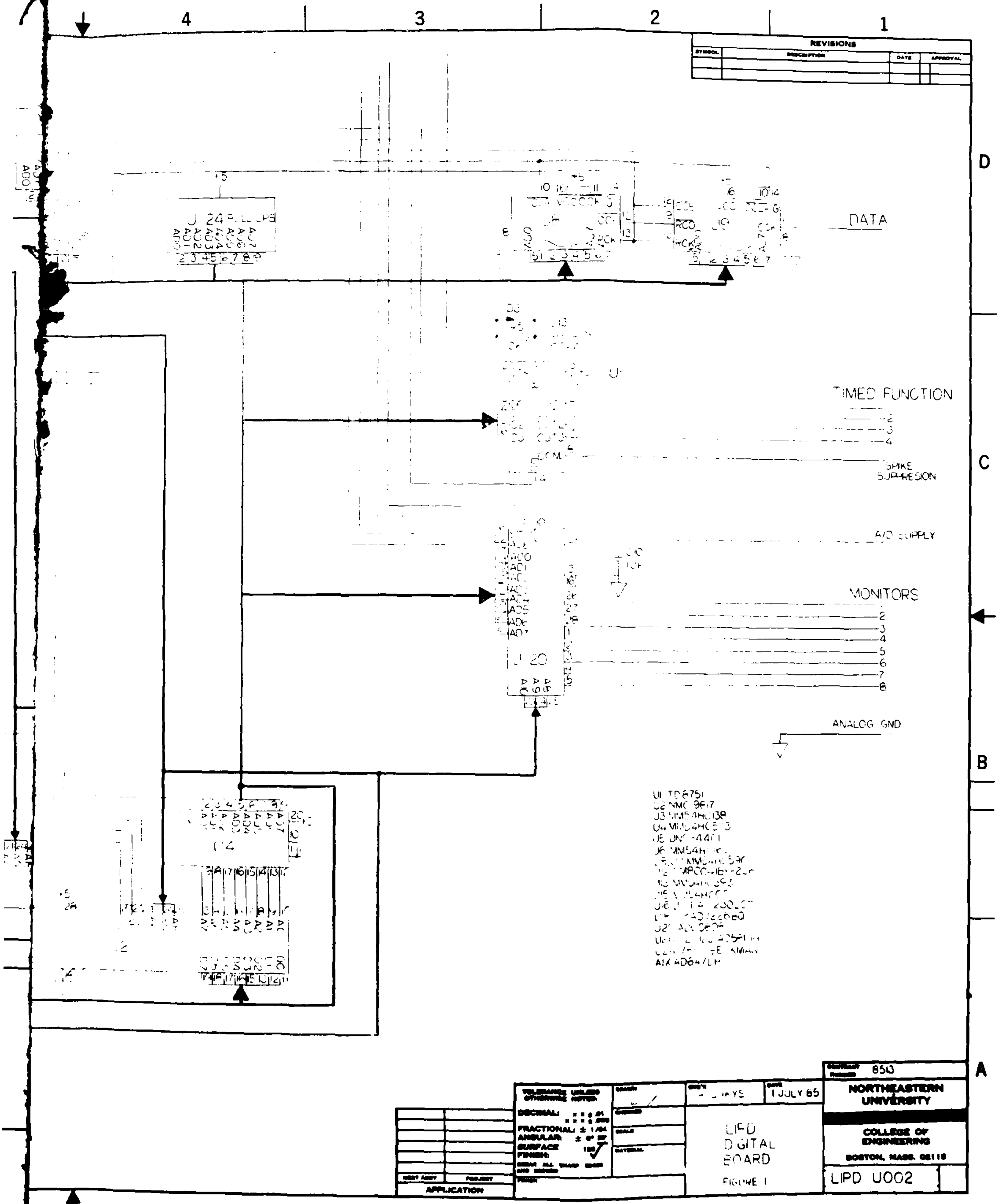
Until the time that the mass filter exciter and HV supplies were activated no meaningful data, except for the frame synchronization words (EB90H), were present within the PCM frame. Once the instrument was activated, the microcontroller loaded the mass filter control circuits with the first set of the stored parameters. The data counters were activated 1ms later. The timing for the operations continued to be provided by the interrupts from the PCM. The support and monitor data was gathered and stored in a bank of temporary storage registers for transmission during the next frame. The ion data was collected during an interval of 9ms in which 18 PCM data words were transmitted. The interval began with the second frame sync word and terminated with the onset of word 18. At that time the data was also transferred into two holding registers. The mass filter control parameter transfer into the circuits also was accomplished during word 18. Therefore, approximately 1ms of settling time was allowed before data gathering resumed with the filter set for a new atomic mass unit.

The mass filter control program was stored in the EEPROM. The first two address locations contained the frame synchronization words for the PCM data. The next four locations stored the time codes for the ejection of the nosecone and the activation of the mass filter. Remaining 10 address locations were left in reserve for other uses which could include an identification code and some other descriptive data for the stored program. The remainder of the 2 k byte EEPROM was reserved for the control program.

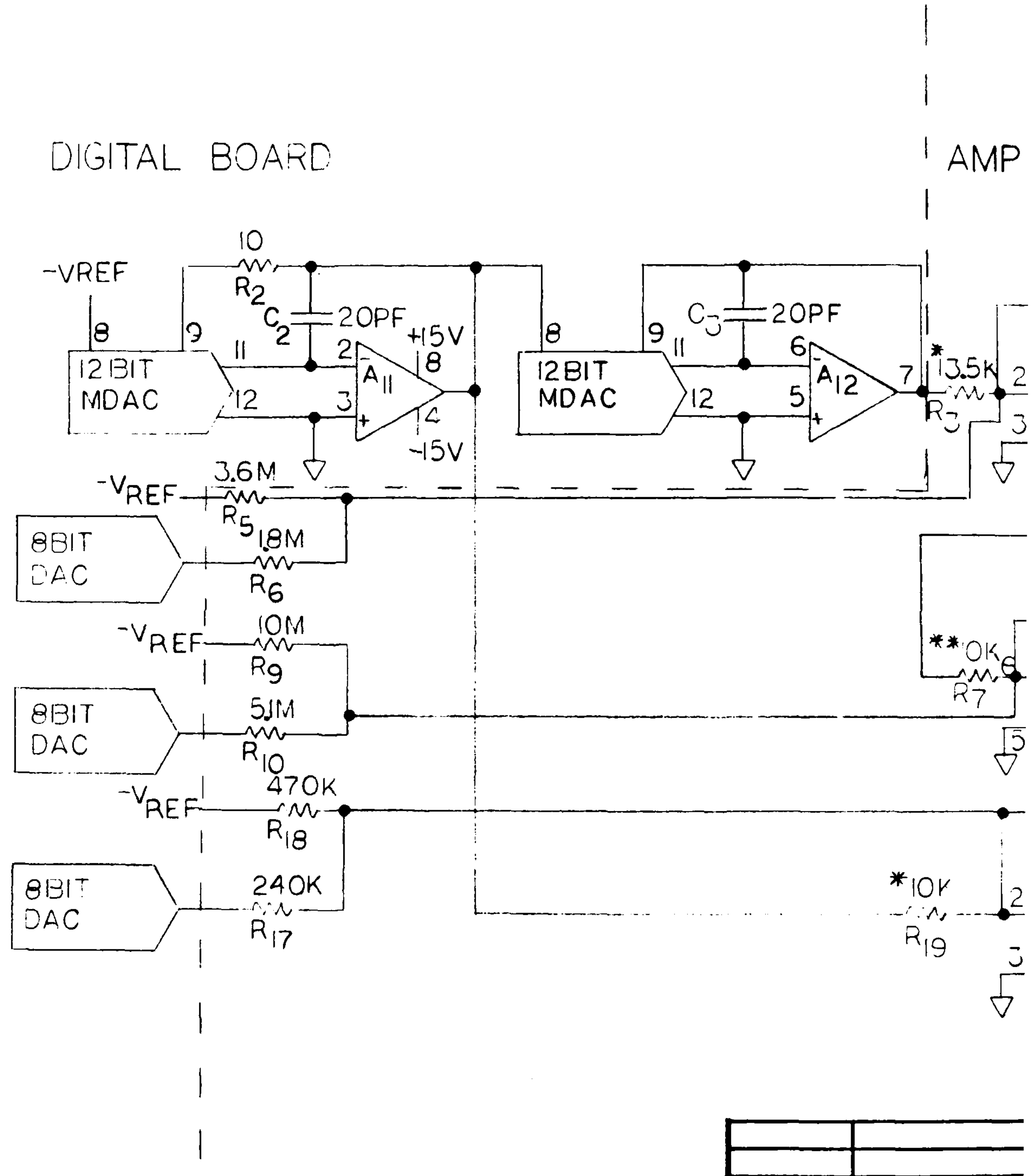
Sixteen locations were used to describe the parameters which stepped the filter through up to 3 atomic mass units. Common bias and ratio conditions were used for the operation in the three mass domains. When the present task was completed, the program advanced into the next block of 16 locations for new instructions. Thus, a total of 127 different parameter combinations could be stored before the flight program repeated. The control parameters and the sequence in which they were stored in the EEPORM are listed in Appendix C. The flow charts and the program of the operating system are presented in Appendix D and E respectively.



8
7
6
5
D
C
B
A
U13
U15A
U15B
J24
PIN 10
U21
PCM CLOCK
PCM
REF
RF CONTROL
DC CONTROL
U16
U17
A11
A12
C7
C8
R1
2K
R2
OFFSET/BIAS
+REF
U23
U19
U22
U18
C4
C5
C6
47UF
PWR GND



REVISIONS
SYMBOL
DESCRIPTION
DATE
APPROVAL
DATA
TIMED FUNCTION
SPIKE SUPPRESION
A/D SUPPLY
MONITORS
ANALOG GND
U20
U24
U14
NORTHEASTERN UNIVERSITY
COLLEGE OF ENGINEERING
BOSTON, MASS. 02115
LIPD DIGITAL BOARD
FIGURE 1
LIPD U002
APPLICATION



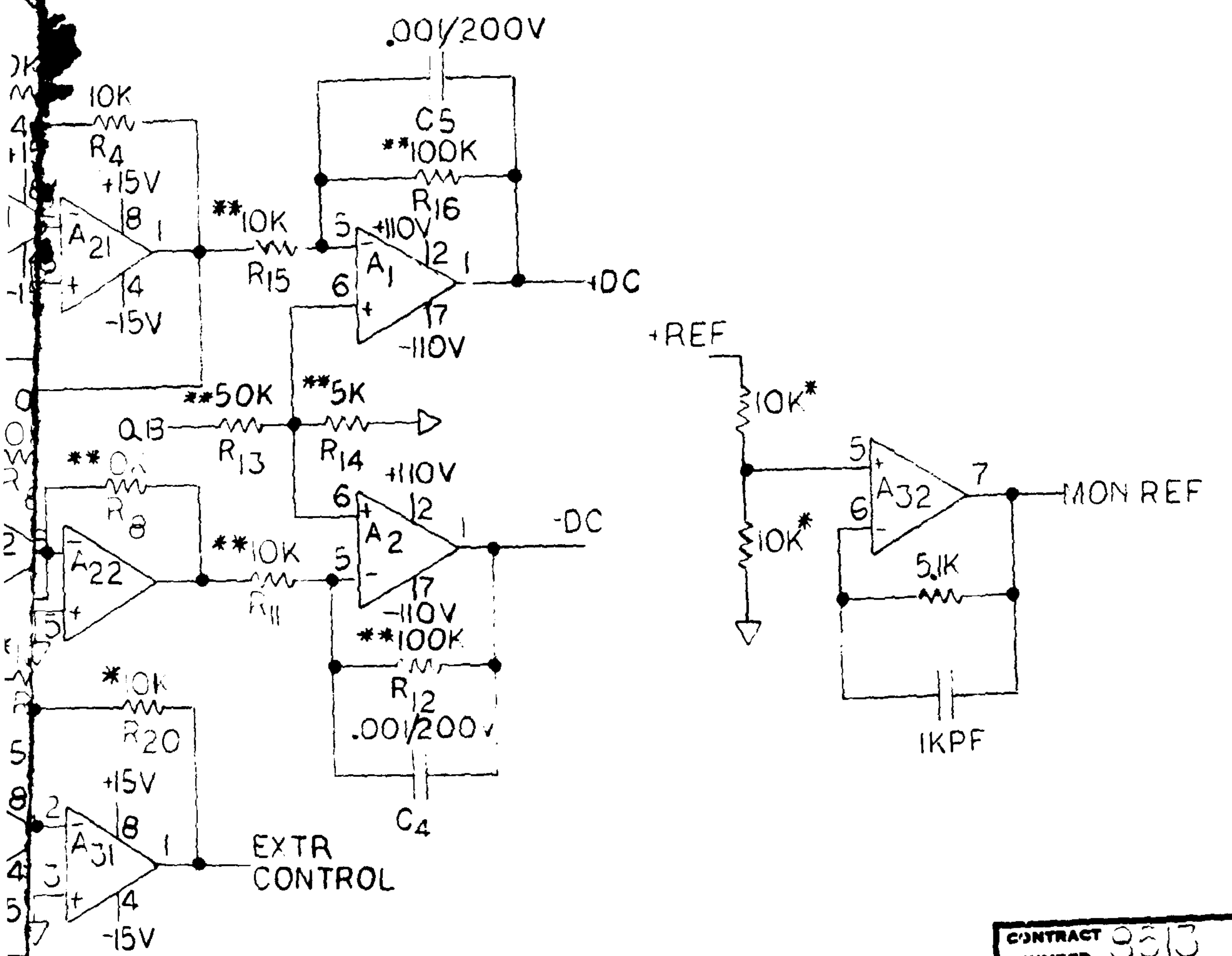
NEXT ASSY	PROJECT
APPLICATION	

MAKEPEACE P-5600

REVISIONS			
SYMBOL	DESCRIPTION	DATE	APPROVAL

MDAC - DAC1230LCD
DAC - $\frac{1}{4}$ AD7226BQ
A_1 - A_2 - BB3582J

* - 1% COMPONENTS (RN55C)
** - .01% COMPONENTS



TOLERANCE UNLESS OTHERWISE NOTED:	DRAWN	ENG'R	DATE	CONTRACT NUMBER 8313
DECIMAL: xx ± .01, xxx ± .005	ADD	R SUFS	10-3-85	NORTHEASTERN UNIVERSITY
FRACTIONAL: ± 1/64	CHECKED	LIFT EXCITER CONTROL		COLLEGE OF ENGINEERING
ANGULAR: ± 0° 30'	SCALE			BOSTON, MASS. 02115
SURFACE FINISH: 125	MATERIAL			LIFDAM000
BREAK ALL SHARP EDGES AND DEBURR				
FINISH		FIGURE 2		

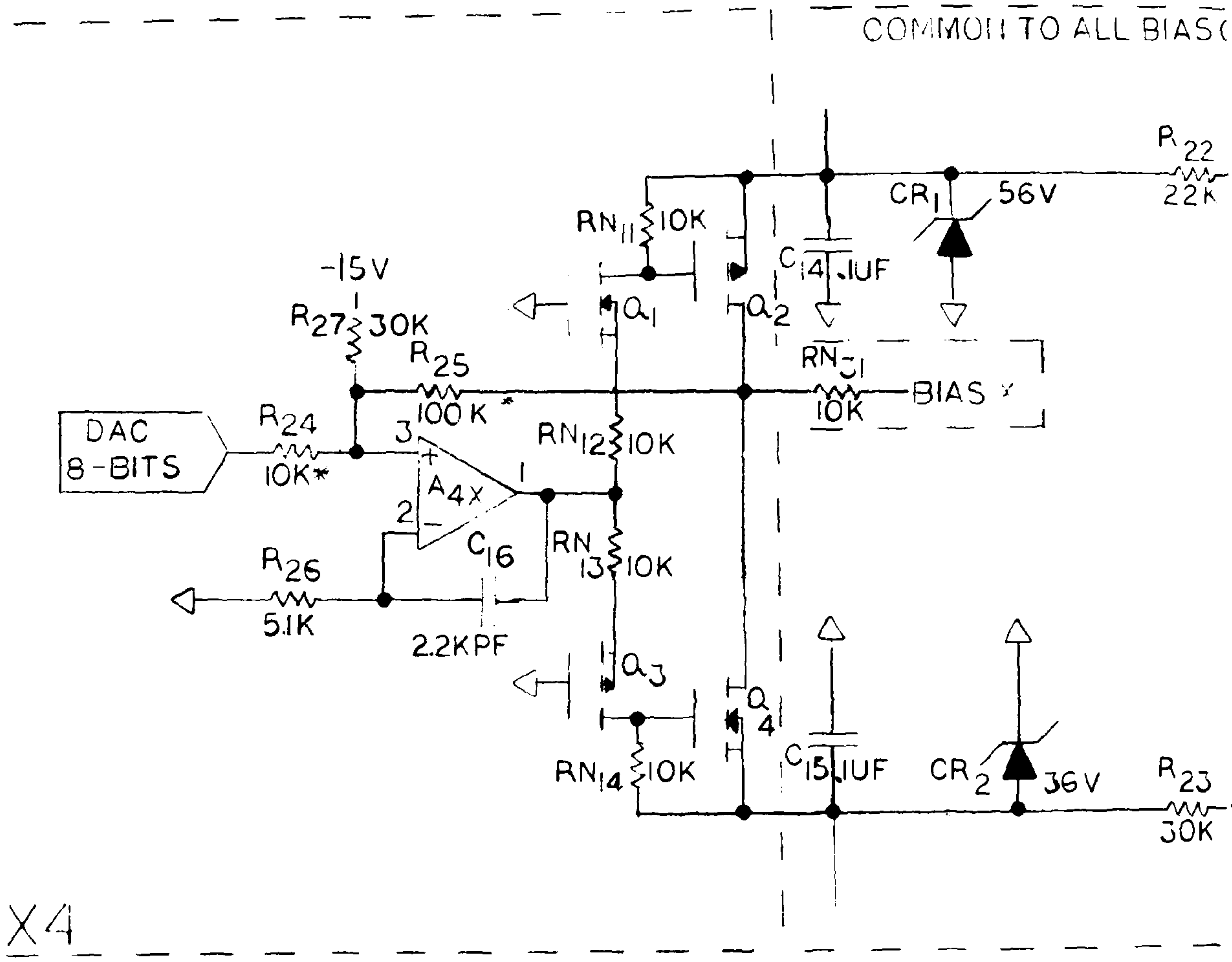
5 | 4

D

C

B

A



NEXT ASSY	PROJECT
APPLICATION	

MAKEPEACE P-5600

3 2 1

REVISIONS

SYMBOL	DESCRIPTION	DATE	APPROVAL

CIRCUITS

—110V

Q_1 - IRFD113
Q_2 - IRFD9122
Q_3 - IRFD 9123
Q_4 - IRFD 112
A - $\frac{1}{4}$ HA4602
DAC - $\frac{1}{4}$ AD7226BQ
C_1 - CKR06BX104K
C_2 - CKR06BX104K
C_3 - CKR105BX103K
C_4 - CKR105BX103K
* - RN55C(X2)
R's - RC07(X7)
Z_1 - IN4758
Z_2 - IN4753
R_4 R_5 - 898-3-10K BECKMAN

—110V

D C B A

CONTRACT NUMBER	8513

TOLERANCE UNLESS OTHERWISE NOTED:
DECIMAL: xx ± .01; xxx ± .005
FRACTIONAL: ± 1/64
ANGULAR: ± 0° 30'
SURFACE FINISH: 125√
BREAK ALL SHARP EDGES AND DEBURR

FINISH

DRAWN: ASO
CHECKED:
SCALE:
MATERIAL:

ENG'R: R SUKYS
DATE: 10-1-85

LIPD
BIAS CKT

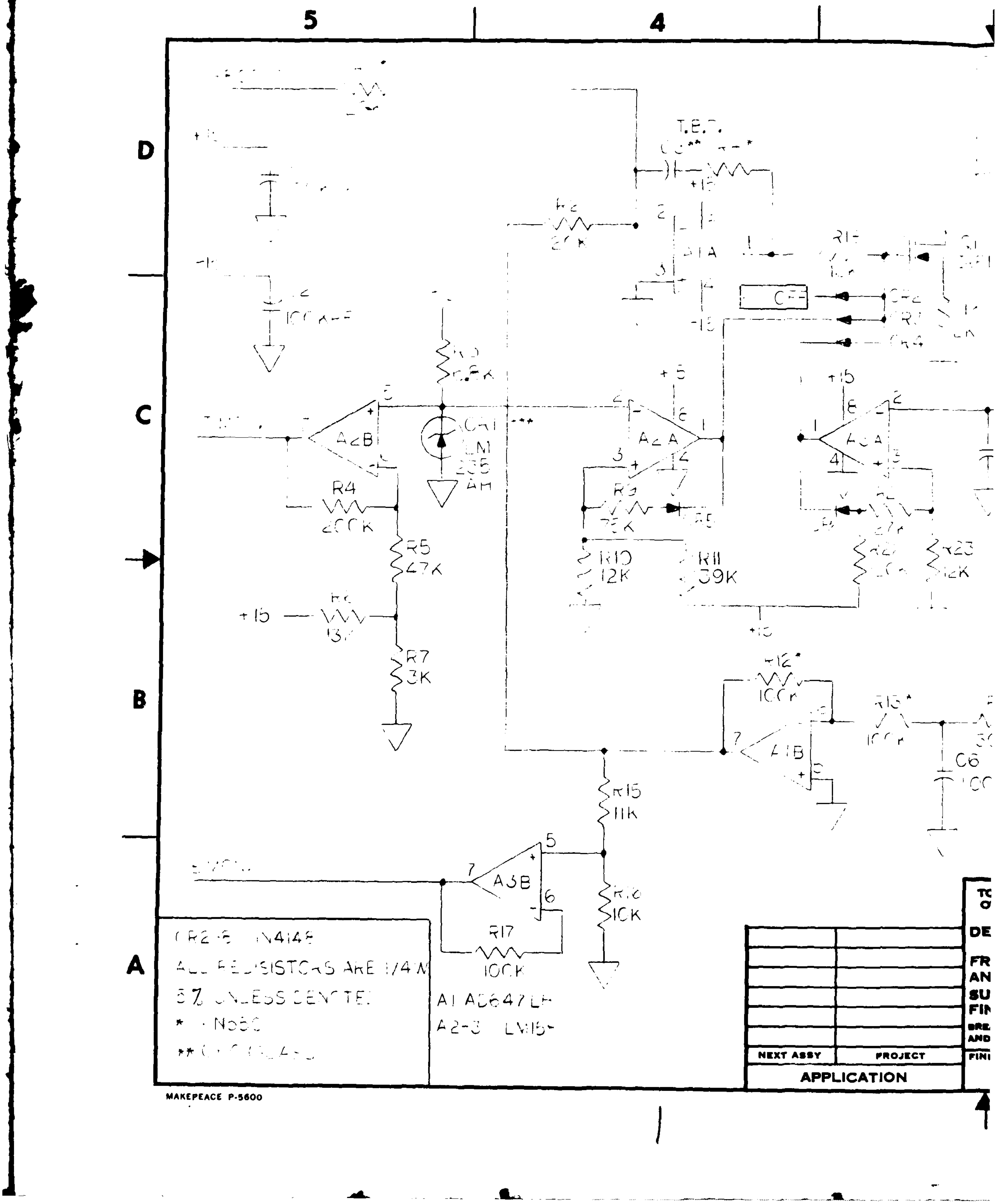
FIGURE 3

NORTHEASTERN UNIVERSITY

COLLEGE OF ENGINEERING

BOSTON, MASS. 02115

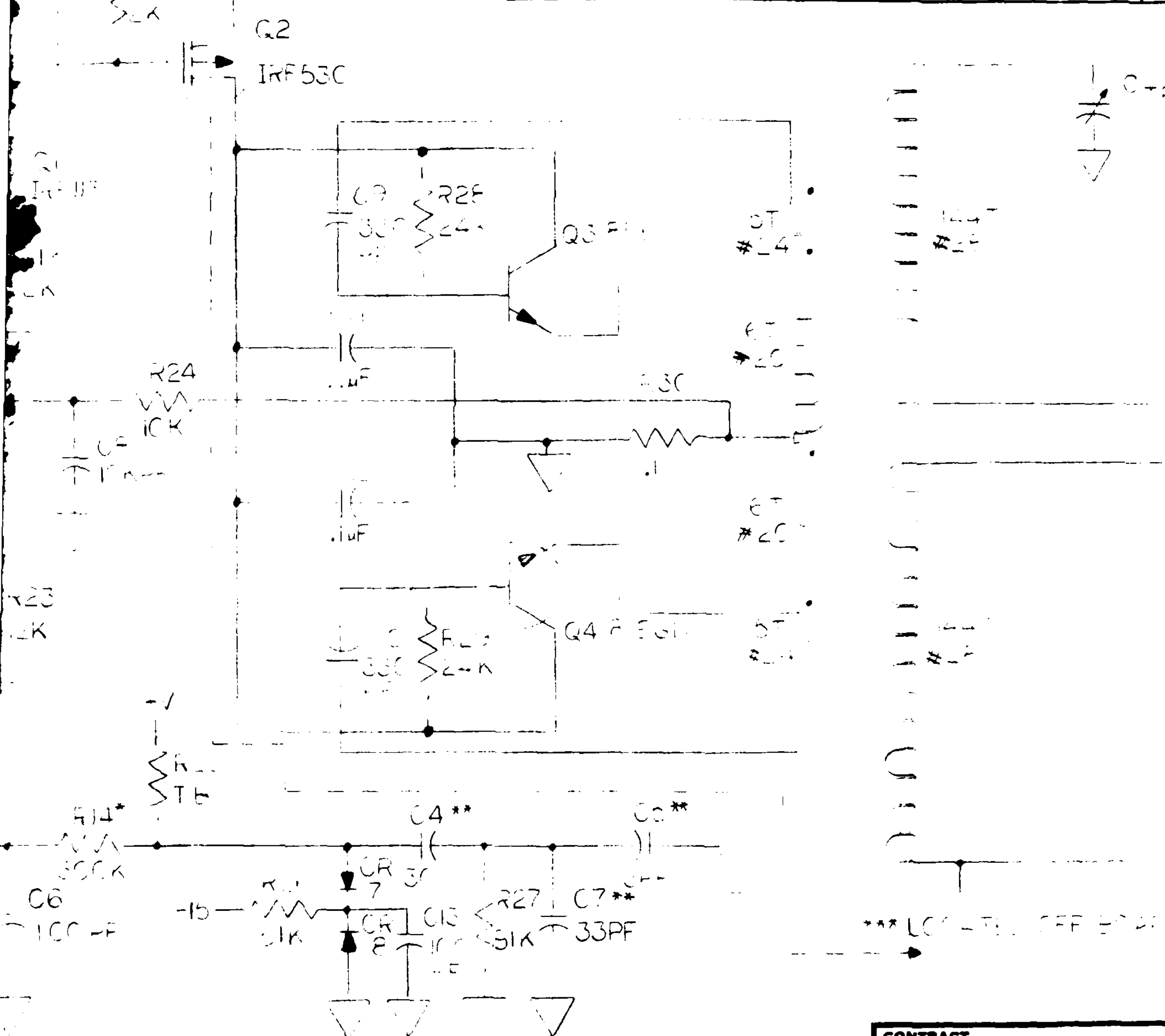
LIPDB001


5
4
D
C
B
A
T.E.D.
A1A
A2B
A2A
A3B
A1B
LM
335
AH
R4
200K
R5
47K
+15
R7
3K
R10
12K
R11
39K
R23
12K
R15
11K
R17
100K
C6
ALL RESISTORS ARE 1/4W
5% UNLESS
A1 AD647LH
A2-3 LM15
NEXT ASSY
PROJECT
APPLICATION
MAKEPEACE P-5600

3 2 1

REVISIONS

SYMBOL	DESCRIPTION	DATE	APPROVAL



D C B A

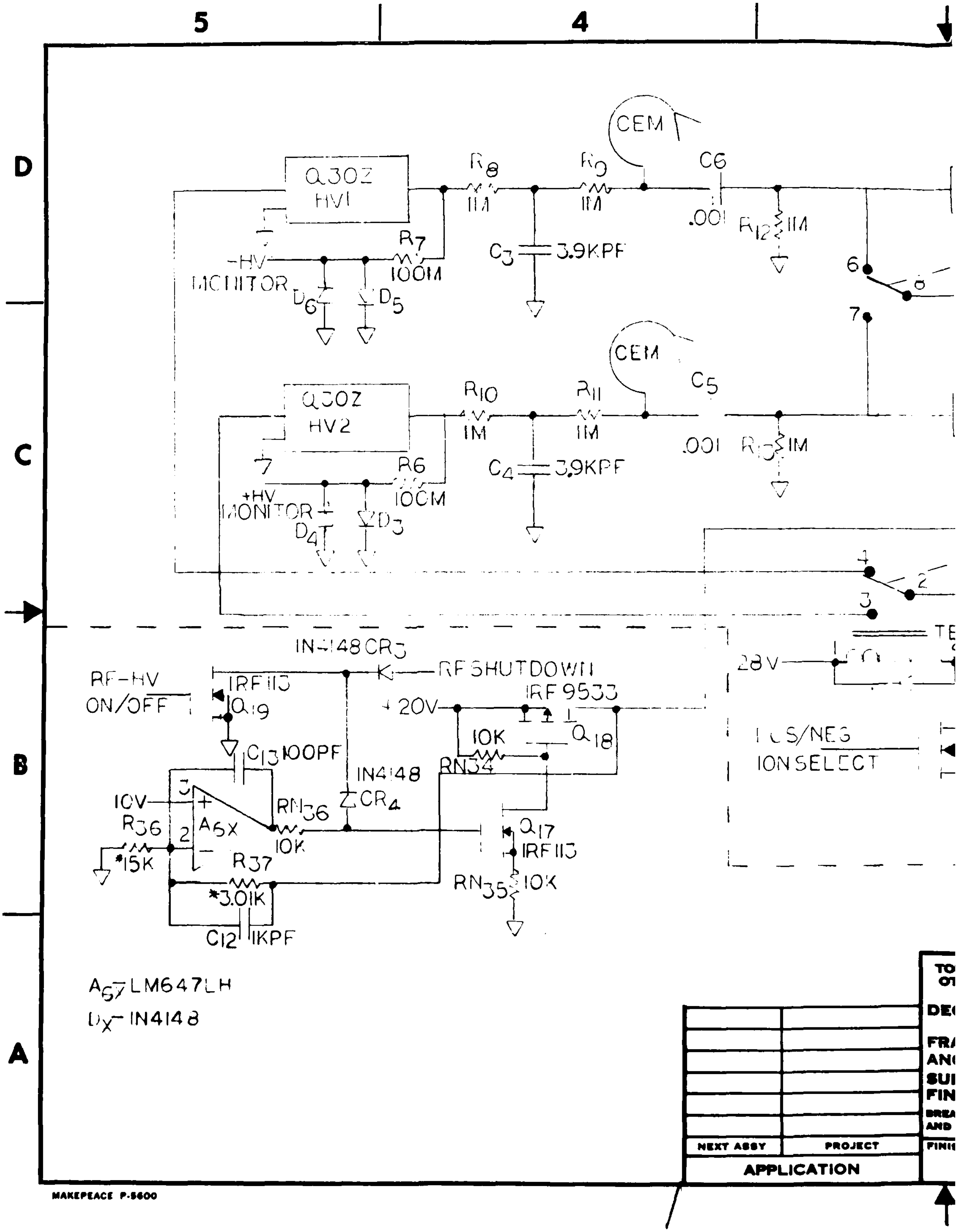
TOLERANCE UNLESS OTHERWISE NOTED:	DRAWN	ENG'R R SUKYS	DATE 20 JUNE
DECIMAL: x x ± .01 / x x x ± .005	CHECKED		
FRACTIONAL: ± 1/64	SCALE		
ANGULAR: ± 0° 30'			
SURFACE FINISH: 125	MATERIAL		
BREAK ALL SHARP EDGES AND DEBURR			
FINISH		FIGURE	

CONTRACT NUMBER

NORTHEASTERN UNIVERSITY

COLLEGE OF ENGINEERING

BOSTON, MASS. 02115



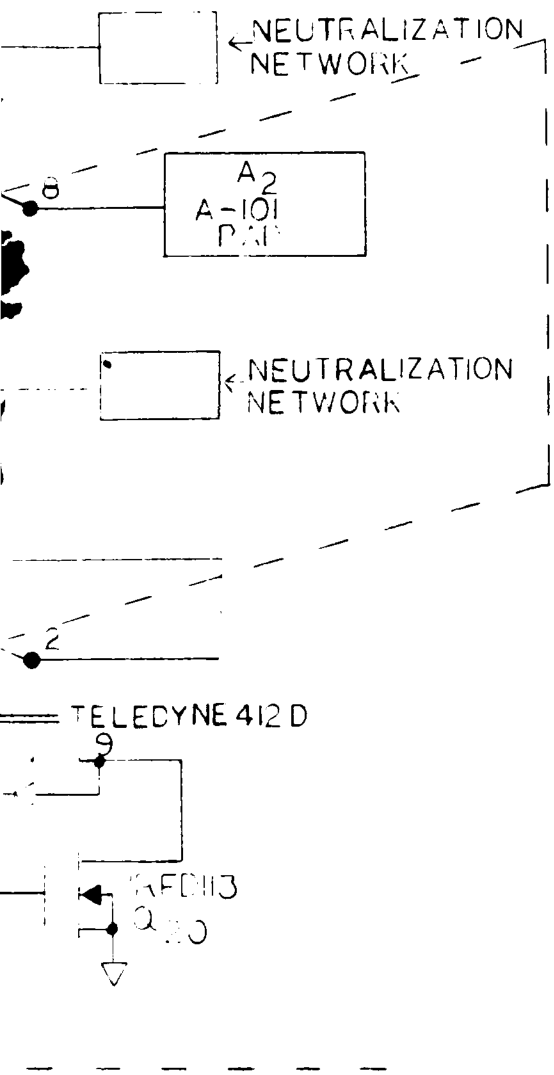
MAKEPEACE P-5600

3	2	1

REVISIONS

SYMBOL	DESCRIPTION	DATE	APPROVAL

D



C

B

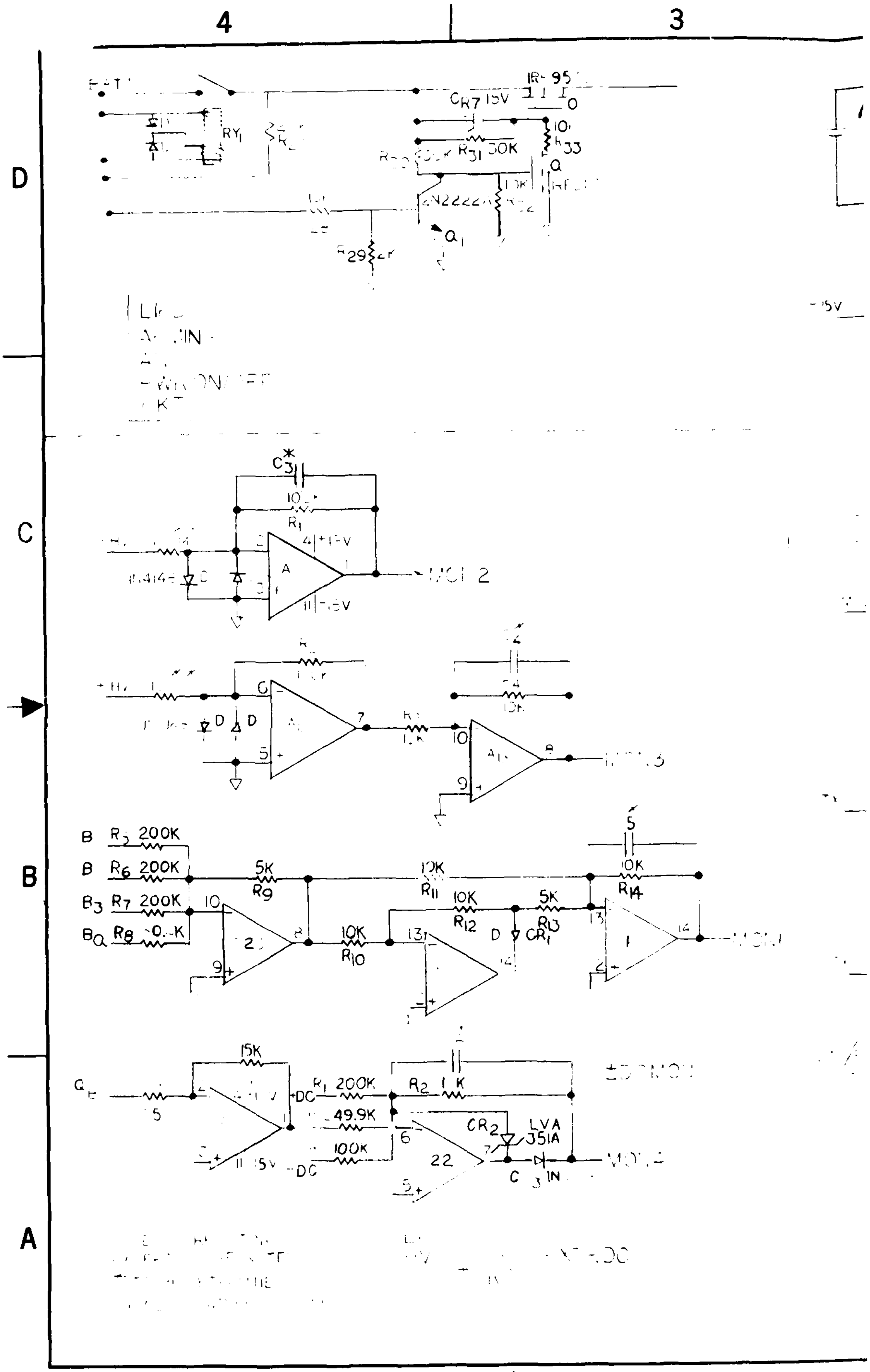
A

TOLERANCE UNLESS OTHERWISE NOTED:	DRAWN	ENG'R	DATE	CONTRACT NUMBER
DECIMAL: x x ± .01, x x x ± .005	ASC	R UKYS	10-2 8	NORTHEASTERN UNIVERSITY
FRACTIONAL: ± 1/64	CHECKED			COLLEGE OF ENGINEERING
ANGULAR: ± 0° 30'	SCALE			BOSTON, MASS. 02115
SURFACE FINISH: 125	MATERIAL			
BREAK ALL SHARP EDGES AND DEBURR				
FINISH				

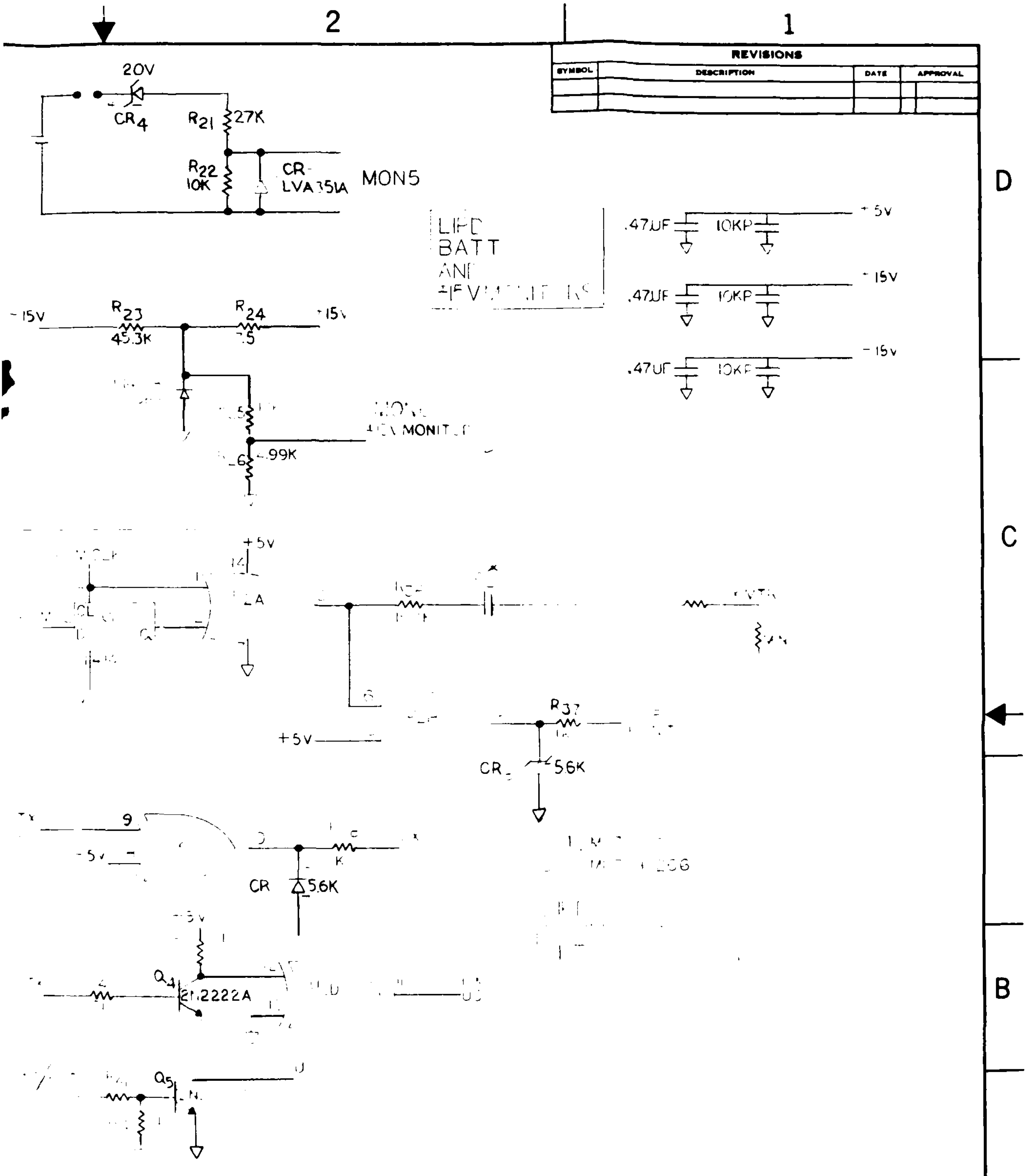
LPD HV SUPPLY AND CHARGE AMPLIFIER CKTS

FIGURE 5

2



MAKEPEACE P-8274



NEXT ASSY	PROJECT
APPLICATION	

TOLERANCE UNLESS OTHERWISE NOTED:
DECIMAL: x x ± .01, x x x ± .005
FRACTIONAL: ± 1/64
ANGULAR: ± 0° 30'
SURFACE FINISH: 125
BREAK ALL SHARP EDGES AND DEBURR
FINISH

DRAWN
CHECKED
SCALE
MATERIAL

ENG'R
DATE

LIPD
MONITO
D

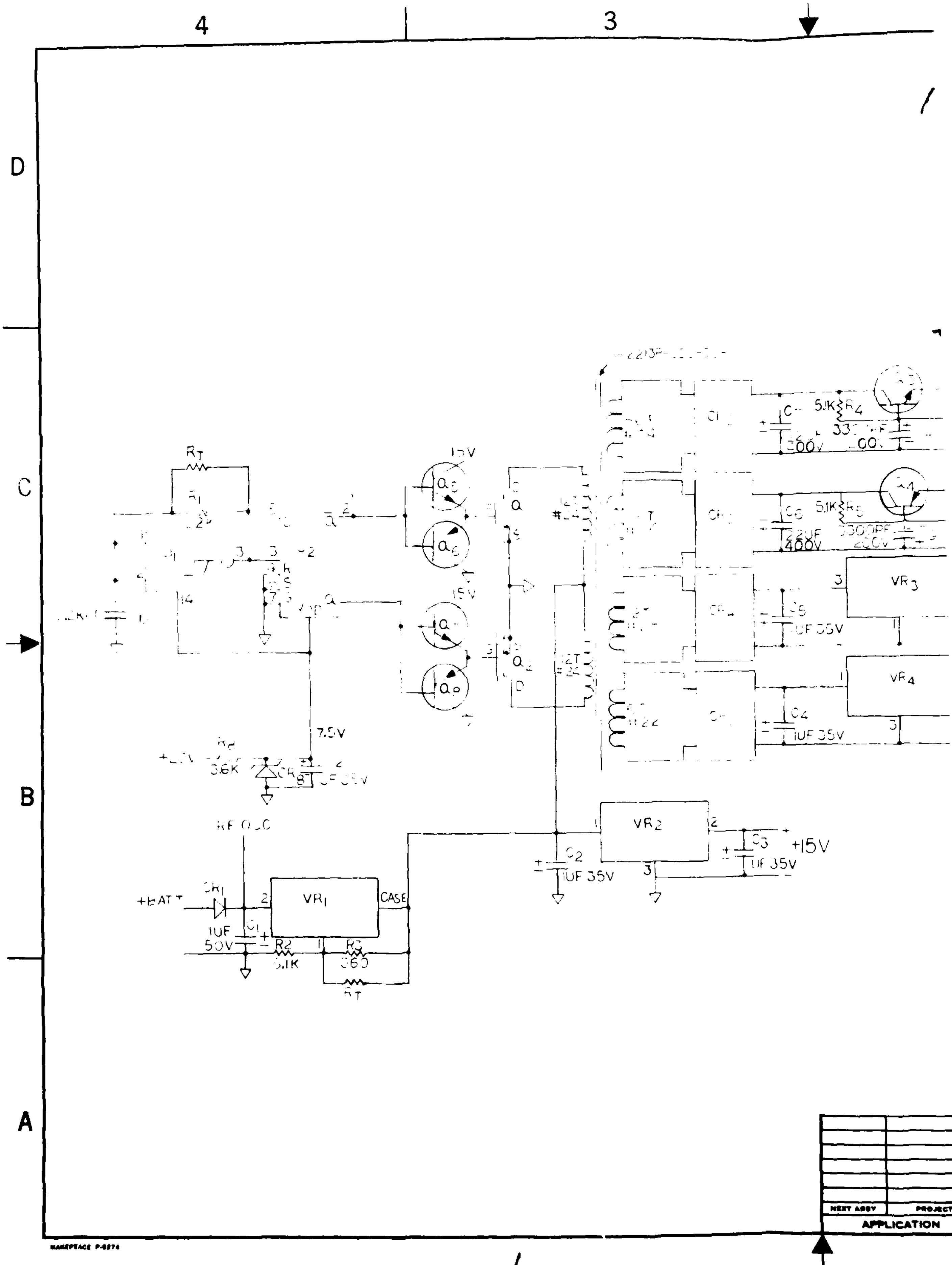
CONTRACT NUMBER 513

NORTHEASTERN UNIVERSITY

COLLEGE OF ENGINEERING

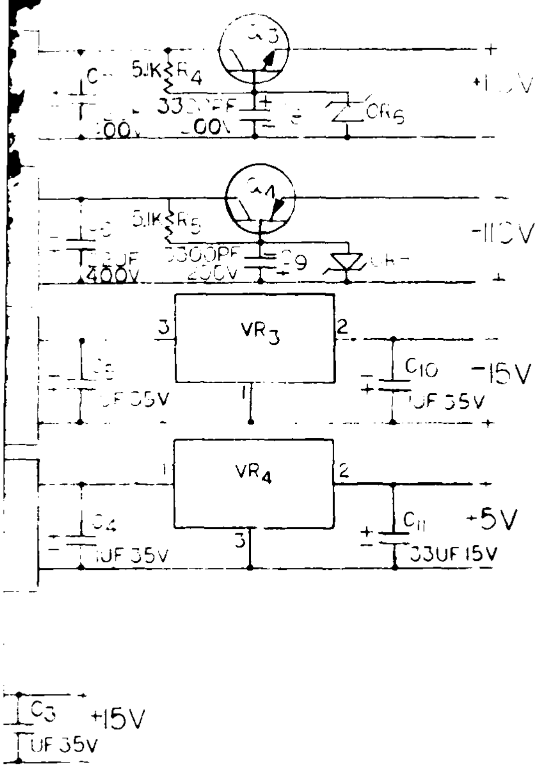
BOSTON, MASS. 02115

A



4
3
D
C
B
A
RT
15V
5.1K R4
5.1K R5
22UF
400V
3300PF
VR3
VR4
VR2
VR1
C4
1UF 35V
C2
1UF 35V
C3
1UF 35V
+15V
7.5V
3.6K
RF OSC
+BATT
CR1
1UF
50V
C1
CASE
R2
5.1K
R3
360
NEXT ASSY
PROJECT
APPLICATION

REVISIONS			
SYMBOL	DESCRIPTION	DATE	APPROVAL



U1- CD4[illegible]3BD (1/2)
U2- CD4[illegible]3BD (1/2)

Q1 - IRF 5[illegible]
Q2 - IRF [illegible]
Q3 - M[illegible]
Q4 - M[illegible]
Q5 - 2N2222A
Q6 - 2N2907A
Q7 - 2N2222A
Q8 - 2N2907A

CR1 - [illegible]
CR2 - 676-2
CR3 - 676-2
CR4 - 676-2
CR5 - 676-2
CR6 - IN4490
CR7 - IN4490
CR8 - IN775

VR1 - LM217K
VR2 - UA78M15K
VR3 - UA79M15HC
VR4 - UA7805UC

NEXT ASSY	PROJECT
APPLICATION	

TOLERANCE UNLESS OTHERWISE NOTED:
DECIMAL: x x ± .01, x x x ± .005
FRACTIONAL: ± 1/64
ANGULAR: ± 0° 30'
SURFACE FINISH: 125
BREAK ALL SHARP EDGES AND DEBURR
FINISH

DRAWN: ASO
CHECKED:
SCALE:
MATERIAL:

ENG'R: R SUKYS
DATE: 8-19-8[illegible]

LIPD POWER SUPPLY

FIGURE 7

CONTRACT NUMBER: 8531

NORTHEASTERN UNIVERSITY

COLLEGE OF ENGINEERING
BOSTON, MASS. 02115

LIPD PS000

APPENDIX A

PCM FRAME

WORD	1	AMU CONTROL DATA MSBYTE
WORD	2	AMU CONTROL DATA LSBYTE
WORD	3	RATIO CONTROL DATA MSBYTE
WORD	4	RATIO CONTROL DATA LSBYTE
WORD	5	SPECTRA COUNTER DATA MSBYTE
WORD	6	SPECTRA COUNTER DATA LSBYTE
WORD	7	AC MONITOR
WORD	8	HV1 MONITOR
WORD	9	HV2 MONITOR
WORD	10	COMBINED BIAS MONITOR
WORD	11	± DC MONITOR
WORD	12	± 15V MONITOR
WORD	13	BATTERY V. MONITOR
WORD	14	TEMPERATURE MONITOR
WORD	15	QUADRUPOLE BIAS CONTROL DATA
WORD	16	BIAS 2 CONTROL DATA
WORD	17	BIAS 3 CONTROL DATA
WORD	18	BIAS 4 CONTROL DATA
WORD	19	FRAME SYNC WORD 1
WORD	20	FRAME SYNC WORD 2

APPENDIX B

COMMAND CODES

Command codes are given in the decimal notation. The address (A) and the data (D) represent hexadecimal numbers.

CMD 1.	128; AAA; DD	-	Enters data into the EEPROM.
CMD 2.	129; AAA	-	Sends data from the EEPROM.
CMD 3.	130; AA	-	Sends data from a selected monitor.
CMD 4.	131; DDD	-	Enters data into the Control DAC.
CMD 5.	132; DDD	-	Enters data into the Ratio DAC.
CMD 6.	133; AA; DD	-	Enters data into the selected Bias DAC.
CMD 7.	134; AA; DD	-	Enter data into the selected Offset DAC.
CMD 8.	135; AA	-	Sends data from the RAM.
CMD 9.	136; AA; DD	-	Enters data into the RAM.
CMD 10.	137;	-	RF/HV ON
CMD 11.	138	-	RF/HV OFF
CMD 12.	139	-	Positive Ion Mode
CMD 13.	140	-	Negative Ion Mode
CMD 14.	141; AAA	-	Executes a segment of a mass filter program and sends one to three frames of data through the serial link.
CMD 15.	142	-	Transfers control to the flight program.
CMD 16.	168	-	End of transmission code.
CMD 17.	127	-	Reset
CMD 18.	255	-	This code is sent back to the external control to indicate an error in the received instruction.

COMMAND ADDRESS ASSIGNMENTS

CMD 1 & 2	EEPROM	000H-7FFH
CMD 3	MONITORS:	
	1. COMBINED BIAS	00H
	2. ± 15V	01H
	3. HV1	02H
	4. HV2	03H
	5. ± DC	04H
	6. BATTERY	05H
	7. AC AMPLITUDE	06H
	8. TEMPERATURE	07H
CMD 6	BIAS:	
	1. DAC A (QUADRUPOLE)	00H
	2. DAC B	01H
	3. DAC C	02H
	4. DAC D	03H
CMD 7	OFFSET:	
	1. DAC A (± DC)	00H
	2. DAC B (-DC)	01H
	3. DAC C (AC)	02H
CMD 8 & 9	RAM	00-7FH
CMD 14	EEPROM PROGRAM BLOC	(010 X N) H WHERE 01H ≤ N ≤ 7FH

APPENDIX C

EEPROM DATA FORMAT

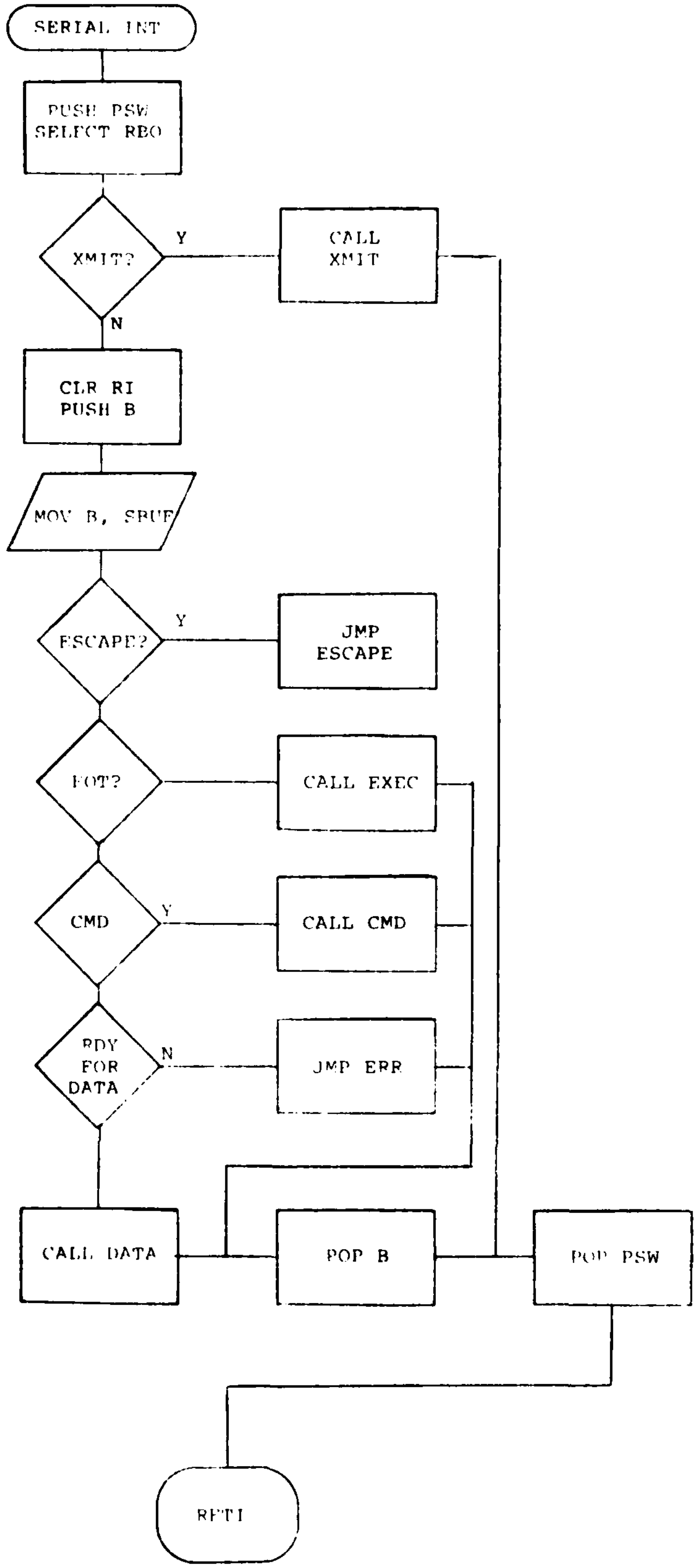
000H	FRAME SYNC. WORD 1 (EBH)
001H	FRAME SYNC. WORD 2 (90H)
002H	NOSECONE EJECT TIME: FIRST INTERVAL
003H	+ SECOND INTERVAL
004H	BACK-UP NOSECONE EJECT TIME
005H	HV AND AC EXCITER ON TIME
006H TO 00FH	AVAILABLE FOR COMMENTS
XX0H	HI-BYTE CONTROL DAC (1st AMU)
XX1H	LO-BYTE CONTROL DAC
XX2H	HI-BYTE RATIO DAC
XX3H	LO-BYTE RATIO DAC
XX4H	OFFSET DAC A
XX5H	OFFSET DAC B
XX6H	OFFSET DAC C
XX7H	BIAS DAC A (QUADRUPOLE)
XX8H	BIAS DAC B
XX9H	BIAS DAC C
XXAH	BIAS DAC D
XXBH	HI-BYTE CONTROL DAC (2nd. AMU)
XXCH	LO-BYTE CONTROL DAC
XXDH	HI-BYTE CONTROL DAC (3rd. AMU)
XXEH	LO-BYTE CONTROL DAC
XXFH	END OF PAGE/PROGRAM FLAG (00H/FFH)

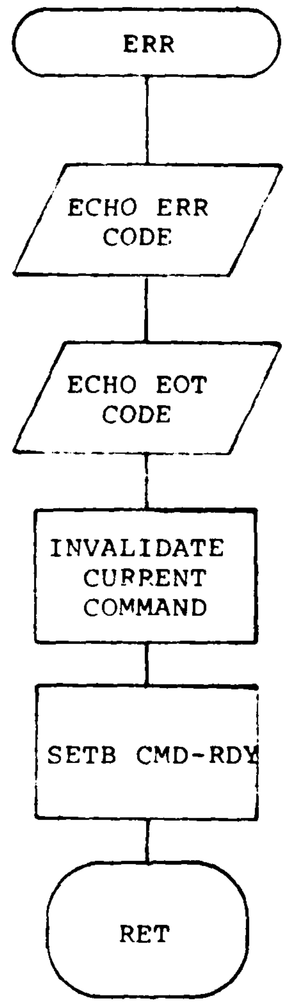
NOTE:

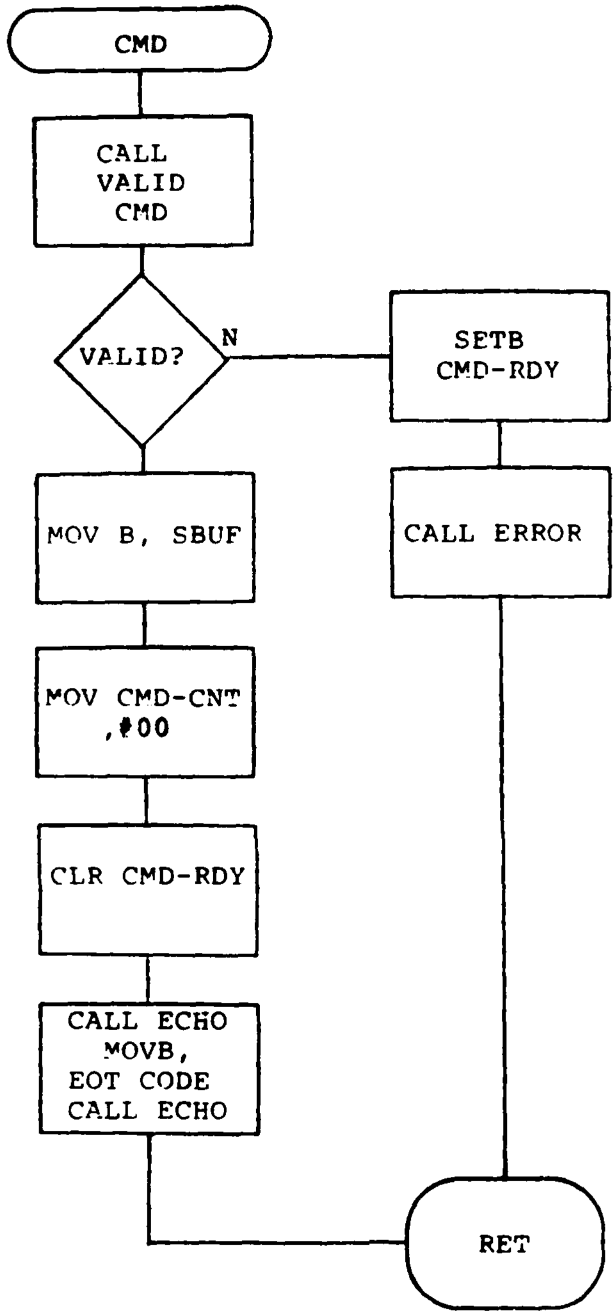
1. Control and ratio DAC data 12 bits left justified.
2. 00H in locations XXBH, XXDH and XXFH advances the program to the next page. [p. XX0H to p. (XX+1) 0H].
3. FFH in locations XXBH, XXDH and XXFH returns program to the first page [p.XX0H to p.010H].

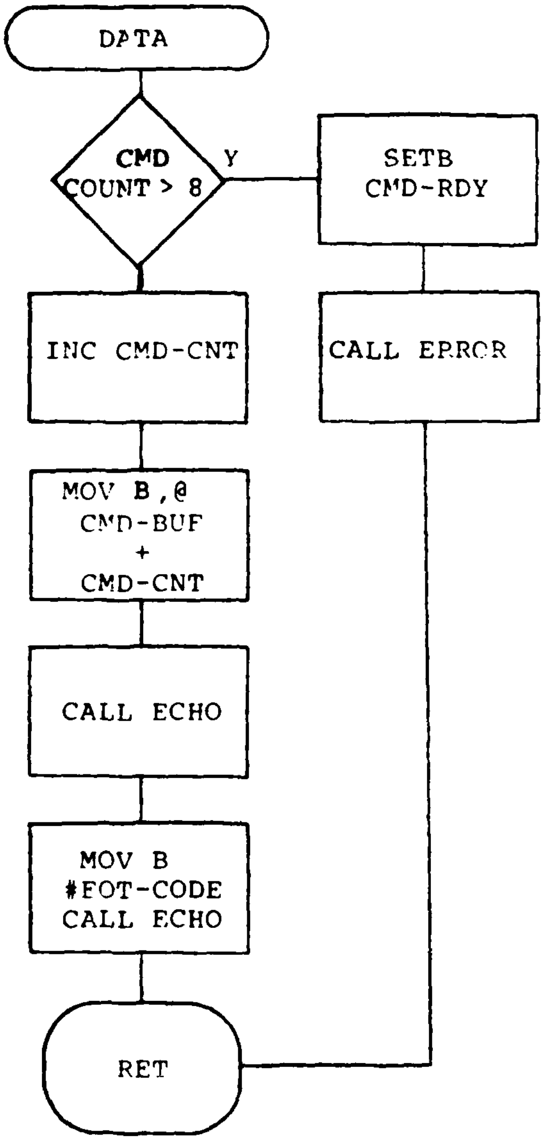
APPENDIX D

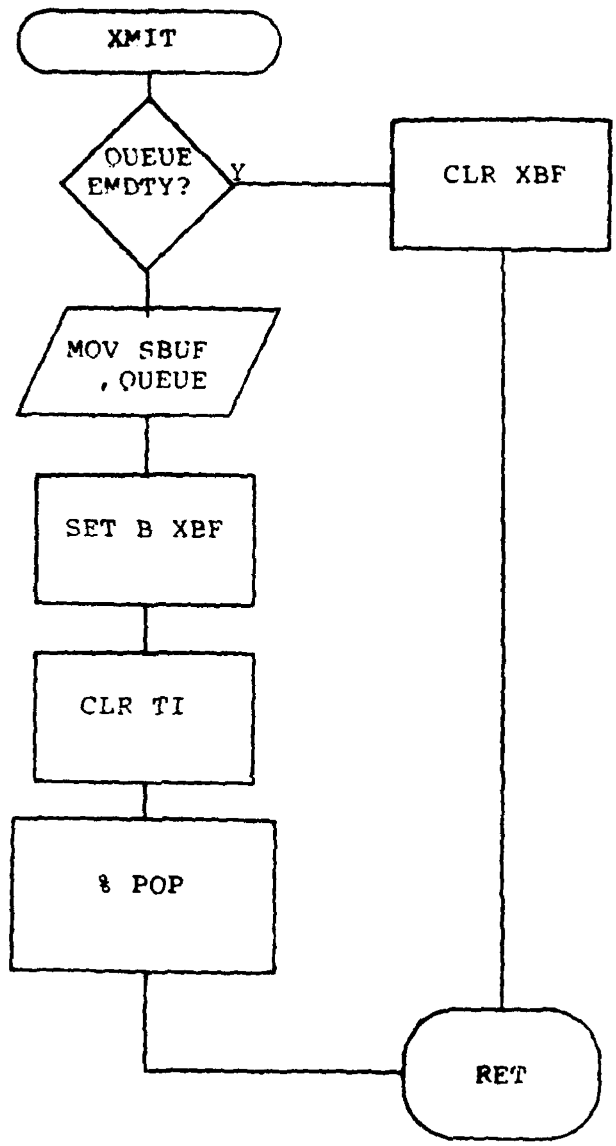
FLOW GRAPHS

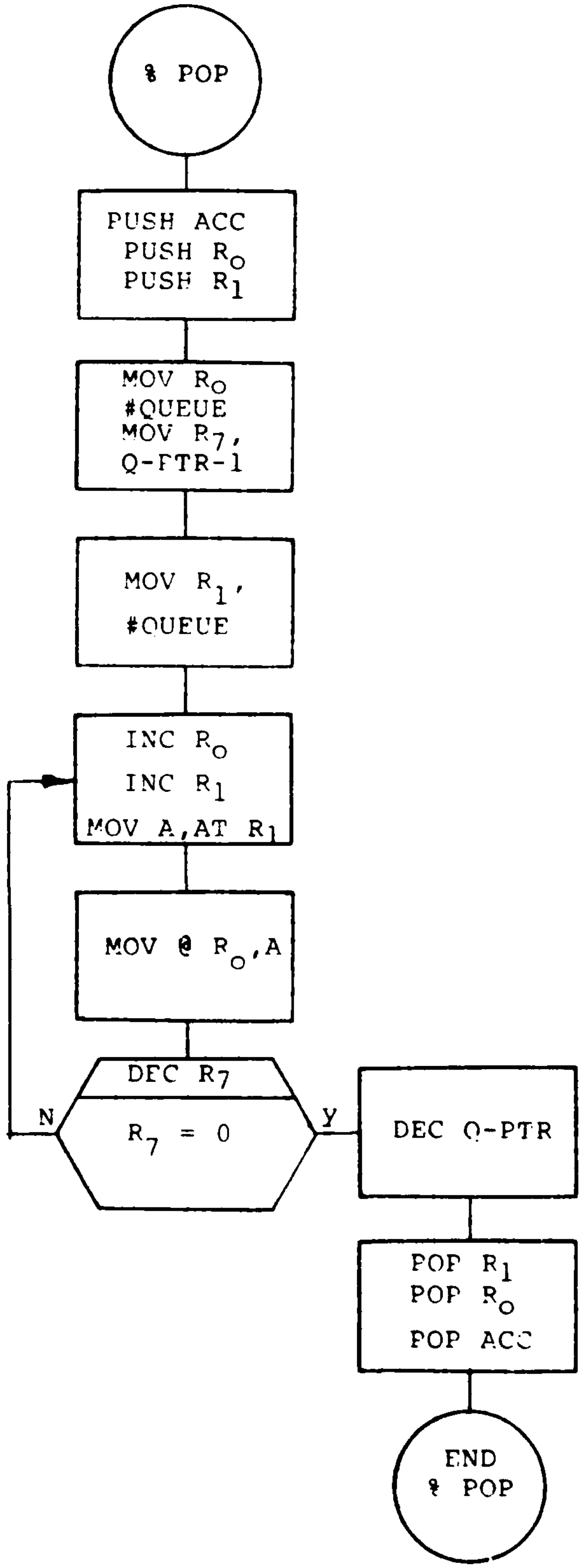

SERIAL INT
PUSH PSW
SELECT RBO
XMIT?
Y
N
CALL
XMIT
CLR RI
PUSH B
MOV B, SBUF
ESCAPE?
Y
JMP
ESCAPE
EOT?
CALL EXEC
CMD
Y
CALL CMD
RDY
FOR
DATA
N
JMP ERR
CALL DATA
POP B
POP PSW
RETI

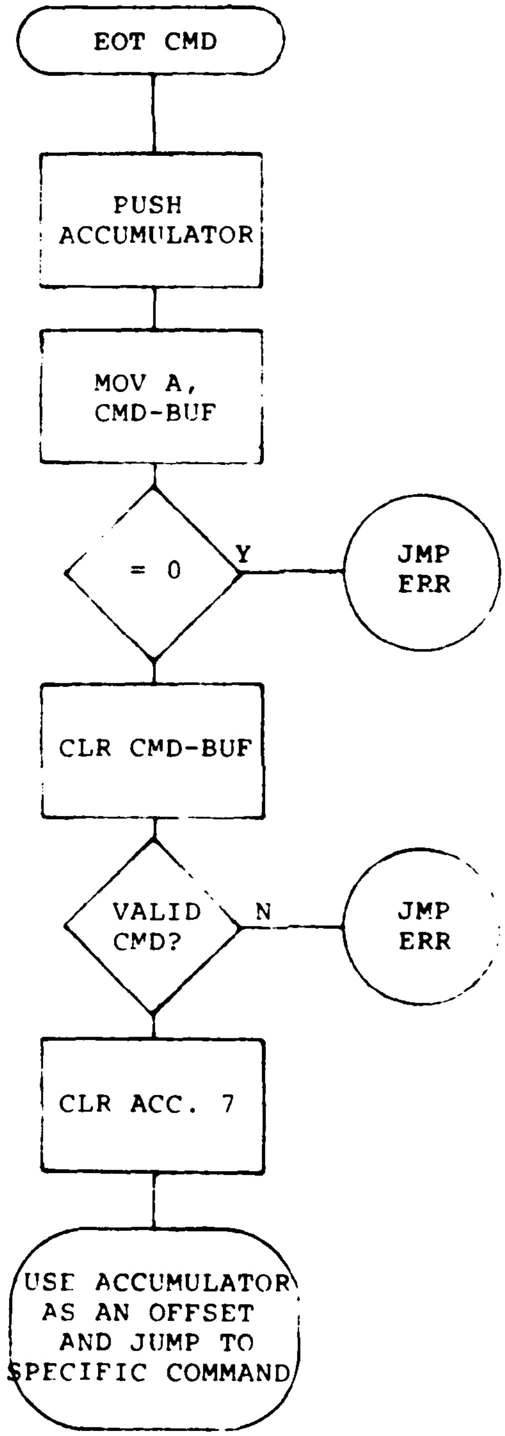

ERR
ECHO ERR CODE
ECHO EOT CODE
INVALIDATE CURRENT COMMAND
SETB CMD-RDY
RET

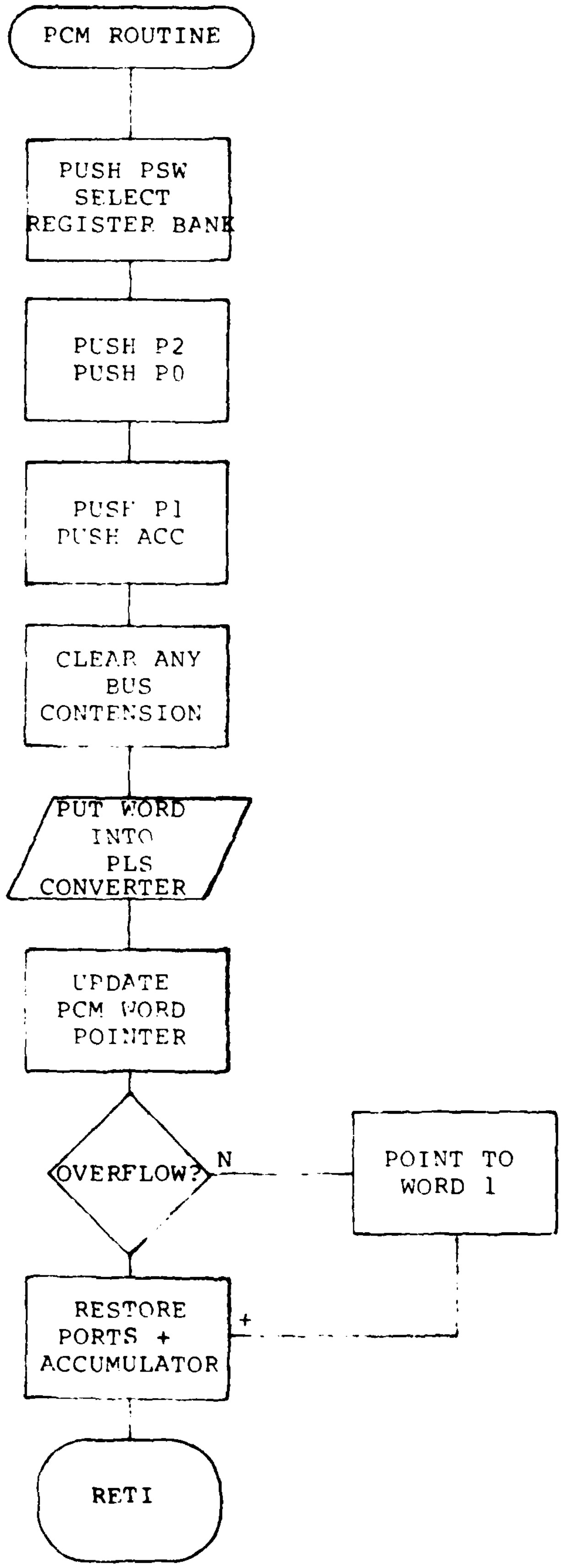

CMD
CALL VALID CMD
VALID?
N
SETB CMD-RDY
CALL ERROR
MOV B, SBUF
MOV CMD-CNT ,#00
CLR CMD-RDY
CALL ECHO MOVB, EOT CODE CALL ECHO
RET

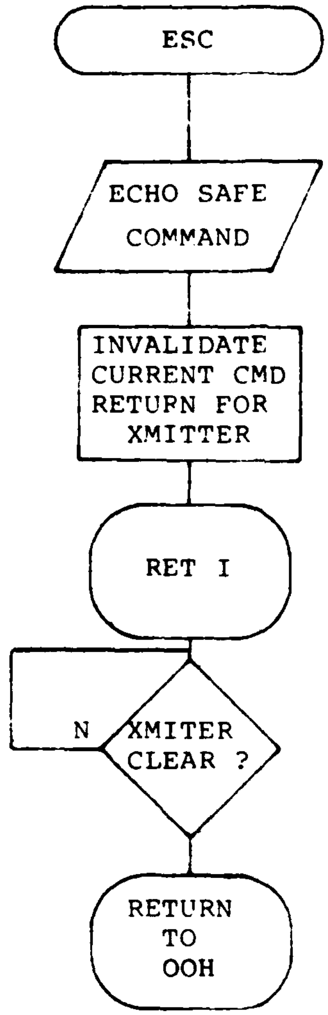

DATA
CMD COUNT > 8
Y
SETB CMD-RDY
INC CMD-CNT
CALL ERROR
MOV B,@ CMD-BUF + CMD-CNT
CALL ECHO
MOV B #EOT-CODE CALL ECHO
RET


XMIT
QUEUE EMPTY?
Y
CLR XBF
MOV SBUF ,QUEUE
SET B XBF
CLR TI
% POP
RET


% POP
PUSH ACC
PUSH R0
PUSH R1
MOV R0
#QUEUE
MOV R7,
Q-PTR-1
MOV R1,
#QUEUE
INC R0
INC R1
MOV A,AT R1
MOV @ R0,A
DEC R7
R7 = 0
N
Y
DEC Q-PTR
POP R1
POP R0
POP ACC
END
% POP


EOT CMD
PUSH ACCUMULATOR
MOV A, CMD-BUF
= 0
Y
JMP ERR
CLR CMD-BUF
VALID CMD?
N
JMP ERR
CLR ACC. 7
USE ACCUMULATOR AS AN OFFSET AND JUMP TO SPECIFIC COMMAND


PCM ROUTINE
PUSH PSW
SELECT
REGISTER BANK
PUSH P2
PUSH P0
PUSH P1
PUSH ACC
CLEAR ANY
BUS
CONTENSION
PUT WORD
INTO
PLS
CONVERTER
UPDATE
PCM WORD
POINTER
OVERFLOW?
N
POINT TO
WORD 1
RESTORE
PORTS +
ACCUMULATOR
+
RETI


ESC
ECHO SAFE COMMAND
INVALIDATE CURRENT CMD RETURN FOR XMITTER
RET I
N
XMITER CLEAR ?
RETURN TO OOH

APPENDIX E

PROGRAM

ISIS-II MCS-51 MACRO ASSEMBLER V2.1
OBJECT MODULE PLACED IN :F1:LIPD.OBJ
ASSEMBLER INVOKED BY: :F1:ASM51 :F1:LIPD.ASM

```
LOC  OBJ          SOURCE

                  $PL(50)
                  $TITLE(             LIPD (SUPER ARCAS))
                  $XREF
                  $DATE(16 OCT 85)
                  $SB
                  $DEBUG
                  $EP(:F1:LIPD.ERR)
                  $NOGE
                  $INCLUDE  :F1:LIPD.DEF
             =1   ;#####################################################################
             =1   ;#                                                                   #
             =1   ;#                    LIPD DEFINITION SECTION                        #
             =1   ;#                                                                   #
             =1   ;#####################################################################
             =1   ;
             =1   ;
0008         =1   PCM_POINT EQU   08H     ;R0 RB1 USE AS POINTER IN QUEUE FOR PCM WORD
----         =1   DSEG AT 09H
             =1   ; RB 1 R1-R7 AND RB2 + RB3 ARE NOT USED SO ASSIGN AS MEMORY
0009         =1   AMU_H:  DS      01      ;PCM WORD 2
000A         =1   AMU_L:  DS      01      :         3
000B         =1   RAT_H:  DS      01      :         4
000C         =1   RAT_L:  DS      01      :         5
000D         =1   Q_BIAS: DS      01      ;COM Q BIAS BIAS DAC 0 #0 ...PCM WORD 16
000E         =1   BIAS_1: DS      01      ;WORD 17
000F         =1   BIAS_2: DS      01      ;WORD 18
0010         =1   BIAS_3: DS      01      ;WORD 19
0011         =1   CAP_SAFETY:     DS      01
             =1   ;
             =1   ;
----         =1   DSEG AT 30H
             =1   ;
0030         =1   CMD_BUF:        DS      8       ;SAVE 8 BYTES FOR COMMAND DECODING
0038         =1   CMD_CNT:        DS      01      ;# BYTES OF DATA RECIEVED FOR COMMAND
0039         =1   QUEUE:          DS      16H     ;20 BYTES FOR PCM/DATA/ECHO QUEUE
004F         =1   Q_PTR:          DS      01              ;HOLD # OF BYTS LEFT IN SERIAL QUEUE
0050         =1   STACK:          DS      01              ;AND THE REMAINING FOR A STACK
             =1   ;
             =1   ;
----         =1   BSEG            ;DEFINE THE BIT FLAGS
```

```
LOC  OBJ         LINE    SOURCE

             =1          ;
 0010        =1          CMD_RDY        BIT    10H
 0011        =1          XBF            BIT    11H      ;XMIT BUSY FLAG
 0012        =1          CMD1FLG        BIT    12H
 0013        =1          IS_FLT         BIT    13H
 0014        =1          SERIAL_STEP    BIT    14H      ;COMMUNICATE DATA VIA THE SERIAL LINK FLAG
 0015        =1          MULTI_AMU      BIT    15H      ;MULTIPLE AMU FLAG
 0016        =1          TIME_BIT       BIT    16H      ;TOGGLING AT INT1 RATE
 0017        =1          SAVE_BIT       BIT    17H      ;STORAGE SPACE FOR MON OE DURING INT1
 0094        =1          MON_ALE        BIT    P1.4     ;MONITOR ALE PIN
 0093        =1          MON_STRT       BIT    P1.3     ;MONITOR START CONVERSION PIN
 0092        =1          MON_OE         BIT    P1.2     ;MONITOR OUTPUT ENABLE PIN
 0090        =1          XFR            BIT    P1.0     ;DC/RAT DAC TRANSFER PIN
 0097        =1          ION_CONT       BIT    P1.7     ;POSITIVE NEGATIVE ION CONTROL PIN
 00B5        =1          RF_HV          BIT    P3.5     ;RF HV DISABLE PIN
 00B4        =1          TST            BIT    P3.4     ;FLIGHT/TEST PIN
 0091        =1          CNT            BIT    P1.1     ;COUNTER LATCH/COUNT PIN
 00A6        =1          SELECT         BIT    P2.6     ;7 LINE DECODER ENABLE PIN
 0095        =1          STROBE         BIT    P1.5     ;RELAY DRIVER STROBE PIN
 0096        =1          OD             BIT    P1.6     ;RELAY DRIVER OUTPUT DISABLE (1 = OFF
             =1          ;
             =1          ;
             =1          ;*************************************************************************
             =1          ;*                                                                       *
             =1          ;*                   SELECTOR VALUES FOR PORT 2                          *
             =1          ;*                                                                       *
             =1          ;*************************************************************************
 0040        =1          EEPROM_SELECT  EQU    40H      ; X1000XXX     Y0
 0048        =1          D_HIGH         EQU    48H      ; X1001XXX     Y1
 0050        =1          D_LOW          EQU    50H      ; X1010XXX     Y2
 0058        =1          LSB_RF         EQU    58H      ; 01011XXX     Y3
 00D8        =1          MSB_RF         EQU    0D8H     ; 11011XXX     Y3
 0060        =1          LSB_DC         EQU    60H      ; 01110XXX     Y4
 00E0        =1          MSB_DC         EQU    0E0H     ; 11110XXX     Y4
 0068        =1          BIAS_0_SELECT  EQU    68H      ; X1101XXX     Y5
 0070        =1          BIAS_1_SELECT  EQU    70H      ; X1110XXX     Y6
 0078        =1          PCM_LOAD       EQU    78H      ; X1111XXX     Y7
             =1          ;
             =1          ;
             =1          ;
 0000        =1          MON_SELECT     EQU    00H
             =1          ;
             =1          ;
             =1          ;WORKING VALUES
             =1          ;
```

```
LOC  OBJ        LINE    SOURCE

0041         =1         AA       EQU    'A'
0042         =1         B        EQU    'B'
0030         =1         ZER      EQU    '0'
0039         =1         NIN      EQU    '9'
0006         =1         RF_MON   EQU    06H
0002         =1         HV_1_MON EQU    02H
0003         =1         HV_2_MON EQU    03H
0000         =1         COMB_MON EQU    00H
0004         =1         DC_MON   EQU    04H
0001         =1         VCC_MON EQU     01H
0005         =1         BAT_MON EQU     05H
0007         =1         TEMP_MON EQU    07H
00F2         =1         BAUD_COUNT EQU  0F2H    ;1200 BAUD COUNT RATE
             =1         ;
             =1         ;
             =1         ;
             =1         ;SPECIAL COMMANDS/CODES
             =1         ;
007F         =1         ESC_CODE        EQU     7FH
00FF         =1         ERR_CODE        EQU     0FFH
00AB         =1         EOT_CODE        EQU     0ABH
             =1         ;
             =1         ;
             =1         ;
----         =1         XSEG AT 4000
0FA0         =1         FRAME_WORD_0:   DS      1       ;FRAME SYNC WORD 0 AT EEPROM 000
0FA1         =1         FRAME_WORD_1:   DS      1       ;              1           001
0FA2         =1         CAP_DELAY:      DS      1       ;THE DELAY COUNT OF INTO'S TO BLOW CAP
0FA3         =1         DELAY_2:        DS      1       ;THE SECONDARY DELAY TO REPEAT THE BLOWING
             =1         ;                                THE CAP AND START OF THE PROFILE
0FA4         =1         DELAY_3:        DS      1
0FA5         =1         TRASH_EE:       DS      11      ; WORDS RESERVED FOR USER RECORDS
0FB0         =1         PROFILE:        DS      2032    ; THE REST OF THE EEPROM
             =1         ;
             =1         ;
             =1         $EJECT
```

```
LOC  OBJ        LINE    SOURCE

           =1    122    SERIAL_BOOT_CODE SEGMENT CODE
           =1    123    PROFILE_FLT_CODE SEGMENT CODE
           =1    124    $EJECT
```

```
LOC  OBJ          SOURCE

                  $INCLUDE( :F1:POP.MAC)
             =1   ;####################### LIFO MACRO DEFINITION SECTION #######################
----         =1   CSEG
             =1   %*DEFINE(POP)
             =1   LOCAL FIFO
             =1   LOCAL TO_DONE
             =1   (
             =1   %'............... FIRST IN FIRST OUT OF QUEUE ..........................%'
             =1          PUSH    00H
             =1          PUSH    01H
             =1          MOV     R0,#QUEUE
             =1          MOV     R1,#QUEUE
             =1          INC     R1
             =1          MOV     R7,Q_PTR
             =1          DJNZ    R7,%FIFO
             =1          JMP     %TO_DONE
             =1   %FIFO:
             =1          MOV     A,@R1
             =1          MOV     @R0,A
             =1          INC     R1
             =1          INC     R0
             =1          DJNZ    R7,%FIFO
             =1   %TO_DONE:
             =1          MOV     @R1,#00H
             =1          DEC     Q_PTR
             =1          POP     01H
             =1          POP     00H
             =1   )
             =1   %*DEFINE(WAIT(WAIT_TIME))
             =1   LOCAL TO_DO_IT
             =1   LOCAL WAIT_ONE_MS
             =1   LOCAL TO_DONE
             =1   (
             =1   %'................ WAIT WAIT_TIME/10 SECONDS ...........................%'
             =1          PUSH    ACC
             =1          PUSH    00H
             =1          PUSH    01H
             =1          MOV     R1,%WAIT_TIME
             =1   %TO_DO_IT:
             =1          MOV     A,R1
             =1          JZ      %TO_DONE
             =1          MOV     R0,#100D
             =1          SETB    TIME_BIT
             =1   %WAIT_ONE_MS:
             =1          JB      TIME_BIT,$
```

```
LOC  OBJ          LINE     SOURCE

                  =1                 JNB     TIME_BIT,$
                  =1                 DJNZ    R0,%WAIT_ONE_MS
                  =1                 DEC     R1
                  =1                 JMP     %TO_DO_IT
                  =1       %TO_DONE:
                  =1                 POP     01H
                  =1                 POP     00H
                  =1                 POP     ACC
                  =1       )
                  =1  130  %*DEFINE(GET_AMU)
                  =1                 MOVX    A,@DPTR             %'GET THE AMU HIGH BYTE%'
                  =1                 MOV     AMU_H,A
                  =1                 INC     DPTR
                  =1                 MOVX    A,@DPTR             %'GET THE AMU LOW BYTE%'
                  =1                 MOV     AMU_L,A
                  =1                 INC     DPTR
                  =1       )
                  =1  131  %*DEFINE(GET_RAT_AND_BIASES)LOCAL GET_NEXT)
                  =1                 MOV     R2,#05H
                  =1                 MOV     R0,#RAT_H
                  =1       %GET_NEXT:
                  =1                 MOVX    A,@DPTR
                  =1                 INC     DPTR
                  =1                 MOV     @R0,A               %'SAVE THE PARAMETER READY%'
                  =1                 INC     R0                  %'POINT TO NEXT PARAMETER%'
                  =1                 DJNZ    R2,%GET_NEXT
                  =1       )
                  =1  132  %*DEFINE(SET_OFFSETS)(
                  =1                 MOVX    A,@DPTR
                  =1                 MOV     P0,ACC
                  =1                 MOV     P2,#BIAS_1_SELECT
                  =1                 MOV     P2,#00
                  =1                 INC     DPTR
                  =1                 MOVX    A,@DPTR
                  =1                 MOV     P0,ACC
                  =1                 MOV     P2,#BIAS_1_SELECT+1
                  =1                 MOV     P2,#00
                  =1                 INC     DPTR
                  =1                 MOVX    A,@DPTR
                  =1                 MOV     P0,ACC
                  =1                 MOV     P2,#BIAS_1_SELECT+2
                  =1                 MOV     P2,#00
                  =1                 INC     DPTR
                  =1                 MOVX    A,@DPTR
                  =1                 MOV     P0,ACC
```

```
LOC  OBJ            LINE     SOURCE

               =1                    MOV     P2,#BIAS_1_SELECT+3
               =1                    MOV     P2,#00
               =1                    INC     DPTR
               =1            ;
               =1   133      %*DEFINE(SET_AMU_VR)(
               =1            %'.............. PUT THE AMU AND VR VALUES INTO THE DACS ...............%'
               =1                    MOV     P0,AMU_H
               =1                    MOV     P2,#MSB_RF
               =1                    MOV     P2,#00
               =1                    MOV     P0,AMU_L
               =1                    MOV     P2,#LSB_RF
               =1                    MOV     P2,#00
               =1                    MOV     P0,RAT_H
               =1                    MOV     P2,#MSB_DC
               =1                    MOV     P2,#00
               =1                    MOV     P0,RAT_L
               =1                    MOV     P2,#LSB_DC
               =1                    MOV     P2,#00
               =1            )
               =1   134      %*DEFINE(SET_BIASES)(
               =1                    MOV     A,0_BIAS
               =1                    MOV     C,ACC.7
               =1                    MOV     ION_CONT,C      %' SELECT POSITIVE OR NEGATIVE ION MODE %'
               =1                    MOV     P0,0_BIAS
               =1                    MOV     P2,#BIAS_0_SELECT
               =1                    MOV     P2,#00H
               =1                    MOV     P0,BIAS_1
               =1                    MOV     P2,#BIAS_0_SELECT+1
               =1                    MOV     P2,#00H
               =1                    MOV     P0,BIAS_2
               =1                    MOV     P2,#BIAS_0_SELECT+2
               =1                    MOV     P2,#00H
               =1                    MOV     P0,BIAS_3
               =1                    MOV     P2,#BIAS_0_SELECT+3
               =1            )
               =1   135      ;#################################################################################
                    136      $INCLUDE(:F1:LIPD.BT)
----           =1   137      CSEG AT 00
               =1   138      ;
               =1   139      ;
0000 020025    =1   140              JMP     TO_BOOT
               =1   141      ;
               =1   142      ;
0003           =1   143      ORG     EXTI0
0003 020000  F =1   144              JMP     PCM_ROUTINE
```

```
LOC  OBJ              SOURCE

               =1     ;
0013           =1     ORG     EXTI1
0013 32        =1             RETI
               =1     ;
               =1     ;
               =1     ;
0023           =1     ORG     SINT
0023 020000   F =1            JMP     SERIAL
               =1     ;
               =1     ;
0035           =1     ORG 35H
               =1     ;
               =1     ;
               =1     TO_BOOT:
               =1     ;
               =1     USING 0
0035 C2D3      =1             CLR     RS0
0037 C2D4      =1             CLR     RS1
0039 75A000    =1             MOV     P2,#00H         ;CLEAR OUT RESET CLEAR
003C D296      =1             SETB    CD              ;PREVENT THE CAP BLOWING
003E C295      =1             CLR     STROBE          ;DONT STROBE ANYTHING INTO THE DRIVER
0040 D2B5      =1             SETB    RF_HV           ;TURN OFF THE VOLTAGES
0042 C292      =1             CLR     MON_OE
0044 C294      =1             CLR     MON_ALE
0046 C290      =1             CLR     XFR
0048 D2B8      =1             SETB    PX0             ;##############################
004A D2B8      =1             SETB    IT0             ; READY INTO FOR WATCH DOG CIRCUIT
004C D2A8      =1             SETB    EX0
004E D2AF      =1             SETB    EA
0050 D289      =1             SETB    IE0             ;CLEAR OUT WATCH DOG WITH INT0 INTERUPT
0052 00        =1             NOP
0053 00        =1             NOP
0054 904000    =1             MOV     DPTR,#4000H     ;ENTER THE PCM SYNC WORDS
0057 E0        =1             MOVX    A,@DPTR
0058 F539      =1             MOV     QUEUE,A
005A A3        =1             INC     DPTR
005B E0        =1             MOVX    A,@DPTR
005C F53A      =1             MOV     QUEUE+1,A
005E 750839    =1             MOV     PCM_POINT,#QUEUE
0061 751100    =1             MOV     CAP_SAFETY,#00  ;PREVENT BLOWING OF CAP
0064 7580FF    =1             MOV     P0,#0FFH                ;RESET PORTS IF AN ESCAPE CMD
0067 75A000    =1             MOV     P2,#00H
006A 758150    =1             MOV     SP,#STACK       ;RESET THE STACK POINTER
               =1     ;##########################################################################
006D 020000   F =1            JMP     SERIAL_BOOT
```

```
LOC  OBJ            SOURCE

               =1   ;*************************************************************************
               =1   ; FOR TESTING PURPOSES
 0005          =1   TEST_TIME      EQU     5D
0070 7805      =1          MOV     R0,#TEST_TIME
0072 7905      =1          MOV     R1,#TEST_TIME
0074 7A05      =1          MOV     R2,#TEST_TIME
0076 D2B4      =1   IF_FLT: SETB   TST              ;TEST FOR #TEST TIME
0078 20B406    =1          JB      TST,DEC_RTN
007B 1A        =1          DEC     R2               ; DEC IF TEST
007C D9F8      =1          DJNZ    R1,IF_FLT        ; LOOP TO TEST PIN
007E 020084    =1          JMP     TO_BOOT_IT
               =1   ;
               =1   ;
               =1   DEC_RTN:
0081 18        =1          DEC     R0               ;DECREMENT IF FLIGHT
0082 D9F2      =1          DJNZ    R1,IF_FLT        ;LOOP TO TEST 5 TIMES
               =1   ;
               =1   ;
               =1   TO_BOOT_IT:                     ;IF EITHR TEST IS VALID FOR TEST TIME TIMES
               =1   ;                               THEN BOOT PROPER FOR TYPE
               =1   ;
0084 EA        =1          MOV     A,R2
0085 6000    F =1          JZ      SERIAL_BOOT      ;IF VALID 5 TIMES THEN BOOT FOR TEST
               =1   MAY_FLIGHT:
0087 E8        =1          MOV     A,R0             ;ELSE
0088 7003      =1          JNZ     TO_RESET_PAYLOAD
008A 020000  F =1          JMP     FLIGHT_BOOT      ;IF NEITHER IS VALID THEN RECYCLE
               =1   TO_RESET_PAYLOAD:
008D 0100      =1          JMP     RESET
               =1   ;
               =1   ;
                    $INCLUDE( :F1:SERIAL.BT)
               =1   ;
               =1   ;
               =1   ;
               =1   ;
               =1   ;****** A BENCH TEST IS IN PROGRESS ******
               =1   ;
----           =1   RSEG SERIAL_BOOT_CODE
               =1   ;
               =1   SERIAL_BOOT:
0000 D210      =1          SETB    CMD_RDY          ;PRESET SRIAL FLAGS
0002 C211      =1          CLR     XBF
0004 753000    =1          MOV     CMD_BUF,#00H
0007 753800    =1          MOV     CMD_CNT,#00H
```

```
LOC  OBJ           LINE     SOURCE

000A 754F00     =1  235              MOV    Q_PTR,#00H
000D 758920     =1  236              MOV    TMOD,#20H       ;TIMER 1 MODE 2
0010 758BF?     =1  237              MOV    TL1,#BAUD_COUNT ;SET UP FOR 1200 BAUD
0013 758DF?     =1  238              MOV    TH1,#BAUD_COUNT
0016 759850     =1  239              MOV    SCON,#50H       ;8 BIT NO PARITY SERIAL LINK
0019 D28E       =1  240              SETB   TR1             ;TURN ON TIMER 1
001B C299       =1  241              CLR    TI              ;CLEAR OUT INTERUPT FLAGS
001D C298       =1  242              CLR    RI
001F C2BC       =1  243              CLR    PS              ;SERIAL PORT LOW PRIORITY
0021 751100     =1  244              MOV    CAP_SAFETY,#00H
0024 D2AC       =1  245              SETB   ES              ;ENABL SERIAL INTERUPT
                =1  246     FLIGHT_BOOT:
0026 20AC03     =1  247              JB     ES,KEEP_SAFETY  ;IF IN A BENCH TEST MODE KEEP CAP SAFETY=00H
0029 7511FF     =1  248              MOV    CAP_SAFETY,#0FFH
                =1  249     KEEP_SAFETY:
002C D2B8       =1  250              SETB   PX0             ;INT 0 HI PRIORITY
002E D288       =1  251              SETB   IT0             ;INTERUPT ON FALLING EDGE INT0
0030 750839     =1  252              MOV    PCM_POINT,#QUEUE;POINT THE PCM TO WORD 0
0033 D2A8       =1  253              SETB   EX0             ;ENABLE INT0
0035 D2AF       =1  254              SETB   EA              ;ENABLE INTERUPTS
0037 30AC05     =1  255              JNB    ES,FLT_DELAY    ;IF A FLIGHT THEN JMP TO DELAY
                =1  256     ;
                =1  257     ;
                =1  258     WAIT:
003A 00         =1  259              NOP
003B 00         =1  260              NOP
003C 00         =1  261              NOP
003D 80FB       =1  262              JMP    WAIT            ;IF IN BENCH TEST MODE WAIT FOR COMMAND
                =1  263     ;
                =1  264     ;
                =1  265     FLT_DELAY:
003F 904002     =1  266              MOV    DPTR,#4002H
0042 E0         =1  267              MOVX   A,@DPTR         ;GET THE FRAME SYNC WORD 0
0043 F539       =1  268              MOV    QUEUE,A
0045 A3         =1  269              INC    DPTR
0046 E0         =1  270              MOVX   A,@DPTR         ;GET FRAME WORD 1
0047 F53A       =1  271              MOV    QUEUE+1,A
0049 A3         =1  272              INC    DPTR
004A E0         =1  273              MOVX   A,@DPTR         ;GET THE DELAY TIME1 FROM EEPROM
                =1  274              %WAIT(A)               ;WAIT EEPROM 002  10 SECONDS
006A A3         =1  296              INC    DPTR
006B E0         =1  297              MOVX   A,@DPTR
                =1  298              %WAIT(A)               ;WAIT EEPROM 003 /10 SECONDS
                =1  320     BLOW_CAP:
008B 74FF       =1  321              MOV    A,#0FFH
```

```
LOC  OBJ              SOURCE

00BD 5511        =1           ANL     A,CAP_SAFETY    ;SAFETY FEATURE
00BF F580        =1           MOV     P0,A
00C1 D295        =1           SETB    STROBE
00C3 C295        =1           CLR     STROBE          ;LATCH IN THE VALUE
00C5 C296        =1           CLR     OE              ;BLOW CAP ##############################
00C7 A3          =1           INC     DPTR
00C8 E0          =1           MOVX    A,@DPTR
                 =1           ZWAIT(A)                ;WAIT EEPROM 004 /10 SECONDS
                 =1   BLOW_CAP_AGAIN:
00E8 74FF        =1           MOV     A,#0FFH
00EA 5511        =1           ANL     A,CAP_SAFETY
00EC F580        =1           MOV     P0,A
00EE D295        =1           SETB    STROBE
00F0 C295        =1           CLR     STROBE          ;CAP IS BLOWN IF SAFETY 2LSB=1
00F2 A3          =1           INC     DPTR
00F3 E0          =1           MOVX    A,@DPTR
                 =1           ZWAIT(A)                ;WAIT EEPROM 005 /10 SECONDS
01E3 C2B5        =1           CLR     RF_HV           ;TURN ON THE RF AND HIGH VOLTAGE
01E5 020000    F =1           JMP     DC_PROFILE
                      $INCLUDE(:F1:LIFD.SER)
                 =1   ;
                 =1   ;
01E8 C0E0        =1   SERIAL: PUSH    ACC
01EA C0D0        =1           PUSH    PSW
                 =1   USING   0
01EC C2D3        =1           CLR     RS0
01EE C2D4        =1           CLR     RS1
01F0 209804      =1           JB      RI,RECIEVE      ;IF DATA/CMD INCOMING THE JMP
01F3 C299        =1           CLR     TI
01F5 120000    F =1           CALL    XMIT            ;ELSE TRNSMIT NEXT IN QUEUE
01F8 D0D0        =1           POP     PSW
01FA D0E0        =1           POP     ACC
01FC 32          =1           RETI                    ;AND GO BACK TO WAITING
                 =1   ;
                 =1   ;
                 =1   RECIEVE:
01FD C298        =1           CLR     RI
01FF 85998A      =1           MOV     B,SBUF          ;SAVE INCOMING IN B
0202 20F779      =1           JB      B.7,CMD         ;JUMP IF A COMMAND IS RECIEVED
0205 201005      =1           JB      CMD_RDY,RCV_ERR ;IF EXPECTING A COMMAND AND RECIEVE
                 =1                                   ;DATA THEN ERR
0208 E53B        =1           MOV     A,CMD_CNT
020A B40803      =1           CJNE    A,#08BH,NO_ERR  ;IF TOO MANY PIECES OF DATA ERROR
                 =1   RCV_ERR:
020D 020000    F =1           JMP     ERR             ;= 8
```

```
LOC  OBJ          LINE    SOURCE

0110 5005      =1   409   NO_ERR: JNC    TO_ERR          ;> 8
0112 E5F0      =1   410           MOV    A,B
0114 B44703    =1   411           CJNE   A,#6,LT_6
0117 020000  F =1   412   TO_ERR: JMP    ERR             ;IF DATA =6 THEN ERR
011A 4003      =1   413   LT_6:   JC     IS_LT_6         ;< 6
011C 020000  F =1   414           JMP    ERR             ;>=6
               =1   415   IS_LT_6:
011F B44003    =1   416           CJNE   A,#AA-1H,NOT_LT_A
0122 020000  F =1   417           JMP    ERR             ;=A-1
               =1   418   NOT_LT_A:
0125 5016      =1   419           JNC    VALID           ;A<= V  =F
0127 B43A03    =1   420           CJNE   A,#NIN+1,LT_9
012A 020000  F =1   421           JMP    ERR             ;9  V  A
012D 4003      =1   422   LT_9:   JC     IS_LT_9
012F 020000  F =1   423           JMP    ERR             ;9  V  A
               =1   424   IS_LT_9:
0132 B42F03    =1   425           CJNE   A,#ZER-1H,GT_0
0135 020000  F =1   426           JMP    ERR
0138 5003      =1   427   GT_0:   JNC    VALID           ;0 = V  =A
013A 020000  F =1   428           JMP    ERR             ;0  V
               =1   429   VALID:
013D E538      =1   430           MOV    A,CMD_CNT       ;GET THE CMD/DATA POINTER
013F 2431      =1   431           ADD    A,#CMD_BUF+1    ;MAKE IT POINT TO THE ADDRESS / DATA SECTION
0141 F8        =1   432           MOV    R0,A
0142 E5F0      =1   433           MOV    A,B
0144 F6        =1   434           MOV    @R0,A           ;AND SAVE THE DATA IN THE BUFFER
0145 0538      =1   435           INC    CMD_CNT         ;POINT TO THE NEXT POSITION
0147 120000  F =1   436           CALL   ECHO            ;ECHO BACK THE DATA
014A D0D0      =1   437           POP    PSW
014C D0E0      =1   438           POP    ACC
014E 32        =1   439           RETI                   ;RETURN FOR MORE DATA OR EOT CODE
               =1   440   ;
               =1   441   ;
               =1   442   XMIT:
014F 7FFF      =1   443           MOV    R7,#0FFH        ;WAIT FOR APPROX 1MS
0151 DFFE      =1   444           DJNZ   R7,$            ;TO ALLOW SEPARATION OF XMITTED DATA
0153 E54F      =1   445           MOV    A,Q_PTR         ;CHECK TO SEE IF QUEUE IS EMPTY
0155 7003      =1   446           JNZ    Q_NOT_EMPTY
0157 C211      =1   447           CLR    XBF             ;NOTHING IN THE PROCESS OF BEING XMITTED
0159 22        =1   448           RET
               =1   449   Q_NOT_EMPTY:
015A 853999    =1   450           MOV    SBUF,QUEUE      ;GET THE NEXT PIECE OF DATA IN LINE FOR XMIT
               =1   451           %POP                   ;TRANSMIT THE NEXT (FIRST IN .. LAST OUT
017B D211      =1   473           SETB   XBF             ;SHOW THE XMIT AS BUSY
017D 22        =1   474           RET                    ;AND LEAVE
```

```
LOC  OBJ            LINE    SOURCE

               =1   475     ;
               =1   476     ;
               =1   477     ;
               =1   478     CMD:
017E E5F0      =1   479             MOV     A,B
0180 B47F03    =1   480             CJNE A,#ESC_CODE,NOT_ESC
0183 020000  F =1   481             JMP     ESC_CMD
               =1   482     NOT_ESC:
0186 B4AB10    =1   483             CJNE    A,#EOT_CODE,NOT_EOT
0189 C082      =1   484             PUSH    DPL
018B C083      =1   485             PUSH    DPH
018D 120000  F =1   486             CALL    EOT_CMD
0190 D083      =1   487             POP     DPH
0192 D082      =1   488             POP     DPL
0194 D0D0      =1   489             POP     PSW
0196 D0E0      =1   490             POP     ACC
0198 32        =1   491             RETI
               =1   492     NOT_EOT:
0199 753B00    =1   493             MOV     CMD_CNT,#00H            ;RESET TO ACCEPT DATA FOR A NEW COMMAND
019C F53C      =1   494             MOV     CMD_BUF,A               ;SAVE THE COMMAND IN THE 1ST POSITION
019E E53B      =1   495             MOV     A,CMD_CNT
01A0 C216      =1   496             CLR     CMD_RDY
01A2 120000  F =1   497             CALL    ECHO
01A5 D0D0      =1   498             POP     PSW
01A7 D0E0      =1   499             POP     ACC
01A9 32        =1   500             RETI
               =1   501     ;
               =1   502     ESC_CMD:
01AA 75F07F    =1   503             MOV     B,#ESC_CODE
01AD 120000  F =1   504             CALL    ECHO
01B0 758150    =1   505             MOV SP,#STACK
01B3 7400      =1   506             MOV     A,#00
01B5 C0E0      =1   507             PUSH    ACC
01B7 C0E0      =1   508             PUSH    ACC
01B9 900000  F =1   509             MOV     DPTR,#PRE_ESC
01BC C082      =1   510             PUSH    DPL
01BE C083      =1   511             PUSH    DPH
01C0 32        =1   512             RETI                    ;ABORT EITHER INTERUPT
               =1   513     PRE_ESC:
01C1 2011FD    =1   514             JB      XBF,$           ;ESC ECHO SENT
01C4 C2AF      =1   515             CLR     EA
01C6 32        =1   516             RETI                    ;AND RETURN TO RESET
               =1   517     ;
               =1   518     ;
               =1   519     ECHO:
```

```
LOC  OBJ                SOURCE

01C7 C0E0         =1            PUSH    ACC
01C9 C000         =1            PUSH    00H
01CB E54F         =1            MOV     A,Q_PTR
01CD B41503       =1            CJNE    A,#Q_PTR-QUEUE-1,ROOM_IN_Q
01D0 020000     F =1            JMP     Q_FULL
                  =1    ROOM_IN_Q:
01D3 2429         =1            ADD     A,#QUEUE              ;POINT INTO THE QUEUE
01D5 F8           =1            MOV     R0,A
01D6 A6F0         =1            MOV     @R0,B                 ;AND ENTER THE ECHO
01D8 054F         =1            INC     Q_PTR
01DA E54F         =1            MOV     A,Q_PTR
01DC B40105       =1            CJNE    A,#01H,GT1            ;CREATE A XMIT INT IF FIRST ENTRY
01DF 201102       =1            JB      YBF,GT1               ;ONLY CREATE AN INTERUPT IF IN PROCESS
                  =1                                          ;OF XMISSION
01E2 D299         =1            SETB    TI                    ;CAUSE AN INTERUPT UPON RETURN
                  =1    GT1:
01E4 D000         =1            POP     00H
01E6 D0E0         =1            POP     ACC
01E8 22           =1            RET
                  =1    ;
01E9 3099FD       =1    Q_FULL: JNB     TI,Q_FULL
01EC 120000     F =1            CALL    XMIT
01EF D000         =1            POP     00H
01F1 D0E0         =1            POP     ACC
01F3 80D2         =1            JMP     ECHO
                  =1    ;
                  =1    ERR:
01F5 C0E0         =1            PUSH    ACC
01F7 E5F0         =1            MOV     A,B
01F9 B47F02       =1            CJNE    A,#ESC_CODE,NO_ESC_ERR
01FC 80AC         =1            JMP     ESC_CMD
                  =1    NO_ESC_ERR:
01FE D0E0         =1            POP     ACC
0200 75F0FF       =1            MOV     B,#ERR_CODE
0203 120000     F =1            CALL    ECHO
0206 753800       =1            MOV     CMD_CNT,#00H    ;INVALIDATE CURRENT COMMAND
0209 753000       =1            MOV     CMD_BUF,#00H    ;POINT TO THE FIRST DATA POSITION
020C D210         =1            SETB    CMD_RDY         ;ACCEPT ONLY A COMMAND AS NEXT
                  =1    FORCE_RETURN:
020E 758154       =1            MOV     SP,#STACK+4
0211 D0D0         =1            POP     PSW
0213 D0E0         =1            POP     ACC
0215 32           =1            RETI
                  =1    ;
                  =1    ;
```

```
LOC  OBJ                SOURCE

              =1        EOT_CMD:
0216 E530     =1                MOV   A,CMD_BUF        ;GET THE CMD'S VALUE
0218 753000   =1                MOV   CMD_BUF,#00H     ;REPLACE WITH A ZERO FLAG
021B 7002     =1                JNZ   CMD_SET          ;IF NO CMD THEN ERR
021D 80D6     =1                JMP   ERR              ;IF CMD=0 THE NO CMD SO ERR
              =1        CMD_SET:
  000E        =1        NO_OF_CMDS    EQU    14D       ;15 COMMANDS 0-14 ARE VALID
021F C2E7     =1                CLR   ACC.7            ;STRIP THE MSB
0221 23       =1                RL    A
0222 23       =1                RL    A                ;PROVIDE A X4 OFFSET
0223 900000 F =1                MOV   DPTR,#TOP_OF_JMP_TBLE
0226 73       =1                JMP   @A+DPTR          ;JUMP TO PROPER VECTOR
              =1        TOP_OF_JMP_TBLE:
0227 020000 F =1                JMP   CMD0
022A 00       =1                NOP
022B 020000 F =1                JMP   CMD1
022E 00       =1                NOP
022F 020000 F =1                JMP   CMD2
0232 00       =1                NOP
0233 020000 F =1                JMP   CMD3
0236 00       =1                NOP
0237 020000 F =1                JMP   CMD4
023A 00       =1                NOP
023B 020000 F =1                JMP   CMD5
023E 00       =1                NOP
023F 020000 F =1                JMP   CMD6
0242 00       =1                NOP
0243 020000 F =1                JMP   CMD7
0246 00       =1                NOP
0247 020000 F =1                JMP   CMD8
024A 00       =1                NOP
024B 020000 F =1                JMP   CMD9
024E 00       =1                NOP
024F 020000 F =1                JMP   CMD10
0252 00       =1                NOP
0253 020000 F =1                JMP   CMD11
0256 00       =1                NOP
0257 020000 F =1                JMP   CMD12
025A 00       =1                NOP
025B 020000 F =1                JMP   CMD13
025E 00       =1                NOP
025F 020000 F =1                JMP   CMD14
0262 00       =1                NOP
0263 00       =1                NOP
0264 00       =1                NOP
```

```
LOC  OBJ              SOURCE

0265 00        =1              NOP
0266 00        =1              NOP
0267 00        =1              NOP
0268 00        =1              NOP
0269 00        =1              NOP
026A 00        =1              NOP
026B 8088      =1              JMP     ERR
               =1     ;
               =1     ;
               =1     ;
               =1     ;
026D C212      =1     CMD0:    CLR     CMD1FLG          ;POKE COMMAND
               =1     CMD_1_DECODE:
026F E531      =1              MOV     A,CMD_BUF+1      ;POKE COMMAND... START DECODING ADDRESS
0271 120000  F =1              CALL    DECODE           ;CHANGE ASCII CHARACTER INTO HEX VALUE
0274 5407      =1              ANL     A,#07H           ;STRIP NOT APPLICABLE BITS
0276 F531      =1              MOV     CMD_BUF+1,A
0278 E532      =1              MOV     A,CMD_BUF+2
027A 120000  F =1              CALL    DECODE
027D C4        =1              SWAP    A
027E F532      =1              MOV     CMD_BUF+2,A
0280 E533      =1              MOV     A,CMD_BUF+3
0282 120000  F =1              CALL    DECODE
0285 4232      =1              ORL     CMD_BUF+2,A
0287 201228    =1              JB      CMD1FLG,CMD1_DECODED    ;ADDRESS IS DECODED INTO CMD_BUF+1 & +2
028A E534      =1              MOV     A,CMD_BUF+4
028C 120000  F =1              CALL    DECODE
028F C4        =1              SWAP    A
0290 F533      =1              MOV     CMD_BUF+3,A
0292 E535      =1              MOV     A,CMD_BUF+5
0294 120000  F =1              CALL    DECODE
0297 4233      =1              ORL     CMD_BUF+3,A      ;DATA AND ADDRESS DECODED
0299 853183    =1              MOV     DPH,CMD_BUF+1
029C 853282    =1              MOV     DPL,CMD_BUF+2
029F 438340    =1              ORL     DPH,#EEPROM_SELECT
02A2 E533      =1              MOV     A,CMD_BUF+3
02A4 F0        =1              MOVX    @DPTR,A          ;AND WRITE IT TO THE EEPROM
               =1     EEPROM_RET:
02A5 75F0AB    =1              MOV     B,#EOT_CODE
02A8 120000  F =1              CALL    ECHO             ;ECHO THE EOT CODE TO SHOW CMD COMPLETE
02AB D210      =1              SETB    CMD_RDY
02AD 22        =1              RET                      ;AND LEAVE
               =1     ;
               =1     ;
02AE D212      =1     CMD1:    SETB    CMD1FLG          ;PEEK COMMAND
```

```
LOC  OBJ            LINE     SOURCE

02B0 80BD        =1   655              JMP     CMD_1_DECODE    ;DECODE THE SAME AS CMD0
                 =1   656      CMD1_DECODED:
02B2 E531        =1   657              MOV     A,CMD_BUF+1
02B4 4440        =1   658              ORL     A,#EEPROM_SELECT
02B6 F583        =1   659              MOV     DPH,A
02B8 853282      =1   660              MOV     DPL,CMD_BUF+2
02BB E0          =1   661              MOVX    A,@DPTR
02BC F5F0        =1   662              MOV     B,A
02BE 120000    F =1   663              CALL    ECHO
02C1 75F0AB      =1   664              MOV     B,#EOT_CODE
02C4 120000    F =1   665              CALL    ECHO
02C7 22          =1   666              RET
                 =1   667      ;
                 =1   668      ;
                 =1   669      CMD2:                            ; ADAC TEST ROUTINE
02C8 E531        =1   670              MOV     A,CMD_BUF+1     ;GET THE HIGH NIBBLE OF THE MONITOR #
02CA 120000    F =1   671              CALL    DECODE
02CD C4          =1   672              SWAP    A
02CE F531        =1   673              MOV     CMD_BUF+1,A
02D0 E532        =1   674              MOV     A,CMD_BUF+2
02D2 120000    F =1   675              CALL    DECODE
02D5 4531        =1   676              ORL     A,CMD_BUF+1
02D7 120000    F =1   677              CALL    GET_MON
02DA F5F0        =1   678              MOV     B,A
02DC 120000    F =1   679              CALL    ECHO
02DF 75F0AB      =1   680              MOV     B,#EOT_CODE
02E2 120000    F =1   681              CALL    ECHO
02E5 22          =1   682              RET
                 =1   683      ;
                 =1   684      ;
                 =1   685      GET_MON:
02E6 4400        =1   686              ORL     A,#MON_SELECT
02E8 7580FF      =1   687              MOV     P0,#0FFH        ;MAKE SURE THE PORT IS CLEAR
02EB F5A0        =1   688              MOV     P2,A
02ED D294        =1   689              SETB    MON_ALE
02EF C294        =1   690              CLR     MON_ALE
02F1 D293        =1   691              SETB    MON_STRT
02F3 C293        =1   692              CLR     MON_STRT
02F5 75A000      =1   693              MOV     P2,#00H         ;DESELECT EVERYTHING
02F8 7FFF        =1   694              MOV     R7,#0FFH                ;PREPARE TO WAIT FOR 250 USEC
02FA DFFE        =1   695              DJNZ    R7,$
02FC 75A000      =1   696              MOV     P2,#MON_SELECT  ;RESELECT ADAC
02FF 7580FF      =1   697              MOV     P0,#0FFH        ;MAKE SURE P0 IS CLEAR
0302 D292        =1   698              SETB    MON_OE          ;ENABLE MONITOR OUTPUT
0304 E580        =1   699              MOV     A,P0            ;AND GET THE VALUE
```

```
LOC  OBJ             LINE     SOURCE

0306 C292       =1    700              CLR     MON_OE
0308 75A000     =1    701              MOV     P2,#00H
030B 22         =1    702              RET
                =1    703     ;
                =1    704     DECODE:
030C C3         =1    705              CLR     C
030D C0E0       =1    706              PUSH    ACC
030F 9441       =1    707              SUBB    A,#AA
0311 4005       =1    708              JC      NOT_A_F
0313 240A       =1    709              ADD     A,#0AH              ;IF A-F CORRECT FOR OFFSET
0315 1581       =1    710              DEC     SP                  ;RE-ALIGN THE STACK
0317 22         =1    711              RET
                =1    712     NOT_A_F:
0318 D0E0       =1    713              POP     ACC
031A C3         =1    714              CLR     C
031B 9430       =1    715              SUBB    A,#ZER
031D 22         =1    716              RET
                =1    717     ;
                =1    718     ;
                =1    719     CMD3:
031E 120000   F =1    720              CALL R12_BIT_DECODE
0321 C080       =1    721              PUSH    P0
0323 853180     =1    722              MOV     P0,CMD_BUF+1
0326 C0A0       =1    723              PUSH    P2
0328 75A0D8     =1    724              MOV     P2,#MSB_RF
032B D0A0       =1    725              POP     P2
032D 853280     =1    726              MOV     P0,CMD_BUF+2
0330 C0A0       =1    727              PUSH    P2
0332 75A058     =1    728              MOV     P2,#LSB_RF
0335 D0A0       =1    729              POP     P2
0337 D080       =1    730              POP     P0
0339 75F0A8     =1    731              MOV     B,#EOT_CODE
033C 120000   F =1    732              CALL    ECHO
033F C290       =1    733              CLR     XFR
0341 D290       =1    734              SETB    XFR
0343 22         =1    735              RET
                =1    736     CMD4:
0344 120000   F =1    737              CALL R12_BIT_DECODE
0347 C080       =1    738              PUSH    P0
0349 853180     =1    739              MOV     P0,CMD_BUF+1
034C C0A0       =1    740              PUSH    P2
034E 75A0E0     =1    741              MOV     P2,#MSB_DC
0351 D0A0       =1    742              POP     P2
0353 853280     =1    743              MOV     P0,CMD_BUF+2
0356 C0A0       =1    744              PUSH    P2
```

```
LOC  OBJ            LINE     SOURCE

0358 75A060     =1   745           MOV    P2,#LSB_DC
035B D0A0       =1   746           POP    P2
035D D080       =1   747           POP    P0
035F 75F0A8     =1   748           MOV    B,#EOT_CODE
0362 120000   F =1   749           CALL   ECHO
0365 C290       =1   750           CLR    XFR
0367 D290       =1   751           SETB   XFR
0369 22         =1   752           RET
                =1   753      ;
                =1   754      ;
                =1   755      R12_BIT_DECODE:
036A E531       =1   756           MOV    A,CMD_BUF+1
036C 120000   F =1   757           CALL   DECODE
036F C4         =1   758           SWAP   A
0370 F531       =1   759           MOV    CMD_BUF+1,A
0372 E532       =1   760           MOV    A,CMD_BUF+2
0374 120000   F =1   761           CALL   DECODE
0377 4231       =1   762           ORL    CMD_BUF+1,A
0379 E533       =1   763           MOV    A,CMD_BUF+3
037B 120000   F =1   764           CALL   DECODE
037E C4         =1   765           SWAP   A
037F F532       =1   766           MOV    CMD_BUF+2,A
0381 22         =1   767           RET
                =1   768      ;
                =1   769      ;
                =1   770      CMD5:                                 ;OFFSET/BIAS POKE
0382 E531       =1   771           MOV    A,CMD_BUF+1
0384 120000   F =1   772           CALL   DECODE
0387 4468       =1   773           ORL    A,#BIAS_0_SELECT
0389 F531       =1   774           MOV    CMD_BUF+1,A
038B E532       =1   775           MOV    A,CMD_BUF+2
038D 120000   F =1   776           CALL   DECODE
0390 C4         =1   777           SWAP   A
0391 F532       =1   778           MOV    CMD_BUF+2,A
0393 E533       =1   779           MOV    A,CMD_BUF+3
0395 120000   F =1   780           CALL   DECODE
0398 4232       =1   781           ORL    CMD_BUF+2,A
039A C080       =1   782           PUSH   P0
039C 853280     =1   783           MOV    P0,CMD_BUF+2
039F C0A0       =1   784           PUSH   P2
03A1 8531A0     =1   785           MOV    P2,CMD_BUF+1
03A4 D0A0       =1   786           POP    P2
03A6 D080       =1   787           POP    P0
03A8 75F0A8     =1   788           MOV    B,#EOT_CODE
03AB 120000   F =1   789           CALL   ECHO
```

```
LOC  OBJ           LINE    SOURCE

03AE 22        =1   790            RET
               =1   791    ;
               =1   792    ;
               =1   793    CMD6:                          ;BIAS/OFFSET POKE
03AF E531      =1   794            MOV     A,CMD_BUF+1
03B1 120000  F =1   795            CALL    DECODE
03B4 4470      =1   796            ORL     A,#BIAS_1_SELECT
03B6 F531      =1   797            MOV     CMD_BUF+1,A
03B8 E532      =1   798            MOV     A,CMD_BUF+2
03BA 120000  F =1   799            CALL    DECODE
03BD C4        =1   800            SWAP    A
03BE F532      =1   801            MOV     CMD_BUF+2,A
03C0 E533      =1   802            MOV     A,CMD_BUF+3
03C2 120000  F =1   803            CALL    DECODE
03C5 4232      =1   804            ORL     CMD_BUF+2,A
03C7 C080      =1   805            PUSH    P0
03C9 853280    =1   806            MOV     P0,CMD_BUF+2
03CC C0A0      =1   807            PUSH    P2
03CE 8531A0    =1   808            MOV     P2,CMD_BUF+1
03D1 D0A0      =1   809            POP     P2
03D3 D080      =1   810            POP     P0
03D5 75F0A8    =1   811            MOV     B,#EOT_CODE
03D8 120000  F =1   812            CALL    ECHO
03DB 22        =1   813            RET
               =1   814    CMD7:                          ;RAM PEEK
03DC E531      =1   815            MOV     A,CMD_BUF+1
03DE 120000  F =1   816            CALL    DECODE
03E1 C4        =1   817            SWAP    A
03E2 F531      =1   818            MOV     CMD_BUF+1,A
03E4 E532      =1   819            MOV     A,CMD_BUF+2
03E6 120000  F =1   820            CALL    DECODE
03E9 4231      =1   821            ORL     CMD_BUF+1,A
03EB C000      =1   822            PUSH    00H            ;R0 RB0
03ED A831      =1   823            MOV     R0,CMD_BUF+1
03EF E6        =1   824            MOV     A,@R0
03F0 D000      =1   825            POP     00             ;R0 RB0
03F2 F5F0      =1   826            MOV     B,A
03F4 120000  F =1   827            CALL    ECHO
03F7 75F0A8    =1   828            MOV     B,#EOT_CODE
03FA 120000  F =1   829            CALL    ECHO
03FD 22        =1   830            RET
               =1   831    ;
               =1   832    ;
               =1   833    CMD8:                          ;RAM POKE
03FE E531      =1   834            MOV     A,CMD_BUF+1
```

```
LOC  OBJ                 SOURCE

0400 120000   F =1                CALL    DECODE
0403 C4         =1                SWAP    A
0404 F531       =1                MOV     CMD_BUF+1,A
0406 E532       =1                MOV     A,CMD_BUF+2
0408 120000   F =1                CALL    DECODE
040B 4231       =1                ORL     CMD_BUF+1,A
040D E533       =1                MOV     A,CMD_BUF+3
040F 120000   F =1                CALL    DECODE
0412 C4         =1                SWAP    A
0413 F532       =1                MOV     CMD_BUF+2,A
0415 E534       =1                MOV     A,CMD_BUF+4
0417 120000   F =1                CALL    DECODE
041A 4532       =1                ORL     A,CMD_BUF+2
041C C000       =1                PUSH    00             ;R0 RB0
041E A831       =1                MOV     R0,CMD_BUF+1
0420 F6         =1                MOV     @R0,A
0421 D000       =1                POP     00             ;R0 RB0
0423 75F0A8     =1                MOV     B,#EOT_CODE
0426 120000   F =1                CALL    ECHO
0429 22         =1                RET
                =1        ;
                =1        ;
                =1        ;
                =1        CMD9:                          ;ENABLE HVRF
042A C2B5       =1                CLR     RF_HV
042C 75F0A8     =1                MOV     B,#EOT_CODE
042F 120000   F =1                CALL    ECHO
0432 22         =1                RET
                =1        ;
                =1        ;
                =1        ;
                =1        CMD10:                         ;DISABLE HVRF
0433 D2B5       =1                SETB    RF_HV
0435 75F0A8     =1                MOV     B,#EOT_CODE
0438 120000   F =1                CALL    ECHO
043B 22         =1                RET
                =1        ;
                =1        ;
                =1        ;
                =1        CMD11:                         ;CLR POS NEG ION SELECT
043C C297       =1                CLR     ION_CONT
043E 75F0A8     =1                MOV     B,#EOT_CODE
0441 120000   F =1                CALL    ECHO
0444 22         =1                RET
                =1        ;
```

```
LOC  OBJ            LINE     SOURCE

               =1    880     ;
               =1    881     ;
               =1    882     CMD12:                          ;SET POS NEG ION SELECT
0445 D297      =1    883             SETB    ION_CONT
0447 75F0A8    =1    884             MOV     B,#EOT_CODE
044A 120000  F =1    885             CALL    ECHO
044D 22        =1    886             RET
               =1    887     ;
               =1    888     ;
               =1    889     ;
               =1    890     CMD13:                          ;STEP SERIAL COMMAND
044E E531      =1    891             MOV     A,CMD_BUF+1
0450 120000  F =1    892             CALL    DECODE
0453 F583      =1    893             MOV     DPH,A
0455 E532      =1    894             MOV     A,CMD_BUF+2     ;HI NIBBLE DPL
0457 120000  F =1    895             CALL    DECODE
045A C4        =1    896             SWAP    A
045B F582      =1    897             MOV     DPL,A
045D E533      =1    898             MOV     A,CMD_BUF+3
045F 120000  F =1    899             CALL    DECODE
0462 4282      =1    900             ORL     DPL,A
0464 D214      =1    901             SETB    SERIAL_STEP
0466 7400    F =1    902             MOV     A,#LOW(CALL_PROFILE)
0468 C0E0      =1    903             PUSH    ACC
046A 7400    F =1    904             MOV     A,#HIGH(CALL_PROFILE)
046C C0E0      =1    905             PUSH    ACC
046E C215      =1    906             CLR     MULTI_AMU
0470 32        =1    907             RETI                    ;RETURN SO AS TO BE ABLE TO INTERUPT VIA THE
               =1    908     ;                                SERIAL LINK
               =1    909     CALL_PROFILE:
0471 2011FD    =1    910             JB      XBF,$           ;LOOP UNTIL QUEUE IS EMPTY
0474 120000  F =1    911             CALL    FLIGHT_PROFILE
               =1    912     NEXT_STEP:
0477 754F14    =1    913             MOV     Q_PTR,#20D
047A D299      =1    914             SETB    TI              ;CREATE A SERIAL INTERUPT
               =1    915     ;PROCESSING INTERUPTS TO SEND QUEUE
047C 00        =1    916             NOP
047D 2011FD    =1    917             JB      XBF,$           ;LOOP UNTIL ALL DATA IS SENT
0480 301508    =1    918             JNB     MULTI_AMU,STEP_EXIT
0483 2011FD    =1    919             JB      XBF,$
0486 120000  F =1    920             CALL    ENTRY
0489 80EC      =1    921             JMP     NEXT_STEP
               =1    922     STEP_EXIT:
048B 75F0A8    =1    923             MOV     B,#EOT_CODE
048E 120000  F =1    924             CALL    ECHO
```

```
LOC  OBJ            LINE     SOURCE

0491 C214       =1   925          CLR     SERIAL_STEP
0493 22         =1   926          RET
                =1   927     ;
                =1   928     ;
                =1   929     ;
                =1   930     CMD14:                        ;PCM RUN COMMAND
0494 900000   F =1   931          MOV     DPTR,#JMP_TO_PROFILE
0497 C082       =1   932          PUSH    DPL
0499 C083       =1   933          PUSH    DPH
049B 32         =1   934          RETI                      ;ALLOW SERIAL COMMANDS TO INTERUPT
                =1   935     JMP_TO_PROFILE:
049C 020000   F =1   936          JMP     DO_PROFILE        ;RELEASE CONTROL TO FLIGHT PROGRAM
                     937     $INCLUDE( :F1:LIPD.FLT)
----            =1   938     RSEG PROFILE_FLT_CODE
                =1   939     ;
                =1   940     ;
                =1   941     ;
                =1   942     DO_PROFILE:
0000 C216       =1   943          CLR     TIME_BIT
0002 904010     =1   944          MOV     DPTR,#4010H
                =1   945     FLIGHT_PROFILE:
0005 438340     =1   946          ORL     DPH,#EEPROM_SELECT
0008 C215       =1   947          CLR     MULTI_AMU
000A D290       =1   948          SETB    XFR
000C 75A060     =1   949          MOV     P2,#D_LOW               ;CLEAR THE COUNTER
000F 75A000     =1   950          MOV     P2,#00
0012 7580FF     =1   951          MOV     P0,#0FFH
                =1   952          %GET_AMU
001D 750838     =1   960          MOV     PCM_POINT,#QUEUE-1      ;ALIGN THE PCM TRAIN
0020 3016FD     =1   961          JNB     TIME_BIT,$              ;WAIT HERE TILL POINTING TO WORD 0
                =1   962     ;
                =1   963     ;
                =1   964     ;  THIS IS T=0 ** WORD 0 IS IN THE PROCESS OF BEING SENT **
                =1   965     ENTRY:
0023 301503     =1   966          JNB     MULTI_AMU,SET_NEW_VALS  ;IF MULTI AMU THEN LEAVE BIASES
0026 020000   F =1   967          JMP     WAIT_T_1
                =1   968     SET_NEW_VALS:
                =1   969          %GET_RAT_AND_BIASES
                =1   979          %SET_OFFSETS
                =1  1001          %SET_AMU_VR              ;SO SEND OUT THE AMU/RATIO VOLTAGES
                =1  1016          %SET_BIASES
00AA D290       =1  1032     WAIT_T_1:SETB   XFR         ;TRANSFER THE RF AND DC CONTROL LEVELS
00AC C290       =1  1033          CLR     XFR
00AE D290       =1  1034          SETB    XFR
00B0 D216       =1  1035          SETB    TIME_BIT         ;MAKE SURE THE FRAME IS ALIGNED
```

```
LOC  OBJ            SOURCE

00B2 2016FD    =1          JB     TIME_BIT,$       ; SO WAIT HERE UNTIL THINGS SETTLE
               =1   ;
               =1   ;  WORD 0 IS SENT BY PCM
               =1   ;
00B5 C083      =1          PUSH   DPH              ;SAVE DATA POINTER
00B7 C082      =1          PUSH   DPL              ;
00B9 904000    =1          MOV    DPTR,#4000H      ; GET FRAME WORD
00BC E0        =1          MOVX   A,@DPTR          ;                0
00BD F539      =1          MOV    QUEUE,A          ; RESTORE IT
00BF A3        =1          INC    DPTR             ;GET FRAME WORD
00C0 E0        =1          MOVX   A,@DPTR          ;                1
00C1 D082      =1          POP    DPL
00C3 D083      =1          POP    DPH              ; RESTORE THE DATA POINTER
               =1   WAIT_T_2:
00C5 3016FD    =1          JNB    TIME_BIT,$       ;WAIT TO SEND WORD 1
00C8 C291      =1          CLR    CNT              ;START COUNTING DATA T=T+1ms
               =1   ;
               =1   ;  WORD 1 IS SENT BY PCM
               =1   ;
00CA F53A      =1          MOV    QUEUE+1,A        ;WORD 1 IS SENT SO RESTORE WORD 1
00CC 2016FD    =1          JB     TIME_BIT,$               ;WAIT TO WRITE WORD 2
               =1   ;
               =1   ; WORD 2 IS SENT BY PCM
               =1   ;
               =1   ;
00CF 3016FD    =1          JNB    TIME_BIT,$       ;WAIT TO WRITE WORD 3
               =1   ;
               =1   ; WORD 3 IS SENT BY PCM
               =1   ;
               =1   ;
00D2 2016FD    =1          JB     TIME_BIT,$       ;WAIT TO WRITE WORD 4
               =1   ;
               =1   ; WORD 4 IS SENT BY PCM
               =1   ;
00D5 85093B    =1          MOV    QUEUE+2,AMU_H    ;RESTORE WORDS 2 AND 3
00D9 850A3C    =1          MOV    QUEUE+3,AMU_L
               =1   ;
00DB 3016FD    =1          JNB    TIME_BIT,$       ;WAIT TO WRITE WORD 5
               =1   ;
               =1   ; WORD 5 IS SENT BY PCM
               =1   ;
00DE 850B3D    =1          MOV    QUEUE+4,RAT_H    ;RESTORE WORD 4
00E1 850C3E    =1          MOV    QUEUE+5,RAT_L    ;RESTORE WORD 5
               =1   ;
00E4 2016FD    =1          JB     TIME_BIT,$       ;WAIT TO WRITE WORD 6
```

```
LOC  OBJ            LINE    SOURCE

               =1  1081     ;
               =1  1082     ; WORD 6 IS SENT BY PCM
               =1  1083             %GET_AMU                  ;GET THE NEXT VALUES FOR AMU
               =1  1091     ;
00EF 3016FD    =1  1092             JNB     TIME_BIT,$
               =1  1093     ;
               =1  1094     ; WORD 7 IS SENT BY PCM
               =1  1095     ;
00F2 7406      =1  1096             MOV     A,#RF_MON
00F4 120000  F =1  1097             CALL    ADC_MON           ;START ADAC CONVERSION OF RF MONITOR
               =1  1098     ;
00F7 2016FD    =1  1099             JB      TIME_BIT,$
               =1  1100     ;
               =1  1101     ; WORD 8 IS SENT BY PCM
               =1  1102     ;
00FA 120000  F =1  1103             CALL    ADAC              ;GET THE RF MONITOR VALUE
00FD F541      =1  1104             MOV     QUEUE+8,A         ;AND RESTORE WORD 8
00FF 7402      =1  1105             MOV     A,#HV_1_MON
0101 120000  F =1  1106             CALL    ADC_MON           ;START ADAC CONVERSION OF HV 1 MONITOR
               =1  1107     ;
0104 3016FD    =1  1108             JNB     TIME_BIT,$
               =1  1109     ;
               =1  1110     ; WORD 9 IS SENT BY PCM
               =1  1111     ;
0107 120000  F =1  1112             CALL    ADAC              ;GET THE HV 1 MONITOR VALUE
010A F542      =1  1113             MOV     QUEUE+9,A         ;AND RESTORE WORD 9
010C 7403      =1  1114             MOV     A,#HV_2_MON       ;
010E 120000  F =1  1115             CALL    ADC_MON           ;START CONVERSION OF HV 2 MONITOR
               =1  1116     ;
0111 2016FD    =1  1117             JB      TIME_BIT,$
               =1  1118     ;
               =1  1119     ; WORD 10 IS SENT BY PCM
               =1  1120     ;
0114 120000  F =1  1121             CALL    ADAC              ;GET THE HV 2 MONITOR VALUE
0117 F543      =1  1122             MOV     QUEUE+10,A        ;AND RESTORE WORD 10
0119 7400      =1  1123             MOV     A,#COMB_MON
011B 120000  F =1  1124             CALL    ADC_MON           ;START CONVERSION OF COMB MONITOR
               =1  1125     ;
011E 3016FD    =1  1126             JNB     TIME_BIT,$
               =1  1127     ;
               =1  1128     ; WORD 11 SENT BY PCM
               =1  1129     ;
0121 120000  F =1  1130             CALL    ADAC              ;GET THE COMB MONITOR VALUE
0124 F544      =1  1131             MOV     QUEUE+11,A        ;AND RESTORE WORD 11
0126 7404      =1  1132             MOV     A,#DC_MON
```

```
LOC  OBJ            LINE     SOURCE

0128 120000   F =1  1133            CALL    ADC_MON         ;START CONVERSION OF THE D.C. MONITOR
                =1  1134     ;
012B 2016FD     =1  1135            JB      TIME_BIT,$
                =1  1136     ;
                =1  1137     ; WORD 12 SENT BY PCM
                =1  1138     ;
012E 120000   F =1  1139            CALL    ADAC            ;GET THE D.C. MONITOR
0131 F545       =1  1140            MOV     QUEUE+12,A      ;RESTORE WORD 12
0133 7401       =1  1141            MOV     A,#VCC_MON
0135 120000   F =1  1142            CALL    ADC_MON         ;START THE CONVERSION OF THE +- 15 V MONITOR
                =1  1143     ;
0138 3016FD     =1  1144            JNB     TIME_BIT,$
                =1  1145     ;
                =1  1146     ; WORD 13 SENT BY PCM
                =1  1147     ;
013B 120000   F =1  1148            CALL    ADAC            ;GET THE +- 15 V MONITOR
013E F546       =1  1149            MOV     QUEUE+13,A      ;RESTORE WORD 13
0140 7405       =1  1150            MOV     A,#BAT_MON
0142 120000   F =1  1151            CALL    ADC_MON         ;START THE CONVERSION OF THE BATTERY MONITOR
                =1  1152     ;
0145 2016FD     =1  1153            JB      TIME_BIT,$
                =1  1154     ;
                =1  1155     ; WORD 14 SENT BY PCM
                =1  1156     ;
0148 120000   F =1  1157            CALL    ADAC            ;GET THE BATTERY MONITOR VALUE
014B F547       =1  1158            MOV     QUEUE+14,A      ;RESTORE WORD 14
014D 7407       =1  1159            MOV     A,#TEMP_MON
014F 120000   F =1  1160            CALL    ADC_MON         ;START THE CONVERSION OF THE TEMP MONITOR
                =1  1161     ;
0152 3016FD     =1  1162            JNB     TIME_BIT,$
                =1  1163     ;
                =1  1164     ; WORD 15 SENT BY PCM
                =1  1165     ;
0155 120000   F =1  1166            CALL    ADAC            ;GET THE TEMP MONITOR VALUE
0158 F548       =1  1167            MOV     QUEUE+15,A      ;RESTORE WORD 15
                =1  1168     ;
015A 2016FD     =1  1169            JB      TIME_BIT,$
                =1  1170     ;
                =1  1171     ; WORD 16 SENT BYE PCM
                =1  1172     ;
015D 850049     =1  1173            MOV     QUEUE+16,Q_BIAS         ;RESTORE WORD 16
0160 E509       =1  1174            MOV     A,AMU_H         ;TEST THE NEXT AMU FOR A CONTINUATION
                =1  1175                                    ; ARE ALREADY SET
0162 6034       =1  1176            JZ      NOT_MULTI_AMU
0164 B4FF08     =1  1177            CJNE    A,#0FFH,NOT_END_PROFILE ;IF FF THEN NEXT IS START
```

```
LOC  OBJ           LINE    SOURCE

0167 904010     =1  1178           MOV    DPTR,#4010H     ;POINT TO NEW BEGINING
016A C215       =1  1179           CLR    MULTI_AMU
016C 020000   F =1  1180           JMP    NOT_MULTI_AMU
                =1  1181    NOT_END_PROFILE:
016F D215       =1  1182           SETB   MULTI_AMU
                =1  1183           %SET_AMU_VR
0195 020000   F =1  1198           JMP    WORD_17_WAIT
                =1  1199    NOT_MULTI_AMU:
0198 A3         =1  1200           INC    DPTR
0199 A3         =1  1201           INC    DPTR
019A A3         =1  1202           INC    DPTR
019B A3         =1  1203           INC    DPTR
019C A3         =1  1204           INC    DPTR            ;ADJUST THE DATA POINTER TO POINT TO THE
                =1  1205                                  ; TOP OF A PAGE
019D 5382F0     =1  1206           ANL    DPL,#0F0H
01A0 538307     =1  1207           ANL    DPH,#07H
01A3 E583       =1  1208           MOV    A,DPH           ;CHECK FOR EEPROM OVERFLOW
01A5 7003       =1  1209           JNZ    NOT_EEPROM_RESET
01A7 758210     =1  1210           MOV    DPL,#10H        ; RESET TO POINT AT 010
                =1  1211    NOT_EEPROM_RESET:
01AA 438340     =1  1212           ORL    DPH,#EEPROM_SELECT
01AD C215       =1  1213           CLR    MULTI_AMU
                =1  1214           %SET_AMU
                =1  1222    ;
                =1  1223    WORD_17_WAIT:
01B7 3016FD     =1  1224           JNB    TIME_BIT,$
                =1  1225    ;
                =1  1226    ; WORD 17 SENT BY PCM
                =1  1227    ;
01BA 850E4A     =1  1228           MOV    QUEUE+17,BIAS_1         ;RESTORE WORD 17 AND SAVE FOR NEXT
                =1  1229    ;
01BD 2016FD     =1  1230           JB     TIME_BIT,$
                =1  1231    ; WORD 18 SENT BY PCM
01C0 850F4B     =1  1232           MOV    QUEUE+18,BIAS_2
                =1  1233    ;#### IN THE PROCESS OF SENDING WORD 19 ####
                =1  1234    ;####    REALIGN TO SEND WORD 0 NEXT    ####
01C3 750839     =1  1235           MOV    PCM_POINT,#QUEUE
01C6 3016FD     =1  1236           JNB    TIME_BIT,$
                =1  1237    ; WORD 19 SENT BY PCM ##### GET NEW DATA FOR QUEUE
01C9 D291       =1  1238           SETB   CNT
01CB 7580FF     =1  1239           MOV    P0,#0FFH
01CE 75A048     =1  1240           MOV    P2,#D_HIGH
01D1 85803F     =1  1241           MOV    QUEUE+6,P0              ;GET THE HIGH BYTE
01D4 75A000     =1  1242           MOV    P2,#00
01D7 7580FF     =1  1243           MOV    P0,#0FFH
```

```
LOC  OBJ            SOURCE

01DA 75A060    =1          MOV   P2,#D_LOW            ;GET THE LOW BYTE AND CLEAR THE COUNTER
01DD 858040    =1          MOV   QUEUE+7,P0
01E0 75A000    =1          MOV   P2,#00
01E3 85104C    =1          MOV   QUEUE+19,BIAS_3      ;RESTORE WORD 19
01E6 201403    =1          JB    SERIAL_STEP,PROFILE_RETURN;IF CALLED THEN EXECUTE A RETURN
01E9 020000  F =1          JMP   ENTRY                ;EXECUTE NEXT PROFILE
               =1   PROFILE_RETURN:
01EC 22        =1          RET                        ;RETURN TO CALLING PROGRAM
               =1   ;
               =1   ADC_MON:                          ;START ADAC CONVERSION
01ED C294      =1          CLR   MON_ALE
01EF 4400      =1          ORL   A,#MON_SELECT
01F1 C0A0      =1          PUSH  P2
01F3 F5A0      =1          MOV   P2,A
01F5 D294      =1          SETB  MON_ALE
01F7 C294      =1          CLR   MON_ALE
01F9 D0A0      =1          POP   P2
01FB D293      =1          SETB  MON_STRT                       ;START THE CONVERSION
01FD C293      =1          CLR   MON_STRT
01FF 22        =1          RET
               =1   ;
               =1   ;
               =1   ADAC:                             ;GET CONVERTED ANALOG VALUE
0200 C0A0      =1          PUSH  P2
0202 C080      =1          PUSH  P0
0204 75A000    =1          MOV   P2,#00
0207 7580FF    =1          MOV   P0,#0FFH
020A D292      =1          SETB  MON_OE
020C E580      =1          MOV   A,P0
020E C292      =1          CLR   MON_OE
0210 D080      =1          POP   P0
0212 D0A0      =1          POP   P2
0214 22        =1          RET
               =1   ;
               =1   ;
               =1   ; INTO DRIVEN ROUTINE FOR PCM LINK
               =1   PCM_ROUTINE:
0215 C0D0      =1          PUSH  PSW
               =1   USING 1                           ;
0217 C2D4      =1          CLR   RS1
0219 D2D3      =1          SETB  RS0
021B C090      =1          PUSH  P1
021D C292      =1          CLR   MON_OE
021F C0E0      =1          PUSH  ACC
0221 C0A0      =1          PUSH  P2
```

```
LOC  OBJ            LINE     SOURCE

0223 C080       =1  1289            PUSH    P0
0225 E6         =1  1290            MOV     A,@R0                   ;GET THE NEXT WORD
0226 08         =1  1291            INC     R0                      ;POINT TO THE NEXT WORD
0227 B84D02     =1  1292            CJNE    R0,#QUEUE+20,NOT_OVERFLOW
022A 7839       =1  1293            MOV     R0,#QUEUE               ;REALIGN IF OVERFLOW
                =1  1294     NOT_OVERFLOW:
022C 75A000     =1  1295            MOV     P2,#00
022F F580       =1  1296            MOV     P0,A
0231 75A078     =1  1297            MOV     P2,#PCM_LOAD            ;PUT THE WORD INTO THE PCM STREAM
0234 75A000     =1  1298            MOV     P2,#00
0237 B216       =1  1299            CPL     TIME_BIT                ;SHOW THAT THE WORD IS BEING SENT
0239 D080       =1  1300            POP     P0                      ;RESTORE THE WAY FOUND
023B D0A0       =1  1301            POP     P2
023D D0E0       =1  1302            POP     ACC
023F D090       =1  1303            POP     P1
0241 D0D0       =1  1304            POP     PSW
0243 32         =1  1305            RETI                            ;AND RETURN
                    1306     END
```

XREF SYMBOL TABLE LISTING
---- ------ ----- -------

```
N A M E            T Y P E  V A L U E      ATTRIBUTES AND REFERENCES

AA . . . . . . . .   NUMB   0041H   A        86# 416 707
ACC. . . . . . . . D ADDR   00E0H   A        276 294 300 318 331 349 361 379 386 395 438 490 499 507 508 520 537 543
                                             547 552 561 572 706 713 903 905 981 986 991 996 1018 1297 1302
ADAC . . . . . . . C ADDR   0200H   R       SEG=PROFILE_FLT_CODE  1103 1112 1121 1130 1139 1148 1157 1166 1266#
ADC_MON. . . . . . C ADDR   01EDH   R       SEG=PROFILE_FLT_CODE  1097 1106 1115 1124 1133 1142 1151 1160 1257#
AMU_H. . . . . . . D ADDR   0009H   A        20# 954 1003 1070 1085 1174 1185 1216
AMU_L. . . . . . . D ADDR   000AH   A        21# 957 1006 1071 1088 1188 1219
B. . . . . . . . . D ADDR   00F0H   A        401 402 410 433 479 503 528 548 553 648 662 664 678 681 731 748 788 811
                                             826 828 852 860 868 876 884 923
BAT_MON. . . . .     NUMB   0005H   A        96# 1150
BAUD_COUNT . . .     NUMB   00F2H   A        98# 237 238
BIAS_0_SELECT. .     NUMB   0068H   A        75# 773 1021 1024 1027 1030
BIAS_1_SELECT. .     NUMB   0070H   A        76# 796 982 987 992 997
BIAS_1 . . . . . . D ADDR   000EH   A        25# 1023 1228
BIAS_2 . . . . . . D ADDR   000FH   A        26# 1026 1232
BIAS_3 . . . . . . D ADDR   0010H   A        27# 1029 1247
BLOW_CAP_AGAIN . . C ADDR   00B6H   R       SEG=SERIAL_BOOT_CODE  351#
BLOW_CAP . . . . . C ADDR   008BH   R       SEG=SERIAL_BOOT_CODE  320#
CALL_PROFILE . . . C ADDR   0471H   R       SEG=SERIAL_BOOT_CODE  902 904 909#
CAP_DELAY. . . . . X ADDR   0FA2H   A        113#
CAP_SAFETY . . . . D ADDR   0011H   A        28# 184 244 248 322 353
CMD_1_DECODE . . . C ADDR   026FH   R       SEG=SERIAL_BOOT_CODE  622# 655
CMD_BUF. . . . . . D ADDR   0030H   A        33# 233 431 494 556 566 567 623 626 627 630 631 633 635 638 639 641 642
                                             643 645 657 660 670 673 674 676 722 726 739 743 756 759 760 762 763 766
                                             771 774 775 778 779 781 783 785 794 797 798 801 802 804 806 808 815 818
                                             819 821 823 834 837 838 840 841 844 845 847 849 891 894 898
CMD_CNT. . . . . . D ADDR   0038H   A        34# 234 405 430 435 493 495 555
CMD_RDY. . . . . . B ADDR   0022H.0 A        42# 231 403 496 557 650
CMD_SET. . . . . . C ADDR   021FH   R       SEG=SERIAL_BOOT_CODE  568 570#
CMD. . . . . . . . C ADDR   017EH   R       SEG=SERIAL_BOOT_CODE  402 478#
CMD0 . . . . . . . C ADDR   026DH   R       SEG=SERIAL_BOOT_CODE  578 621#
CMD1_DECODED . . . C ADDR   02B2H   R       SEG=SERIAL_BOOT_CODE  634 656#
CMD1 . . . . . . . C ADDR   02AEH   R       SEG=SERIAL_BOOT_CODE  580 654#
CMD10. . . . . . . C ADDR   0433H   R       SEG=SERIAL_BOOT_CODE  598 866#
CMD11. . . . . . . C ADDR   043CH   R       SEG=SERIAL_BOOT_CODE  600 874#
CMD12. . . . . . . C ADDR   0445H   R       SEG=SERIAL_BOOT_CODE  602 882#
CMD13. . . . . . . C ADDR   044EH   R       SEG=SERIAL_BOOT_CODE  604 890#
CMD14. . . . . . . C ADDR   0494H   R       SEG=SERIAL_BOOT_CODE  606 930#
CMD1FLG. . . . . . B ADDR   0022H.2 A        44# 621 634 654
CMD2 . . . . . . . C ADDR   02C8H   R       SEG=SERIAL_BOOT_CODE  582 669#
CMD3 . . . . . . . C ADDR   031EH   R       SEG=SERIAL_BOOT_CODE  584 719#
```

N A M E	T Y P E	V A L U E		ATTRIBUTES AND REFERENCES
CMD4	C ADDR	0344H	R	SEG=SERIAL_BOOT_CODE 586 736#
CMD5	C ADDR	0382H	R	SEG=SERIAL_BOOT_CODE 588 770#
CMD6	C ADDR	03AFH	R	SEG=SERIAL_BOOT_CODE 590 793#
CMD7	C ADDR	03DCH	R	SEG=SERIAL_BOOT_CODE 592 814#
CMD8	C ADDR	03FEH	R	SEG=SERIAL_BOOT_CODE 594 833#
CMD9	C ADDR	042AH	R	SEG=SERIAL_BOOT_CODE 596 858#
CNT.	B ADDR	0090H.1	A	57# 1051 1238
COMB_MON	NUMB	0000H	A	93# 1123
D_HIGH	NUMB	0048H	A	69# 1240
D_LOW.	NUMB	0060H	A	70# 949 1244
DC_MON	NUMB	0004H	A	94# 1132
DEC_RTN.	C ADDR	0081H	A	197 203#
DECODE	C ADDR	030CH	R	SEG=SERIAL_BOOT_CODE 624 628 632 636 640 671 675 704# 757 761 764 772 776 780 795 799 803 816 820 835 839 842 846 892 895 899
DELAY_2.	X ADDR	0FA3H	A	114#
DELAY_3.	X ADDR	0FA4H	A	116#
DO_PROFILE . . .	C ADDR	0000H	R	SEG=PROFILE_FLT_CODE 382 936 942#
DPH.	D ADDR	0083H	A	485 487 511 642 644 659 893 933 946 1040 1048 1207 1208 1212
DPL.	D ADDR	0082H	A	484 488 510 643 660 897 900 932 1041 1047 1206 1210
EA	B ADDR	00A8H.7	A	173 254 515
ECHO	C ADDR	01C7H	R	SEG=SERIAL_BOOT_CODE 436 497 504 519# 544 554 649 663 665 679 681 732 749 769 812 827 829 853 861 869 877 885 924
EEPROM_RDY . . .	C ADDR	02A5H	R	SEG=SERIAL_BOOT_CODE 647#
EEPROM_SELECT. .	NUMB	0040H	A	68# 644 658 946 1212
ENTRY.	C ADDR	0023H	R	SEG=PROFILE_FLT_CODE 920 965# 1249
EOT_CMD.	C ADDR	0216H	R	SEG=SERIAL_BOOT_CODE 486 565#
EOT_CODE	NUMB	00A8H	A	106# 483 648 664 680 731 748 788 811 828 852 860 868 876 884 923
ERR_CODE	NUMB	00FFH	A	105# 553
ERR.	C ADDR	01F5H	R	SEG=SERIAL_BOOT_CODE 408 412 414 417 421 423 426 428 546# 569 616
ES	B ADDR	00A8H.4	A	245 247 255
ESC_CMD.	C ADDR	01AAH	R	SEG=SERIAL_BOOT_CODE 481 502# 550
ESC_CODE	NUMB	007FH	A	104# 480 503 549
EX0.	B ADDR	00A8H.0	A	172 253
EXTI0.	C ADDR	0003H	A	143
EXTI1.	C ADDR	0013H	A	146
FIFO14	C ADDR	016DH	R	SEG=SERIAL_BOOT_CODE 459 461# 466
FLIGHT_BOOT. . .	C ADDR	0026H	R	SEG=SERIAL_BOOT_CODE 216 246#
FLIGHT_PROFILE .	C ADDR	0005H	R	SEG=PROFILE_FLT_CODE 911 945#
FLT_DELAY. . . .	C ADDR	003FH	R	SEG=SERIAL_BOOT_CODE 255 265#
FORCE_RETURN . .	C ADDR	020EH	R	SEG=SERIAL_BOOT_CODE 558#
FRAME_WORD_0 . .	X ADDR	0FA0H	A	111#
FRAME_WORD_1 . .	X ADDR	0FA1H	A	112#
G.	NUMB	0047H	A	87# 411
GET_MON.	C ADDR	02E6H	R	SEG=SERIAL_BOOT_CODE 677 685#
GET_NEXT17 . . .	C ADDR	002DH	R	SEG=PROFILE_FLT_CODE 972# 977

NAME	TYPE	VALUE		ATTRIBUTES AND REFERENCES
GT_0	C ADDR	0138H	R	SEG=SERIAL_BOOT_CODE 425 427#
GT1.	C ADDR	01E4H	R	SEG=SERIAL_BOOT_CODE 531 532 535#
HV_1_MON	NUMB	0002H	A	91# 1105
HV_2_MON	NUMB	0003H	A	92# 1114
IE0.	B ADDR	0088H.1	A	174
IF_FLT	C ADDR	0076H	A	196# 199 205
ION_CONT	B ADDR	0090H.7	A	54# 875 883 1019
IS_FLT	B ADDR	0022H.3	A	45#
IS_LT_9.	C ADDR	0132H	R	SEG=SERIAL_BOOT_CODE 422 424#
IS_LT_6.	C ADDR	011FH	R	SEG=SERIAL_BOOT_CODE 413 415#
IT0.	B ADDR	0088H.0	A	171 251
JMP_TO_PROFILE .	C ADDR	049CH	R	SEG=SERIAL_BOOT_CODE 931 935#
KEEP_SAFETY. . .	C ADDR	002CH	R	SEG=SERIAL_BOOT_CODE 247 249#
LSB_DC	NUMB	0060H	A	73# 745 1013 1195
LSB_RF	NUMB	0058H	A	71# 728 1007 1189
LT_9	C ADDR	012DH	R	SEG=SERIAL_BOOT_CODE 420 422#
LT_6	C ADDR	011AH	R	SEG=SERIAL_BOOT_CODE 411 413#
MAY_FLIGHT . . .	C ADDR	0087H	A	213#
MON_ALE.	B ADDR	0090H.4	A	50# 168 689 690 1254 1258 1259
MON_OE	B ADDR	0090H.2	A	52# 167 698 700 1271 1273 1286
MON_SELECT . . .	NUMB	0000H	A	81# 686 696 1255
MON_STRT	B ADDR	0090H.3	A	51# 691 692 1261 1262
MSB_DC	NUMB	00E0H	A	7?# 741 1010 1192
MSB_RF	NUMB	00D8H	A	72# 724 1004 1186
MULTI_AMU. . . .	B ADDR	0022H.5	A	47# 906 918 947 966 1179 1182 1213
NEXT_STEP. . . .	C ADDR	0477H	R	SEG=SERIAL_BOOT_CODE 912# 921
NIN.	NUMB	0039H	A	89# 420
NO_ERR	C ADDR	0110H	R	SEG=SERIAL_BOOT_CODE 406 409#
NO_ESC_ERR . . .	C ADDR	01FEH	R	SEG=SERIAL_BOOT_CODE 549 551#
NO_OF_CMDS . . .	NUMB	000EH	A	571#
NOT_A_F.	C ADDR	0318H	R	SEG=SERIAL_BOOT_CODE 708 712#
NOT_EEPROM_RESET	C ADDR	01AAH	R	SEG=PROFILE_FLT_CODE 1209 1211#
NOT_END_PROFILE.	C ADDR	016FH	R	SEG=PROFILE_FLT_CODE 1177 1181#
NOT_EOT.	C ADDR	0199H	R	SEG=SERIAL_BOOT_CODE 483 492#
NOT_ESC.	C ADDR	0186H	R	SEG=SERIAL_BOOT_CODE 480 482#
NOT_LT_A	C ADDR	0125H	R	SEG=SERIAL_BOOT_CODE 416 418#
NOT_MULTI_AMU. .	C ADDR	0198H	R	SEG=PROFILE_FLT_CODE 1176 1180 1199#
NOT_OVERFLOW . .	C ADDR	022CH	R	SEG=PROFILE_FLT_CODE 1292 1294#
OD	B ADDR	0090H.6	A	60# 164 326
P0	D ADDR	0080H	A	185 323 354 687 697 699 721 722 726 730 738 739 743 747 782 783 787 805 806 810 951 981 986 991 996 1003 1006 1009 1012 1020 1023 1026 1029 1185 1188 1191 1194 1239 1241 1243 1245 1268 1270 1272 1274 1289 1296 1300
P1	D ADDR	0090H	A	50 51 52 53 54 57 59 60 1285 1303
P2	D ADDR	00A0H	A	58 163 186 688 693 696 701 723 724 725 727 728 729 740 741 742 744 745 746 784 785 786 807 808 809 949 950 982 983 987 988 992 993 997 998 1004

NAME	TYPE	VALUE		ATTRIBUTES AND REFERENCES
				1005 1007 1008 1010 1011 1013 1014 1021 1022 1024 1025 1027 1028 1030
				1186 1187 1189 1190 1192 1193 1195 1196 1240 1242 1244 1246 1256 1257
				1260 1267 1269 1275 1288 1295 1297 1298 1301
P3	D ADDR	00B0H	A	55 56
PCM_LOAD	NUMB	0078H	A	77# 1297
PCM_POINT. . . .	NUMB	0008H	A	17# 183 252 960 1235
PCM_ROUTINE. . .	C ADDR	0215H	R	SEG=PROFILE_FLT_CODE 144 1280#
PRE_ESC.	C ADDR	01C1H	R	SEG=SERIAL_BOOT_CODE 509 513#
PROFILE_FLT_CODE	C SEG	0244H		REL=UNIT 123# 938
PROFILE_RETURN .	C ADDR	01ECH	R	SEG=PROFILE_FLT_CODE 1248 1250#
PROFILE.	X ADDR	0FB0H	A	118#
PS	B ADDR	00B8H.4	A	243
PSW.	D ADDR	00D0H	A	387 394 437 489 498 560 1281 1304
PX0.	B ADDR	00B8H.0	A	170 250
Q_BIAS	D ADDR	000DH	A	24# 1017 1020 1173
Q_FULL	C ADDR	01E9H	R	SEG=SERIAL_BOOT_CODE 524 540# 540
Q_NOT_EMPTY. . .	C ADDR	015AH	R	SEG=SERIAL_BOOT_CODE 446 449#
Q_PTR.	D ADDR	004FH	A	36# 235 445 458 469 522 523 529 530 913
QUEUE.	D ADDR	0039H	A	35# 179 182 183 252 268 271 450 455 456 523 526 960 1044 1055 1070 1071
				1077 1078 1104 1113 1122 1131 1140 1149 1158 1167 1173 1228 1232 1235
				1241 1245 1247 1292 1293
R12_BIT_DECODE .	C ADDR	036AH	R	SEG=SERIAL_BOOT_CODE 720 737 755#
RAT_H.	D ADDR	000BH	A	22# 971 1009 1077 1191
RAT_L.	D ADDR	000CH	A	23# 1012 1078 1194
RCV_ERR.	C ADDR	010DH	R	SEG=SERIAL_BOOT_CODE 403 407#
RECIEVE.	C ADDR	00FDH	R	SEG=SERIAL_BOOT_CODE 391 399#
RESET.	C ADDR	0000H	A	218
RF_HV.	B ADDR	00B0H.5	A	55# 166 381 859 867
RF_MON	NUMB	0006H	A	90# 1096
RI	B ADDR	0098H.0	A	242 391 400
ROOM_IN_Q. . . .	C ADDR	01D3H	R	SEG=SERIAL_BOOT_CODE 523 525#
RS0.	B ADDR	00D0H.3	A	161 389 1284
RS1.	B ADDR	00D0H.4	A	162 390 1283
SAVE_BIT	B ADDR	0022H.7	A	49#
SBUF	D ADDR	0099H	A	401 450
SCON	D ADDR	0098H	A	239
SELECT	B ADDR	00A0H.6	A	58#
SERIAL_BOOT_CODE	C SEG	049FH		REL=UNIT 122# 228
SERIAL_BOOT. . .	C ADDR	0000H	R	SEG=SERIAL_BOOT_CODE 189 212 230#
SERIAL_STEP. . .	B ADDR	0022H.4	A	46# 901 925 1248
SERIAL	C ADDR	00E8H	R	SEG=SERIAL_BOOT_CODE 152 786#
SET_NEW_VALS . .	C ADDR	0029H	R	SEG=PROFILE_FLT_CODE 966 968#
SINT	C ADDR	0023H	A	151
SP	D ADDR	0081H	A	187 505 559 710
STACK.	D ADDR	0050H	A	37# 187 505 559

```
N A M E            T Y P E   V A L U E      ATTRIBUTES AND REFERENCES

STEP_EXIT. . . . . C ADDR    049BH   R      SEG=SERIAL_BOOT_CODE  918 922#
STROBE . . . . . . B ADDR    0090H.5 A        53# 165 724 725 755 756
TEMP_MON . . . . .   NUMB    0007H   A        97# 1159
TEST_TIME. . . . .   NUMB    0005H   A        192# 193 194 195
TH1. . . . . . . . D ADDR    008DH   A        228
TI . . . . . . . . B ADDR    0098H.1 A        241 392 534 541 914
TIME_BIT . . . . . B ADDR    0020H.6 A        48# 284 286 287 308 311 311 339 341 342 369 371 372 847 851 1035 1036
                                              1050 1056 1061 1066 1077 1081 1092 1099 1108 1117 1126 1135 1144 1153
                                              1162 1169 1214 1221 1226 1298
TL1. . . . . . . . D ADDR    008BH   A        227
TMOD . . . . . . . D ADDR    0089H   A        226
TO_BOOT_IT . . . . C ADDR    0084H   A        200 208#
TO_BOOT. . . . . . C ADDR    0075H   A        140 158#
TO_DO_ITAH . . . . C ADDR    005DH   R      SEG=SERIAL_BOOT_CODE  290# 291
TO_DO_ITB5 . . . . C ADDR    007DH   R      SEG=SERIAL_BOOT_CODE  314# 314
TO_DO_ITCA . . . . C ADDR    00A8H   R      SEG=SERIAL_BOOT_CODE  335# 345
TO_DO_ITCF . . . . C ADDR    00CEH   R      SEG=SERIAL_BOOT_CODE  365# 375
TO_DONECA. . . . . C ADDR    0064H   R      SEG=SERIAL_BOOT_CODE  292 291#
TO_DONECF. . . . . C ADDR    0085H   R      SEG=SERIAL_BOOT_CODE  306 315#
TO_DONETE. . . . . C ADDR    00B2H   R      SEG=SERIAL_BOOT_CODE  337 346#
TO_DONE1D. . . . . C ADDR    00D0H   R      SEG=SERIAL_BOOT_CODE  367 376#
TO_DONE16. . . . . C ADDR    0173H   R      SEG=SERIAL_BOOT_CODE  461 467#
TO_ERR . . . . . . C ADDR    0117H   R      SEG=SERIAL_BOOT_CODE  409 412#
TO_RESET_FAILOAD   C ADDR    008DH   A        215 217#
TOP_OF_IMP_TBLE.   C ADDR    0227H   R      SEG=SERIAL_BOOT_CODE  575 577#
TR1. . . . . . . . B ADDR    0088H.6 A        240
TRASH_EE . . . . . C ADDR    0FA5H   A        117#
TST. . . . . . . . B ADDR    00B0H.4 A        56# 196 197
VALID. . . . . . . C ADDR    010DH   R      SEG=SERIAL_BOOT_CODE  419 427 429#
VDD_MON. . . . . .   NUMB    0001H   A        95# 1141
WAIT_ONE_MS02. . . C ADDR    0059H   R      SEG=SERIAL_BOOT_CODE  285# 288
WAIT_ONE_MS07. . . C ADDR    007AH   R      SEG=SERIAL_BOOT_CODE  309# 312
WAIT_ONE_MS0C. . . C ADDR    00A7H   R      SEG=SERIAL_BOOT_CODE  340# 343
WAIT_ONE_MS11. . . C ADDR    00D2H   R      SEG=SERIAL_BOOT_CODE  370# 373
WAIT_T_1 . . . . . C ADDR    00AAH   R      SEG=PROFILE_FLT_CODE  967 1032#
WAIT_T_2 . . . . . C ADDR    0105H   R      SEG=PROFILE_FLT_CODE  1049#
WAIT . . . . . . . C ADDR    003AH   R      SEG=SERIAL_BOOT_CODE  258# 262
WORD_IT_WAIT . . . C ADDR    01B7H   R      SEG=PROFILE_FLT_CODE  1198 1223#
XEF. . . . . . . . B ADDR    0020H.1 A        47# 232 447 473 514 522 910 917 919
XFR. . . . . . . . B ADDR    0090H.0 A        52# 169 732 734 751 751 948 1032 1033 1034
XMIT . . . . . . . C ADDR    014FH   R      SEG=SERIAL_BOOT_CODE  393 443# 541
ZER. . . . . . . .   NUMB    0030H   A        59# 425 715

REGISTER BANK(S) USED: 0 1
```

```
N A M E          T Y P E   V A L U E      ATTRIBUTES AND REFERENCES

ASSEMBLY COMPLETE, NO ERRORS FOUND
```

IX. PERSONNEL

A list of the engineers who contributed to the work reported is given below:

J. Spencer Rochefort, Professor of Electrical and Computer Engineering and Principal Investigator.

Raimundas Sukys, Senior Research Associate, Engineer.

X. RELATED CONTRACTS AND PUBLICATIONS

F19628-74-C-0042	1 Sept. 1973 through Oct. 1976
F19628-76-C-0256	1 Aug. 1976 through 31 Oct. 1978
F19628-78-C-0218	15 Sept. 1978 through Sept. 1981
F19628-81-C-0162	15 Sept. 1981 through Sept. 1985

Raimundas Sukys, Steven Goldberg, "Control Circuits for Rocket Payload Neutralization Experiment and Other Topics", Scientific Report No. 1 for Contract F19628-74-C-0042, October 1974, AFGRL-TR-74-0580, ADA008039.

R. Sukys, J. Spencer Rochefort, S. Goldberg, "Bias and Signal Processing Circuits for a Mass Spectrometer in the Project EXCEDE: SWIR Experiment", Scientific Report No. 2 for Contract F19628-74-C-0042, October 1975, AFGL-TR-76-0060, ADA026514.

J. Spencer Rochefort, Raimundas Sukys, "Instrumentation Systems for Maas Spectrometers", Final Report for Contract F19628-74-C-0042, September 1976, AFGL-TR-76-0200, ADA032313.

J. Spencer Rochefort, Raimundas Sukys, "A Digital Control Unit for a Rocket Borne Quadrupole Mass Spectrometer", Scientific Report No. 1, for Contract F19628-76-C-0256, April 1978, AFGRL-TR-78-0106, ADA57251.

J. Spencer Rochefort, Raimundas Sukys, "Electronics for a Rocket Borne Quadrupole Cluster Ion Mass Filter", Final Report for Contract F19628-76-C-0256, October 1978, AFGL-TR-78-0292, ADA066289.

Gerousis, V.S., "A Programmable Control Unit for a Balloon-Borne Mass Spectrometer Based on Intel 8085A Microprocessor", Scientific Report No. 1, Contract AF19628-78-C-0218, September 1979, AFGL-TR-79-0225, ADA106398.

Palasek, T., "An RF Oscillator for Rocket-Borne and Balloon-Borne Mass Spectrometers", Scientific Report No. 2, Contract AF19628-78-C-0218, September 1979, AFGL-TR-79-0226, ADA078797.

Sukys, R. and Rochefort, J.S. "Control and Data Transmission System for a Balloon-Borne Ion Mass Spectrometer", Proceedings International Telemetering Conference, October 1980, Vol. XVI, pp. 335-341.

Sukys, R. and Rochefort, J.S. "Control and Data Transmission System for a Balloon-Borne Ion Mass Spectrometer", Scientific Report No. 3 Contract AF19628-78-C-0218, October 1980, AFGL-TR-81-0202, ADA104512.

J. Spencer Rochefort, Raimundas Sukys, "Control Electronics for Airborne Quadrupole Ion Mass Spectrometer", Final Report for Contract F19628-78-C-0218, October 1981, AFGL-TR-82-0056, ADA115399.

Sukys, R. and Rochefort, J.S. "GSE for Balloon Borne I.M.S.: Decommutator and D/A Units", Scientific Report No.1 for Contract F19628-81-C-0162, October 1982, AFGL-TR-83-0095, ADA131845.

Sukys, R. and Rochefort, J.S. "Downrigger Instrumentation to Record Thermosonde Data", Scientific Report No. 2 for Contract F19628-81-C-0162, October 1983, AFGL-TR-85-0085, ADA161748.

Sukys, Raimundas, "Control and Signal Conditioning Circuits for E.I.R.M.A., Scientific Report No. 3 for Contract F19628-81-C-0162, October 1984, AFGL-TR-85-0117, ADA166683.

ATE

MED

-8