W4AQL
SATELLITE
OPERATING
SYSTEM

BY

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GEORGIA TECH RADIO CLUB, W4AQL

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INDEX

INDEX

TECHNICAL INFORMATION (CONT)

INDEX

LIST OF FIGURES

SECTION A-1

SCOPE

This document is intended to describe in detail the concept of the W4AQL satellite operating system. Additionally, the many difficulties encountered during construction, and proposed changes, will be documented in the interest of helping future Georgia Tech Radio Club members in trouble shooting and modifying the system.

To make the mass of data appear in a coherent fashion, the system has been broken down into several sub-systems. The introduction will tie these together, and the following sections will detail each part of the system. Unfortunately the complexity of the system prohibits presentation of every different interaction, and the documentation may appear piecemeal. It is hoped that the interested club member, and the Shack Steward, can become familiar with this system after a few weeks of working with it. Keep in mind that this booklet serves only as a guide; not gospel.

SECTION A-2

OVERVIEW OF SYSTEM

The W4AQL satellite operating system is designed to allow the amateur radio club station at Ga. Tech to communicate reliably through several amateur radio satellites currently and soon to be in orbit. (See Figure 1.) The implementation of the system has to pose as few problems as possible. The resulting design is an interesting approach to the task, which culminates in a unique station.

Figure 2 shows a block diagram of the system. Most satellite operation is done in full duplex. Our setup accomodates this. In general the uplink for the satellites is in the amateur two meter band (approx. 145.9 Mhz). An all mode Icom 251A two meter synthesized transceiver provides the source of RF from the shack. This is amplified by a Mirage linear power amplifier on the roof. A set of Cushcraft crossed yagis phased to allow switchable circular polorization is mounted on a set of AZ-EL rotors. We have two such antennas, one for the uplink and one for the 70cm downlink. There are two popular downlinks, one in the ten meter amateur band (approx. 29.4 MHz) and one in the 70cm band (approx. 435.1 MHz). Our ten meter downlink antenna is a loop and the 70cm is the yagi mentioned earlier. The receiver is an Icom 701 high frequency synthesized transceiver located in

AMATEUR RADIO SATELLITES CURRENTLY IN ORBIT

Satellite	Period (minutes)
OSCAR 8	103.16911
RS-5	119.55500
RS-6	118.71619
RS-7	119.19495
RS-8	119.76366

Figure 1.

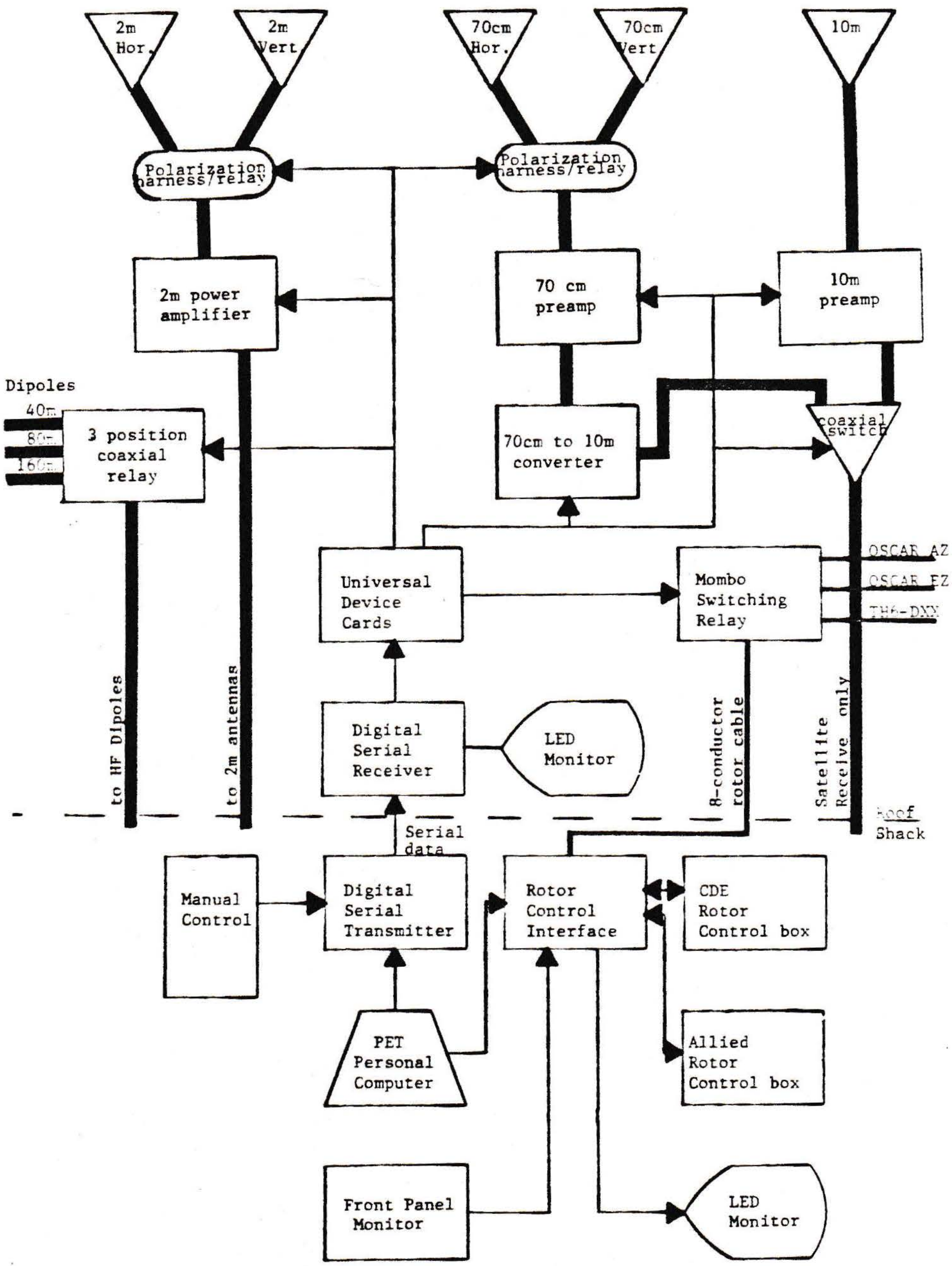

2m Hor.
2m Vert
70cm Hor.
70cm Vert
10m
Polarization harness/relay
Polarization harness/relay
2m power amplifier
70 cm preamp
10m preamp
Dipoles
40m
80m
160m
3 position coaxial relay
70cm to 10m converter
coaxial switch
Universal Device Cards
Mombo Switching Relay
OSCAR AZ
OSCAR EZ
TH6-DXX
to HF Dipoles
to 2m antennas
8-conductor rotor cable
Satellite Receive only
Digital Serial Receiver
LED Monitor
Roof
Shack
Serial data
Manual Control
Digital Serial Transmitter
Rotor Control Interface
CDE Rotor Control box
PET Personal Computer
Allied Rotor Control box
Front Panel Monitor
LED Monitor

Figure 2.

the shack. The ten meter downlink is received through a preamp, while the 70cm downlink is converted to an IF of ten meters and then detected by the rig. Note the conversion occurs on the roof.

The control of this maze of equipment poses some problems. If the system is to be installed with ease, no more cables can be run to the roof from the shack. If the system is to work well, the RF gear needs to be located near the antennas. Our conduit to the roof is currently full with only two spare wires. Our approach to this dilemma was to locate the gear on the roof and control it with serial data, using only one of the two wires. This serial technique suggests the use of a computer and the use of a computer in turn suggests automatic control. An eight bit control word was selected and the following concept adopted.

The eight bit word is divided into two halves. Four bits are called the address buss and are used to select one of up to 16 "devices". Each device is a circuit card which converts TTL signals into usuable control signals. Each device, once selected, uses the other half of the control word, the data buss, to operate four small relays. These relays then place the required voltages on the proper control lines to the gear.

The control word originates from either the computer or the optional manual control, and is converted to serial form by the Digital Serial Transmitter (DSX). On the roof it is received and converted back to parallel form by a complementary receiver.

The computer has been programmed to track the satellites, thus leaving the operator free to communicate without being concerned about steering the antennas. Experience so far has shown the system to be quite adequate with most of the bugs exterminated. Obviously having the computer track a satellite is a great improvement upon the typical installation requiring an operator to continually "bump" the antennas along.

SECTION B-1

ANTENNAS AND MOUNTINGS

The system uses three antennas for satellite communications. For the uplink and the 70cm downlink, a Cushcraft crossed yagi array is used. The vertical and horizontal elements are fed through a phasing harness shown in Figure 3. By activating the coaxial switch, both right-hand and left-hand circular polarizations are possible. The physical length of the harness is difficult to determine, especially at 70cm, where the electrical length of the relay becomes significant. The exact velocity factor of the relay is 0.45, and the electrical length from the input to either output is almost exactly one quarter wavelength at 70cm. Both harnesses have been measured and are within a few percent of being the desired multiple of a quarter wavelength. Note that the 70cm and the two meter antennas are virtually identical except for size.

The two yagis are mounted on a horizontal boom approximately six feet long. The boom passes through a horizontally mounted Allied rotor, which provides elevation control. The Allied rotor is mounted to a short vertical boom which protrudes from the CDE azimuth rotor. The CDE is in turn mounted on the satellite "tower"; a piece of square steel stock with holes along each face. The tower is clamped to a stantion on the roof. This setup

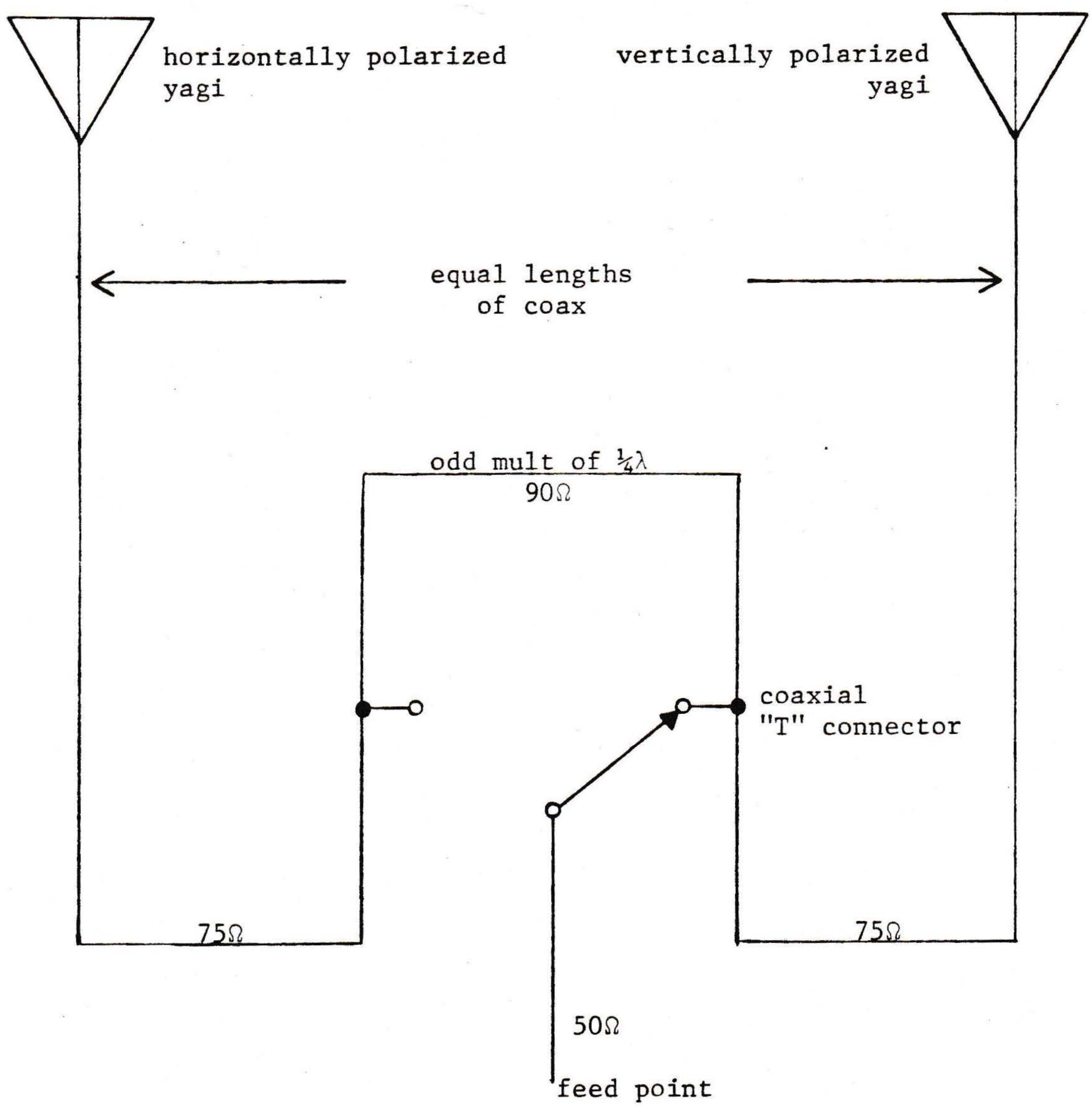

horizontally polarized
yagi
vertically polarized
yagi
equal lengths
of coax
odd mult of ¼λ
90Ω
coaxial
"T" connector
75Ω
75Ω
50Ω
feed point

Figure 3.

seems more than adaquate for the lightweight loads imposed by the yagis.

A future improvement to the antenna rotation system will be the replacement of the Allied elevation rotor. This rotor was very old when we received it. Although it works now; it is barely adequate. In addition, the Allied rotor does not have any feedback to the shack to indicate where the antennas are pointed in elevation. See Section C-3 for further discussion on antenna positioning feedback.

Another antenna is used for ten meter reception. The Hy-Gain TH6-DXX tri-band beam was not adaquate for satellite purposes since it has a deep null in the overhead pattern. Several designs were tried and the current antenna, a full wave loop, seems to work well. (See Figure 4.) The loop was tried at several heights above roof level and it did not perform well until placed at its current height of approximately 18 feet. The loop antenna is matched by a quarter wavelength of 75 ohm coax. The design and theory behind this antenna may be obtained from the ARRL Antenna Book.

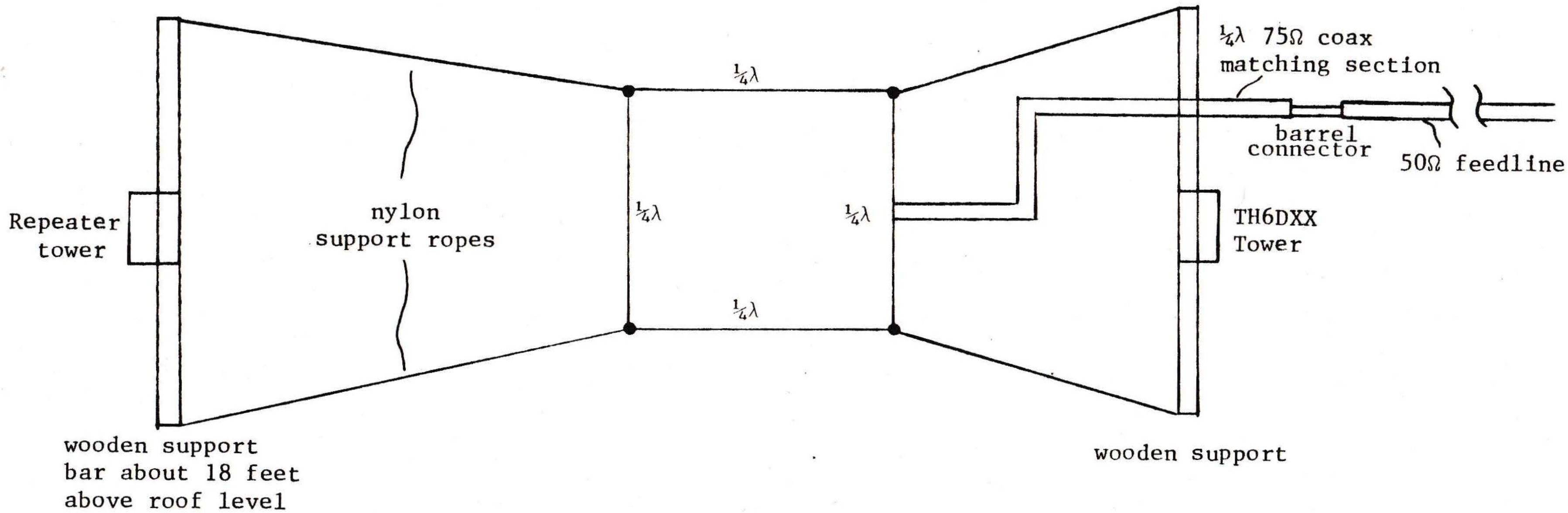

¼λ 75Ω coax
matching section
barrel
connector
50Ω feedline
¼λ
¼λ
¼λ
¼λ
Repeater
tower
nylon
support ropes
TH6DXX
Tower
wooden support
bar about 18 feet
above roof level
wooden support

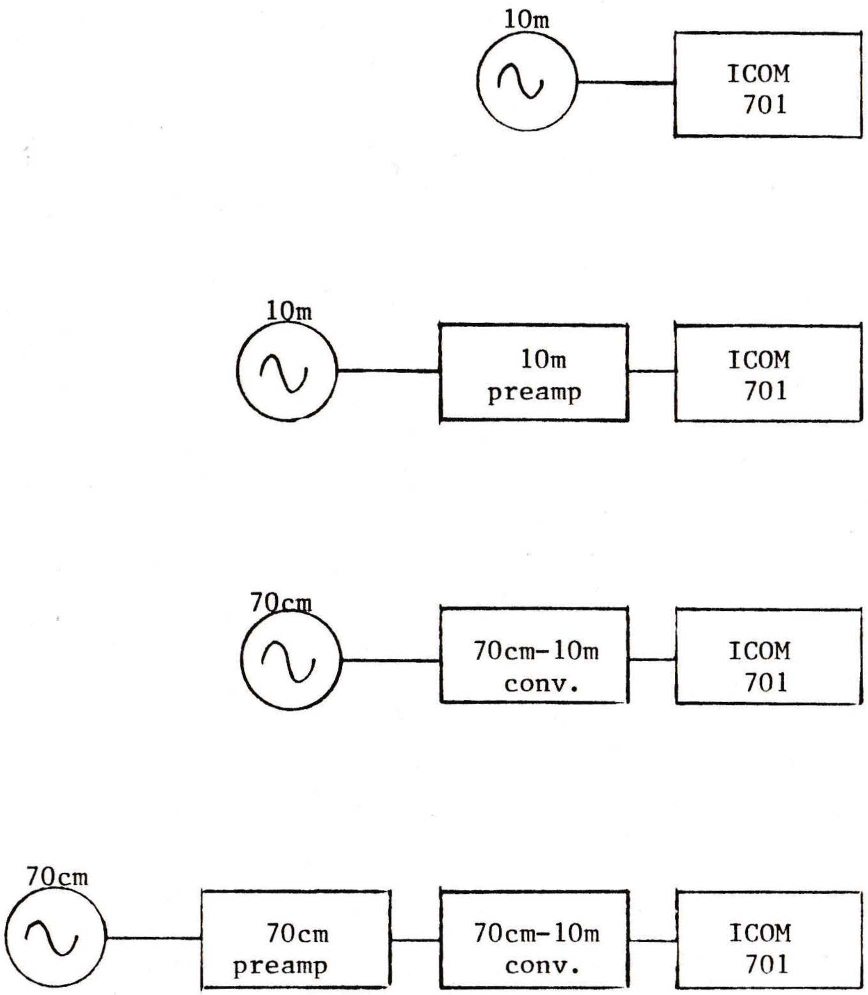
Figure 4.

SECTION B-2

PREAMPS AND CONVERTERS

The decision to place the RF gear near the antennas requires that the various preamps and converters be located on the roof. They are located inside a weather-proof box. Each item was purchased in kit form by the club and assembled by several members. Testing was done in a Faraday shielded room, and the result shown in Figure 5. All the gear worked in the lab but as of this writing some problems have remained unsolved in the 70cm receiving path. The current theory is that the local oscillator of the downconverter won't operate in the cold environment of the Georgia winter.

The 70cm Hamtronics downconverter has had a rough life. In the beginning of the project, someone accidentally transmitted 10 watts on two meters into the output of the converter. This blew out two tripler transistors in the circuit, but after replacement the converter tested in the lab as good as new. The accident resulted in a a very careful labeling of the antenna patch panel in the shack, which will hopefully prevent a similar incident from recurring.



RF voltage required for S1 reading (uV)	RF voltage required for S9 reading (uV)	gain at S1 (dB)	gain at S9 (dB)	avg. gain (dB)
3.6	90	0	0	0
0.1	10	31.1	19.1	19.3
8.25	200	-7.20	-6.94	-6.95
0.75	24	13.6	11.5	11.6

Figure 5.

The 70cm and the ten meter preamp, both manufactured by Hamtronics, have operated without problems since construction. For the schematics and specifications of these, see Section E.

SECTION B-3

TWO METER POWER AMPLIFIER

The Mirage two meter power amplifier is located on the roof in the weather-proof box. This unit provides 160 watts output with 10 watts input. This is more than adaquate to access the low altitude satellites in circumpolar orbit, and should also access the newer high altitude satellites in elliptical orbits.

This amplifier has not given any problems and is designed for remote control. Interfacing it was exceptionally easy; all functions can be controlled from the shack. There are three functions: power amp on/off, two meter preamp on/off and mode select (FM/SSB). Our actual power output is less than the rated 160 watts because we are not able to excite it with the full ten watts from the shack. The two meter transceiver has only ten watts output and the coax to the roof has an attenuation of about six db. Our actual power output is closer to sixty watts CW. This has been proven to be more than adaquate for accessing all the satellites currently in orbit.

SECTION B-4

TRANSCEIVERS

The two rigs used for satellite work are both manufactured by Icom. The ten meter receiver is an IC-701 and the two meter unit is an IC-251A. Both rigs work well and the added feature of dual VFOs makes working the satellites even easier. The IC-701 has an auxilliary receiver input which we use to detect the 10 meter received signal. This gives the receiver a bit more sensitivity than receiving through the transmitter output circuitry. Using the auxiliary receiver input also provides a degree of protection since one cannot accidentally transmit out the receiver input.

The choice of rigs is not entirely arbitrary. Although we have only two HF stations, the Icoms have the added advantage of being readily adaptable to digital control. One future project is to interface the VFO control so that the computer may control the VFOs to compensate for Doppler.

SECTION C-1

COMMODORE PET PERSONAL COMPUTER

The choice of computer for the shack was not critical. Since we were given two Commodore PET computers a year earlier, it was decided to use them. The only requirment for our computer is that there be a provision for sending two 8 bit words (TTL signals) to the "real world". Our PET has an expansion memory card which not only allows 32K of memory, but provides these two output ports as well. This simplified the hardware needs considerably.

The software will not be dealt with in detail here, but in general was written using a structured, or modular, approach. One nuisance associated with the PET was the means of data storage, or lack thereof. Our only means of program storage is a built in cassette recorder which is not only slow but unreliable. This lead to many backup versions being made on a frequent basis.

The PET computer is the main source of RF noise in the shack. Generally this does not affect communications as we are receiving signals from the roof through coax, which shields much of the noise. Operating a hand-held FM transceiver in the shack, however, will make the computer noise more evident. Although it is present, the noise does not seem a major problem.

Another problem which perplexed us for quite a while was the PET's crashing at apparently random times. After several months of this, it was obvious that these crashes were caused by the rotor boxes being turned on to rotate the antennas. At first it was thought that electrical spikes were getting to the PET through the control wires run to the rotor control interface. When placing capacitors to ground on all of these lines didn't solve the problem, we took a closer look at the AC power lines. With a little experimenting, it was discovered that by plugging the rotors into a different electrical outlet from the PET, and placing a filter capacitor across the line; that the rate of computer crash was greatly reduced (although not completely.) Further experimentation showed that the placement of the rotor boxes was critical, and we concluded that the further away the rotor controls were from the PET, the better. Additionally the power lines were run well away from any of the TTL lines near the computer. This problem appears to be eliminated.

SECTION C-2

DIGITAL SERIAL TRANSMITTER

The eight bit words that come from the computer go straight to the Digital Serial Transmitter (DSX). This board resides inside the PET and converts the parallel data to 300 baud serial form. It was decided in the beginning that the system should have a provision for manual control for those times when the PET was down. For this reason the DSX has a provision for a second data input, called manual control. The manual control is simply a box with switches, where the adept user can toggle the correct data word and control the gear on the roof as does the PET, although more slowly. The selection of what bits control what devices was chosen so that an operator could track a satellite manually with a minimum of switch manipulation. There is a plaque in the shack displaying the various switch positions necessary to control all the gear on the roof. (See Figure 6.)

A planned addition to the manual control system is a small desktop console to be placed at both operating stations that will allow several frequently used data words to be transmitted with the push of a single button. For example, a coaxial relay

		D4	D3	D2	D1
		2m Pol.	70 cm Pol.	Rotor	Rotor
Device #1 (0100)	1	Right hand cir.	Right hand cir.	TH6DXX	to D2 control
	0	Left hand cir.	Left hand cir.	OSCAR Elevation	OSCAR Azimuth
			HF Dipole	2m mode	2m amp
Device #2 (0110)	1		80 meters	SSB/CW	ON
	0		40 meters	FM	OFF
		70cm conv.	70cm pre.	10m pre.	2m pre.
Device #3 (1111)	1	ON	ON	ON	ON
	0	OFF	OFF	OFF	OFF

Figure 6.

on the roof selects between our 80m and 40m dipole antennas. It is controlled by one of the devices on the roof. Currently a member who wants to change the antenna from 80m to 40m must either run a computer program to do so, or toggle the appropriate data word using the manual control box. The small consoles would allow this and other functions to be performed more easily.

SECTION C-3

ROTOR CONTROL INTERFACE

The Rotor Control Interface (RCI) is the circuitry that allows the PET to steer the antennas. Our antenna rotor situation is unusual. We only have one eight-conductor rotor cable going to the roof and we have three rotors up there to operate. At the roof the cable passes through a homemade eight-pole triple-throw TTL controlled switch. In the shack, there is a similar eight-pole double-throw switch. Only a double-throw is needed because two of the rotors require the same rotor control box, while the third (satellite antenna elevation) requires a different control box.

The RCI places the correct box on line in the shack and allows the computer to steer the rotor using several relays. The RCI also serves as a terminal strip for both rotor boxes, the cable going to the roof and the control wires coming from the PET. There is also a front panel associated with the RCI which allows the operator to monitor what the PET is doing to the rotors. The operator can also intervene should the computer start to act up.

This critical switch, labeled REALWORLD ON/OFF, is used to shut off the automatic control of the rotors in the event of a malfunction. This has proved useful in debugging program modifications. See Section E-2 for the block diagrams of the RCI, which should make the concept of the RCI a bit clearer.

The convention for rotation is based on the CDE control box. For example, turning the rotor clockwise requires two contacts be made. First, the AC power to the primary transformer (brake) must be applied. Next, rotor wire #2 must be shorted to rotor wire #5, and the antenna will turn clockwise. Similarly, for counter-clockwise rotation, wire #2 is shorted to wire #6. Any other control box attached to the system must be wired in the same format. This proved to be no problem with the Allied rotor currently being used for elevation control.

The CDE box allows the operator to see at a glance where the antenna is pointed. The Allied box did not have such a feature operational when we acquired it. Numerous attempts were made to provide elevation rotor feedback but all were failures. Originally a bizarre circuit was built that operated a bit differently from the current technique. The computer sent an eight-bit word to a D-A converter which produced a signal from 0 to 12 volts. This was subtracted from the 0-12 volt position indicating voltage on the CDE rotors, and the sign of the result, positive or negative, determined which way to steer the antennas. When the result of the subtraction changed sign, the system stopped rotating the antennas.

This approach failed for two reasons. First, the positioning signal had quite a bit of 60Hz hum on it which frequently fooled the comparison circuitry. Secondly, we never could get a similar signal for the elevation rotor. Thus in the interest of expediency we settled for our current approach.

We decided that the computer would operate the rotors without any feedback. This meant that the computers would simply keep track of how long it rotated the antennas and convert that to degrees using a numerical constant associated with the rotor. Both types of rotors turn approximately ninety degrees in 14 seconds. As expected this is not exceptionally accurate, but is close enough to be within the beamwidth of our antennas.

Since receiving a set of synchro motors, we plan once again to use an analog voltage as feedback. This time we will convert the positioning voltage to digital form and have the computer read this, rather than depending on the hardware to rotate the antennas.

Although the PET computes antenna positions, occasionally it will lose track (power failure, system crash, etc). At these times the operator must go outside the shack to a position where he can see the antennas and have another person in the shack reposition the elevation rotor manually until it is at a known position (usually horizontal). This is cumbersome, frustrating and unnecessary. The addition of the elevation sychro-motors will correct this flaw.

SECTION C-4

POWER SUPPLIES

To power the various circuits in the shack, a club member designed and built what has become known as the Mombo Power Supply. This is a simple, unique but effective supply that provides +5V at 3A, +12V at 1A, -5V and -12V at 500 milliamps each, with no more than 10% ripple at maximum ratings. Should the need arise, the +12 volt portion can easily be expanded to three amps by replacing a single regulator. The supply is constructed on a 19-inch panel and is mounted in the rack that also houses the Rotor Control Interface. The same rack also holds a commercial power supply which provides the voltage for the 24 volt relays. A future modification will incorporate the +24 volts within the Mombo supply.

SECTION D-1

WEATHER-PROOF BOX

The desire to place the RF gear on the roof required some means of keeping the elements out of the equipment. The club had an old army-surplus box which we weather-proofed with a seal applied to the door of the box by a local gasket company. This box is divided into several basic volumes, each of which serve a specific function. The lower area houses the power supplies and a package of dessicant. In the middle area reside the receiving equipment (right) and the switching relays (left) for the rotor cable. The top area holds the Digital Control Cage. This is a card cage which holds the Digital Serial Receiver and several Universal Device Cards. In the very back of the weather-proof box is located the two meter power amplifier. All cables and coax are connected through the very bottom of the box.

The preamps, amplifiers and converter are housed in their own individual aluminum chassis. This is to provide shielding between each other and the digital signals. The power amplifier is mounted in an unusual manner, and is shown in detail in Section E-19. The idea here is to mount the heat sink on the outside of the box and yet keep all the electronics inside.

Using a large aluminum flange, some bolts and generous amounts of weather-proofing putty, this was accomplished while still permitting the power amplifier to be removed for servicing. In order to minimize condensation, a small bag of dessicant is placed in the box and is changed after several months of exposure.

Control signals, outputs to the rotor cables, phasing relays, power line, coaxial inputs and outputs are brought through the box at the bottom. Here five UHF barrel connectors, a DB-50 connector and a grommetted hole are provided for these connections. See Section E-10 for the layout of these connectors. The DB-50 carries most of the control signals for the system. All the rotor cables, switching lines and serial input pass through here.

The rotor cable is an eight-conductor cable from the shack. It enters the box through the DB-50, through a ten-pin Molex connector to the Mombo switching relays. This is an arrangement of 6 triple-pole, double-throw relays wired together to form an eight-pole triple-throw switch capable of handling the currents necessary for rotor control. It has TTL inputs to perform the switching functions. See Section E-14 for a schematic of this circuit. The resulting 3 eight-conductor rotor cables come off the relay board on identical 10-pin Molex connectors and pass through the DB-50 to proceed to the three rotors on the roof--the tri-band beam, azimuth and elevation.

There are three coaxial relays on the roof. Two are mounted on the boom of the AZ-EL antenna array. They are used in conjunction with a phasing harness to provide the two orthogonal senses of circular polarization for both the two meter transmit antenna and the 70cm receive antenna. The other relay was installed to allow the operator in the shack to use one of three high frequency dipoles from a single coax line to the roof. The control wires for these three coaxial relays pass through the DB-50, through a 9-pin Molex connector to a terminal strip where the appropriate signals are attached coming from the Universal Device Cards.

The RF connections run from the feedthrough barrel connectors to the various pieces of gear. All these connections are made using 50 ohm coaxial line and appropriate RF connectors (BNC, UHF or SMA).

The AC power line comes straight into the box via a grommetted hole and is attached to a terminal strip. At the strip three metal oxide varistors (MOVs) are connected from hot to ground, hot to neutral, and neutral to ground. MOVs are AC-line surge protectors. Without these protectors, we were losing TTL chips whenever a lightning storm was in the Atlanta area. After installing these MOVs we have had no damage to the digital circuitry because of thunderstorms.

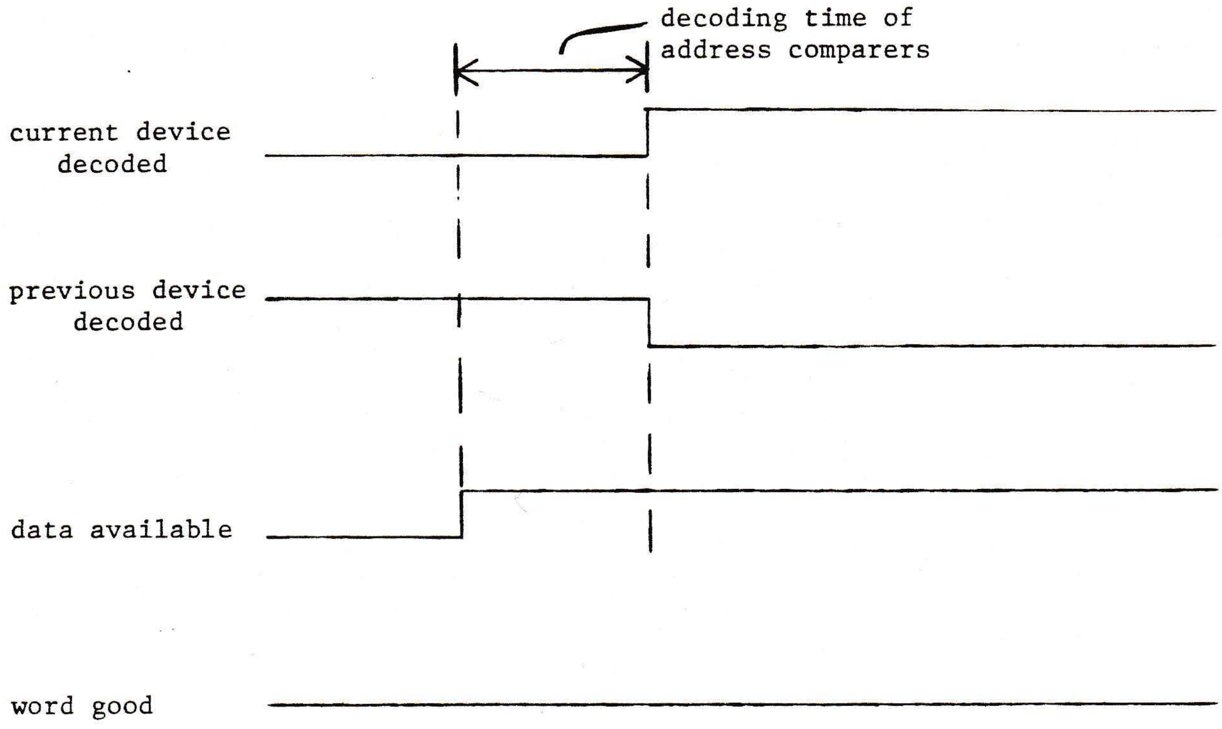
SECTION D-2

DIGITAL CONTROL CAGE

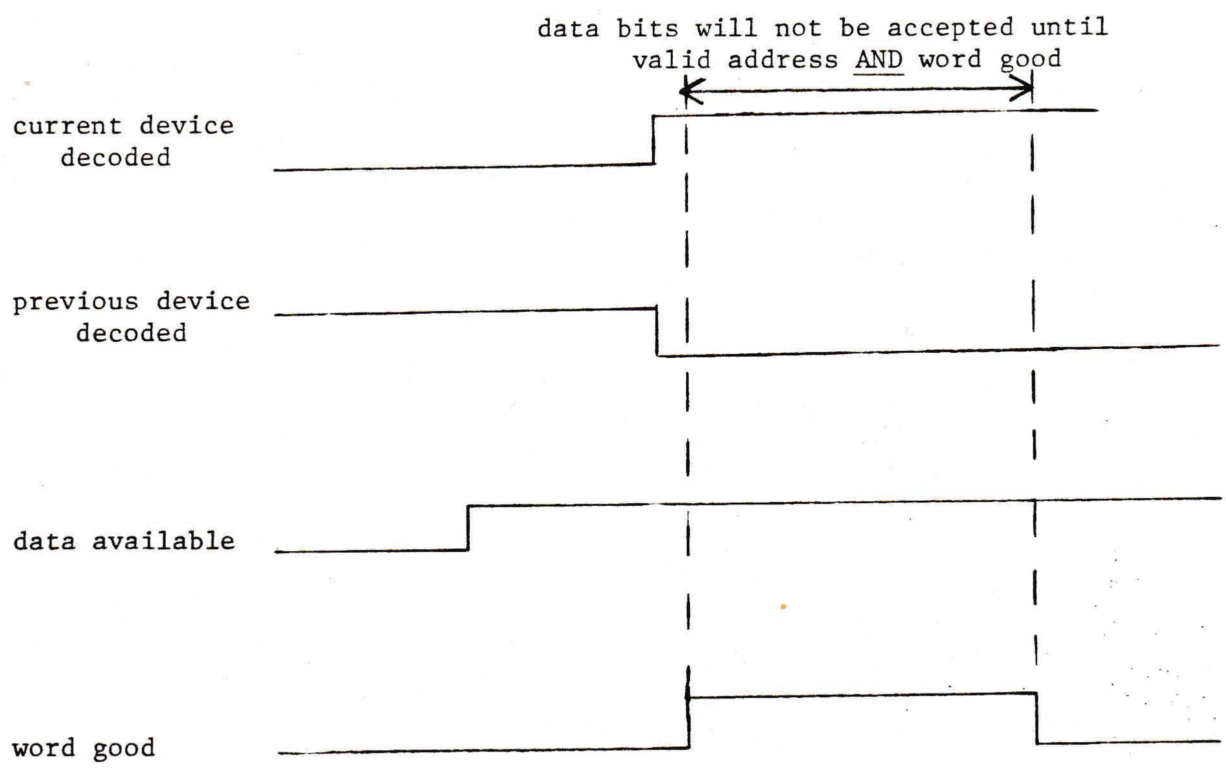
The Digital Control Cage (DCG) is located in the weather-proof box. This holds all the digital control circuitry for the system on the roof. Here reside the Digital Serial Receiver and the Universal Device Cards; all connected to a common backplane. Signals on the backplane are listed in Section E-11. A block diagram of the DCG appears there also.

A problem arises with the decoding of addresses in system by the 7485 4-bit magnitude comparators. The entire eight-bit word becomes available on the buss at the same time. Since it takes a finite amount of time to decode the address, the data bits will, for the duration of the decoding time, be available for whatever device was previously selected. (See Figure 7). to get around this, a provision was added to provide a signal on the buss called WORDGOOD. This signal is currently held active all the time, but will be modified to strobe only after the addresses have had a chance to decode.

We bypass this problem for the time being by writing to a null device after every word sent to the roof. The null device is



Current timing scheme



Modified timing scheme

Figure 7.

simply an address for a non-existent device card. This way any time a new word is sent; the previously selected device doesn't exist, and the problem is eliminated. Note that this method requires two 8-bit words be sent for each control word transmission. Eventually the previously outlined solution involving WORDGOOD will eventually be used to increase, by a factor of two, the time required to transmit an 8 bit word to the roof.

SECTION D-3

DIGITAL SERIAL RECEIVER

The Digital Serial Receiver is the mate of the DSX and is based on the same chips. This board receives the serial pulses from the shack and converts them to parallel form. The schematic is shown in Section E-12. Note that this card serves as a source of signals onto the data buss, while the other cards on the buss receive the signals.

Another improvement will be the construction of a board to replace the DSX card during debugging on the roof. The degugging card will have eight toggle switches to supply signals to the buss. This eliminates the current nuisance of requiring one person in the shack to operate the computer or manual control while coordinating with a second person on the roof troubleshooting the hardware.

SECTION D-4

UNIVERSAL DEVICE CARDS

The Universal Device Cards are the main interface between the digital signals and the functions they are designated to control. The four data bits are latched when the address is selected and the WORDGOOD signal is active. These data bits control four miniature DIP relays. The relays are wired to a printed circuit board matrix. One can select, with the use of printed circuit board feedthroughs, the desired signal to pass when the relay is active (closed). This method allows the same circuit board to control a variety of devices which require different control signals. See Figure 8 for the configuration used at W4AQL.

Device number \ Relay number	4	3	2	1
1	+12V	+12V	GND	GND
2	——	+12V	GND	+12V
3	+12V	+12V	+12V	+12V

Note: Relay number corresponds to data bit number in the 8-bit control word (1 = LSB)

Figure 8.

SECTION D-5

POWER SUPPLIES

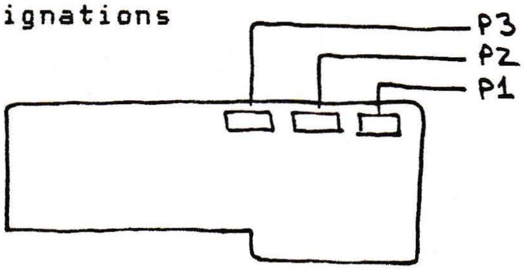
The power supplies on the roof pose some problems. They must be small enough to fit inside the weather-proof box, yet also supply the power demands of the equipment. This proved to be no problem except with the +12V supply. The two meter power amplifier requires a twelve volt source that can handle 20 to 25 amps. No power supply capable of that current can fit inside the weather-proof box. We temporarily decided on a deep-cycle battery that we could place below the box. The battery is on constant charge and supplies all the 12V needs on the roof. See Section E-15 for a diagram of the roof top power supply system.

E-1 Digital Serial Transmitter

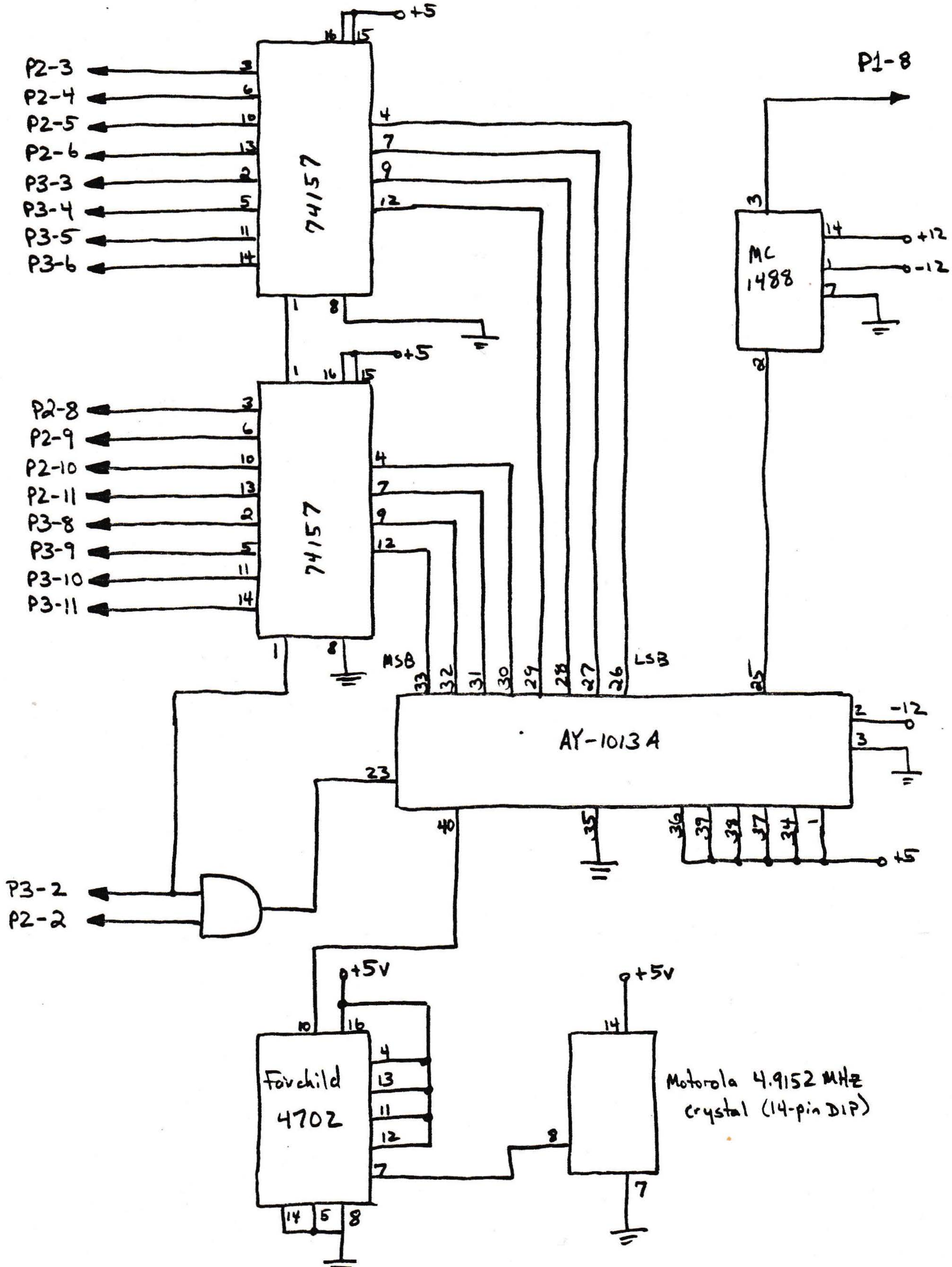
The Digital Serial XMTR has two eight-bit input words, from P2 and P3. These two words go into two 74157 four bit data selectors, which are arranged to act as an eight-pole double-throw TTL switch. Which data word to use is selected by the Manual Control handshake, which is an active low signal. When the MCR handshake is strobed low, it not only selects the data word from the MCR, but also initiates the serial data transmission from the UART chip. The PET's data word is the default setting for the TTL switch.

The UART's transmission clock is provided by a Fairchild baud rate generator, using a Motorola crystal housed in a DIP package. The resulting serial data from the UART is used as input to a MC1488 RS-232 line driver. A TTL high signal is converted to -12 volts, and low is converted to +12 volts. This signal is then sent to the roof, for reception by the Digital Serial Receiver.

Digital Serial XMTR (DSX)
Pin Designations

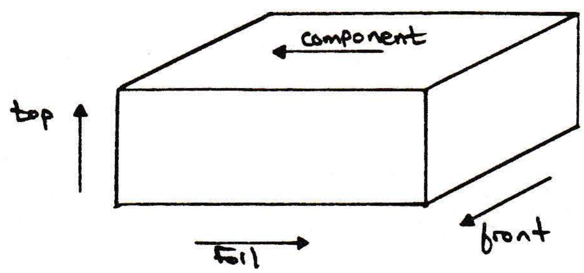


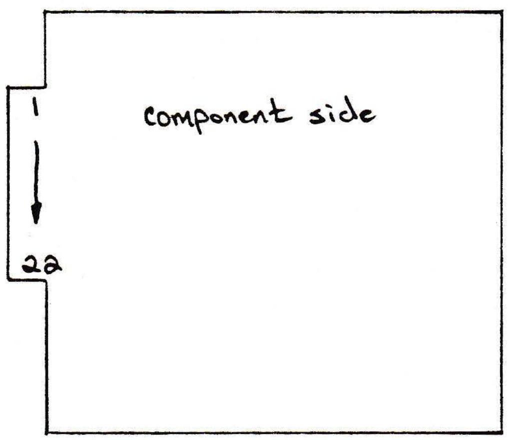
P1:	1) unused	8) RS-232 to roof	
	2) unused	9) unused	
	3) unused	10) unused	
	4) unused	11) unused	
	5) unused	12) -12 volts	These voltages are
	6) unused	13) +12 volts	supplied to the DSX
	7) Ground	14) +5 volts	by the MPS.
P2:	1) unused	8) Data bit 5	
	2) Pet handshake	9) Data bit 6	
	3) Data bit 1	10) Data bit 7	
	4) Data bit 2	11) Data bit 8	
	5) Data bit 3	12) unused	
	6) Data bit 4	13) unused	
	7) Ground	14) unused	
P3:	1) unused	8) Data bit 5	
	2) MCR handshake	9) Data bit 6	
	3) Data bit 1	10) Data bit 7	
	4) Data bit 2	11) Data bit 8	
	5) Data bit 3	12) -12 volts	These voltages are
	6) Data bit 4	13) +12 volts	supplied to the MCR
	7) Ground	14) +5 volts	by the DSX.

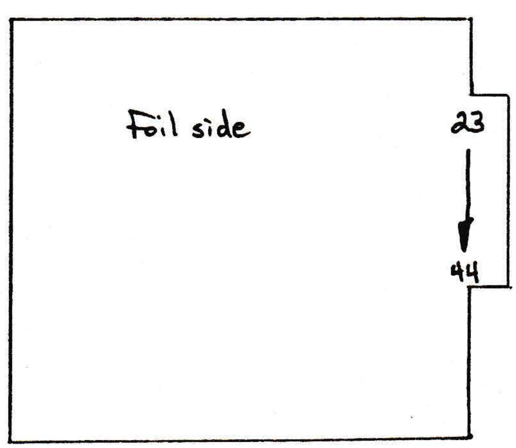

+5
P2-3
P2-4
P2-5
P2-6
P3-3
P3-4
P3-5
P3-6
74157
P1-8
MC 1488
+12
-12
+5
P2-8
P2-9
P2-10
P2-11
P3-8
P3-9
P3-10
P3-11
74157
MSB
LSB
AY-1013 A
-12
+5
P3-2
P2-2
+5V
Fairchild 4702
+5V
Motorola 4.9152 MHz crystal (14-pin DIP)

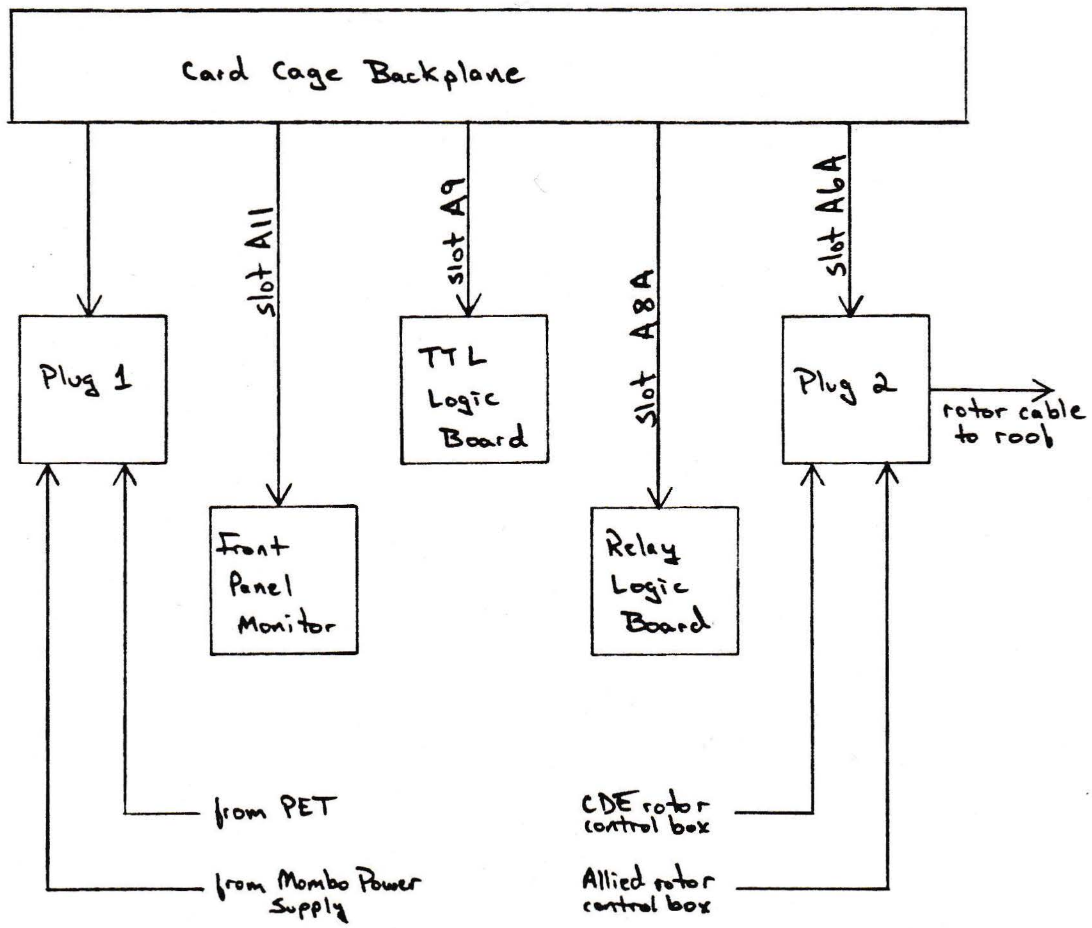
E-2 Rotor Control Interface

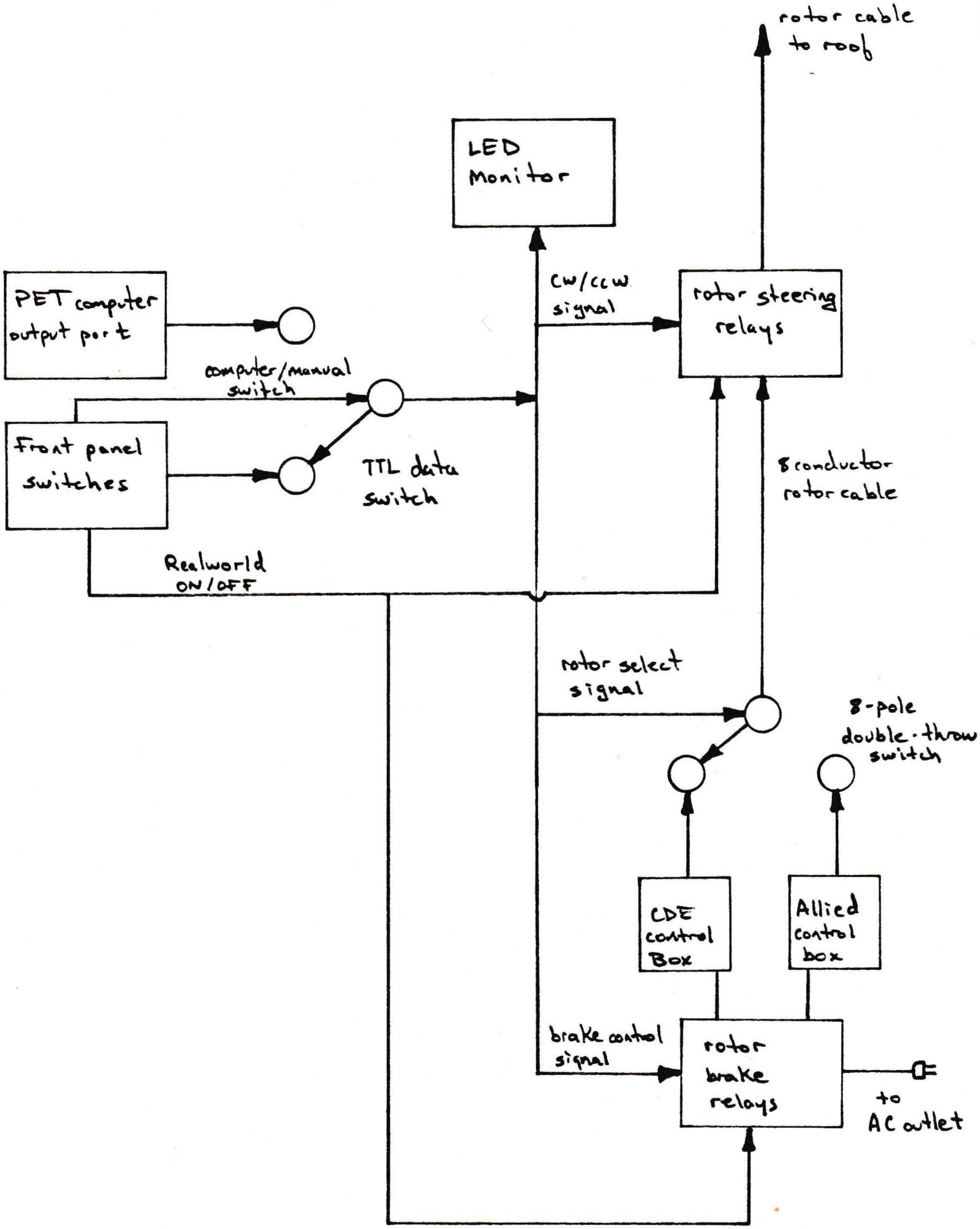
The RCI is the interface that allows the computer to rotate the antennas. The physical layout shows how the components of the RCI connect. Note that Plug 1 isn't located in a slot. It is plugged into an edge connector that is bolted onto the back of the card cage, and is not numbered. Plug 2 should not be handled without first unplugging the rotors, as it will have live 110VAC on the brake lines. The Front Panel Monitor, the TTL Logic Board, the Relay Logic Board, and both plugs are numbered as shown in the diagram on circuit board numbering.


component
top
foil
front


component side
1
22


Foil side
23
44


Card Cage Backplane
slot A11
slot A9
slot A8A
slot A6A
Plug 1
TTL Logic Board
Plug 2
rotor cable to roof
Front Panel Monitor
Relay Logic Board
from PET
from Mombo Power Supply
CDE rotor control box
Allied rotor control box


rotor cable to roof
LED Monitor
PET computer output port
CW/CCW signal
rotor steering relays
computer/manual switch
Front panel switches
TTL data switch
8 conductor rotor cable
Realworld ON/OFF
rotor select signal
8-pole double-throw switch
CDE control Box
Allied control box
brake control signal
rotor brake relays
to AC outlet

E-3 Relay Logic Board

Relay Logic Board (RLB)
Circuit Description

This board interfaces the TTL control signals from the TTL Logic Board (TLB) to the desired rotor functions; CW, CCW, Brake, and rotor select.

All the relays are driven by identical TTL-controlled circuits. When the TTL signal is low, the switching transistor, 2N2222 or similar, is not conducting, with the collector-emitter voltage being approximately equal to the voltage applied to the relay. When the TTL signal is high, current flows through the 2.2K resistor and the base-emitter junction, driving the transistor into saturation. With the transistor thus on, current flows from the relay voltage source, through the coil and through the collector to ground, thus energizing the relay.

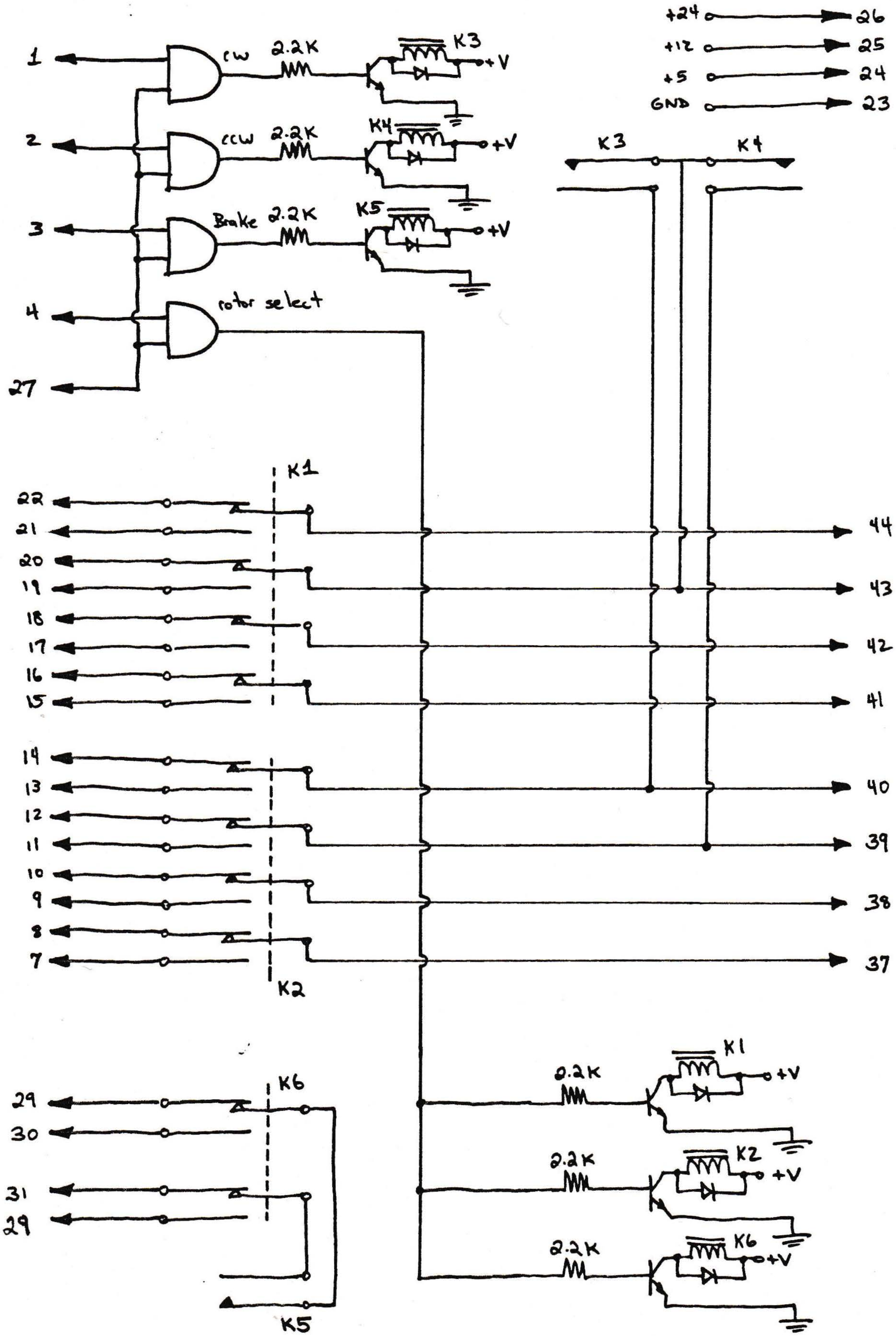
When the rotor select signal is low, the relays K1, K2, and K6 will be in their normal position, thus placing the A rotor box (CDE) onto the rotor output lines to the roof, and placing the A rotor primaries onto the brake relay, K5. With rotor select high, K1, K2, and K6 will be energized, placing the B rotor box (Allied) online.

If the brake signal goes high, relay K5 is on, and primary power will be applied to the transformer of the selected rotor box. When CW or CCW goes high, output line #2 will be shorted to output lines #5 or #6, respectively.

All of the above signals pass through AND gates, which act as a switch. The realworld signal controls the state of these switches. When realworld is off, the output of all the gates is low, thus effectively turning off rotor control. When the realworld is on, all signals will be passed onto the relay driving circuits.

Relay Logic Board (RLB)
Pin Designations

Pin number	Function	
1.	CW	TTL inputs
2.	CCW	
3.	Brake	
4.	Rotor select	
5.	(unused)	
6.	(unused)	
7.	B8	Rotor box inputs
8.	A8	
9.	B7	
10.	A7	
11.	B6	
12.	A6	
13.	B5	
14.	A5	
15.	B4	
16.	A4	
17.	B3	
18.	A3	
19.	B2	
20.	A2	
21.	B1	
22.	A1	
23.	Ground	
24.	+5 volts	
25.	+12 volts	
26.	+24 volts	
27.	Realworld	
28.	B primary	
29.	A primary	
30.	B primary	
31.	A primary	
32.	(unused)	
33.	(unused)	
34.	(unused)	
35.	(unused)	
36.	(unused)	
37.	Output 8	
38.	Output 7	
39.	Output 6	
40.	Output 5	
41.	Output 4	
42.	Output 3	
43.	Output 2	
44.	Output 1	


+24 26
+12 25
+5 24
GND 23
cw
ccw
Brake
rotor select
2.2K
K3
K4
K5
+V
1
2
3
4
27
K1
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
K2
44
43
42
41
40
39
38
37
K6
29
30
31
29
K5
K1
K2
K6

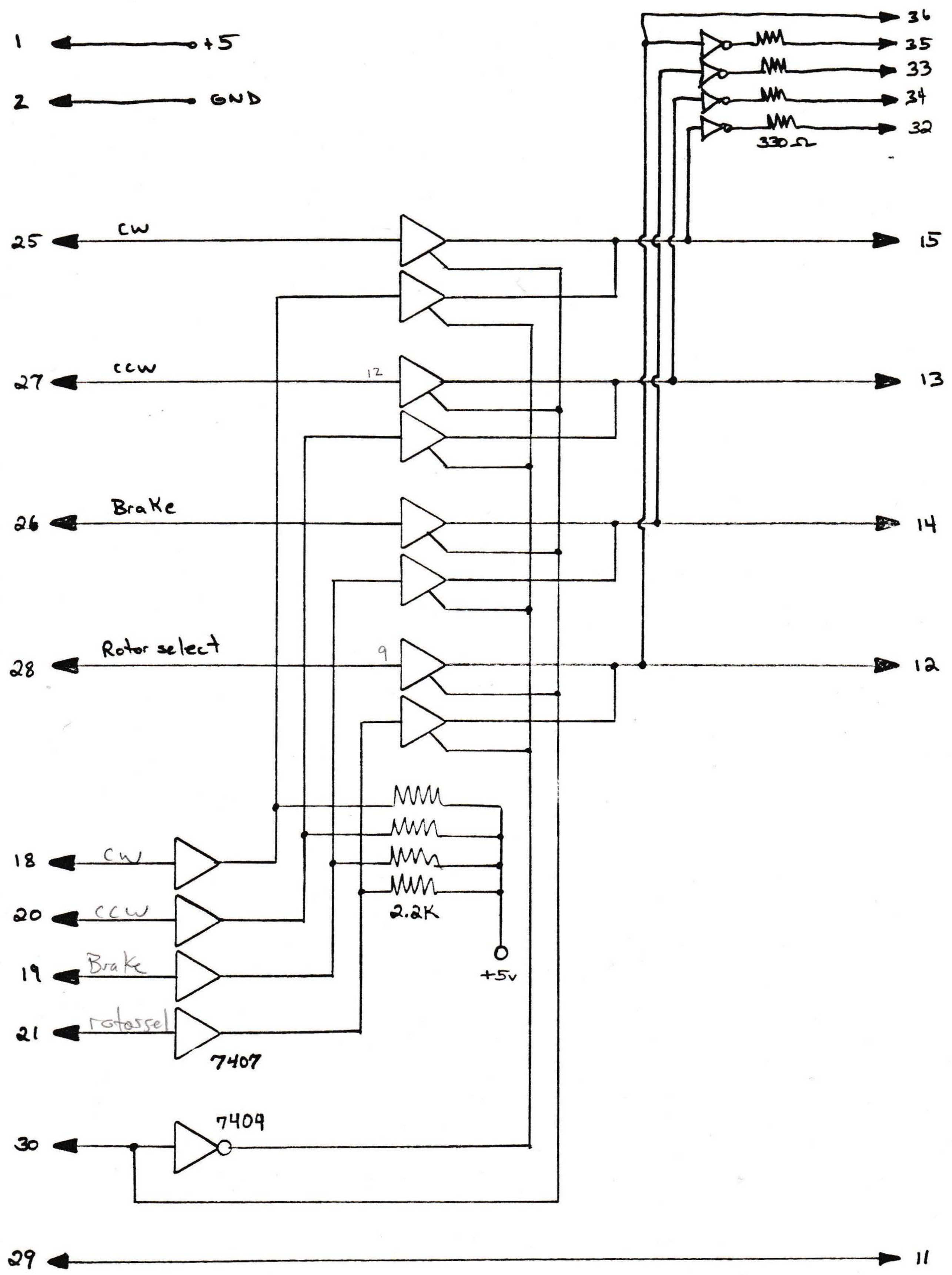
E-4 TTL Logic Board

This circuit board serves to select one of two sets of TTL signals (from the PET or Front Panel Monitor), and send them on to the Relay Logic Board. A 7407 acts as a safety buffer between the computer and the interface circuitry. The actual switching is performed by tristate non-inverting buffers. The computer/manual select signal from the Front Panel Monitor enables only one set of signals at a time onto the output lines going to the Relay Logic Board.

The output lines also drive the LED's located on the Front Panel Monitor through open-collector inverters and 330 ohm resistors. The REALWORLD on/off signal passes through this board, but has no effect on the function of the board.

TTL Logic Board (TLB)
Pin Designations

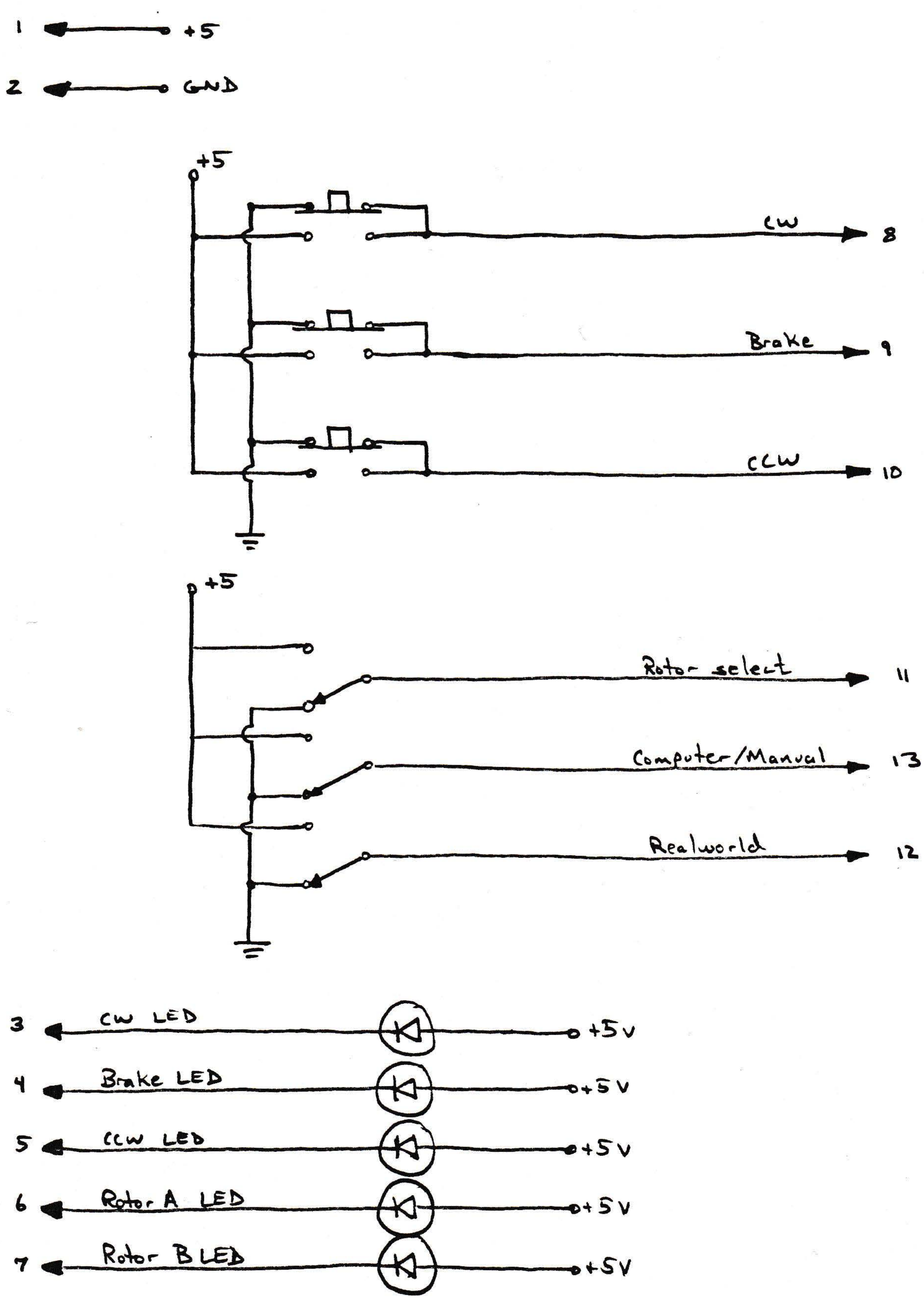
Pin number	Function	
1	+5 volts	
2	Ground	
3	(unused)	
4	(unused)	
5	(unused)	
6	(unused)	
7	(unused)	
8	(unused)	
9	(unused)	
10	(unused)	
11	Realworld	
12	Rotor select	
13	CCW	Outputs from
14	Brake	TTL board
15	CW	
16	(unused)	
17	(unused)	
18	CW	
19	Brake	Computer
20	CCW	inputs
21	Rotor select	
22	(unused)	
23	+5 volts	
24	Ground	
25	CW	
26	Brake	
27	CCW	Inputs from
28	Rotor select	Front Panel
29	Realworld	Monitor
30	Computer/Manual	
31	(unused)	
32	CW	
33	Brake	LED output
34	CCW	signals to
35	Rotor A (CDE)	Front Panel Monitor
36	Rotor B (Allied)	
37	(unused)	
38	(unused)	
39	(unused)	
40	(unused)	
41	(unused)	
42	(unused)	
43	(unused)	
44	(unused)	


1
+5
2
GND
36
35
33
34
32
330Ω
25
CW
15
27
CCW
12
13
26
Brake
14
28
Rotor select
9
12
18
CW
20
CCW
19
Brake
21
rotorsel
2.2K
+5v
7407
30
7409
29
11

E-5 Front Panel Monitor

Front Panel Monitor (FPM)
Pin Designations

Pin number	Function	
1	+5 volts	
2	Ground	
3	CW	
4	Brake	active low signals to drive LED's
5	CCW	
6	Rotor A	
7	Rotor B	
8	CW	
9	Brake	
10	CCW	Output signals to TTL Logic Board
11	Rotor select	
12	Realworld	
13	Computer/Manual	
14	(unused)	
15	(unused)	
16	(unused)	
17	(unused)	
18	(unused)	
19	(unused)	
20	(unused)	
21	(unused)	
22	(unused)	
23	(unused)	
24	(unused)	
25	(unused)	
26	(unused)	
27	(unused)	
28	(unused)	
29	(unused)	
30	(unused)	
31	(unused)	
32	(unused)	
33	(unused)	
34	(unused)	
35	(unused)	
36	(unused)	
37	(unused)	
38	(unused)	
39	(unused)	
40	(unused)	
41	(unused)	
42	(unused)	
43	(unused)	
44	(unused)	


1
+5
2
GND
+5
CW
8
Brake
9
CCW
10
+5
Rotor select
11
Computer/Manual
13
Realworld
12
3
CW LED
+5V
4
Brake LED
+5V
5
CCW LED
+5V
6
Rotor A LED
+5V
7
Rotor B LED
+5V

E-6

Plug 1

Plug 1 (PG1)
Pin Designations

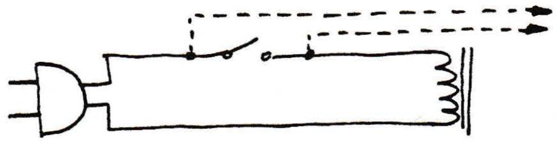
Pin number	Function	
1.	(unused)	
2.	Ground	
3.	Ground	
4.	Ground	
5.	+5 volts	
6.	+12 volts	
7.	+24 volts	
8.	(unused)	
9.	(unused)	
10.	(unused)	
11.	(unused)	
12.	(unused)	
13.	(unused)	
14.	Data bit 8 (MSB)	
15.	7	
16.	6	
17.	5	Eight-bit word
18.	4	from PET computer
19.	3	
20.	2	
21.	Data bit 1 (LSB)	
22.	Digital ground	
23.	(unused)	
24.	(unused)	
25.	(unused)	
26.	(unused)	
27.	(unused)	
28.	(unused)	
29.	(unused)	
30.	(unused)	
31.	(unused)	
32.	(unused)	
33.	(unused)	
34.	(unused)	
35.	(unused)	
36.	(unused)	
37.	(unused)	
38.	(unused)	
39.	(unused)	
40.	(unused)	
41.	(unused)	
42.	(unused)	
43.	(unused)	
44.	(unused)	

E-7

Plug 2

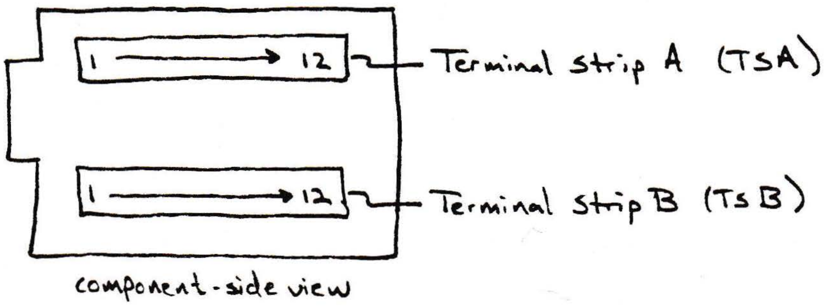
Plug 2 (PG2)
Circuit Description

This circuit board serves to interface the from the back of the card cage to the "realworld". It simply provides two terminal strips, which should be connected to the rotor cables as shown in the wiring diagram. The interface uses two connections made in the transformer primary circuit, as shown below, to operate each rotor's brake.



The dotted lines indicate the two wires which must be installed on each rotor box. The rotor boxes should be unplugged while handling this plug. Note that if the elevation rotor is replaced with one that requires more than four wires, then the circuit board will need to be remade using 3 terminal strips instead of two.

Plug 2 (PG2)
Wiring diagram



TSA1.......	from CDE box 1
TSA2.......	2
TSA3.......	3
TSA4.......	4
TSA5.......	5
TSA6.......	6
TSA7.......	7
TSA8.......	8
TSA9.......	Allied box GND
TSA10......	CW
TSA11......	CCW
TSA12......	Power

TSB1.......	to roof 1
TSB2.......	2
TSB3.......	3
TSB4.......	4
TSB5.......	5
TSB6.......	6
TSB7.......	7
TSB8.......	8
TSB9.......	CDE primary
TSB10......	CDE primary
TSB11......	Allied primary
TSB12......	Allied promary

Plug 2 (PG2)
Pin Designations

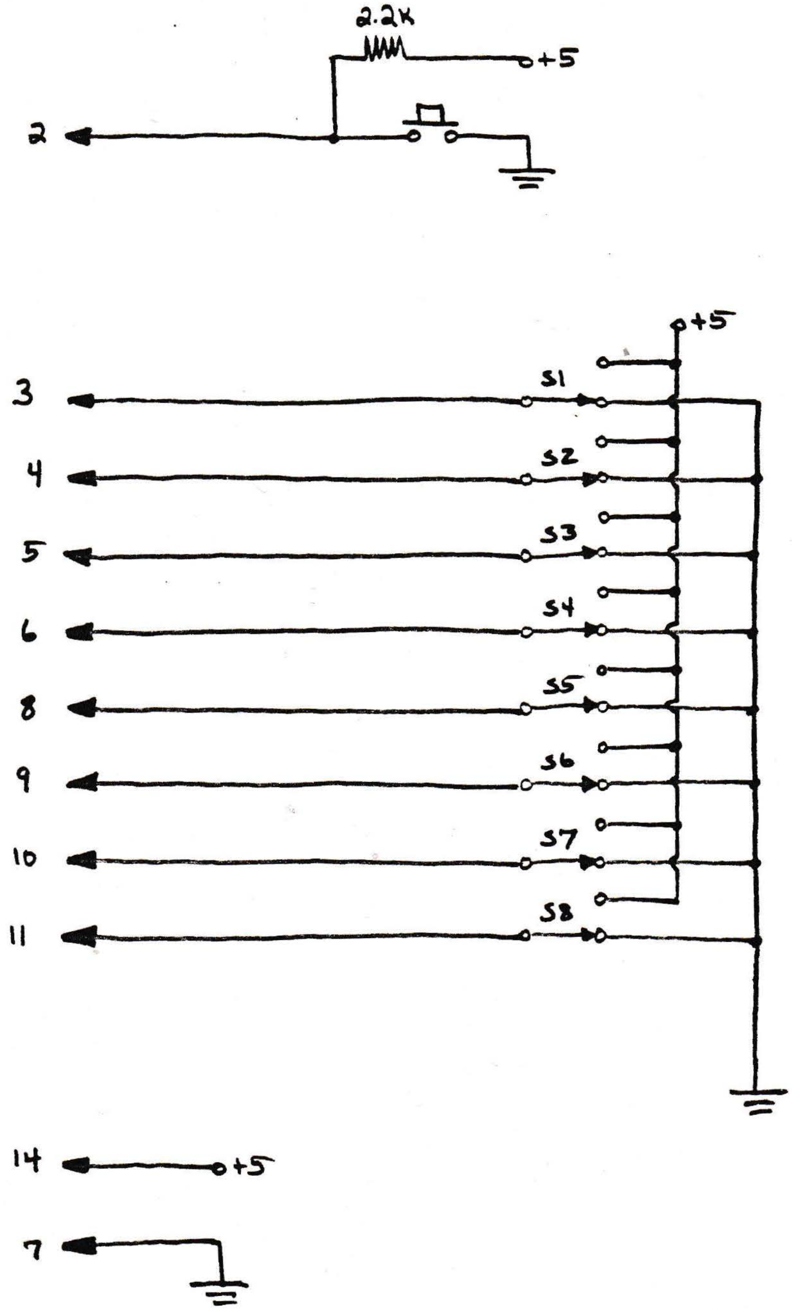
Pin number	Function
1.	(unused)
2.	(unused)
3.	(unused)
4.	(unused)
5.	TSA7
6.	TSA8
7.	TSA9
8.	TSA10
9.	TSA11
10.	TSA12
11.	(unused)
12.	(unused)
13.	(unused)
14.	(unused)
15.	(unused)
16.	(unused)
17.	TSB12
18.	TSB11
19.	TSB10
20.	TSB9
21.	TSB8
22.	TSB7
23.	(unused)
24.	(unused)
25.	(unused)
26.	(unused)
27.	TSA1
28.	TSA2
29.	TSA3
30.	TSA4
31.	TSA5
32.	TSA6
33.	(unused)
34.	(unused)
35.	(unused)
36.	(unused)
37.	(unused)
38.	(unused)
39.	TSB6
40.	TSB5
41.	TSB4
42.	TSB3
43.	TSB2
44.	TSB1

E-8 Manual Control

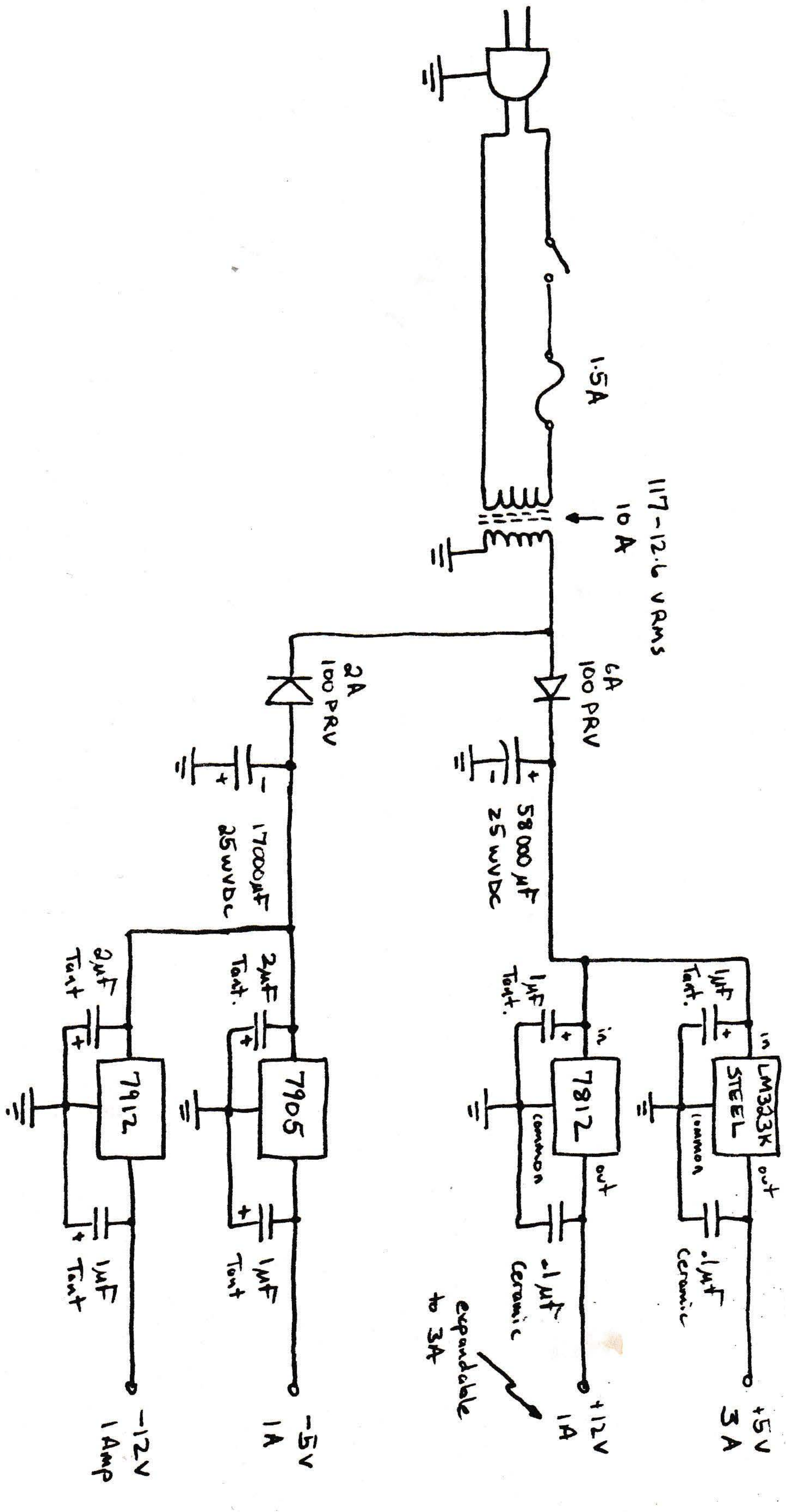
Manual Control (MCR)
Pin Designations

Pin number	Function
1.	(unused)
2.	Data send (active low)
3.	Data bit 1
4.	Data bit 2
5.	Data bit 3
6.	Data bit 4
7.	Ground
8.	Data bit 5
9.	Data bit 6
10.	Data bit 7
11.	Data bit 8
12.	(unused)
13.	(unused)
14.	+5 volts

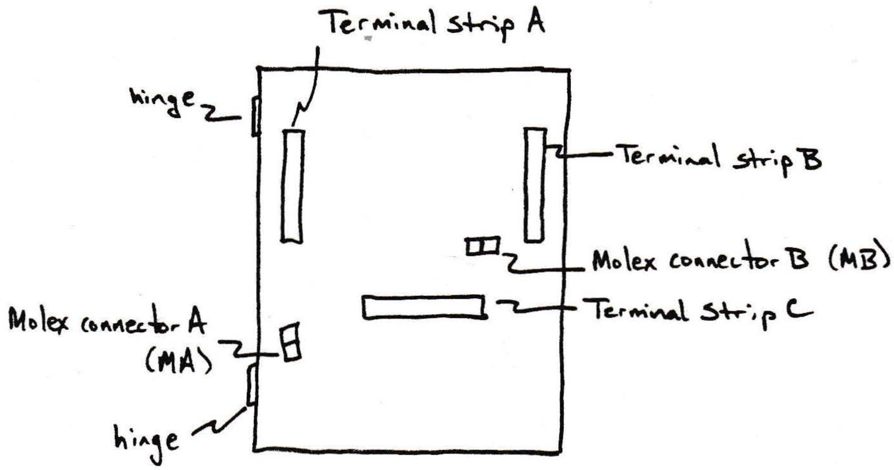
These pin numbers are for the 14-pin DIP header used to connect the MCR box the the DSX.


2.2K
+5
2
+5
3
4
5
6
8
9
10
11
S1
S2
S3
S4
S5
S6
S7
S8
14
+5
7

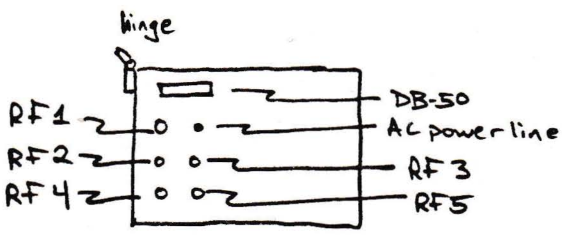
E-9 Mombo Power Supply


1.5A
117-12.6 VRMS
10 A
6A
100 PRV
2A
100 PRV
58000 µF
25 WVDC
17000µF
25WVDC
1µF
Tant.
in
LM323K
STEEL
common
out
.1µF
Ceramic
7812
2µF
Tant.
7905
7912
1µF
Tant
expandable
to 3A
+5V
3 A
+12V
1A
-5V
1A
-12V
1 Amp

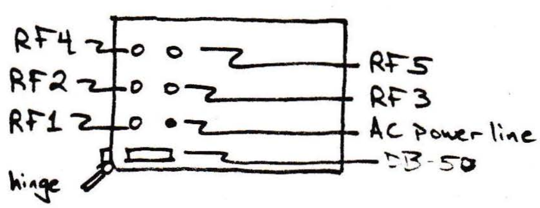
E-10 Weather-proof Box



Front view



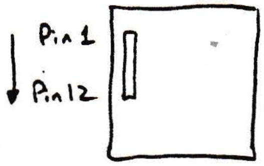
Bottom view of Box bottom



Top view of Box bottom

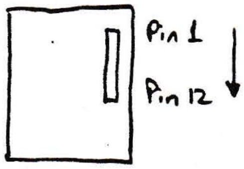
Weather-proof Box (WPB)

Pin designations for Terminal Strip A



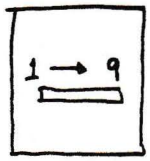
Pin number	Function
1.	Ground (MA1)
2.	Power to 70cm phasing harness relay (MA-2)
3.	Power to 2m phasing harness relay (MA-3)
4.	Power to HF dipole relay (MA-4)
5.	Serial data input (MA-5)
6.	(unused)
7.	(unused)
8.	(unused)
9.	(unused)
10.	(unused)
11.	MSR control input #1
12.	MSR control input #2

Weather-proof Box (WPB)
Pin designations for Terminal Strip B



Pin number	Function
1.	Ground (MB-1)
2.	Power to 10m preamp (MB-2)
3.	Power to 70cm preamp (MB-7)
4.	Power to 70cm-2m converter (MB-4)
5.	Auxillary (MB-5)
6.	Auxillary (MB-5)
7.	Mirage control #1 (brown)
8.	#2 (orange)
9.	#3 (white)
10.	#4 (black)
11.	#5 (green)
12.	#6 (blue)

Weather-proof Box (WPB)
Pin designations for Terminal Strip C



Pin number	Function
1	GROUND--------
2	NEUTRAL : incoming AC power line
3	HOT-----------
4	-12 volts
5	Ground
6	+5 volts
7	+12 volts
8	Battery voltage
9	+24 volts

Weather-proof Box (WPB)
Pin designations for DB-50 connector

Pin number	Function
1.	#1 (Input rotor cable from shack)
2.	#2
3.	#3
4.	#4
5.	#5
6.	#6
7.	#7
8.	#8
9.	(unused)
10.	(unused)
11.	#1 (Output rotor cable to TH6-DXX rotor)
12.	#2
13.	#3
14.	#4
15.	#5
16.	#6
17.	#7
18.	#8
19.	(unused)
20.	(unused)
21.	#1 (Output cable to Satellite Azimuth)
22.	#2
23.	#3
24.	#4
25.	#5
26.	#6
27.	#7
28.	#8
29.	(unused)
30.	(unused)
31.	#1 (Output cable for Satellite Elevation)
32.	#2
33.	#3
34.	#4
35.	#5
36.	(unused)
37.	(unused)
38.	(unused)
39.	(unused)
40.	(unused)
41.	(unused)
42.	(unused)
43.	(unused)
44.	(unused)
45.	Ground (MA-1)
46.	to 70cm phasing harness (MA-2)
47.	to 2m phasing harness (MA-3)
48.	to HF dipole relay (MA-4)
49.	Serial input from shack (MA-5)
50.	(unused)

Weather-proof Box (WPB)

RF connectors:

RF1 - RF output to shack (Receive only; 28 MHz)
RF2 - 10m loop antenna
RF3 - 70cm yagi antenna
RF4 - 2m yagi antenna
RF5 - 2m RF from shack

Molex connectors:

MA1 - Ground
2 - 70cm phasing harness relay
3 - 2m phasing harness relay
4 - HF dipole relay
5 - Serial data from shack
6 - unused
7 - unused
8 - unused
9 - unused

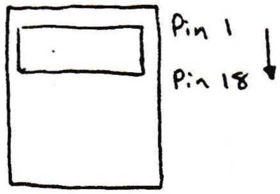
MB1 - Ground
2 - Power to 10m preamp
3 - unused
4 - Power to 70cm-10m converter
5 - Auxillary
6 - unused
7 - Power to 70cm preamp
8 - Auxillary
9 - unused

E-11 Digital Control Cage

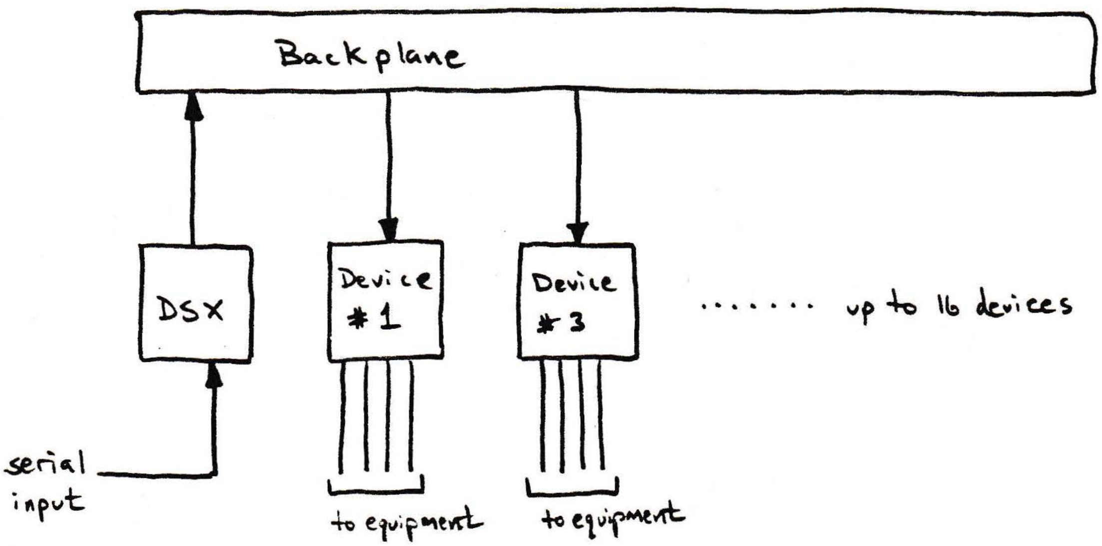
Digital Control Cage (DCG)
Circuit Description

The DCG is located in the top of the Weather-proof Box (WPB). The card cage houses the digital control cards that convert the serial data into usable control signals. To do this, a serial receiver and several (up to 16) device cards are employed. The backplane buss of the cage is parallel, so that the slot locations of the cards is unimportant. Also wired to the backplane is a LED monitor, which shows the status of the 8-bit buss at all times. This is very useful in trouble shooting the system, as bringing test equipment to the roof is very difficult and cumbersome.

Digital Control Cage (DCG)
Pin Designations for backplane

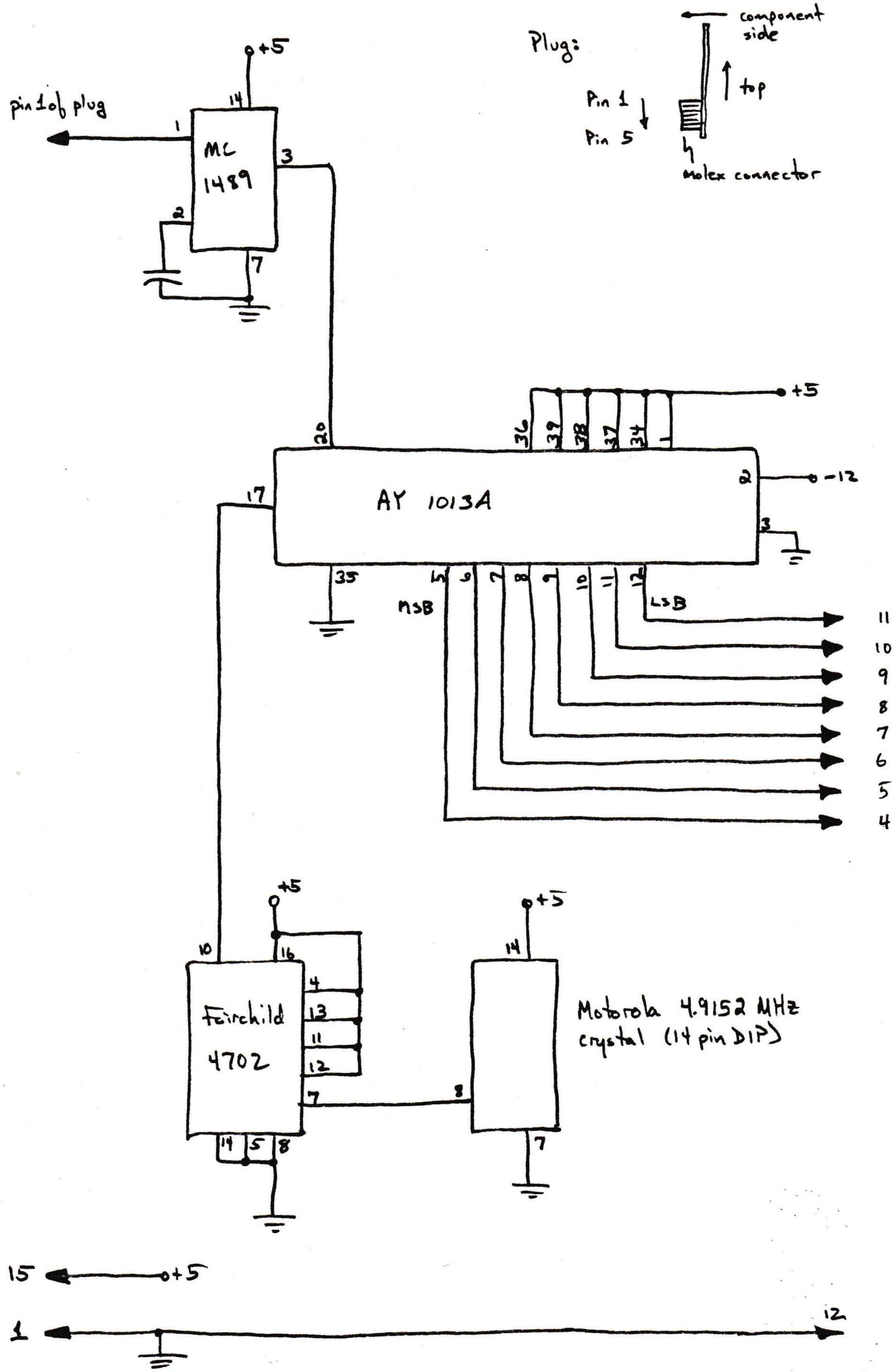


Pin number	Function	
1	Ground	
2	(unused)	
3	(unused)	
4	Data bit 8------	
5	Data bit 7 :	Address
6	Data bit 6 :	Buss
7	Data bit 5------	
8	Data bit 4------	
9	Data bit 3 :	Data
10	Data bit 2 :	Buss
11	Data bit 1------	
12	WORD GOOD (active low)	
13	(unused)	
14	(unused)	
15	+5 volts	
16	+24 volts	
17	+12 volts	
18	-12 volts	


Backplane
DSX
Device #1
Device #3
.... up to 16 devices
serial input
to equipment
to equipment

E-12 Digital Serial Receiver

The serial input from the shack comes onto this board on a 5-pin Molex connector. The RS-232 signal is then converted back into TTL signals using a MC1489 line receiver. The serial data goes into the UART, and is converted back into serial form. As with the DSX, a Fairchild baud rate chip and a Motorola crystal are used to provide the UART a receive clock. The resulting eight-bit word is then placed onto the backplane of the Digital Control Cage.

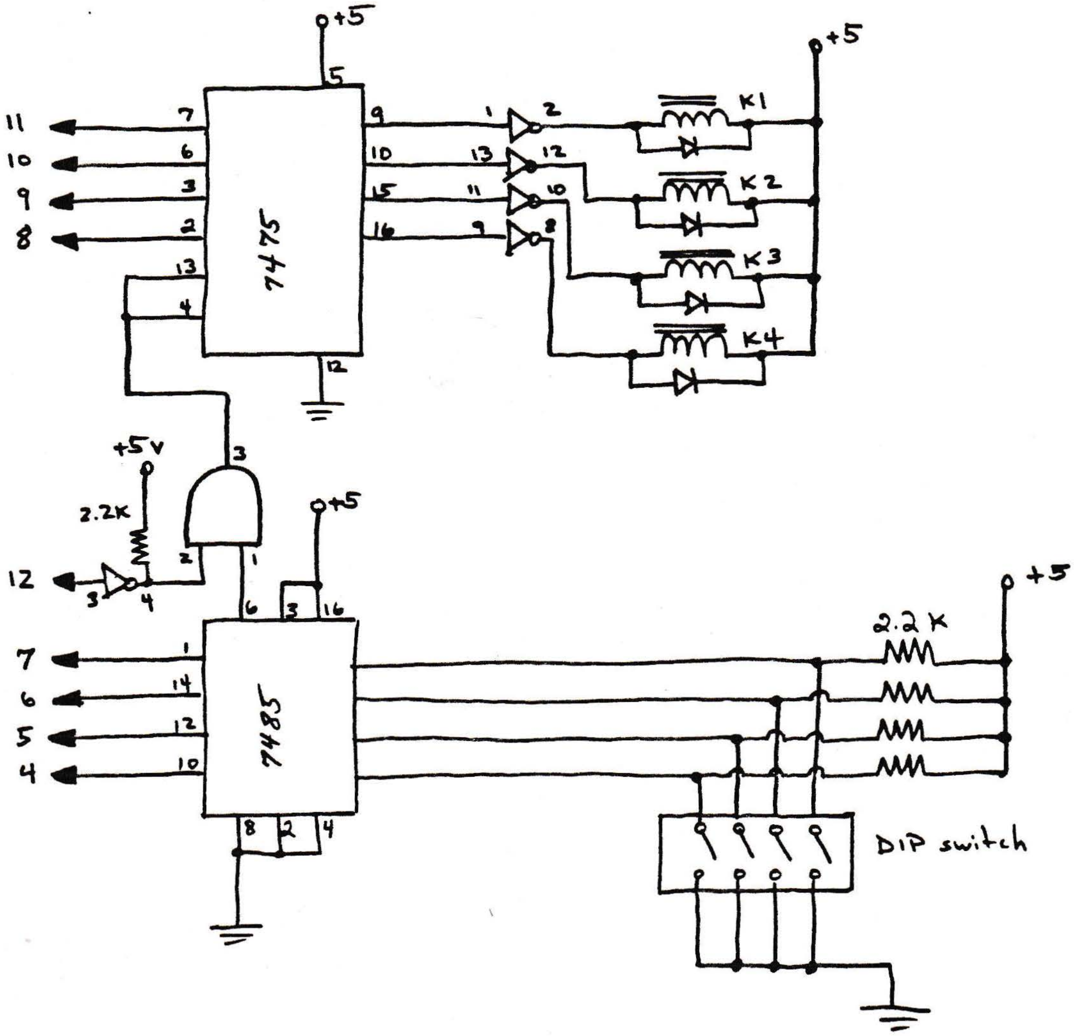


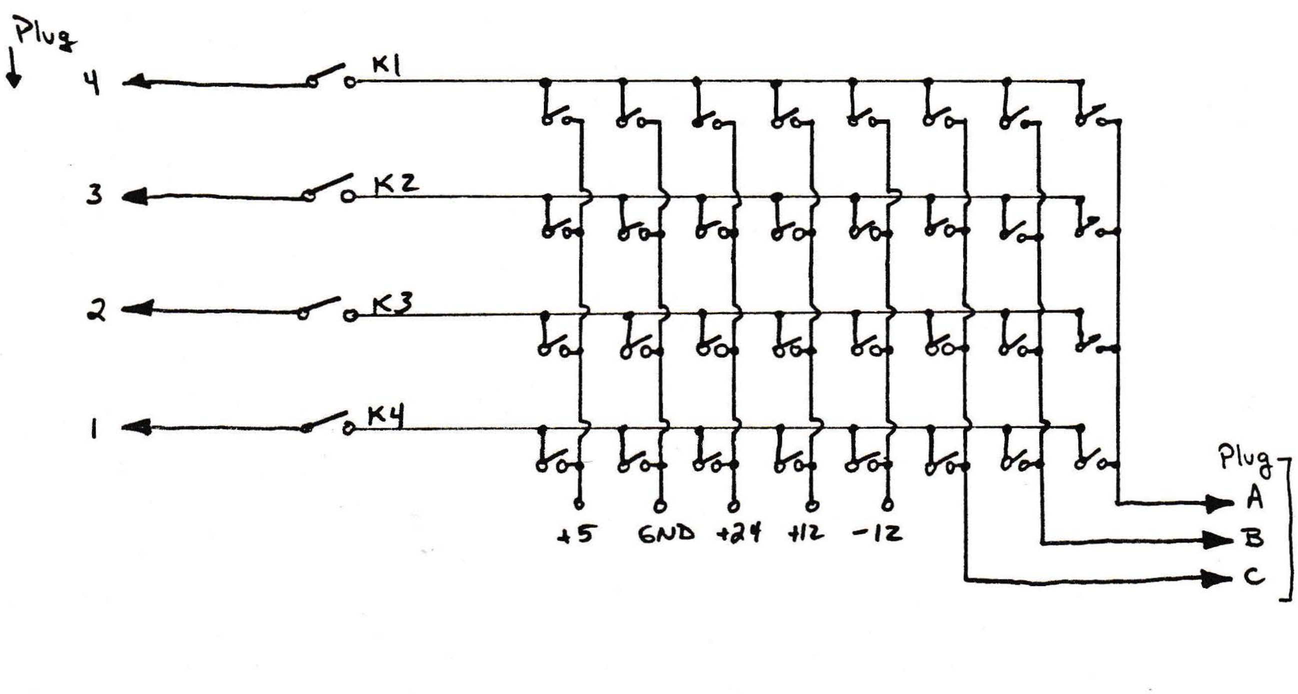
Plug:
component side
top
Pin 1
Pin 5
molex connector
+5
pin 1 of plug
MC 1489
+5
-12
AY 1013A
MSB
LSB
11
10
9
8
7
6
5
4
+5
Fairchild 4702
+5
Motorola 4.9152 MHz crystal (14 pin DIP)
15
+5
1
12

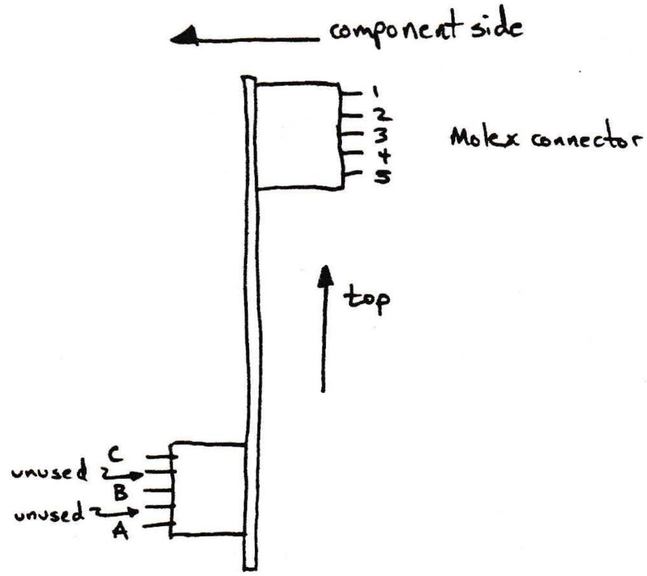
E-13 Universal Device Card

Circuit Description

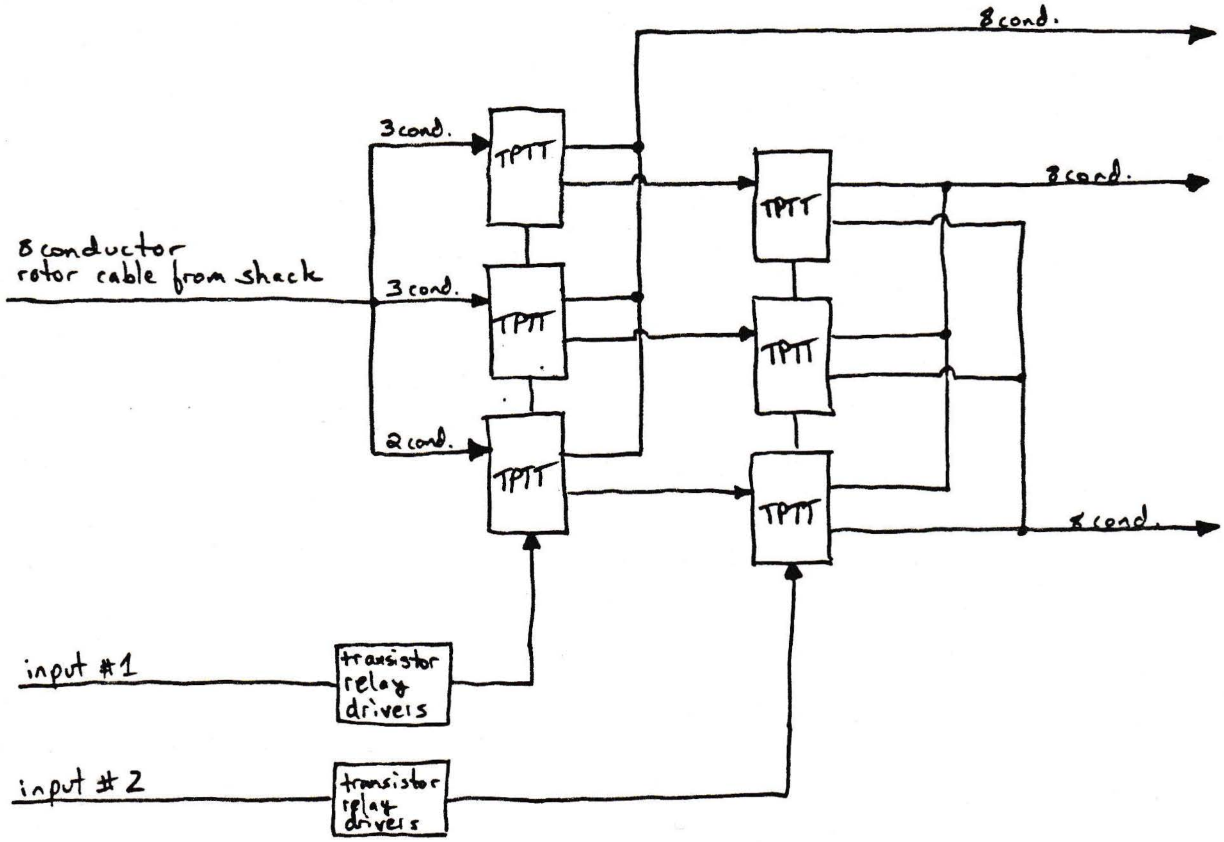
This circuit converts TTL signals into usable control signals for the various gear located on the roof. The upper four bits are decoded as an address, and the lower four are then used as data bits to control the gear. Each card has a programmable address (via DIP switches), which may or may not agree with its logical address used in the software. When the upper four bits equal the selected address for a particular card, and the WORD GOOD signal is low, the four bit latch is enabled. The signals then go to open collector inverters, which in turn activate the DIP relays mounted on the card. Note on the schematic that the voltage the relay passes when it is closed is a function of a switching matrix. The connections are made by soldering feedthroughs on the board for the desired configuration.

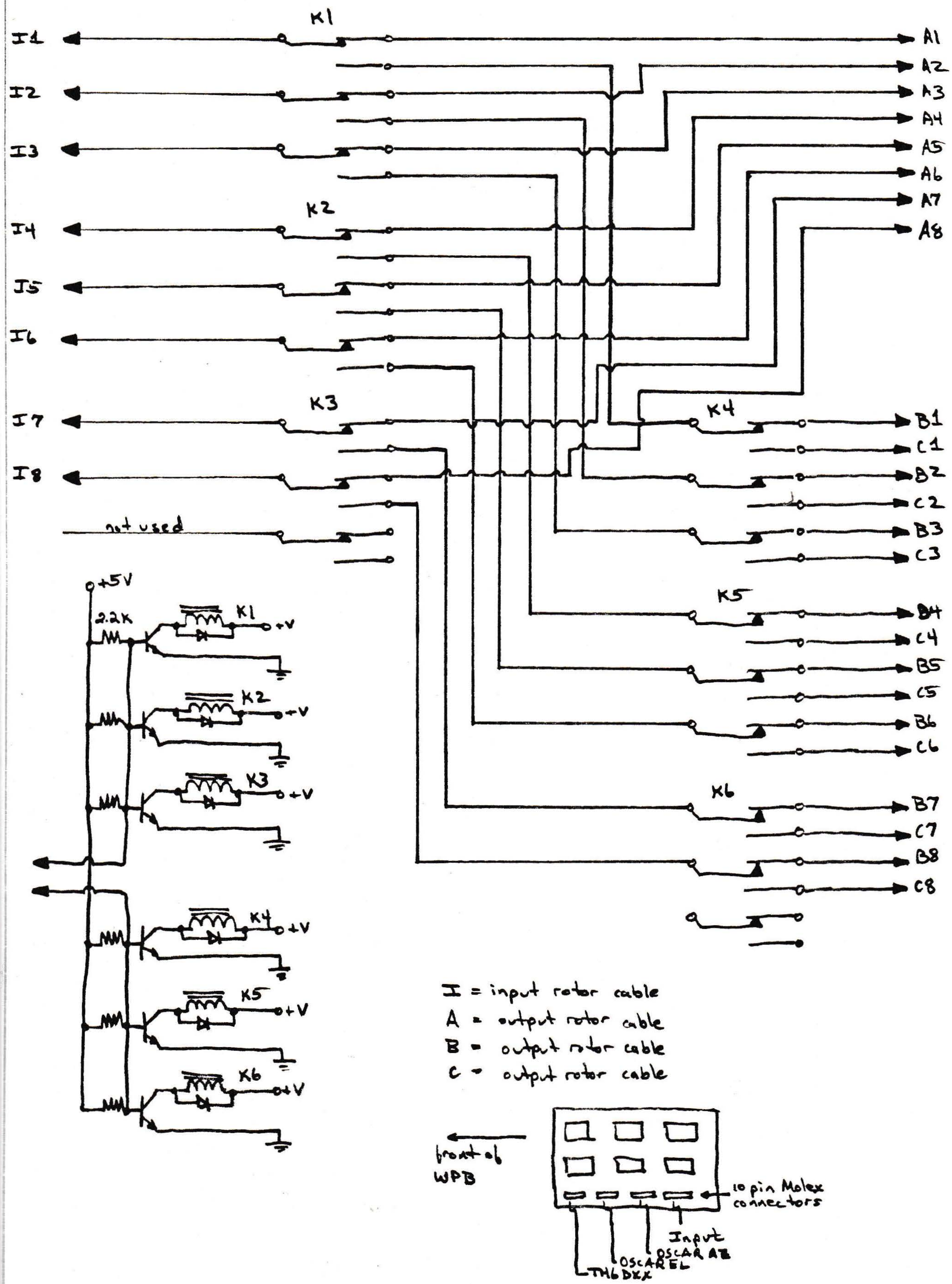

+5
7475
K1
K2
K3
K4
+5V
2.2K
7485
2.2 K
DIP switch
11
10
9
8
12
7
6
5
4


Plug
4
3
2
1
K1
K2
K3
K4
+5
GND
+24
+12
-12
Plug
A
B
C


component side
1
2
3
4
5
Molex connector
top
C
unused
B
unused
A

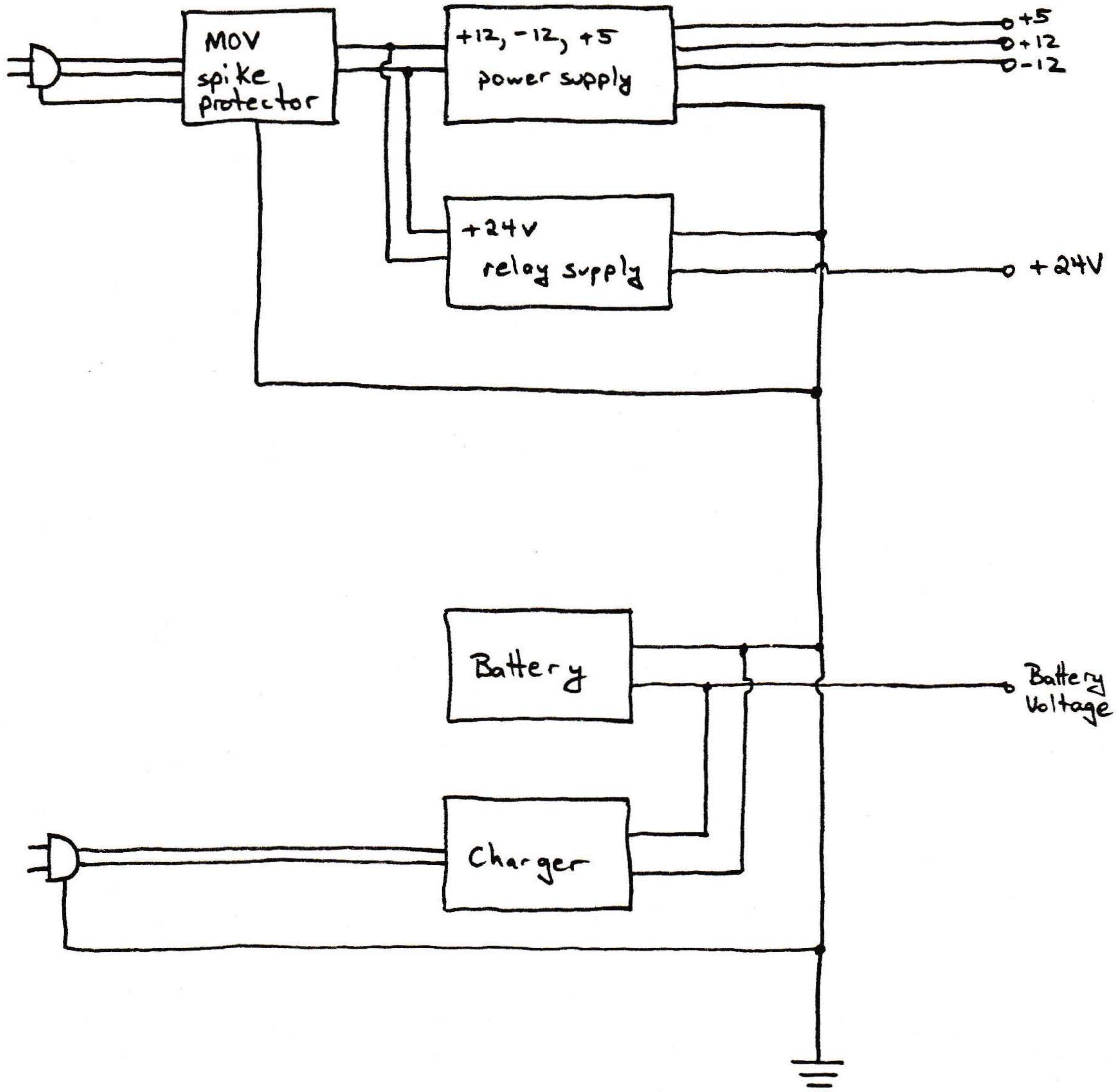
E-14 Mombo Switching Relays

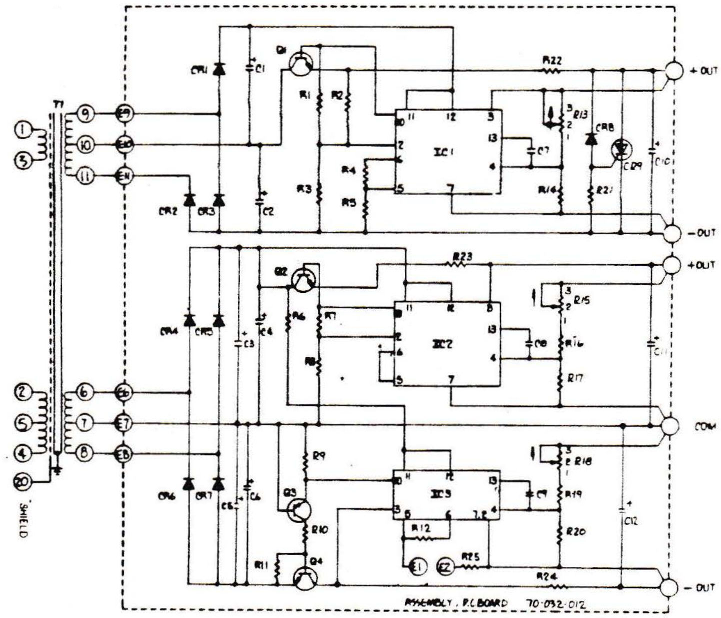

8 cond.
3 cond.
TPTT
8 cond.
TPTT
8 conductor
rotor cable from shack
3 cond.
TPTT
TPTT
2 cond.
TPTT
TPTT
8 cond.
input #1
transistor
relay
drivers
input #2
transistor
relay
drivers

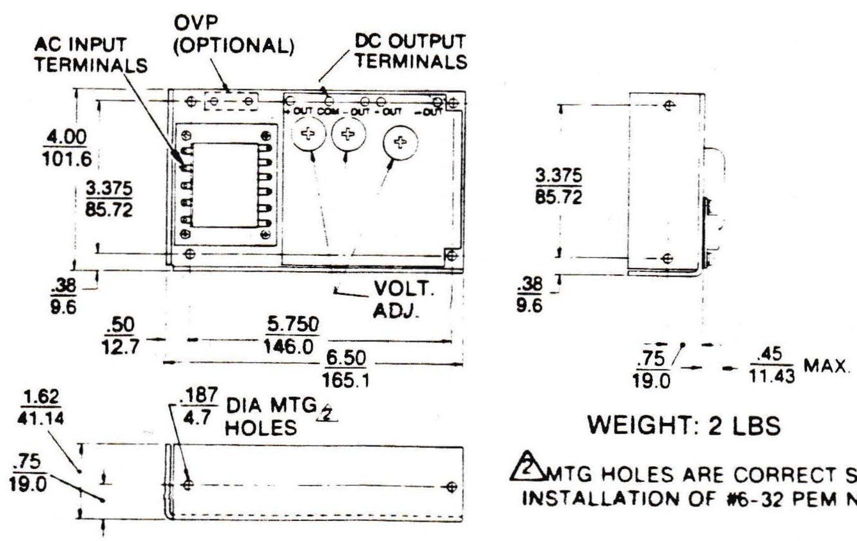

K1
I1
I2
I3
K2
I4
I5
I6
K3
I7
I8
not used
A1
A2
A3
A4
A5
A6
A7
A8
K4
B1
C1
B2
C2
B3
C3
K5
B4
C4
B5
C5
B6
C6
K6
B7
C7
B8
C8
+5V
2.2K
K1 +V
K2 +V
K3 +V
K4 +V
K5 +V
K6 +V
I = input rotor cable
A = output rotor cable
B = output rotor cable
C = output rotor cable
front of WPB
10 pin Molex connectors
Input
OSCAR AZ
OSCAR EL
TH6 DXX

E-15

Power system on roof


MOV
spike
protector
+12, -12, +5
power supply
+5
+12
-12
+24V
relay supply
+24V
Battery
Battery
Voltage
Charger

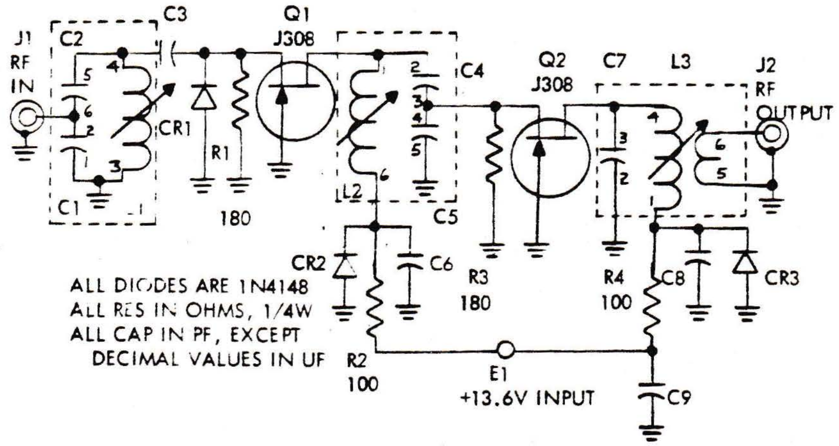


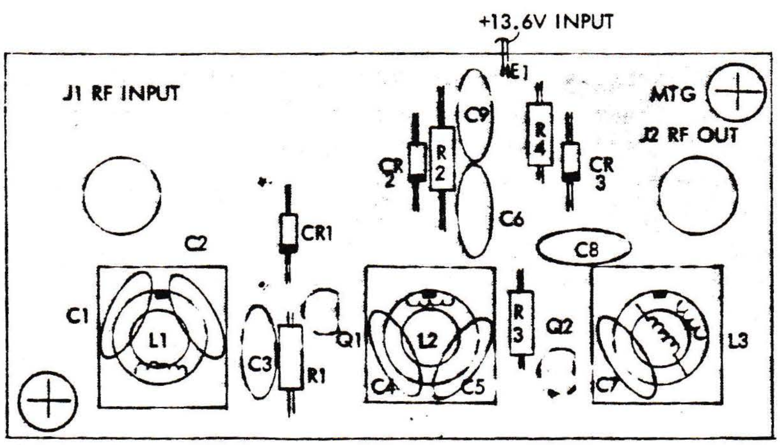


WEIGHT: 2 LBS

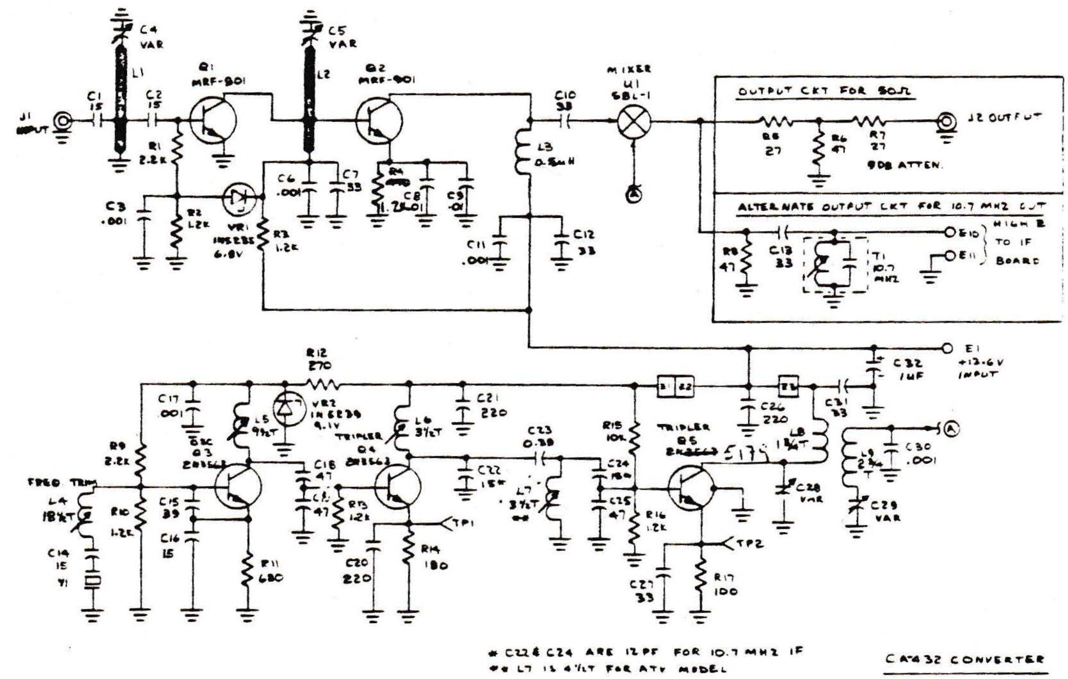
△2 MTG HOLES ARE CORRECT SIZE FOR INSTALLATION OF #6-32 PEM NUT

E-16 Ten meter Preamp


J1
RF
IN
C1
C2
C3
CR1
R1
180
Q1
J308
L2
C4
C5
CR2
C6
R2
100
Q2
J308
R3
180
C7
L3
J2
RF
OUTPUT
R4
100
C8
CR3
E1
+13.6V INPUT
C9
ALL DIODES ARE 1N4148
ALL RES IN OHMS, 1/4W
ALL CAP IN PF, EXCEPT
DECIMAL VALUES IN UF

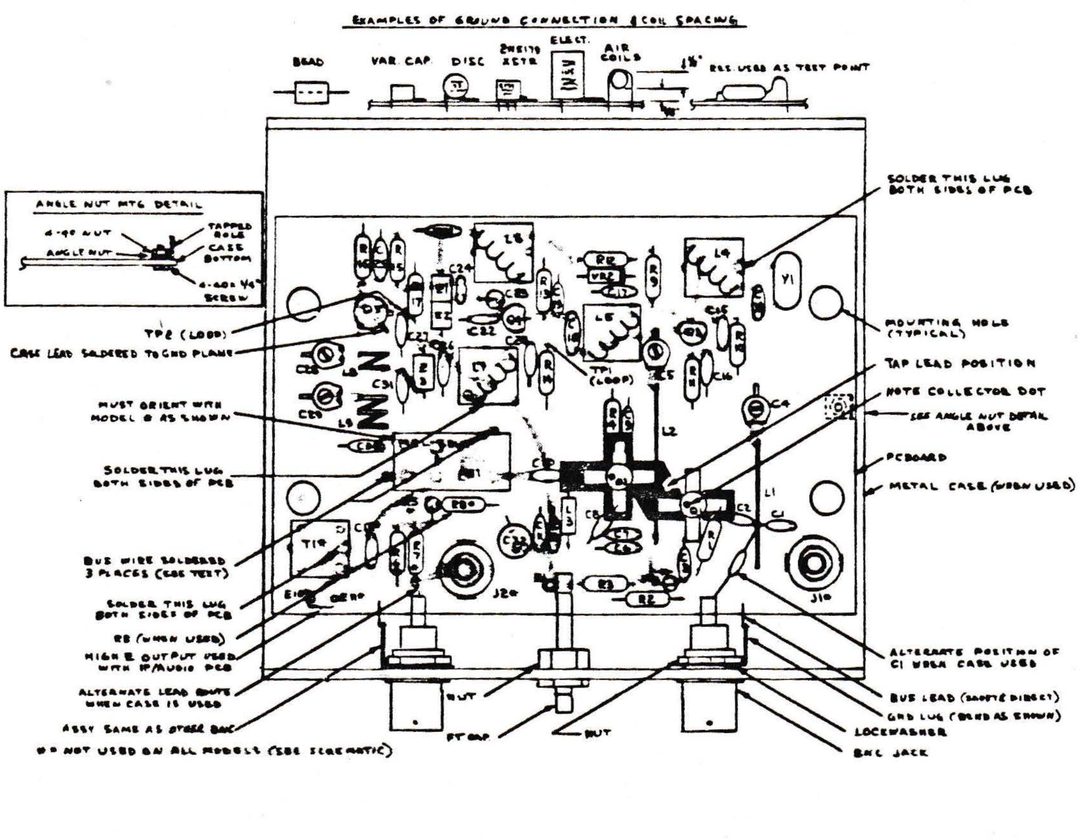

+13.6V INPUT
E1
J1 RF INPUT
MTG
J2 RF OUT
C9
CR2
R2
R4
CR3
C6
C8
CR1
C2
C1
L1
C3
R1
Q1
L2
C4
C5
R3
Q2
L3
C7

E-17 70cm-10m Converter

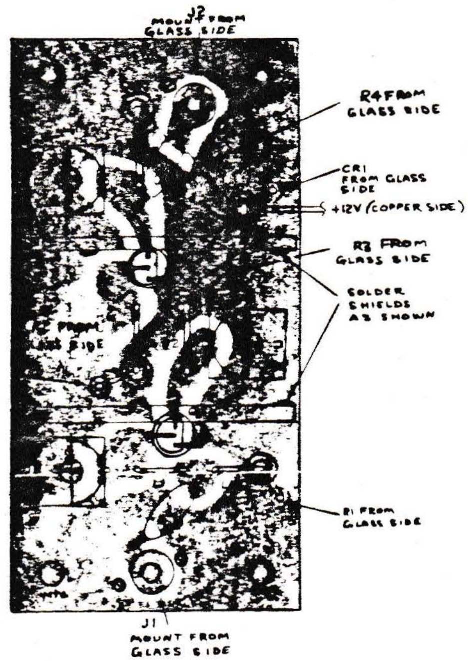


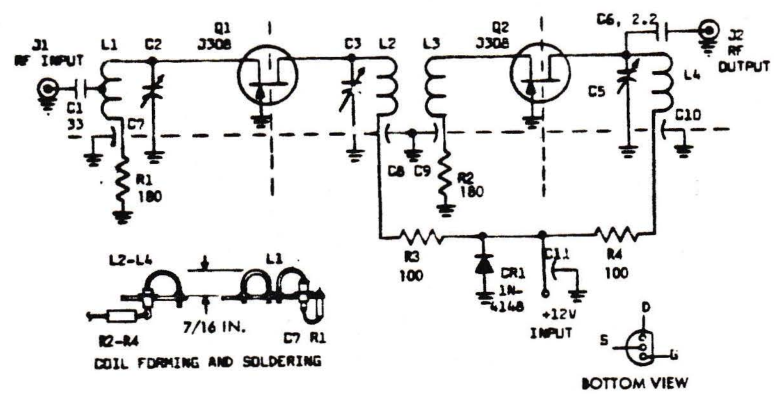
CA432 CONVERTER

EXAMPLES OF GROUND CONNECTION & COIL SPACING

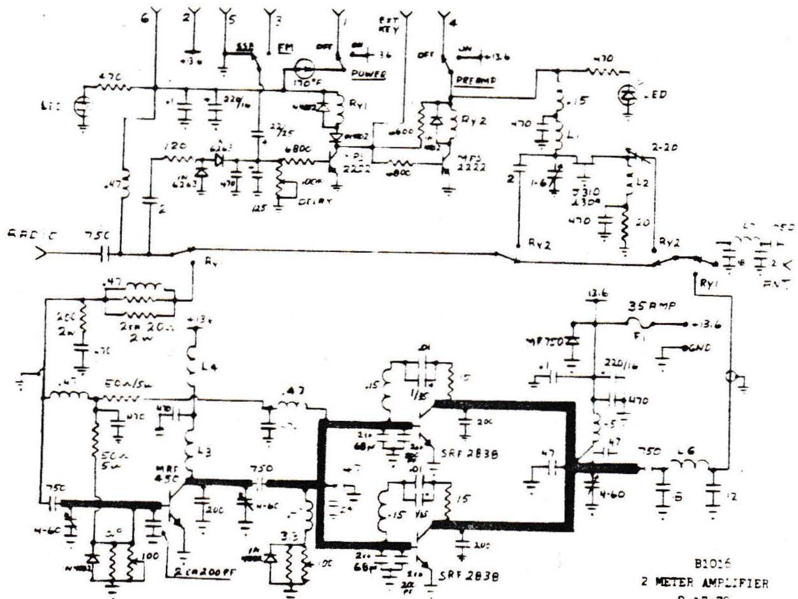


E-18 70cm Preamp


J2
MOUNT FROM
GLASS SIDE
R4 FROM
GLASS SIDE
CR1
FROM GLASS
SIDE
+12V (COPPER SIDE)
R3 FROM
GLASS SIDE
SOLDER
SHIELDS
AS SHOWN
R1 FROM
GLASS SIDE
J1
MOUNT FROM
GLASS SIDE


J1
RF INPUT
L1
C2
Q1
J308
C3
L2
L3
Q2
J308
C6, 2.2
J2
RF
OUTPUT
C1
33
C7
C5
L4
C10
R1
180
C8
C9
R2
180
R3
100
CR1
1N-
4148
C11
R4
100
+12V
INPUT
L2-L4
L1
7/16 IN.
R2-R4
C7 R1
COIL FORMING AND SOLDERING
D
S
G
BOTTOM VIEW

E-19 Two meter Power Amplifier



B1016
2 METER AMPLIFIER
9-17-79

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SECTION F

SOFTWARE OVERVIEW

The software for the Satellite Operating System has been developed by the club over the past year and a half. It is written in BASIC on a Commodore PET using a high level structured approach.

The main features of the program are:

1. Portability
2. Ease of modification
3. Adaptable to many station configurations
4. User friendliness
5. Can track both circumpolar and elliptical orbits
6. Provision to compute "windows" to other stations

Although a complete software discription would be within the scope of this paper, it has been eliminated because of space and time limitations. Instead, a brief summary of the program's main features is presented, with a few illustrative flowcharts and examples. A code listing is also omitted as a simple listing of the software without accompaning comments and routine discriptions would not only be confusing, but worthless to all but the most experienced programmers.

1. PORTABILITY

While the code was written using PET BASIC, conversion to other computers will be easy. Only one subroutine uses any machine dependent POKE statements. The most difficult aspect of moving the code would be the conversion of the screen graphics. All graphic routines are located in separate subroutines, and any potential computer need only relative cursor control, home, and clear screen functions to be suitable for the graphic routines.

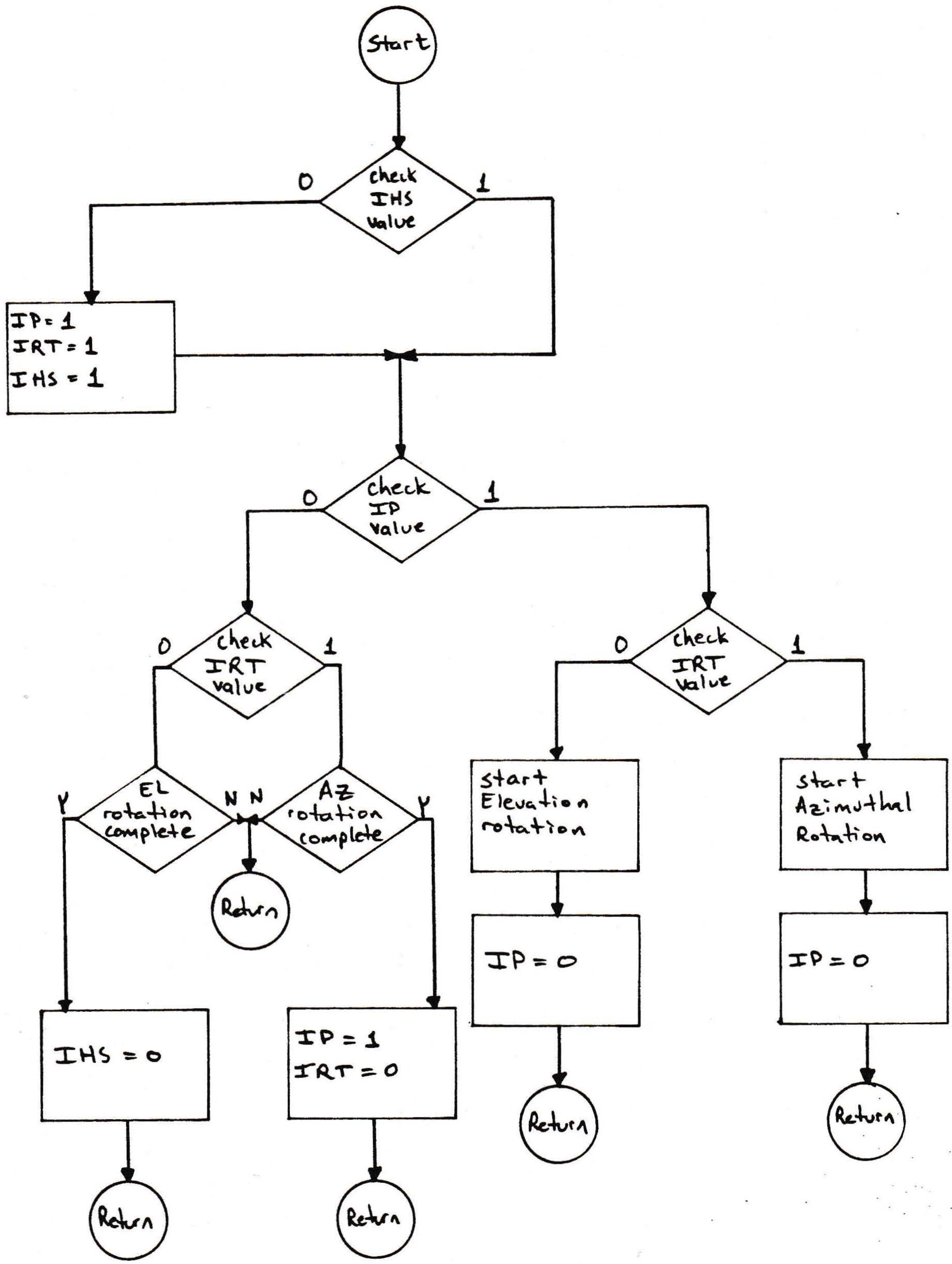
As mentioned in Section C-1, any computer must have two TTL output ports. On the PET, these ports are memory-mapped into the upper section of memory. Other architectures utilizing devices and I/O instructions would prove just as satisfactory. A provision for an 8-bit TTL input port would come in handy should the user ever want to incorporate a more accurate rotor feedback loop as discussed in Section C-3.

2. EASE OF MODIFICATIONS

Modification of the program is made simpler by the modular programming approach utilized. Liberal use of subroutines and indexed variable storage makes this possible despite the cumbersome PET BASIC. Two examples should amply illustrate this principle.

Because of frequent hardware changes during the initial stages of testing, it was decided that all the different software routines would communicate with the hardware using a subroutine, rather than scattering POKE statements throughout the program. First, the subroutine receives a command to perform a function, say "select TH6-DXX" rotor. The routine looks up this function in a large command table and sees what IO steps are required. In this case, two bits in device #1 must be set, and the appropriate rotor box, the CDE, is placed on line in the shack. Although this approach requires a bit of overhead to accomodate the added bookkeeping, it has the advantage of being very flexible. Making a modification to the hardware only requires a corresponding change in the command table. Furthermore, a change in the method of output to hardware requires only a single subroutine be modified, rather than replacing several hundred POKE statements, as would be necessary without this approach.

As a second example of the ease of software modifications, consider those software changes made necessary by modifications to the rotor control feedback. Any antenna rotation is initiated by executing a subroutine called ROTATE. (See accompaning flowchart.) If a section of code needs to rotate the antennas, it simply sets the desired AZ and EL values and executes a GOSUB to the ROTATE routine. It then checks the handshake variable to see if rotation is complete. If not, then it continues executing the GOSUBs until the handshake variable indicates rotation completion. Note that only two branches of the logic flow, check


Start
check IHS value
0
1
IP = 1
IRT = 1
IHS = 1
check IP value
0
1
check IRT value
0
1
check IRT value
0
1
EL rotation complete
Y
N
N
AZ rotation complete
Y
Return
start Elevation rotation
start Azimuthal Rotation
IP = 0
IP = 0
IHS = 0
IP = 1
IRT = 0
Return
Return
Return
Return

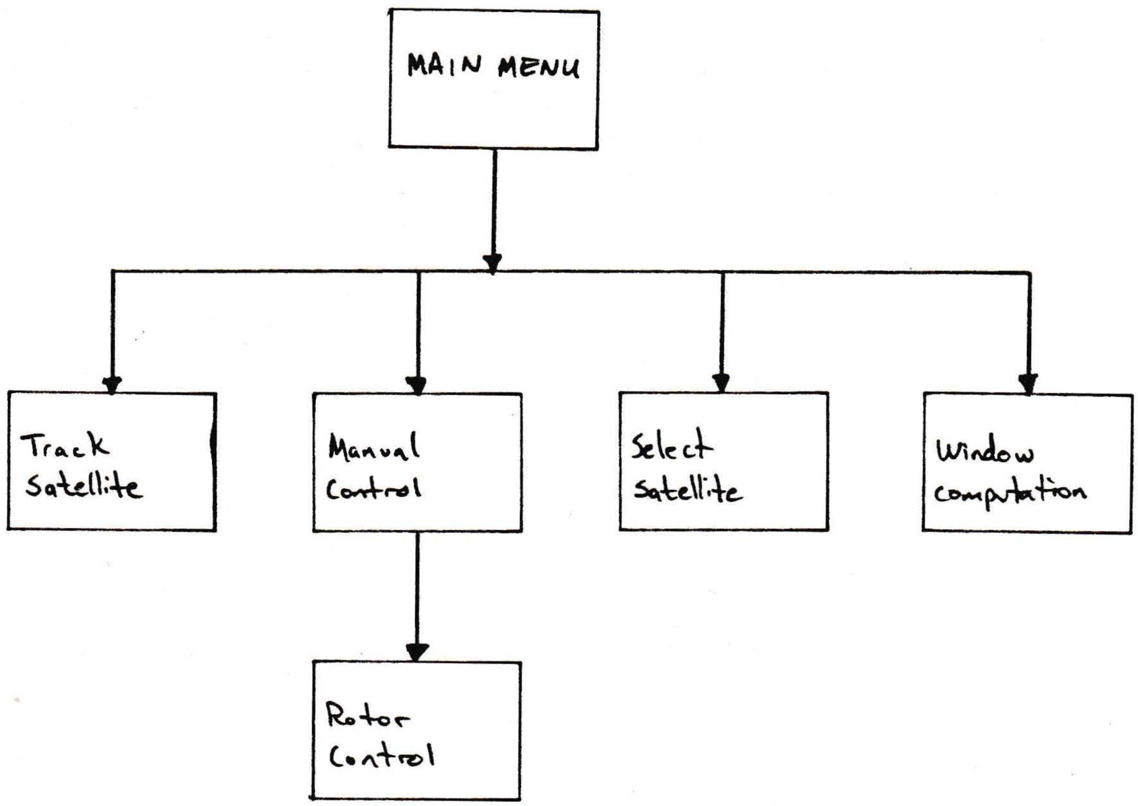
to see if the rotor has arrived at the desired location. As mentioned earlier, this is currently accomplished by checking the time of rotation. The only modification required is to add a new function to the command table, which would read the output of an A-D converter. The comparison would then be made as before with only a few changes to the two above mentioned branches.

3. ADAPTABILITY TO OTHER STATIONS.

Moving the program to another station would require a complete reentry of the DATA block used to fill the command table, and rewriting one I/O subroutine to conform to the input/output hardware at the installation. Several menus, primarily the manual control menu, would be modified to display that station's hardware.

4. USER FRIENDLINESS

Since the program was conceived over a year ago, we have had the benefit of frequent advise on methods to improve user interaction with the program. Everyone, from computer jocks to those adamantly opposed to computers in the ham shack, has critisized. The current version seems to please everyone, and its menu-driven operation makes it easy to understand after a few minutes of operation. The menu structure, shown here, is self explanatory.


MAIN MENU
Track Satellite
Manual Control
Select Satellite
Window computation
Rotor Control

5. TRACKING CODE

We are currently incoporating a section from a program written by Dr. Tom Clark, W3IWI, to compute the AZ-EL values of a selected satellite. Arrays are used to store the various satellite and station parameters. This method facilitates rapid change from one satellite to another by changing an index to an array. These parameters are in DATA statements, so updating satellite parameters, for example, is a trivial program change. Dr. Clark's code allows us to track both the elliptical and circumpolar satellites, and has proven quite accurate. Entering new satellites as they are launched only requires an addition to the DATA block.

6. WINDOW STATIONS

Our original tracking code, while only tracking circumpolar orbits, lent itself well to the use of windows; time periods when a satellite will be in range of two stations. With the installation of Dr. Clark's code, window times are no longer simple to determine. Several approaches have been considered, but none tried as of this writing. Our program is written to accomodate these windows and such computation, in real time, is trivial. The problem arises when the user wants to know ahead of time when a window will open and when it will close. The next version of the software will compute a window in some manner. At this time which approach to take is unclear.