SETUP PROCEDURE FOR NBS/GPS TYPE RECEIVER

1. Unpack and inventory equipment:
   - A. Antenna electronics package, approx 9"x9"x5".
   - B. Receiver - 5"x16"x16" rack mount.
   - C. Microprocessor/counter 7"x16"x16" rack mount.
   - D. Keyboard, RCA VP-601.
   - E. Modem and telephone (if on packing list.)
   - F. Printer-MX-80 (if on packing list.)
   - G. Cables as follows:
     1. Antenna cables, 2ea, 1 for IF output marked with blue tape on both ends, with delay marked in ns. 1 for LO and +15v marked with red tape on both ends. (cables 50 to 300 ft long, as required for the location.) BNC connectors, both ends.
     2. BNC,BNC - 4 ft 2ea, 1PPS and 5mHz from rcvr to microprocessor.
     3. 4 ft braided dc power between rcvr & up, 9pin Amphenol conn.
     4. 34 wire ribbon, control cable between rcvr & up.
     5. 20 wire ribbon, processor to keyboard.
     6. Printer cable, DB25 connectors (if on packing list)

2. Install equipment as convenient and power it up.

3. After unit is powered up, enter correct receiver delay under main menu option 9 , sub-menu option 3 "enter rcvr delay". (The measured delay of the receiver and antenna package are positive numbers, approximately 50ns. The antenna cable delay is also a positive number, stated in ns. The delay between the user clock reference point and the counter start input on the microprocessor is a negative number. For example, at NIST, the delay from UTC(NIST) to our receiver #5 is 977ns, rcvr #5 delay is 48ns and the antenna cable delay is 232ns. The delay value entered is: -977ns +48ns +232ns = -697ns.)
   The value should be entered as: - 0.697000000000000 E-06 seconds.
   REFER TO "TEST & CALIB" AT THE FRONT OF YOUR OPERATIONS AND SERVICE MANUAL FOR THE VALUE OF YOUR RECEIVER, ANTENNA, AND CABLE DELAY. IF YOU ARE SUPPLYING YOUR OWN ANTENNA CABLE, EITHER MEASURE THE DELAY OR FOR RG-58, TAKE (LENGTH, IN FEET)/0.66 = DELAY IN ns. (to 1%)

RCVR DELAY = +54ns

4. Enter correct coordinates for your location--or if you do not have a first order survey point in WGS-84 coordinates, enter approximate coordinates and allow the receiver to do navigation solutions for 1 or more days. If the GPS constellation is being well controlled, the resulting average of 4 days of nav solutions should be accurate to better than 10 meters.

5. If required, enter tracking schedule for your geographic area. (Refer to your service manual, page 39 of 180)

6. When all else fails, call Dick Davis, (303) 497-3639 FTS-320-3639
   No answer?--leave message at -3294 and I will get back to you.

PLEASE NOTE DETAILS OF MODEM CABLE AND MODEM CONFIGURATION SWITCHES ON THE FOLLOWING PAGE

DETAILS OF MODEM CABLE AND CONFIGURATION SWITCHES

A modem cable should be constructed to interconnect the GPS receiver and a 300/1200 baud external modem. Software versions Nov 89 or later will automatically configure to the calling speed.

DB-25 MALE	DB-25 MALE
2	3
3	2
7	7
8	20
20	8
12	12

Note that the cable is symmetrical so either end can go to modem or gps receiver.

MODEM CONFIGURATION SWITCHES SHOULD BE SET AS FOLLOWS:

	SWITCH FUNCTION	(UP/DN)	DESIRED RESULT
1.	DTR	(UP)	Hangs up if DTR drops
2.	Result codes	(DN)	Single digits
3.	Result codes	(UP)	No result codes sent
4.	Character echo	(DN)	No echo in command mode
5.	Auto answer	(UP)	Enable auto answer
6.	Carrier detect	(UP)	Enable carrier detect
7.	Telco jack	(UP)	RJ-11
8.	Commands	(UP)	Commands not recognized
	---below for 10 sw modems---		
9.	Comm standard	(UP)	Bell 212
10.	DTR response	(UP)	Hangs up if DTR drops

Verify that UP/DN position corresponds to desired result as described in your modem manual.

UNITED STATES DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
[formerly National Bureau of Standards]
325 Broadway
Boulder, Colorado 80303-3328

Reply to the attention of:

November 2, 1989

TO: ALL USERS OF "NIST/GPS" TYPE COMMON VIEW RECEIVERS
(INCLUDING VSL, COLLINS AND AOA UNITS)

FROM: Dick Davis - NIST Time and Frequency Division
325 Broadway
Boulder, Co. 80303
(303) 497-3639 FAX: (303) 497-6461
FTS 320-3639

This version (Nov 2, 89) of the software corrects six problems.

1. Corrects a bug in the Geocentric to Geodetic conversion routine. (In certain locations, this iterative conversion didn't converge, so the receiver printed out all FFFF's for the X,Y,Z values.)

2. Moves the relativity correction for ("e*Sin[Ek]") to Ref-Sv rather than waiting to apply it to Ref-GPS.

3. Upgrades the Iono model correction to ICD 200B specifications.

4. Upgrades the parity check algorithm to ICD 200B specifications. (Prior version of software did not consistently decode the data from block II SV's.)

5. Provides a fix for newer receivers that use static rams (manufactured after 1987) in fail-safe.

6. Implements autobaud (300-1200) for modem use.

Item 6 requires a minor modification to the microprocessor. Disconnect the wire going to pin 20 of the printer connector and hook it instead to pin 12 of the modem connector. In addition, a new cable must be fabricated that includes a connection of pin 12 of the modem (the high speed line) to pin 12 of the microprocessor.

If no modifications are made, the receiver will operate at 300 baud unless commanded to go to 1200 baud with the "O" command(*). If the carrier detect line is presently connected, the receiver will always revert to 300 baud when carrier detect is received.

* - TO USE THE "O" COMMAND, FIRST ISSUE THE PRIVILEDGED UNLOCK COMMAND "QWERDXCMD<CR>" , FOLLOWED BY "0OCMD<CR>" TO GO TO 300 BAUD FROM 1200 OR "1OCMD<CR>" TO GO TO 1200 BAUD FROM 300.

OVERVIEW ARTICLE

REMOTE SYNCHRONIZATION WITHIN A FEW NANOSECONDS BY SIMULTANEOUS VIEWING OF THE 1.575 GHz GPS SATELLITE SIGNALS

Dick D. Davis, Marc Weiss, Alvin C. Clements,
and David W. Allan
Time and Frequency Division
National Bureau of Standards
325 Broadway
Boulder, Colorado 80303

ABSTRACT

The NBS/GPS receiver has been designed around the concept of obtaining high accuracy, low cost time and frequency comparisons between remote frequency standards and clocks with the intent to aid international time and frequency coordination. Simultaneous viewing with the USNO commercial GPS receiver at Washington, DC and the NBS constructed receiver at Boulder, CO (3000 km baseline) yielded synchronization accuracies of less than 10 ns as compared with several portable clock trips.

The hardware and software of the NBS/GPS receiver will be outlined in the text. The receiver is fully automatic under microprocessor control with a built-in 0.1 ns resolution time interval counter. The microprocessor also does data processing. A navigation program is included in the software capable of locating the antenna in earth-fixed coordinates to within about 5 meters. Satellite signal stabilities are routinely at the 5 ns level for 15 s averages, and the internal receiver stabilities are at the 1 ns level. The second generation receiver has a built-in CRT and parallel keyboard for operator interface. A full duplex RS-232 serial interface is provided for telephone modem use. An additional RS-232 output is included for use with a local printer to generate hardcopy.

PHYSICAL CONSTRUCTION

Two versions of the NBS/GPS receiver have been constructed. The first version uses linear power supplies in a 13 cm (5") rack mount case. The microprocessor and time interval counter, along with a video display, are contained in a 18 cm (7") rack mount case. The second version includes a switching power supply in the microprocessor case. The receiver electronics are contained in a separate 13 cm rack mount case.

The antenna electronics are contained in a hermetically sealed metal drum. The antenna package is 25 cm (10") in diameter and 50 cm (20") high, including the fiberglass antenna dome. The antenna is a quad spiral helix with hemispheric coverage.

RECEIVER BASIC FREQUENCY PLAN

Figure 1 is a block diagram of the receiver electronics. The NBS/GPS receiver utilizes triple conversion, with the first IF at 75.42 MHz. This IF stage is wide band (25-100 MHz) and provides about 50 to 55 dB of net gain. The correlation mixer converts the IF to 10.7 MHz. The post-correlation bandwidth is set by a 12 kHz crystal filter. The 10.7 MHz IF gain of 1 to 30 dB is controlled by a microprocessor during lock-up and by coherent AGC after lockup. The third IF of 700 kHz was chosen for ease of implementation of the phase coherent detectors using CMOS switches. Approximately 40 dB of gain is provided in the 700 kHz IF amplifier. By limiting gain at each IF to less than 60 dB, we minimize stability problems. With this selection of IF frequencies we have no problems with carrier false lock due to spurious frequency interference.

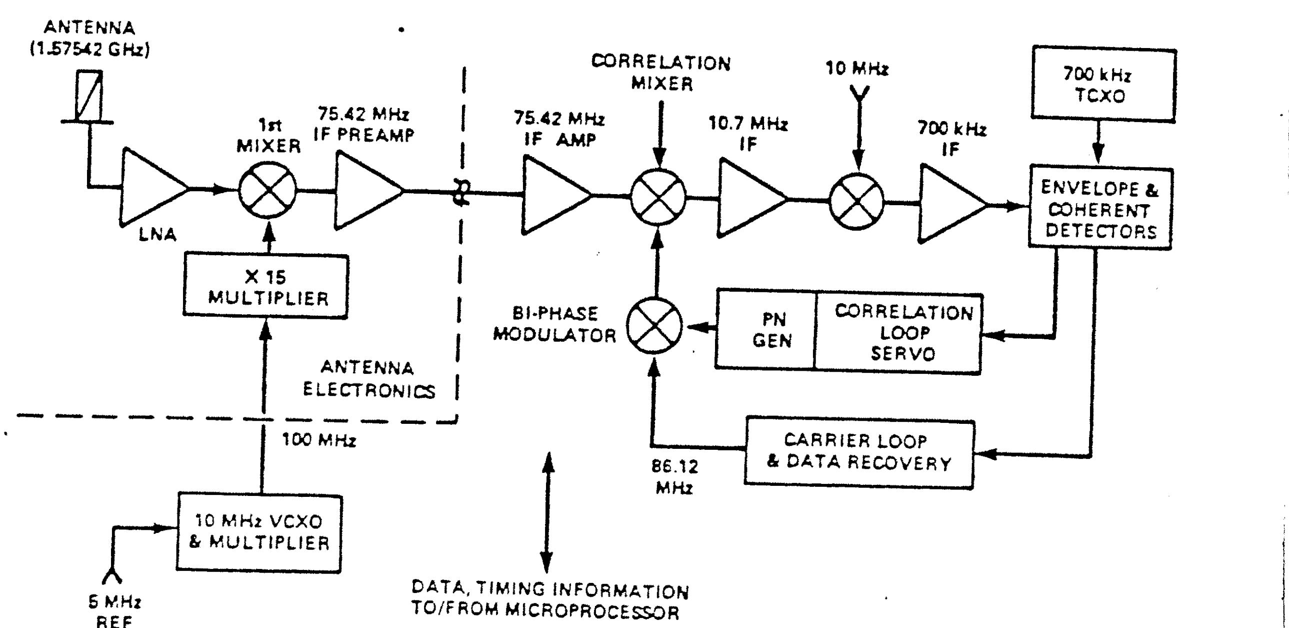


Figure 1. Simplified Receiver Block Diagram.

CORRELATION LOOP

The primary function of a spread spectrum timing receiver is to lock a locally generated replica of the "pseudo-noise" (PN) sequence to the received PN sequence. This function is performed by the correlation loop. The ultimate time accuracy of the receiver is primarily determined by how well the correlation loop is able to track the received PN sequence, in this case, the 1,023 bit C/A code. Since the chipping rate of the C/A code is 1.023 Mega-Bits/Second we obtain a correlation interval of approximately 2 micro-seconds from $-\tau$ to $+\tau$(See Figure 2). Time resolution to 1 ns requires that the correlation loop be able to track to 1/2000 of the total correlation interval.

Several different implementations of the correlation tracking loop are possible. For more information on spread spectrum techniques, see [4] and [5]. We chose to use the non-coherent tau-dither loop because of its simplicity and the fact that most of the loop is self balancing. A simplified block diagram of the tau-dither loop is shown in Figure 3.

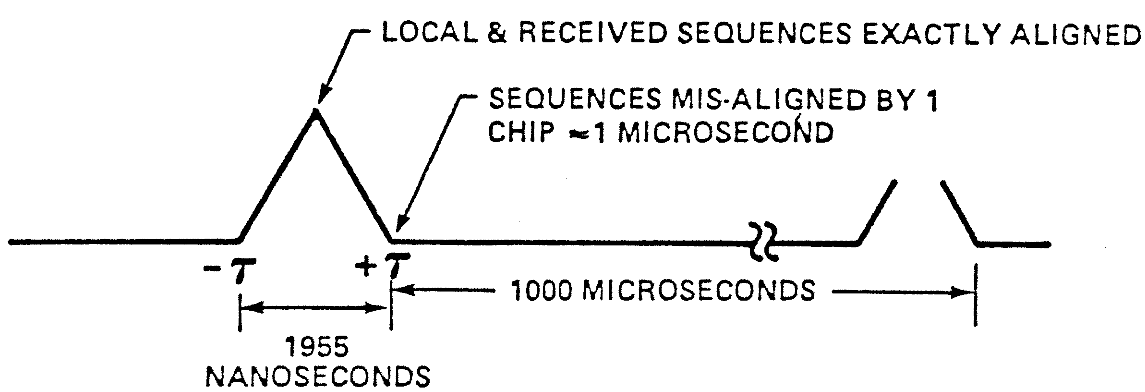


Figure 2. Cross correlation of Received and Local PN Sequences.

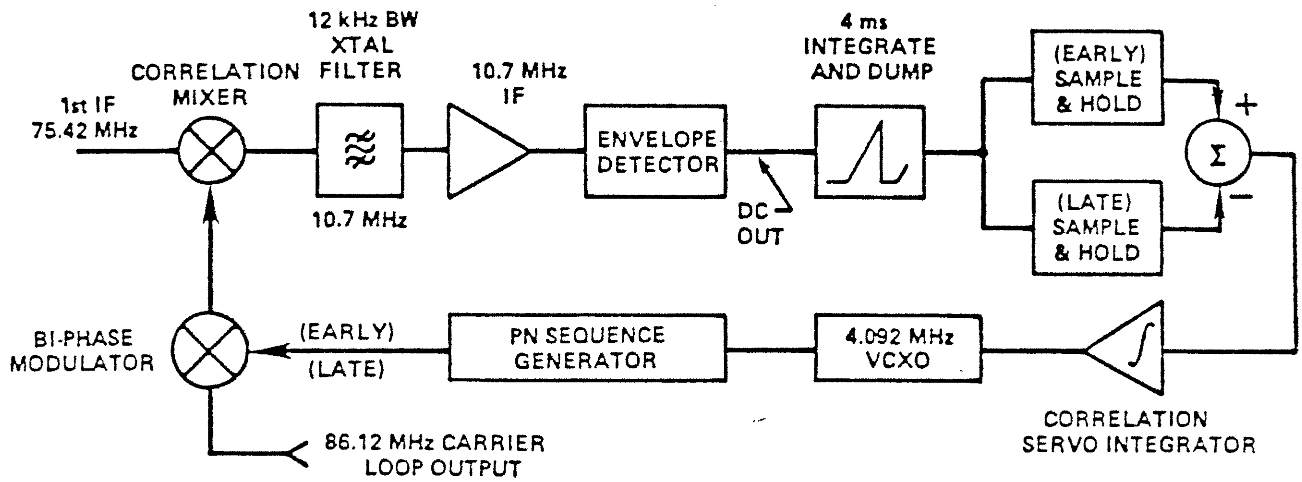


Figure 3. Simplified Block Diagram of Tau-dither loop used in the NBS/GPS Receiver.

The basic cross correlation process illustrated in Figure 2 does not provide any sensing information that would allow the correlation servo to maintain lock, since we have a single correlation peak with the output dropping symmetrically on either side. Sensing information is provided by generating two local PN sequences, one being ½ chip early and the other being ½ chip late relative to the tracking point. By inverting the late sequence and summing the correlation outputs of the Early and Late sequences, we generate an error voltage that provides sensing information to the correlation servo integrator.
These waveforms are illustrated in Figure 4.

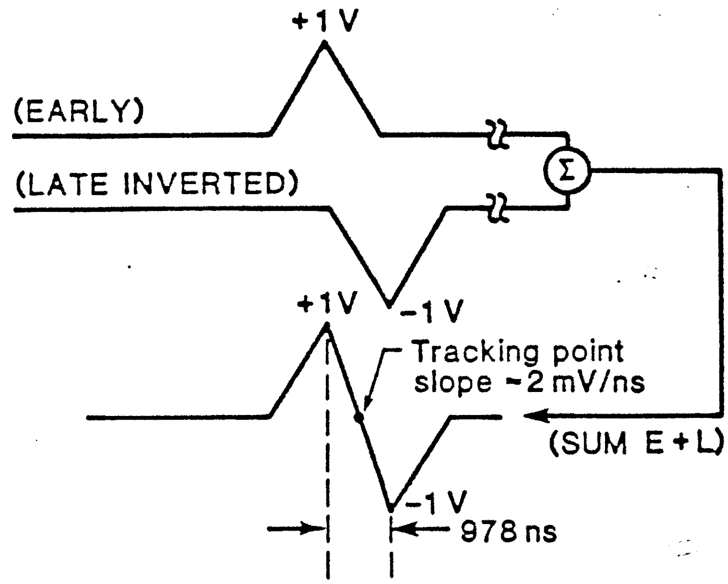


Figure 4. Use Of Early/Late PN Sequences To Provide Sense Information For Correlation Servo.

In this implementation of the tau-dither loop, the local PN generator outputs an early sequence for 4 milliseconds. The resultant correlation output from the envelope detector is integrated by the integrate and dump circuit (I&D). At the end of 4 ms, the early Sample and Hold (S&H) is strobed to sample the output of the I and D. The early S and H will maintain this constant dc value for 8 ms. This process is then repeated for the late PN sequence. The correlation servo integrator will sense any deviation from zero volts at the summing output and will generate an output voltage to the 4.092 MHz vcxo that will drive the error toward zero. (At this point, operation is the same as a conventional second order phase lock loop).

The tau-dither loop "time shares" a single IF channel for generating the early and late code sequences. This time sharing reduces the signal-to-noise ratio of the loop by 3 dB over a delay lock loop that has separate early and late IF channels. However, the delay lock loop imposes much more stringent requirements on the IF amplifiers since their gain balance is then critical to time accuracy. A 1% unbalance in the early/late IF amplifiers will result in a 10 ns shift in recovered time. In the tau-dither loop, only unbalances in the dc amplifiers following the (I&D) circuit affect timing accuracy. It is relatively easy to maintain gain balance in these circuits to 0.1%, with dc offsets of less than 1 mv. This translates into correlation loop stabilities below the 1 ns level. Measurements of several NBS/GPS receivers over a period of several months have verified differential time recovery stabilities at the 1 ns level.

(In the actual receiver the correlation error voltage is obtained from the envelope detector during initial lock and from an in phase coherent detector through a 1 ms delay sampler while tracking. Correlation loop bandwidth is set to 3 Hz during acquisition and 1 Hz while tracking).

CARRIER LOOP

The carrier loop operates as a frequency synthesizer during correlation loop acquisition and a Costas loop when tracking. The companion microprocessor computes the expected Doppler from almanac data and sets the carrier synthesizer accordingly. The range is ±4800 Hz in 400 Hz steps. The carrier synthesizer will therefore be within ±200 Hz of the carrier center frequency when the track mode is initiated. Carrier acquisition follows within one second.

MICROPROCESSOR/COUNTER

The microprocessor card used in this system includes a Z80A microprocessor operating at 4 MHz, 72 I/O lines, 2 RS-232 serial interfaces 10 strobe lines for parallel I/O expansion and a self-contained video display generator. Memory includes 16K of EPROM and 32K of dynamic ram, with an additional 16K of EPROM and 2K of static CMOS ram on a separate "fail safe" card that is backed up by 3 AA alkaline cells in case of power failure. The "fail safe" card also contains a CMOS clock chip whose contents are loaded to main memory during a power on reset. If power fails, the processor will reload all critical data from the "fail safe" card and continue normal operation. All that will be lost is any tracking data beyond the most recent 20 data points and the data from any track times that would have occurred during the time ac power was off.

The start-stop time interval card (15 cm x 24 cm) was originally developed for use with the GOES satellite timing system and improved for application in the GPS receiver. It contains start and stop interpolation channels and a main time base channel. The analog circuits in the interpolators are calibrated by the microprocessor and provide 0.1 ns resolution. Absolute stability of the counter is better than 1 ns. Maximum count is 999,999.9999 microseconds. Software is provided to allow use of the counter for conventional time interval measurements, for example, comparing a portable clock with the laboratory time scale. Total parts and assembly cost of the counter is less than $300.00 which helps in keeping overall costs of the receiver down.

SOFTWARE

A measurement computation involves doing a least squares quadratic fit to 15 seconds of pseudo-range data, evaluating the mid-point estimate of the fit, computing the slant range to the space vehicle, SV, making the Sagnac correction, computing the SV clock correction and storing a value for LOCAL-SV and LOCAL-GPS. This data is also output to the video display and to the hard copy device, if desired. A complete measurement computation sequence executes in 2.1 seconds. The main program is busy about 20-25% of the time and is in the idle loop the rest of the time.

Up to 40 track times per day may be programmed into the receiver. At the end of each track time -- normally about 8 minutes--the main program then does a least squares linear fit on the 15 second data points for LOCAL-SV and LOCAL-GPS. It then stores the intercepts and slopes, along with the SV#, time at beginning of track, azimuth and elevation (AZ/EL) at the end of the track, and sigma for the fits. The sigma values vary from 2 ns to 20 ns depending on the time of day, AZ/EL, and the SV.

The navigation program included in the system takes the LOCAL-GPS linear fit from special two minute tracks of four different satellites and uses their differences along with the received satellite ephemerides to determine antenna location in earth fixed coordinates. The system first sequentially locks on the four satellites and stores their respective data blocks and measured clock offsets. It then uses this information to set the internal PN code and GPS clock enabling a fast lock on the next satellite. Data is taken during two minutes of lock, at the end of which the system locks on the next satellite in the sequence. The sequence of four satellites is repeated to allow multiple navigation solutions. The program outputs 32 solutions after 1 hour and 24 minutes. The accuracies of these depend on the geometric configuration of the satellites. The system outputs a geometric dilution of position factor with each solution. For good geometries an RMS for the solutions of about 5 meters has been achieved.

The main program is by far the largest of the nine programs running in the machine. It receives commands to do various functions through a 16-byte circular buffer. Up to 15 commands may be queued up at one time. Normally no more than three or four commands will be queued in the buffer. A total of 31 different commands are executed by the main program. All precise arithmetic functions are handled through a 15-decimal digit floating point package with hex interpreter, especially developed for this system. The floating point package occupies about 2k bytes.

The software is structured to make the system both effective and friendly. Three of eight interrupt driven programs, the UTC clock program, the receiver program, and the counter program enable the system to initiate lock automatically at user programmed times, to lock properly and serialize the bit stream from the satellite, and to make counter measurements every second. The system is always responsive both to the telephone modem and the local user due to the command queue for the main program and the other five interrupt driven programs.

Two RS-232 programs are concerned with communications over the telephone modem. The video, keyboard, and hard copy programs provide the local operator interface.

NATIONAL BUREAU OF STANDARDS/
GLOBAL POSITIONING SYSTEM

TIME TRANSFER SYSTEM

USER'S MANUAL

Contents

DESCRIPTION OF THE NBS/GPS TIME TRANSFER SYSTEM

The NBS/GPS receiver is designed to perform a high density of state-of-the-art time measurements and make the data easily and reliably available to a wide variety of users. It compares a user's clock to the GPS system, accurate to better than 100 nanoseconds. It is designed for use at separate ground stations tracking the same satellite vehicle (SV) in common view. In this mode it can perform time comparisons between remote ground station clocks at about the 10 ns accuracy level. Figure #1 illustrates the cancellation of satellite ephemeris errors in common-view time transfer.

The software is designed to be both friendly and versatile by having a main-line interruptible program as well as eight interrupt driven programs (see Table #1). Each interrupt driven program runs as a separate in-line program time-sharing with the other programs, with full context switching for each interrupt. This differs significantly from usual 8 bit microprocessor interrupt structures where an interrupt driven program always does the same operations following its interrupt. In-line time sharing programs allow both for all functions to be operable simultaneously, and for each function to act with memory, i.e., to execute a new process dependent on what it did previously. Thus the keyboard, screen, modem, and printer are always alive and responsive even during the essential process of tracking a satellite. The interruptible program has a circular command buffer which allows execution of many of its approximately 30 different functions in a time share mode even while the eight interrupt-driven programs are also sharing processor time via the interrupt structure. The interruptible program commands are queued up and executed in a first-in first-out priority. Many of them share processor time by executing, for a short time, then queuing a return to that operation. This creates a noticeable pause in some operations such as printing data, printing track times, or graphing when other operations are happening simultaneously such as tracking or transmitting over the modem. This pause is usually no more than a few seconds.

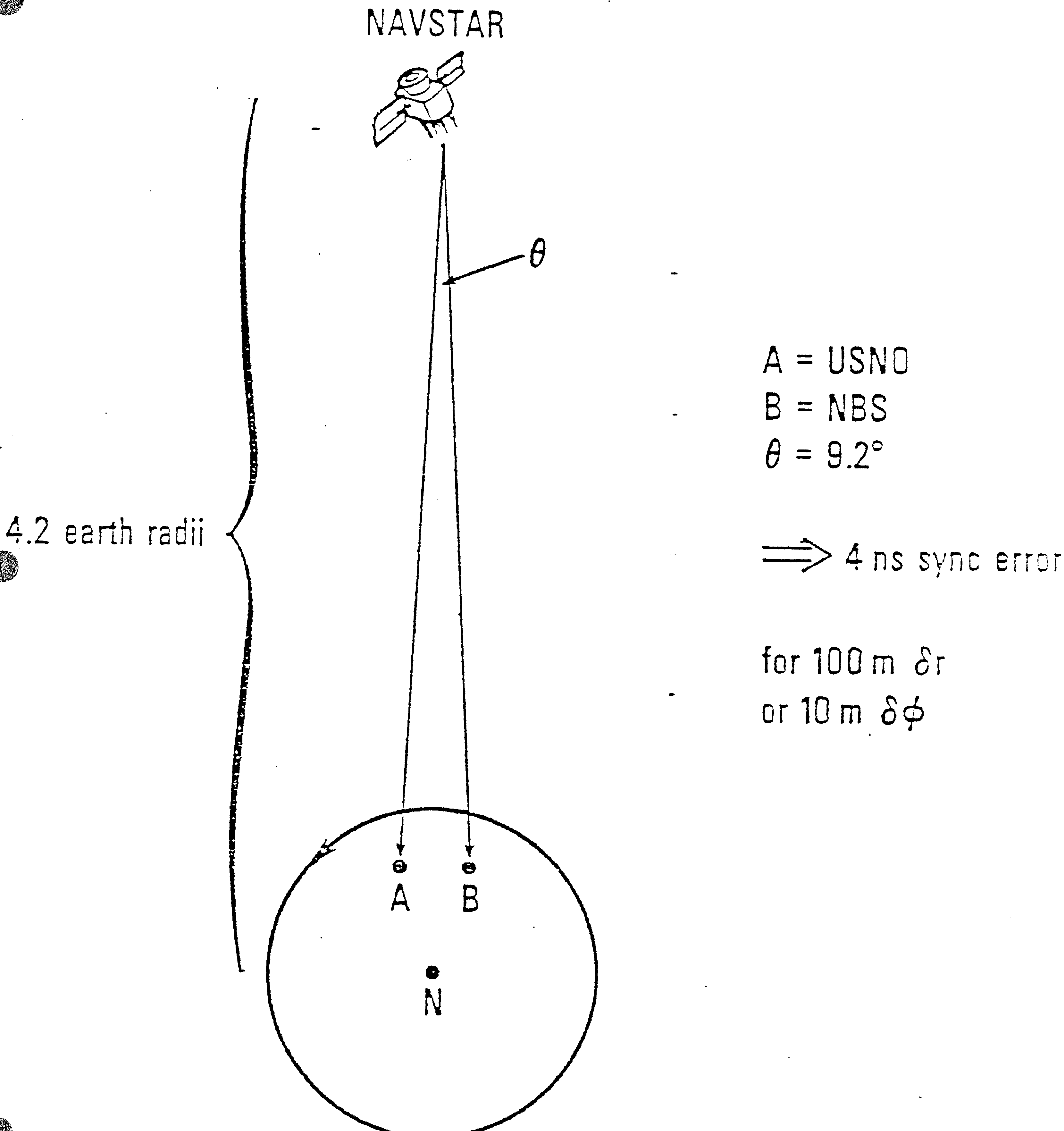


Figure =1. Cancellation of satellite ephemeris errors in common-view time transfer

Interrupt Driven Programs

Program	Function	Interrupt Rate
Highest Priority		
RCV	Operates Receiver	50 Hz
PRINT	Prints to hard copy	150 Hz
RX	Receives messages from modem	Demand (30 Hz)
VID	Displays on video screen	100 Hz
KBD	Receives messages from keyboard	30 Hz
CTR	Operates Counter	180 Hz
TX	Transmits messages to modem	150 Hz
HZ	Operates UTC Clock	75 Hz
Lowest Priority		

Table #1

The fundamental function of the receiver is to track satellites and acquire data. In order to track a satellite you need 1) an SV above the horizon, 2) the almanac data for that SV in memory, 3) the local co ordinates for your antenna in memory, and 4) the UTC clock set. To determine SV scheduling the NBS/GPS system will generate a hard copy graph, on request, with the elevation and azimuth for up to 5 SV's vs. time of day during any chosen day for any chosen location. In order to graph, valid almanac data for these satellites must be in memory. Thus, we see that there are three kinds of data essential for the operation of the system: the almanac, local coordinates, and the UTC time. A "fail-safe" card is included in the microprocessor to protect this essential data, along with programmed track times and the 19 most recent data points. Thus the machine should always have almanac data and the UTC time. Local coordinates can be determined upon initial set-up using the navigation program contained in the system. In case of power failure, battery backup (3 each AA alkaline cells) will continue operation of the fail- safe card for at least two years. Normally, when primary power is lost or the receiver is disconnected from power and moved, after power is restored this "essential" data will be reloaded and the system will continue normal operation.

There is a navigation, or position location, program for refining local coordinates. If the initial estimate is within a few kilometers, the program can yield a navigation solution accurate to about 10 meters, depending on satellite ephemerides and clock accuracies.

If for some reason, the fail- safe card fails, the local co-ordinates and UTC clock can be manually loaded by the user. The satellite almanac data, which is normally used to compute the expected Doppler of the satellite during acquisition cannot be loaded manually. The user must initiate a "cold start" search mode for a satellite, and once locked, the receiver will re-load almanacs from satellite data.

Once data is acquired via tracking, the system makes the data readily available to users. One hundred and fifty (150) data points, from the last 150 consecutive tracks are stored in RAM. The latest 19 see p 15, P#2 (LER)

are backed up in CMOS RAM in case of power failure. The most immediate availability of the data is the display. Any three consecutive tracks from the 150 stored can be displayed. Secondly, the data can be printed out locally. There is a sorting system to choose which class of data you want in the print-out. Finally, the data is available over the telephone modem with the same sorting system that's avaliable locally.

A third operation for which the NBS/GPS system can be used is simply as a 0.1 ns resolution time interval counter. The counter is normally used while tracking to measure the time interval between the local clock and the received signal. However, it is available for use under micro-processor control to measure the time interval between any start-stop pulses.

II. Tracking

Tracking a satellite involves the interruptible program, the receiver program, and the counter program. Automatic tracking also involves the UTC clock program. The system can be easily programmed by the user to perform up to 48 automatic tracks per day. These are started when the UTC clock reaches second zero of the programmed hour and minute. The UTC clock program then counts down the programmed track length in minutes minus five seconds. At this time it receives a "stop tracking" command. Measurements will not be used until after the first two minutes of the track, which are allowed for lock. This is to standardize the start times of the data. Valid track lengths are from 04 to 79 minutes though data will cease to be stored when memory is full after 40 minutes. Thus, data can be taken from 02 to 40 minutes. Also there is an automatic update function which the user can choose to enable or disable. This function automatically decrements each automatic track start time by 4 minutes immediately after it is executed each day. This allows satellites to be tracked in the same position in the sky each day since they are in 12 hour (sidereal) orbits.

We will now describe the software activities relevant to tracking. Refer to Table #2. To start tracking, the interruptible program sets the proper PN code for the desired SV, computes the Doppler and sets the

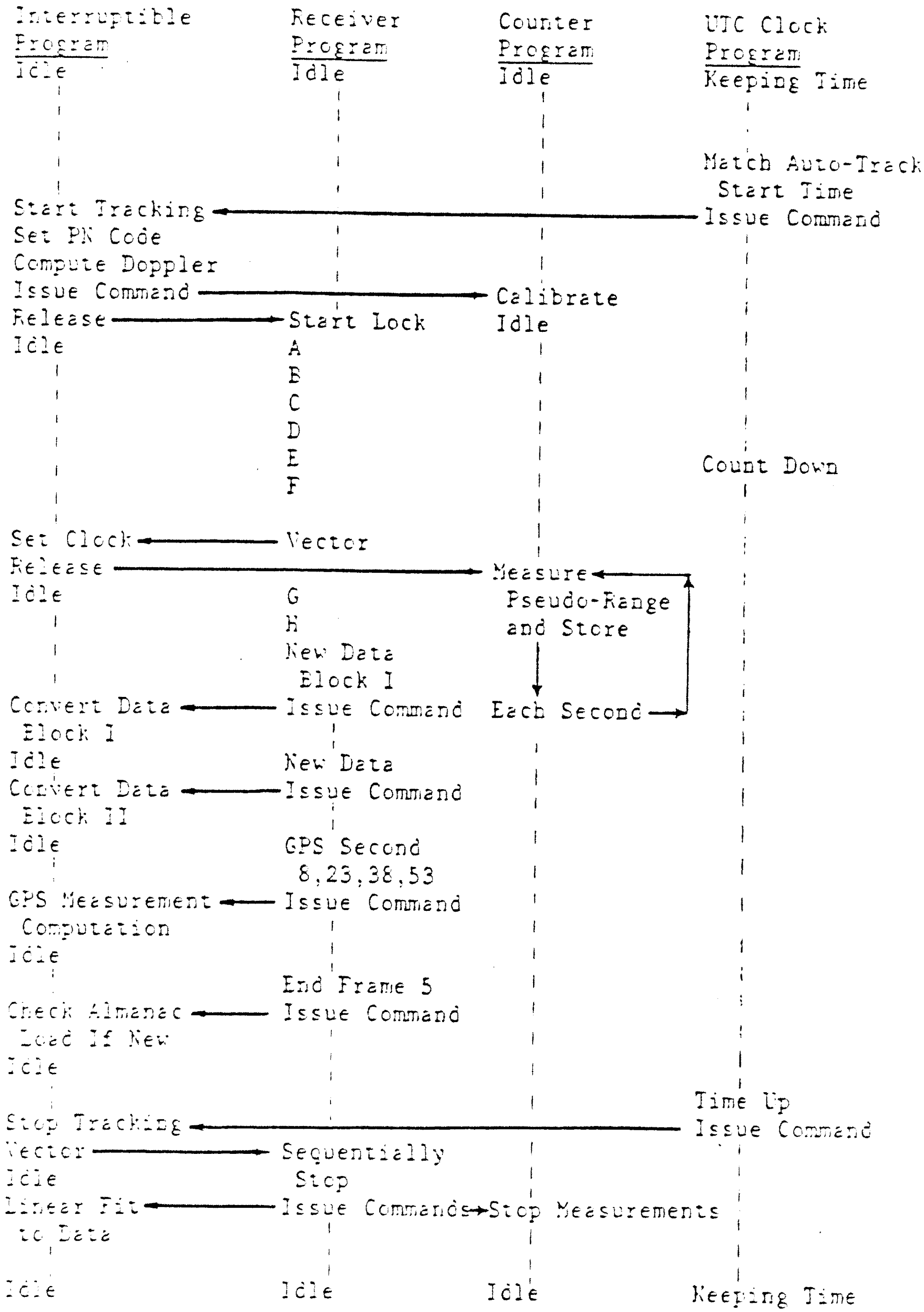

Interruptible Program
Idle
Receiver Program
Idle
Counter Program
Idle
UTC Clock Program
Keeping Time
Match Auto-Track Start Time
Issue Command
Start Tracking
Set PN Code
Compute Doppler
Issue Command
Calibrate
Idle
Release
Start Lock
Idle
A
B
C
D
E
F
Count Down
Set Clock
Vector
Release
Measure
Pseudo-Range and Store
Idle
G
H
New Data Block I
Convert Data Block I
Issue Command
Each Second
Idle
New Data
Convert Data Block II
Issue Command
Idle
GPS Second 8,23,38,53
GPS Measurement Computation
Issue Command
Idle
End Frame 5
Check Almanac Load If New
Issue Command
Idle
Time Up
Stop Tracking
Issue Command
Vector
Sequentially Stop
Idle
Linear Fit to Data
Issue Commands
Stop Measurements
Idle
Idle
Idle
Keeping Time

Table #2

receiver to synthesize it. It then releases the receiver program to lock and issues a command to the counter program to calibrate.

The receiver program has eidht stages for lock which are displayed on the screen with letters A through H and appropriate messages. First, A, the gain is adjusted. Next, B, the DAC for the correlation hit threshold is adjusted above the noise level. If the antenna software switch is set for high gain this stage is omitted. C, the receiver searches for correlation between the signal and the locally generated PN code. Once found the servos are released for tracking and, D, the program waits for carrier lock on the signal. If this last message, D, stays on the screen even long enough to read, something is wrong. In that case either the signal is weak or the synthesized Doppler is wrong as a result of the UTC clock being off by many minutes or the almanac data being bad. Once carrier lock is found, the program proceeds to E, look for the 50 Hz data transitions in the 1 KHz C/A code. Having found these, the program waits five seconds to allow the correlation loop servo to settle. Then, F, the reciever program begins searching the data stream for the sync word,the telemetry word preamble, followed by the Z-count, checking six seconds later that the preamble re-occurs and the Z-count increments properly. At this point the receiver program vectors the interruptible program to set the GPS clock, based on the Z-count, then proceeds to, G, wait for the start of frame 1 in the data. The interruptible program sets the clock immediately then releases the counter program to measure the "pseudo range" time intervals every second and to store these measurements according to the GPS second. Meanwhile, once the receiver program finds the start of frame 1 it begins to iteratively serialize the five data frames into memory. In this loop it issues commands to the interruptible program to convert the transmitted data from binary to floating point decimal form, to make GPS measurement computations, and to store almanac data. A data convert command is issued at the end of serializing the binary form of that block of data if either that data block is not yet converted or if the binary age of data changes. The measurement computation commands are issued every 15 seconds on GPS second 8, 23, 38, and 53 if the data blocks have been converted. The command to load the almanac is issued at the end of each frame five. The interruptible program recieves this "load almanac" command from its buffer and executes it, if the health of the transmitting SV is good, by first checking parity then comparing the newly received almanac reference time with the stored one. Only if this is different is the new binary almanac stored. The ionospheric and UTC parameters are transmitted once every 12½ minutes. They are converted at the end of frame five. The receiver program continues looping throug h the five data frames until it sequentially returns to its idle loop because either carrier lock is lost or it is vectored to its idle loop by the interruptible program via a "stop tracking" command. The sequential return to its idle loop consists of the receiver program stopping the counter and issuing a command to do a linear fit to whatever data there is from measurement computations.

The GPS measurement computation performed by the interruptible program is at the heart of the NBS/GPS receiver's mission. To standardize the times for these, the first computation in an automatic track will not be done until two minutes after the start time. The computation starts by fitting a quadratic curve to the last fifteen counter measurements and evaluating this at the midpoint to obtain a smoothed pseudo-range measurement. The times for these estimates are GPS seconds 0, 15, 30, and 45 of every minute. Then the slant range, Sagnac, and ionospheric corrections are computed from the transmitted SV ephemeris data and ionospheric model and subtracted along with the receiver delay from the pseudo-range estimate to obtain an estimate of the local minus SV clock bias. The transmitted SV clock correction is then included to give the local minus GPS time bias. If the ionospheric model in memory is older than 99 hours when the first measurement computation is performed, then there will be no ionospheric correction applied for the entire track even if new parameters are loaded during that track. In this case, the value for the ionospheric correction on the printout will be "F"s.

III. Navigation

There is a navigation or position location program to print out a first order correction to entered local coordinates. This is done in one of two modes. In the first mode data points and ephermerides from four normal tracks are used. The user programs this by setting the two high order bits of the programmed track length. If only the highest order bit is set, the data point and ephemeris are simply stored for use by pushing them down on stacks. If the two highest order bits are set the data from the current track is both stored and used, along with the three previously stored data sets, to compute a new estimate for receiver position. Thus, the maximum track length for use with the navigation program is 39 minutes. If three previous data sets have not yet been stored, the solution will not be attempted. These are not backed up on the fail-safe board.

A second mode for the navigation program is a method of locking quickly from one satellite to the next. This is "fast-lock navigation". This can either be programmed to be done automatically every day, or it can be commanded manually to start immediately. One can program up to two separate fast-lock navigations per day. First the receiver locks normally on four different satellites, storing data from each of the satellites to enable finding the signal again quickly. This must be completed by second 0, nine minutes from when the slow locks are started.

Then this data is used to "fast-lock" from one satellite to the next sequentially every two minutes. Thrity seconds is allowed for the antenna to point (if using a steerable antenna), for the receiver to lock, and for the servos to settle. Ninety seconds of data are used from each satellite. After each 90 second track the data is reduced to a single point, as for normal tracks, and stored both with the normal data and for us in the navigation solution. The first solution is done after the fourth data point. The program continues until either 32 solutions are computed, the receiver loses lock or fails to lock on one of the satellites, a stop tracking command is given, or an automatic track time comes up. The soultions are printed out only at the end of the fast-lock navigation program.

The advantage of fast-lock navigation over using normal tracks for navigation is the short time between data points. This is useful when the reference clock is less stable or when one doesn't want to wait as long for a solution. The normal track navigation may use longer track times. This tends to eliminate more of the short term noise fluctuations. For this reason the fast-lock mode is primarily intended for use with a high gain antenna. Also, navigation with normal tracks does not necessitate having four satellites above the horizon forming a good GDOP simultaneously.

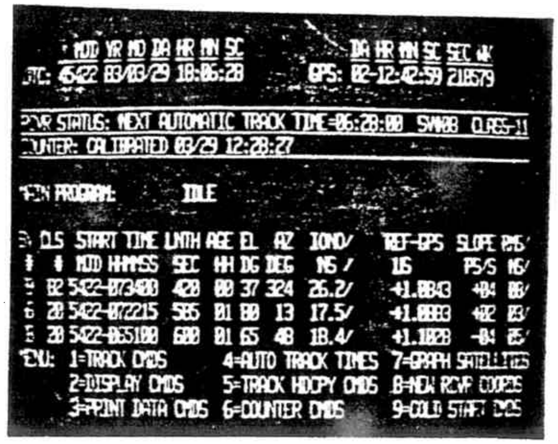
IV. Description of the Display

The display has six regions (see Figure #2). The top two lines are for clock displays: the UTC clock and the GPS clock. The UTC clock is set initially from the fail-safe clock or by the user, and reset each time GPS time is acquired. For it to be set properly relative to GPS time, the correct value of GPS minus UTC must be stored. The difference results from the leap-seconds applied to UTC and not to GPS. The value is recovered from transmitted data every 12½ minutes at the time of the ionospheric model, and backed-up to fail-safe RAM. It can also be entered via the SET CLOCK function in the COLD START CMDS.

The UTC clock runs continuously. It gives the modified Julian day, the year/month/day of the month, and the hour, minute, and UTC second. The GPS clock runs only while the receiver is locked to a satellite and has found its sync word and Z-count. It gives the day of the week (0-6), the hour, minute, and GPS second, and second of the week.

The fourth line describes the status of the receiver program. When not tracking it displays the next automatic track time. While tracking it displays a series of letters, A-H, and the message corresponding to the latest letter describing the current process of lock the receiver program is performing.

The fifth line describes the state of the counter. Two messages appear on this line. The left either says "calibrating", if the



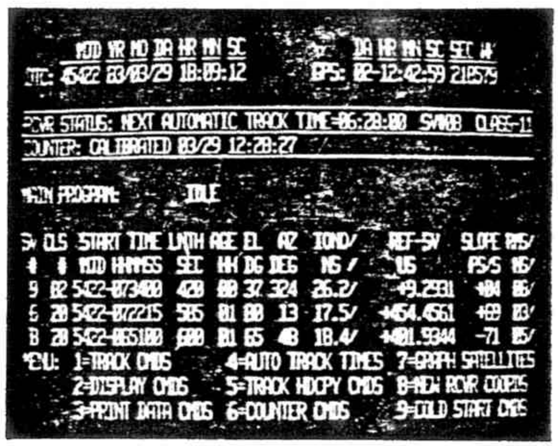


Figure #2. Normal display when not tracking with: REF-GPS data (above) and REF-SV data (below) counter program is doing that, or the time of last calibration. The right portion of the line displays the activity of the counter program, if any.

The seventh line describes the activity of the main, or interruptible, program. When the SV clock correction or ephemeris data is loaded, "CK" or "EP" respectively will appear and blink on this line for a few seconds then stop blinking but stay displayed until the track ends. Many of the interruptible program's functions, such as setting up print masks, are not dispalyed because they execute concurrently with other programs in a time-shared fashion. When these are in progress the last message displayed remains displayed until they are done. Most messages remain displayed until the main program has actually been idle five seconds, to allow the messages to be read. Then the word "IDLE" is displayed. The GPS measurement computation displays the message "IDLE" immediately on completion, so the measurement message is on the screen for about 3 seconds.

Lines 9 through 13 are the data area. These five lines are used for various purposes. When not tracking they normally are used to display any three consecutive data points in memory. The format is described in "V. A. Track Data". While tracking, the last three 15 second GPS measurement computations are normally displayed. The display format matches the track hard-copy. See "V. D. Track Hard Copy" for details.

The data area also has two other uses which can be requested at any time. These are to edit the automatic track times and to display the actual hex memory. The hex memory dump displays the contents of memory locations on the screen from any chosen starting location either incrementing or decrementing. A single line of 16 bytes is displayed at a time. All five lines of the data area can be used. The top line is a live display, while those below are previously displayed values.

Automatic track times are viewed in three separate pages. An entire page of 16 track times is displayed in the data area at one time.

Refer to Figure #3. Each track time consists of the class byte, the SV ID number, the hour and minute to start and the track length in minutes. A void or deleted track time is FF's in all elements. The class byte is used to sort the data upon retrieval: data of only a specific class can be printed. The UTC clock program will initiate tracking the indicated SV when it reaches second 0 of the entered hour and minute. The UTC program will count down the track length in minutes minus 5 seconds then issue a stop tracking command. The automatic track time is effective the moment it is entered.

The bottom three lines, 14 through 16, are used to display the various menus, messages, and instructions. One always starts with the main menu. Sub-menus and instructions appear as one chooses options for the various functions.

V. Printed Data

A. Track Data

The track data is what the NBS/GPS Time Transfer System is all about. Data taken from tracking a satellite is distilled into a single data point as follows. Counter measurements are made every second comparing a local 1 pps to the received 1 pps, thus measuring the "pseudo-range". Every 15 seconds the last 15 counter measurements are smoothed with a quadratic curve fit. This fit gives an estimate for a local minus received 1pps measurement at the middle of the 15 second period. This estimate is corrected for the transmission time by computing the slant range to the satellite, the Sagnac correction, and the ionospheric correction at the middle second of the 15 second period. If the ionospheric model has not been updated for 99 hours at the start of a track, the ionospheric correction is omitted for the entire track, even if the model is updated during that track. This corrected estimate gives a measurement of the bias between the local and SV clocks, the "REFERENCE-SV" data. This is then corrected with the transmitted clock correction to pass from the SV clock to the GPS time scale giving the "REFERENCE-GPS" data. Thus there is a sequence of data points taken every 15 seconds during tracking. When the track is terminated this data is

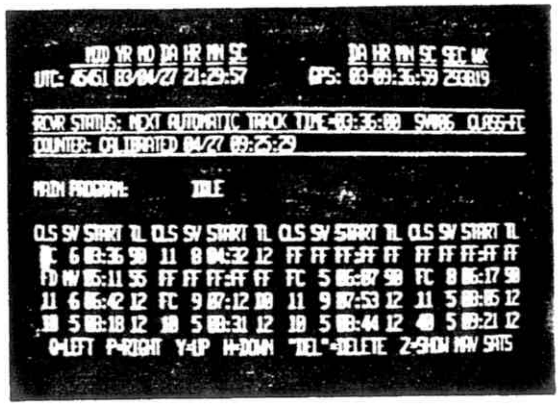


Figure #3. Automatic track times: editing (above) and viewing NAV SATS (below).

fitted with a straight line whose slope, intercept and RMS and are stored to give the single data point for the track. A straight line is fit to both the "REFERENCE-SV" data and the "REFERENCE-GPS" data.

The track data can both be displayed and printed out. The format is as follows. (Refer to Figures #2 and #4). Each line has a separate data point representing a separate track. The first column is the SV ID #. Then comes the hex class byte. Manual tracks are always class FF. Automatic tracks are assigned any hex byte by the user. Upon retrieval, data can be printed by class. After the class byte comes the reference time. First is the last four digits of the MJD, then the GPS hour, minute, and second of the first 15 second measurement computation. This is the reference time. Following the reference time is the length of time for the track in seconds. Then the age of the ephemeris data at the end of the track in hours is printed or displayed, followed by the last elevation angle and azimuth in degrees. Next is the value for the last ionospheric correction. This value is in nanoseconds on the display and locally printed data. The display includes the 0.1 ns digit, the printout omits it. Over the modem, the ionospheric correction is available in either units of 1.0ns or 0.1ns.

The processed measurement follows. The format differs for displayed vs. printed data. The display shows either "REF-GPS" or "REF-SV" data, but not both. The printed data includes both on the same line. Recall from above that a data point from a track consists of a linear fit to the "REF-SV" and "REF-GPS" 15 second data point sequences. The display shows the intercept in microseconds of one of these linear fits at the reference time, the slope in picoseconds per second and the RMS in nanoseconds. The printed data has the intercept and slope for "REF-SV" data, then the intercept and slope for "REF-GPS" data, and finally the RMS for both fits. For locally printed data, the intercepts are in nanoseconds, the slopes in picoseconds per second and the RMS in nanoseconds. Over the modem the 0.1ns digit of the intercepts is also available.

HELLO!
GPS RCVR: NBS09
READY

11DCMD

NBS09: REFERENCE-GPS DATA
MJD=45457 YR=1983 MONTH=05 DAY=03 HMS=21:38:33 (UT)

SV #	CLS #	START TIME MJD'	HH MM SS	LNTH SEC	AG HR	EL DG	AZM DEG	ION NS	REF-SV NS	SLOPE PS/S	REF-GPS NS	SLOPE PS/S	RMS NS
5	11	5457	07:47:00	600	2	64	344	19	+164897	+8	+1179	+6	7
9	11	5457	07:35:00	600	2	56	205	21	+8879	-8	+1209	-8	5
6	11	5457	06:24:00	600	0	53	163	22	+655958	+60	+1183	+27	8
8	11	5457	04:14:00	210	1	72	71	19	+201955	-65	+1204	-0	5
6	11	5456	06:28:00	285	0	56	162	23	+650168	+58	+1171	+64	10

11NCMD

NBS09: REFERENCE-GPS DATA
MJD=45457 YR=1983 MONTH=05 DAY=03 HMS=21:38:59 (UT)

SV #	CLS #	START TIME MJD'	HH MM SS	LNTH SEC	AG HR	EL DG	AZM DEG	ION .1NS	REF-SV 0.1NS	SLOPE PS/S	REF-GPS 0.1NS	SLOPE PS/S	RMS NS
5	11	5457	07:47:00	600	2	64	344	195	+1648973	+8	+11798	+6	7
9	11	5457	07:35:00	600	2	56	205	215	+88791	-8	+12096	-8	5
6	11	5457	06:24:00	600	0	53	163	229	+6559581	+60	+11832	+27	8
8	11	5457	04:14:00	210	1	72	71	194	+2019552	-65	+12044	-0	5
6	11	5456	06:28:00	285	0	56	162	237	+6501689	+58	+11713	+64	10

Figure #4. Printed track data, class 11H 1.0ns data (above), and 0.1ns data (below).

B. Navigation Data

Navigation solutions are printed out either at the end of a fast-lock program or when a solution is performed after a normal track. After a fast-lock sequence there can be from 1 to 32 solutions. A single solution is printed when it is computed from normal tracks. Solutions are not stored. The format can be seen in Figure #5.
The MJD HH MM is the reference time of the last data point used in the solution. The X, Y, and Z values are the geocentric earth-fixed co ordinates in the GPS system in meters. T in nanoseconds is the value REF-GPS would have had if the entered coordinates had been the X, Y, and Z of the solution. Next follow the geometric dilution of precision (GDOP) values for X, Y, Z and T. If one knows the RMS error in satellite ephemerides, the expected error in X, Y, Z or T is obtained by multiplying by the given factor. This factor is a function only of the geometric configuration of the satellites at the times used for the solution. Next on the line are the equivalent geodetic coordinates and dilution of precision factors.

C. Track Times

One can print out the current automatic track times sorted by class. Included in this print-out is a statement whether the automatic update function in enabled or disabled. Each track time is printed on a separate line under a header. Refer to Figure #6. First is the hex class byte for the track time, then the ID number of the SV to be tracked. If the letters "NV" appear for the ID then this is an auto matic start time for fast-lock navigation. These are followed by the UTC hour and minute to start tracking. The track is initiated on second 0 of that hour and minute. Finally, the track length in minutes is printed. If this is a start time for fast-lock navigation there will be four additional numbers printed on this line, listing the four satellites to be used in the navigation program. For a normal track, a valid track length is from 04 to 79 minutes. If the high order bit of the high order nibble is set, a track length of 80 hex plus the track length in minutes, then the data from this track is saved for use as one of

NBS10:

MJD HR MM	X (M)	Y (M)	Z (M)	T (NS)	XDOP	YDOP	ZDOP	TDOP	LAT MN SEC	LON MN SEC	HGT (M)	LADP	LODP	HDOP
	-1288376.75	-4721666.59	+4078661.02						+39 59 43.8500	254 44 15.1810	1646.30			
5457 07:46	-1288387.30	-4721667.10	+4078668.26	+1117.4	1.6	2.3	2.5	2.5	+39 59 43.9593	254 44 14.7434	1650.53	2.4	1.6	[illegible]
5457 07:48	-1288385.02	-4721665.06	+4078666.30	+1124.7	1.5	2.2	2.3	2.3	+39 59 43.9642	254 44 14.8113	1650.30	2.3	1.5	2.2
5457 07:50	-1288384.92	-4721669.92	+4078668.99	+1111.3	1.4	2.2	2.4	2.4	+39 59 43.9339	254 44 14.8694	1655.81	2.3	1.5	2.2
5457 07:52	-1288374.46	-4721670.53	+4078655.08	+1150.4	1.4	2.2	2.3	2.3	+39 59 43.6336	254 44 15.3013	1645.01	2.3	1.5	2.2
5457 07:54	-1288374.56	-4721669.69	+4078653.60	+1154.4	1.4	2.3	2.6	2.5	+39 59 43.6131	254 44 15.2878	1643.45	2.5	1.5	2.2
5457 07:56	-1288376.64	-4721671.92	+4078655.62	+1147.8	1.3	2.2	2.5	2.3	+39 59 43.6071	254 44 15.2280	1646.82	2.3	1.4	2.3

DONE

NBS10:

MJD HR MM	X (M)	Y (M)	Z (M)	T (NS)	XDOP	YDOP	ZDOP	TDOP	LAT MN SEC	LON MN SEC	HGT (M)	LADP	LODP	HDOP
	-1288376.75	-4721666.59	+4078661.02						+39 59 43.8500	254 44 15.1810	1646.30			
5427 10:10	-1288373.85	-4721666.71	+4078663.01	+1137.2	1.1	2.1	1.8	1.6	+39 59 43.9105	254 44 15.2838	1647.16	1.5	1.2	1.9

DONE

Figure #5. Navigation data from fast-lock tracks (above), and normal tracks (below).

```
NBS11:
MJD=45458 YR/MO/DA=1983/05/04 HMS=22:49:48 (UT)
AUTO-UPDATE FUNCTION IS ENABLED
AUTO TRACK TIMES, CLASS FFH

CLASS SV HH MM LNTH
  11   08 04:04  12M
  FC   08 04:48  90M
  FC   06 04:58  90M
  FD   NV 05:08  42M = 08,06,09,05
  FC   09 05:51  DOM
  FC   05 06:02  DOM
  11   06 06:14  12M
  11   09 07:25  12M
  11   05 07:37  12M
  10   05 07:50  12M
  10   05 08:03  12M
  10   05 08:16  12M
  40   05 08:53  12M
DONE
```

Figure #6. Printed auto-track times.

four in the navigation solution. If both of the two high order bits are set, the track length is printed as C0 hex plus the acutal track length in minutes. In this case the data from this track is stored and then used along with the three previously stored for a navigation solution.

D. Track Hard Copy

There are three kinds of print-outs available during tracking: satellite positions, 1 second counter measurements, and 15 second GPS measurements. If "SATELLITE POSITIONS" is selected then the X, Y, Z coordinates in meters are printed out as well as the range to the satellite from the ground station coordinates, the path length of the signal in meters, which is the range plus the Sagnac correction, the transmission delay in seconds, which is simply the path length divided by the speed of light, and the clock correction, which is derived from the transmitted clock model and the computed general relativistic correction. This is done after every 15 second GPS measurement computation. In addition coordinates computed during initial lock are printed. These include the inital range and the coordinates and range 100 seconds later. These two ranges are used in computing the expected Doppler. The path length, range delay and clock correction printed during lock are invalid. See Figure #7.

If "EACH 1 SEC MEASUREMENT" is selected then data related to the counter is printed out. First the results of calibration are printed. This will look something like:

DEL, SLO, DEL, ELO 3757 4754 3527 4461

DELAY 0027FF.

The first number, 3757 in this case, is the start interpolation delta count = high count minus low count for 200 ns. Thus, in this case 3757/200ns = 18.785 counts per ns scale factor. The second number, here 4754, is the start interpolator's lowest count during the calibration. The third number, here 3527, is the stop interpolation delta count. The fourth number, here 4461, is the stop interpolator lowest

```
RANGE1= 2.368535474407895E+07
SATX=-0.181049822496023E+08
SATY= 0.179575392848500E+07
SATZ= 1.943499481568542E+07
RANGE= 2.368738042901585E+07
PATH LENGTH= 0.238512202012764E+08
RANGE DELAY (S)= 0.795591481580702E-01
CLK XTION=-0.391643939681155E-03

SATX=-0.182043175906949E+08
SATY= 0.175235455155528E+07
SATZ= 1.934657183889104E+07
RANGE= 2.368905059983545E+07
PATH LENGTH= 0.236890720565144E+08
RANGE DELAY (S)= 0.790182790661145E-01
CLK XTION=-0.391522213818803E-03

SATX=-0.182377653687839E+08
SATY= 0.173753773250495E+07
SATZ= 1.931651816164206E+07
RANGE= 2.368956307337355E+07
PATH LENGTH= 0.236895845638236E+08
RANGE DELAY (S)= 0.790199886064832E-01
CLK XTION=-0.391521202574375E-03

SATX=-0.182711806366334E+08
SATY= 0.172278787039058E+07
SATZ= 1.928637266929392E+07
RANGE= 2.369010612232110E+07
PATH LENGTH= 0.236901276465261E+08
RANGE DELAY (S)= 0.790218001353860E-01
CLK XTION=-0.391520191329945E-03

SATX=-0.183045631298594E+08
SATY= 0.170810494633366E+07
SATZ= 1.925613550607570E+07
RANGE= 2.369067972982040E+07
PATH LENGTH= 0.236907012877635E+08
RANGE DELAY (S)= 0.790237135965892E-01
CLK XTION=-0.391519180085517E-03

SATX=-0.183379125842375E+08
SATY= 0.169348894063682E+07
SATZ= 1.922580681664604E+07
RANGE= 2.369128387865330E+07
PATH LENGTH= 0.236913054703176E+08
RANGE DELAY (S)= 0.790257289326591E-01
CLK XTION=-0.391518168841087E-03
```

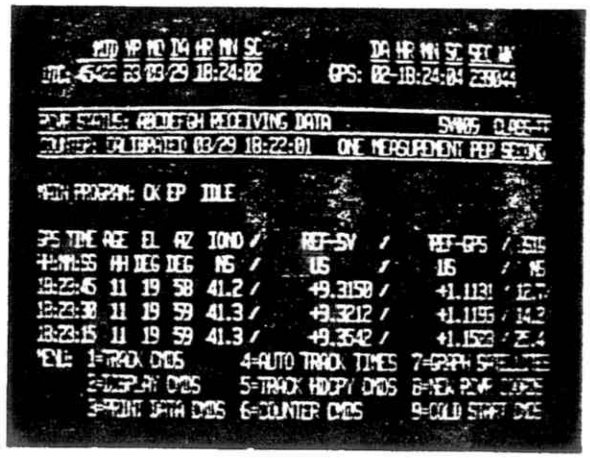
Figure #7. Track hard copy: satellite positions count. On the second line is printed the delay correction. The first four digits are the value in tenths of nanoseconds, the last two digits represent the sign of the correction: + if 00, - if FF. Thus, here the delay is -2.7 ns. After lock, when the counter is started the results of each measurement are printed out in microseconds.

If "EACH 15 SEC MEASUREMENT" is selected then information about the track is printed out. Letters A-H are printed as the receiver program passes through each stage of lock. When the SV clock model is loaded, the expected user range accuracy is printed in meters. This value is to be interpreted as "no better than" accuracy. When the ephemeris is loaded, the letters "EPH" are printed. Also, when the ionospheric model and UTC clock parameters are loaded, the letters "IONO" are printed. Finally, when the almanac for an SV is loaded a message is printed. The results of each 15 second GPS measurement computation are printed.

The format of the GPS measurement computations' print-out is as follows: Refer to Figure #8. First is the hour, minute, and second. Then the age of the transmitted ephemeris data in hours appears. Next comes the elevation and azimuth of the SV in degrees. Then the iono spheric correction in nanoseconds. These are followed by the actual measurement results: the reference minus SV value in micro-seconds for 15 seconds, the reference minus GPS value in micro-seconds for 15 seconds, and finally the RMS of the quadratic curve fit to the 15 counter measurements in nano-seconds. For an explanation of the meaning and use of this data see section A. "Track Data".

E. Other Printed Data

When new coordinates are entered, they are entered in geodetic coordinates, then converted to geocentric. Also entered is a five character receiver label. When this is done, the receiver label, the entered geodetic coordinates, and the resultant X, Y, Z coordinates are printed out. See Figure #9.



MES09: TRACK SV#09 MJD=45457 05:35:00 EL=+46 AZ= 325 DOP=+2.7KHZ

TIME HH:MM:SS	AGE HH	EL DEG	AZ DEG	IONO NS	REF-SV US	REF-GPS US	SIG NS	ABCDEFGH
URA=2**00 EPH								
05:37:00	1	46.	325.	024.5 /	+8.8833 /	+1.2119 /	9.	
05:37:15	1	46.	325.	024.5 /	+8.8832 /	+1.2118 /	6.	
05:37:30	1	46.	325.	024.5 /	+8.8624 /	+1.1910 /	17.	
05:37:45	1	46.	325.	024.5 /	+8.8623 /	+1.1909 /	12.	
05:38:00	1	46.	325.	024.5 /	+8.8685 /	+1.1971 /	9.	
05:38:15	1	46.	325.	024.5 /	+8.8880 /	+1.2166 /	5.	
05:38:30	1	46.	325.	024.5 /	+8.8757 /	+1.2043 /	9.	
05:38:45	1	47.	325.	024.1 /	+8.8643 /	+1.1929 /	6.	
05:39:00	1	47.	325.	024.1 /	+8.8740 /	+1.2026 /	6.	
05:39:15	1	47.	325.	024.1 /	+8.8714 /	+1.2000 /	7.	
05:39:30	1	47.	325.	024.1 /	+8.8633 /	+1.1919 /	6.	
05:39:45	1	47.	325.	024.1 /	+8.8675 /	+1.1961 /	6.	
05:40:00	1	47.	325.	024.1 /	+8.8651 /	+1.1937 /	4.	
05:40:15	1	47.	325.	024.1 /	+8.8686 /	+1.1972 /	8.	
05:40:30	1	47.	325.	024.1 /	+8.8666 /	+1.1952 /	4.	
05:40:45	1	48.	325.	023.8 /	+8.8669 /	+1.1955 /	10.	
05:41:00	1	48.	325.	023.8 /	+8.8551 /	+1.1837 /	10.	
05:41:15	1	48.	325.	023.8 /	+8.8558 /	+1.1844 /	7.	IONO
05:41:30	1	48.	325.	023.8 /	+8.8678 /	+1.1964 /	7.	
05:41:45	1	46.	325.	023.8 /	+8.8581 /	+1.1867 /	12.	
05:42:00	1	48.	325.	023.8 /	+8.8501 /	+1.1787 /	6.	
05:42:15	1	48.	325.	023.8 /	+8.8645 /	+1.1931 /	2.	
05:42:30	1	48.	325.	023.8 /	+8.8800 /	+1.2086 /	11.	
05:42:45	1	49.	325.	023.5 /	+8.8913 /	+1.2199 /	4.	

STOP TRACKING

Figure #8. 15 Second Measurements display (above), and track hard copy (below).

```
HELLO!
GPS RCVR:   NBS09
READY

LATITUDE: N/SN  DEG39  MIN59  SEC43.8500
LONGITUDE: DEG EAST254  MIN44  SEC15.1810
HEIGHT ABOVE ELLIPSOID:1646.30M

X=-1.28637635124126 7E+06
Y=-4.72166659571829 2E+06
Z= 4.07866102930184 8E+06
DONE
```

Figure #9. Receiver label and local coordinates.

```
RCVR DLY: (+/-)+ 0.0000000000000000 EE(+/-)+ 00 SEC
```

Figure #10. Receiver delay: printed upon entry.

```
ENTER MINS TO CHANGE:(+/-)- 05M
DONE
```

Figure #11. Adding a common value to automatic track times.

A receiver delay may be entered, which will be subtracted as a constant from all REF-SV and REF-GPS data. When this is entered, it is printed on the hard-copy. See Figure #10.

There is a facility for adding a common value to all automatic track times. When this done a message to that effect is printed out. See Figure #11.

VI. Graphing

The graph program is important for showing users when satellites are available for tracking and when there is common view with other locations. The program produces a graph of elevation with azimuth vs. time at fifteen minute intervals for up to 5 satellites over any chosen MJD at any entered location. The graph is produced from almanac data. Points are plotted with the letters A through E, each letter corresponding to the respective satellite chosen to be graphed by the user. The program does not attempt to check if almanac data is valid. Thus if a graph is requested for a satellite with invalid or no almanac, random results are possible. The graph may be performed at any time and ordinary track messages will be inhibited to keep from contaminating the graph. Emergency and error messages will be printed out, however. See Figure #12 for a portion of a graph.

VII. The Fail-Safe Memory

In the event of power failure the NBS/GPS Time Transfer System will easily recover by loading its program and essential data from fail-safe memory. The RAM program is backed up with EPROM on the fail-safe board. In addition, the almanac, the automatic track times, the local coordinates, and the most recent 19 data points out of the 150 total stored are backed up in fail-safe RAM on the fail-safe board. The UTC clock is backed up on the fail-safe board by a CMOS clock chip. Also user selectable software switches are backed up. This memory is kept alive during a power failure by three AA alkaline batteries. These batteries are good for at least two years of continuous operation. The batteries should be replaced every two years.

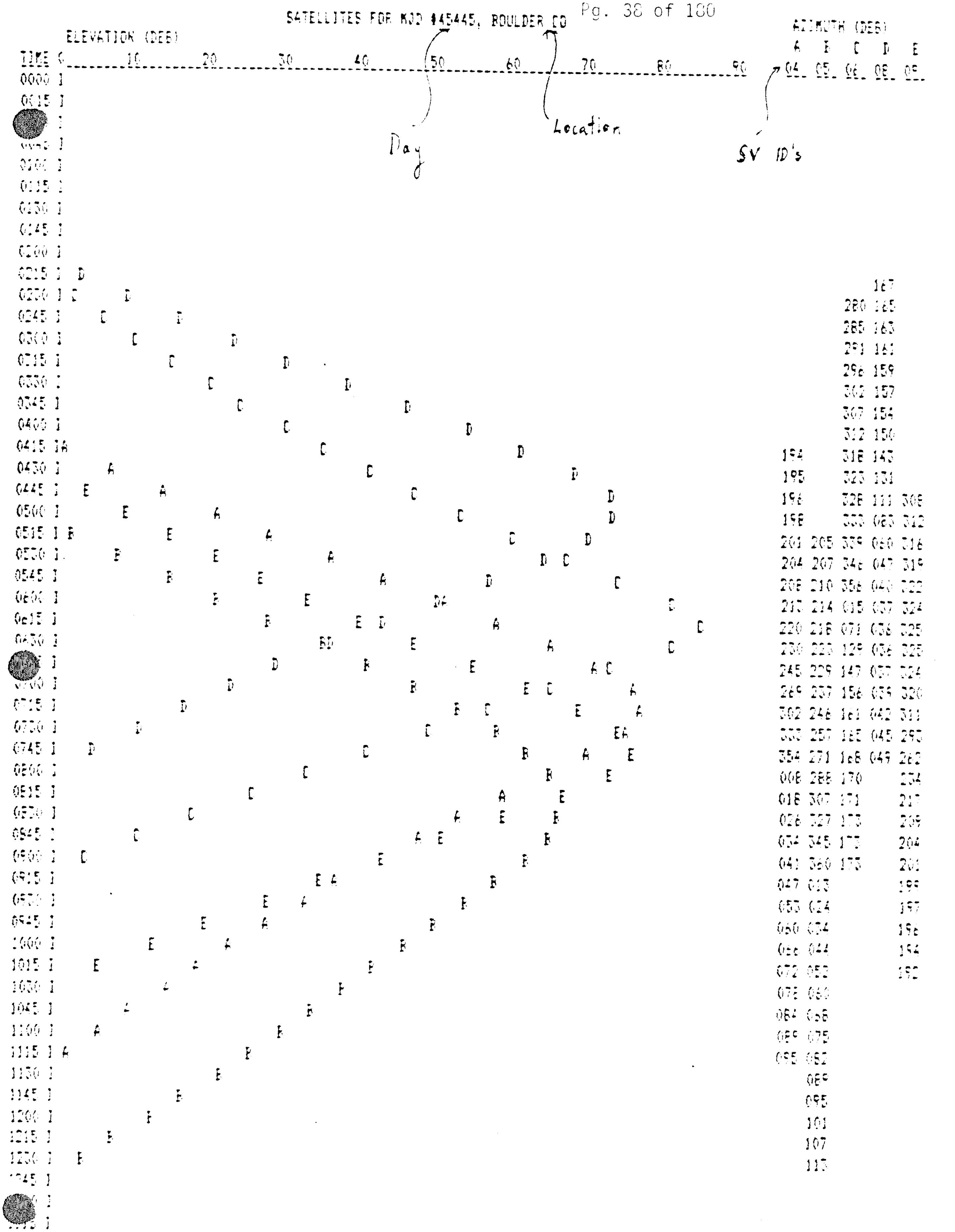


Figure #12. Portion of graph of satellite elevations. Full graph is for 24 hours, for as many as 5 SV's for any location on any designated day.

Instructions for Use

In general when using the keyboard to enter commands, as various sub-menus and options appear, to abort and return to the main menu one needs only to hit the "ESC" key. When entering data in the form of a line of characters the "DEL" key will delete the previous character entered on a line.

I. Tracking

A. Manual Tracking

1. To start tracking a satellite vehicle (SV) immediately enter first 1=TRACK CMDS from the main menu, then 1=START TRACKING from the sub-menu. If the system is already tracking, a message is displayed. In this case you must stop tracking first. Otherwise, then enter the two digit satellite ID number as prompted. Note that an automatic track, if set, will interrupt a manual track.

2. To stop tracking, enter 1=TRACK CMDS from the main menu, followed by 2=STOP TRACKING on the sub-menu.

B. Automatic Tracking

To obtain the sub-menu of commands related to automatic tracking enter 4=AUTO TRACK TIMES from the main menu. To enter, change or delete individual automatic track time now enter either 1, 2, 3 for the appropriate page. Alternatively, now enter 4=PRINT BY CLASS to print out the track times sorted by class. Also all the track times can be changed by a constant amount by now entering 5=ADD TO ALL TIMES, then entering + or - followed by the minutes to add or subtract. Finally, one can enable or disable the auto-update function by choosing 6=DIS/ENB AUTO UPDATE from the AUTO TRACK TIMES sub-menu, then entering either 0=DISABLE AUTO UPDATE or 1=ENABLE AUTO UPDATE.

To enter, change or delete individual track times get into the desired page as mentioned above. Use the keys: Q,P, Y, and H to move the cursor left, right, up and down respectively until it is positioned on the desired location to enter, change, or delete. To enter or change the track time, position the cursor under CLS and enter the two hex digit class to be assigned to this auto track. The cursor will move under SV. Enter the SV ID number. Then under START enter the hour then the minute to start. The track will begin on second 0 of that minute. Then under "TL" enter track length in minutes. Values from 04 to 79 are valid.

To delete a track time simply position the cursor on any of the data in that particular auto track except the class byte or the high order nibble of the track length then enter the letters "D", "E", "L".

C. Hard-copy during tracking

There are four options for hard copy during tracking. To choose among these enter 5=TRACK HDCPY CMDS from the main menu. 0=NO TRACK MESSAGES allows only error and emergency messages. 1=SATELLITE POSITIONS prints out the initial range and the range and geocentric X,Y,Z, 100 seconds later derived from the almanac and used in computing the Doppler. The path length, range delay and clock correction at this time are invalid. Then after lock, the positions are printed for every 15 sec. measurement derived from the transmitted ephemeris. 2=EACH 1 SEC MEASUREMENT prints data from the counter. First, the results from calibration are printed and then each 1 second pseudo-range measurement. 3=EACH 15 SEC MEASUREMENT prints a header and the initial azimuth, elevation, and Doppler, then, after lock, the results of each 15 sec measurement computation are printed. See "V. Printed Data" under "Description of the System" for details.

II. Navigation

A. Using Normal Tracks

The data from four normal auto-tracks can be stored and used for a navigation solution. The high-order bit of the high-order nibble of the track length is a flag which when set commands the microprocessor to store the data from that track on special stacks of four such data sets. The oldest one is discarded and the most recent three are pushed down. If the two high-order bits of the high-order nibble of the track length are both set the system both stores the data from that track and then does a solution using the four data points stored.

To use normal tracks for navigation, first pick four track times for satellites with good geometry. An ideal geometry is one satellite directly overhead and three equally spaced on the horizon. Of course to minimize ionospheric and troposhperic effects, satellites must be considerably above the horizon. Also the closer in time the tracks are, the better, to minimize clock drift. Choose track lengths. Good track lengths are from 8 to 15 minutes. Then enter these track times as for automatic tracking, as in section I.B., but set the high order bit of the track length for the first three by adding 80 hex to the track length, and set the two high order bits of the fourth track length by adding C0 hex. If a fifth track can be found to replace approximately the elevation and azimuth of the first, a second solution may be performed. Again, add C0 hex to the track length of this fifth track. Similarly, other solutions may be done. These solutions will be done every day and, if the automatic update feature is enabled, when the satellites are in the same positions.

B. Manual Fast-Lock

When there are four satellites up with a good geometry, one with high elevation and three with equally spaced low elevations, one may start fast-lock navigation using these. Enter 1 = TRACK CMDS from the main menu, then 3 = START NAVIGATION from the submenu. Then enter the four SV ID numbers to use. The first fast lock will be attempted on GPS second 8 of the minute nine away from when commanded to start. If the four satellites have not been acquired through the normal lock sequence by this time, the program will abort. Fast locks will continue until either lock is lost, 32 solutions are done, a "stop tracking" command is entered, or an automatic track time comes up. The solutions will be printed out upon termination.

C. Automatic Fast-Lock

The microprocessor can be programmed to initiate fast-lock navigation at a pre-set time everyday. As for automatic tracking, I.B., set up to edit an appropriate page of track times and position the cursor over an unused track time. Enter the class byte. Then, when the cursor is over the high order digit of the SV ID number, enter "N". The machine will then request the four satellite ID's to use for navigation. When these are entered, the letters "NV" will appear for the SV ID in the track time, and the cursor will appear over the START time, requesting the hour and then the minute to start. Once these are entered, you next enter the track length. As for auto-tracks, values from 04 to 79 are valid, though the first solution will not be performed until 16 minutes have elapsed: 8 minutes for initial slow locks, then 8 minutes for four 2 minute tracks. After this, another solution is done every two minutes, though only every fourth solution is independent. Only two auto fast-locks per day can be programmed. If both have already been programmed, a message to that effect will appear when entering "N". An auto-nav time may be deleted in the same way as an auto-track time.

If an automatic fast-lock has been programmed, it is not apparent from the page of track times which satellites are to be used. These may be seen by positioning the cursor over any of the data in the auto-nav, then entering "Z". To return to edit mode, hit any character.

The automatic fast-lock program will begin normal locks on second 0 of the programmed hour and minute. The first fast-lock will begin on second 8, eight minutes later. If the normal locks are not completed by this time, the program will abort. Fast locks will continue sequentially until either: the receiver loses or fails to lock on a satellite, 32 solutions are done, or a "stop tracking" command is either entered manually, or issued because the track length time is up. The solutions done will be printed upon termination.

III. Use of the Data Display Area

A. Measurement Data

When not tracking one can choose between comparisons with SV clocks or with the GPS time scale. From the main menu, choose 2=DISPLAY CMDS and either 1=LOCAL-GPS DATA or 2=LOCAL-SV DATA. One can also choose which three data points to display. Again, choose 2=DISPLAY CMDS. The data displayed are from three consecutive passes or tracks with the most recent being on the top. Entering Y=ROLL UP moves the data up one line thus displaying older data. Enter H=ROLL DOWN to move the data down one line displaying more recent data. The roll function stops at the top, the most recent, and at the bottom, 150 data points down. After each track the most recent three are displayed.

B. Memory Dump

One can display the hex contents of memory on the screen at any time. Enter 2=DISPLAY CMDS from the main menu. You can choose to display memory incrementing or decrementing from a starting address by now entering 3=MEMORY INCREMENTING or 4=MEMORY DECREMENTING, respectively. Then enter the four hex digit starting address. Memory data will be displayed on one line from the starting address to the next 16 byte boundary in memory. This is a live display. As memory changes the display changes. To continue the incrementing/decrementing dump hit the space bar. The data display will be rolled down one line and the next 16 bytes will be displayed on the top line. Only the top line is live. The others reflect the memory contents at the time of the roll. Hit back space and the previous memory locations will be re-displayed. Hitting any other key ends the memory dump and returns the data area to its previous state.

C. Editing Track Times

The data display area is also used for editing automatic track times. See instructions under IB Automatic Tracking, and II Navigation.

IV. Printing Out Data

A. Local Data

To print out data from local measurements enter 3=PRINT DATA CMDS from the main menu. Then enter 1=GPS TRACKING DATA (see "V. Printed Data" under "Description of the System") in the sub-menu and then enter the class search byte. Only data with classes matching the search byte will be printed, unless the search byte is "FF". In this latter case, all data will be printed. To stop the print before all the data of that class contained in memory is printed enter 2=PRINT DATA CMDS from the main menu followed by 3=STOP PRINT in the sub-menu.

B. Data from a remote receiver.

To print out data locally via the modem from a remote receiver enter 3=PRINT DATA CMDS from the main menu, then 3=PRINT FROM REMOTE RCVR from the sub-menu. Now turn the switch on the modem phone to "Voice" and call the number of the receiver. When you hear the tone, push the switch on the modem to "Originate" and a sub-menu will be displayed. The keyboard and screen now become a terminal for transmitting to the remote receiver, and the printer prints all that is received. First hit carriage return (cr) to clear any parity errors. To print data accurate to 1.0ns, enter "XXDCMD (cr)", where "XX" is the hex class search byte. Only data points matching that class will be printed. To print data with the 0.1ns digit enter "XXNCMD (cr)." To terminate the transmission data before the remote receiver is done, hit any character. To print remote track times enter "XXTCMD." In general as characters are entered from the keyboard, they will be echoed on the screen on one line, then wrapped around. Hitting "CR" will clear the line. To terminate or abort the call at any time hit "ESC". When done, hang up the telephone and switch the modem back to "ANSWER".

V. Use of the Counter

First the counter must be calibrated. Enter 6=COUNTER CMDS from the main menu to obtain the counter sub-menu. Then enter 3=CALIBRATE. Attach the start and stop signals to the BNC connectors on the back of the micro-processor. The level of the start-stop signals should be 0 to + 3V(max). (The trigger threshold for inputs is + 0.5V). Then, from the counter sub-menu choose 1=START TI to start time interval measurement. The results will be printed in microseconds with 0.1ns resolution. Measurements will be made continuously until you enter 2=stop TI. If the counter does not get a stop pulse within 2 seconds of receiving a start pulse, it will display the message "COUNTER FAILED". To reset this enter 4=RESET ERROR MESSAGE from the counter sub-menu.

VI. Graphing

To graph elevation with azimuth vs. time for up to 5 satellites, enter 7=GRAPH SATELLITES from the main menu. Then enter 1=START GRAPH. Note once the graph is started it can be stopped at any time by entering 7=GRAPH SATELLITES from the main menu and 2= ABORT GRAPH from the graph sub-menu. To continue, after entering 1=START GRAPH then enter up to 5 SV ID numbers which will be plotted with the letters A-E respectively. If fewer than 5 satellites are to be graphed, terminate entry with "RET". Then enter the last four digits of the MJD for which the graph applies. Next choose whether to graph for a different location than locally or not by entering "Y" (yes) or "N" (no). If "Y" is chosen then enter the 10 character name for that location to appear on the graph, followed by the geodetic coordinates in the format for entering new coordinates.

VII. Entering a new receiver name or coordinates

Enter 8=NEW RECEIVER COORDINATES. Then enter the 5 character receiver name. Then you are requested for the local name for the graph program. Hitting "ESC" now will abort the entry of new coordinates but leave the new name intact. Now enter from 1 to 10 characters to be used as the header for graphs from local coordinates. Hit "RET" if less than 10 characters are entered. Now the sub-menu will appear to enter co-ordinates. Enter the geodetic coordinates as prompted with appropriate digits except the first blank which needs either "N" or "S" for latitude degrees north or south, respectively. To back up on the same line hit "DEL". To re-start the entry any time before all spaces are filled you may hit "RET". After all spaces are filled new instructions are dis played saying to hit "RET" to enter these as new coordinates or "ESC" to abort the routine. Thus, you have a chance to check that the co ordinates are entered properly before they are used. Of course, hitting "ESC" at any time before the routine is executed will abort it.

VIII. Cold Start and Receiver Delay

These commands are for use if the backup clock or the fail-safe memory is lost during a power failure. Also, a receiver delay constant may be entered from this sub-menu. If you suspect that the fail-safe memory has actually failed, first push the reset button on the back of the microprocessor while the printer is turned on. If the back-up memory or clock is lost, error messages will be printed out. Refer to the section on error messages.

To acquire an almanac after losing back-up memory, first enter the receiver coordinates. See Section VI. When there is a satellite to obtain an almanac from above the horizon enter 9=COLD START CMDS from the main menu and choose 1=SEARCH MODE. Then enter, as prompted, the SV ID number of the satellite currently up. The receiver program will attempt lock by iteratively cycling through the possible Doppler values. Now during this search, choose from the TRACK HARD COPY sub-menu 3=EACH 15 SECOND MEASUREMENT. This will provide documentation of the search, in particular giving a print-out of which almanacs have been acquired. It is possible to start search on a satellite when it is below the horizon, but this may fail. The receiver program will search for lock until the SV crosses the horizon. It will then lock at an extremely low elevation angle and may lose lock before a full almanac has been loaded.

To set the UTC clock manually, or to change the value in memory of GPS minus UTC choose 2=SET UTC CLOCK from the COLD START sub-menu. A replica of the UTC clock will appear at the left side of the menu area, along with the current stored value of GPS minus UTC. You may now use Q or P to position the cursor to the LEFT or RIGHT. Then enter the desired digit in the appropriate location for a time about to happen. Also the correct value of GPS minus UTC in seconds can be set. When the correct time arrives, now hit "RET" and that time will be entered. At the next second 0, the back-up clock will be set. The MJD will be computed by the interruptible program in its time-share mode. Of course to abort the routine, enter "ESC".

To either view the current receiver delay or enter a receiver delay choose 3= SET RCVR DELAY from the sub-menu. The receiver delay currently in memory will appear. To abort entry of a new delay, hit "ESC". To continue, now enter first the sign, then fifteen decimal digits, then the sign of the exponent and the value of the exponent in decimal. This number in seconds will be subtracted from all tracking data. Upon entry it will be backed up on the fail-safe board and printed out locally.

The receiver may be used with either an omni-directional or high gain antenna. To set the receiver for this, choose 4= SET ANT TYPE from the sub-menu. Then choose either 0 or 1 for the omni or high gain antenna, respectively.

List of Menus

1. TRACK CMDS

    (1) START TRACKING — TRACK SV#

    (2) STOP TRACKING

    (3) START NAVIGATION — NAVIGATE USING: _ _,_ _,_ _, _ _

2. DISPLAY CMDS

    (1) REFERENCE - GPS DATA

    (2) REFERENCE - SV DATA

    Y = ROLL UP   H= ROLL DOWN

    (3) MEMORY INCREMENTING

    (4) MEMORY DECREMENTING

    DUMP FROM _ _ _ _ (HEX)

3. PRINT DATA CMDS

    (1) GPS TRACKING DATA — ENTER CLASS SEARCH BYTE _ _

    (2) STOP PRINT

    (3) PRINT FROM REMOTE RCVR

    CALL REMOTE RCVR

    ENTER COMMANDS FROM KBD

4. AUTO TRACK TIMES

    (1) EDIT PAGE 1

    (2) EDIT PAGE 2

    (3) EDIT PAGE 3

    (4) PRINT BY CLASS — ENTER CLASS SEARCH BYTE

    (5) ADD TO ALL TIMES — ENTER MINS TO CHANGE (+/-)_ _ _M

    (6) DIS/ENB AUTO UPDATE

    (0)=DISABLE

    (1)=ENABLE

5. TRACK HD COPY CMDS

    (0) NO TRACK MESSAGES

    (1) SATELLITE POSITIONS (X,Y,Z)

    (2) EACH 1 SECOND MEASUREMENT

    (3) EACH 15 SECOND MEASUREMENT

6. COUNTER CMDS

    (1) START TI (time interval measurements)

    (2) STOP TI

    (3) CALIBRATE

    (4) RESET ERROR MESSAGE (counter failed)

7. GRAPH SATELLITES

    (1) START GRAPH

    SATS TO GRAPH   A B C D E
                       __ __ __ __ __

    ENTER MJD: 4_ _ _ _

    DO YOU WANT TO ENTER COORDINATES (Y/N)?

    (N)

    (Y) ENTER LOCAL NAME _ _ _ _ _ _ _ _ _ _

    LATITUDE: N/S _ DEG _ _ MIN _ _ SEC _ _._ _ _ _

    LONGITUDE: DEG EAST _ _ _ MIN _ _ SEC _ _._ _ _ _

    HEIGHT ABOVE ELLIPSOID: _ _ _ _._ _M

    HIT RET TO ENTER

    HIT ESC TO ABORT

    (2) ABORT GRAPH

8. NEW RCVR COORDS

    RECEIVER NAME _ _ _ _ _

    LOCAL NAME FOR GRAPH: _ _ _ _ _ _ _ _ _ _

    (followed by coordinate entry table as for graph above)

9. COLD START

(1) SEARCH MODE TRACK SV# _ _

(2) SET UTC CLOCK

Q=CURSOR LEFT P=CURSOR RIGHT 0-9=SET DIGIT RET=ENTER TIME

YR/MO/DA HR MN SC GPS-UTC

82/05/17 19:05:22 02S

(3) SET RCVR DELAY

RCVR DLY: (+/-)+0.123456789012345 EE(+/-)- 01 SEC

(4) SET ANT TYPE

0=OMNI ANT
1=HI GAIN ANT

Index

Menu	Sub Menu	Function	Relevant Comments in Description Section	Location of Instructions
1	1	Start Tracking	II	IA1
	2	Stop Tracking	II	IA2
	3	Start Navigation	III, VB	IIB
2	1 & 2	Display Track Data	II, IV, VA	IIIA
	3 & 4	Display Memory Inc/Dec	III	IIIB
3	1	Print Track Data	II, VA	IVA
	2	Stop Print	VA	IVA
	3	Print from Remote Rcvr	VA	IVB
4	1, 2, 3	Edit Auto Track Times	II, III, IV	IB, IIA, IIC,
	4	Print by Class	VC	IB
	5	Add to All Track Times	VE	IB
	6	Dis/Enb Auto-Update	II, VC	IB
5		Track Hard-Copy Cmds	VD	IC
6		Counter Cmds	I	V
7		Graphing Cmds	I, VI	VI
8		New Rcvr Coords	VE	VII
9	1	Cold Start Search	I	VIII
	2	Manually Set UTC Clock	I	VIII
	3	Set RCVR Delay	II, VE	VIII
	4	Set Ant Type	II, III, VB	VIII

ERROR MESSAGES

PORTS INITIALIZED

This is printed on a power on reset before interrupts are enabled.

READY

This is printed after interrupt stacks are initialized and interrupts enabled.

5382 21: 16: 48

The last four digits of the MJD then the hour, minute, and second is printed with most error messages.

LOST LOCK!!?

This means the carrier came unlocked for more than 30 seconds while the receiver program was tracking.

SV #XX HLTH = YY

When loading binary almanac data the health byte of the particular SV is checked. If it is non-zero the above message is printed, where XX is the particular SV ID# and YY is the hex value of the binary health byte.

BAD EPROM #(0-3):X

A parity check of the firmware EPROM on the processor board is done upon a power-on reset before interrupts are enabled. This message is printed if EPROM #X fails the parity check.

RAM FAILED BEFORE XXXXH

As programs or data are read from the fail-safe memory into dynamic RAM on a power-on reset, the byte written to RAM is read back to see if RAM is functioning. If this fails the above message is printed out at the end of the read operation. The hex address XXXX is the address following the block of RAM read to. The possibilities are:

LOCATION XXXX	RAM CONTENTS PRECEDING XXXX
1000	Program
2000	Program
3000	Program
4000	Program
7C38	Almanac
77FD	Automatic Track Times
599D	Local Coordinates
41AC	Receiver Label
41CD	GPS Minus UTC
417F	Update Track Times Flag
1911	Local Name for Graph
4114	Hi Gain vs. Omni Antenna Flag
6B86	Track Data Points
5830	Ionospheric Model
4364	Ionospherice Conversion Time

BACKUP CLOCK ERROR

When the UTC clock is loaded from the backup clock on the fail-safe board, the year in the clock is compared with the year written to the fail-safe memory. If the clock year equals neither the last year recorded nor the last year recorded plus one, the above message is printed.

FAIL-SAFE MEMORY PARITY ERROR BEFORE XXXXH

When programs or data are read from the fail-safe memory, parity check is done. If it fails the above message is printed out with XXXX being the next hex address in fail-safe memory following the block with a parity error. The possibilities are:

5000	RAM Program
6000	RAM Program
7000	RAM Program
8000	RAM Program
8002	Last Clock Year Written
83C3	Almanac

84C1	Automatic Track Times
853F	Local Coordinates
8545	Receiver Label
8547	Last GPS Minus UTC Value Written
8549	Update Track Times Flag
8554	Local Name for Graph
8556	Hi Gain vs. Omni Antenna Flag
87F0	Track Data Points
87FC	Ionospheric Model

TRACK TIMES TOO OLD TO UPDATE

When track times are read in during a power-on reset, the time and date when they were last written to fail-safe memory is also read in. If the automatic update flag is set, they are normally updated 4 minutes per day for the time power was lost. If they are more than 60 days old, however, they are not updated, and the above message is printed.

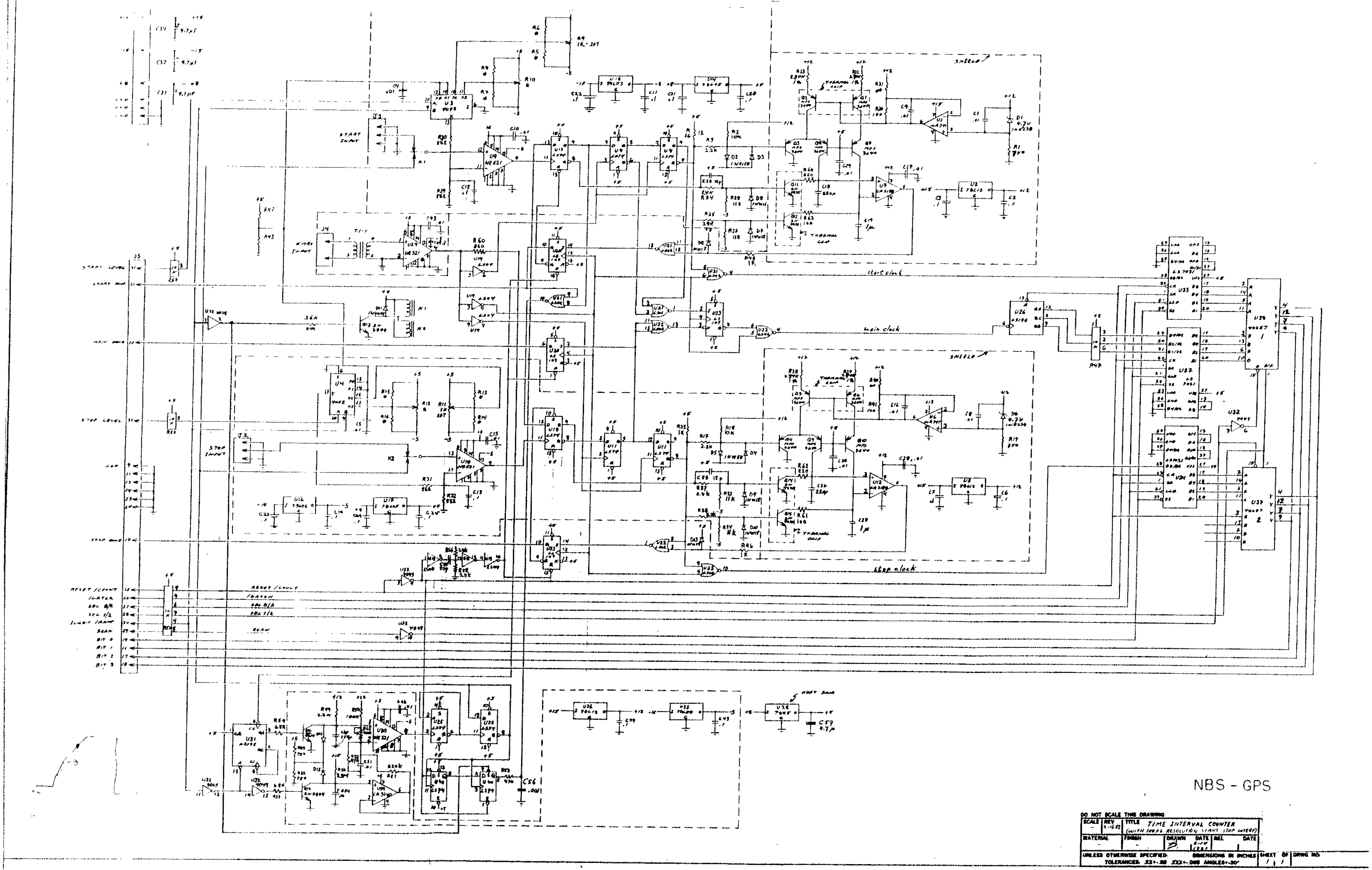
** CTR CAL ERROR **

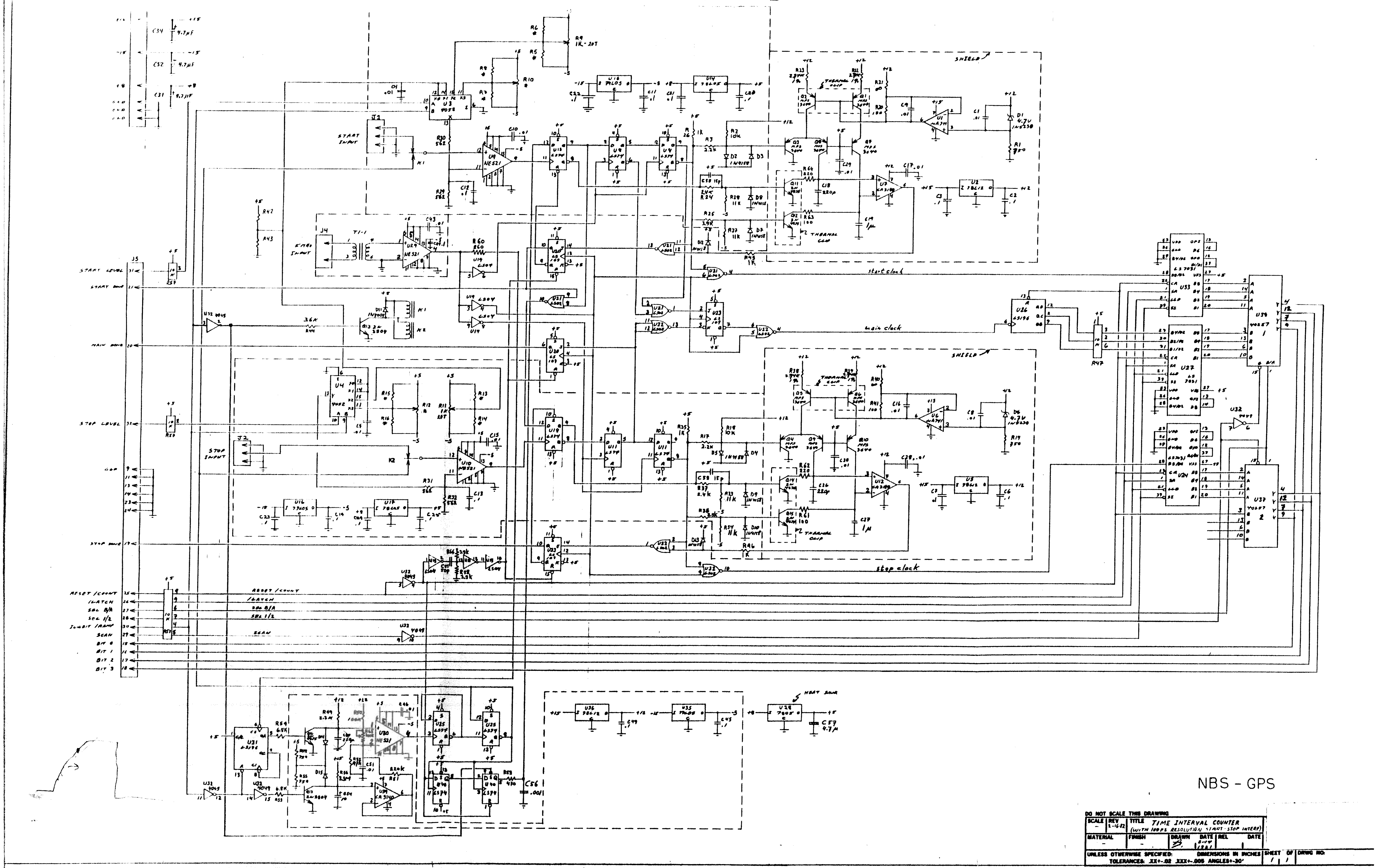
If the values from counter calibration are outside an acceptable range, this message is printed along with the invalid calibration results.

** CTR FAILED **

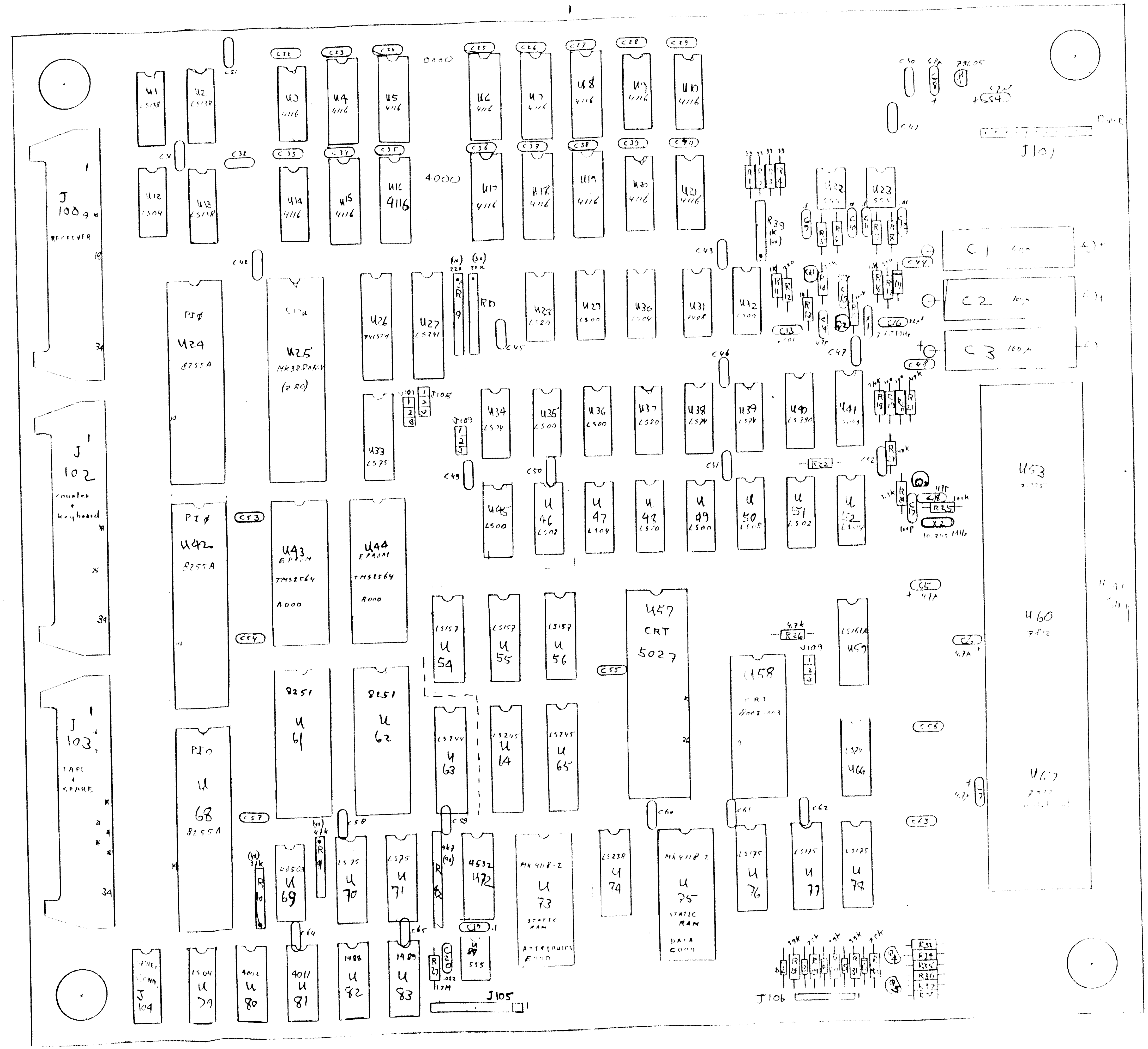
This is printed if the counter was unable to make a measurement.

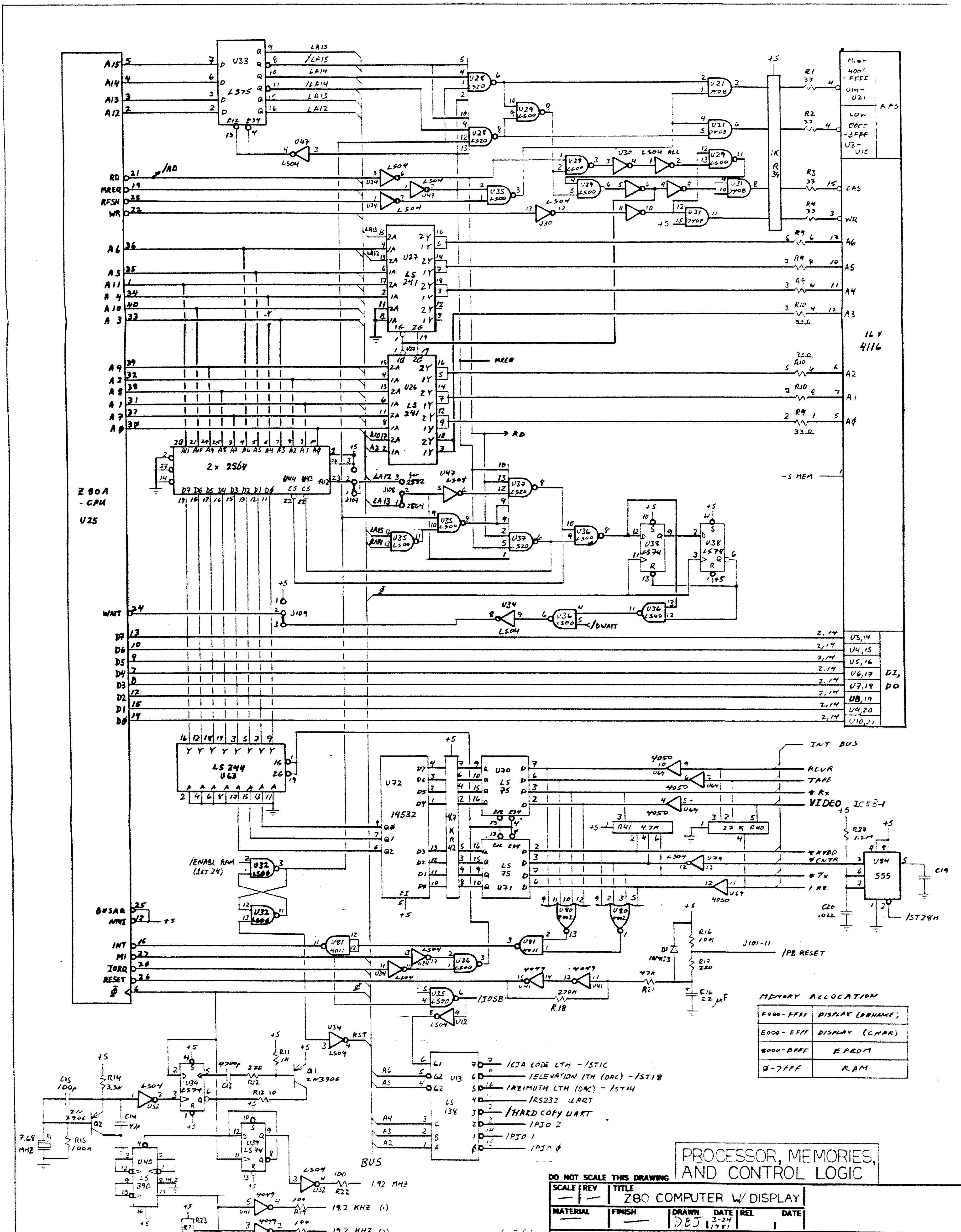
MICRO PROCESSOR

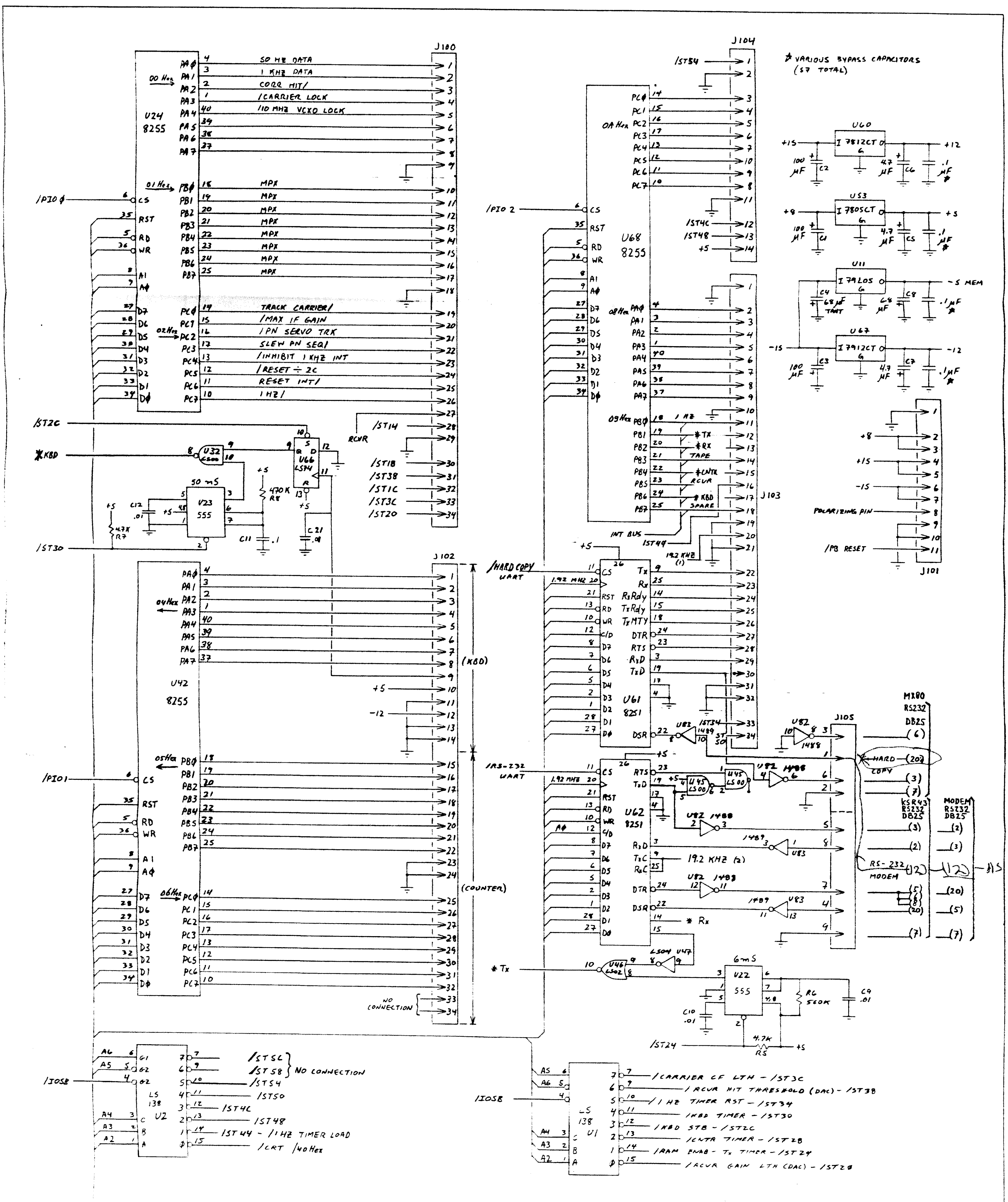

start clock
main clock
stop clock
SHIELD
NBS - GPS
TIME INTERVAL COUNTER


START LEVEL
START SYNC
MAIN SYNC
STOP LEVEL
STOP SYNC
RESET /COUNT
/LATCH
SEL B/A
SEL 1/2
SCAN
BIT 0
BIT 1
BIT 2
BIT 3
START INPUT
STOP INPUT
5 MHz INPUT
SHIELD
THERMAL CLIP
start clock
main clock
stop clock
HEAT SINK
NBS - GPS
DO NOT SCALE THIS DRAWING
SCALE
REV
TITLE
TIME INTERVAL COUNTER
(WITH 100PS RESOLUTION START-STOP INTERP)
MATERIAL
FINISH
DRAWN
DATE
REL
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES
TOLERANCES: XX+-.02 XXX+-.005 ANGLES+-30'
SHEET
OF
DWG NO.

26 +5
Bypass
9 +12
9 - 5 MEM

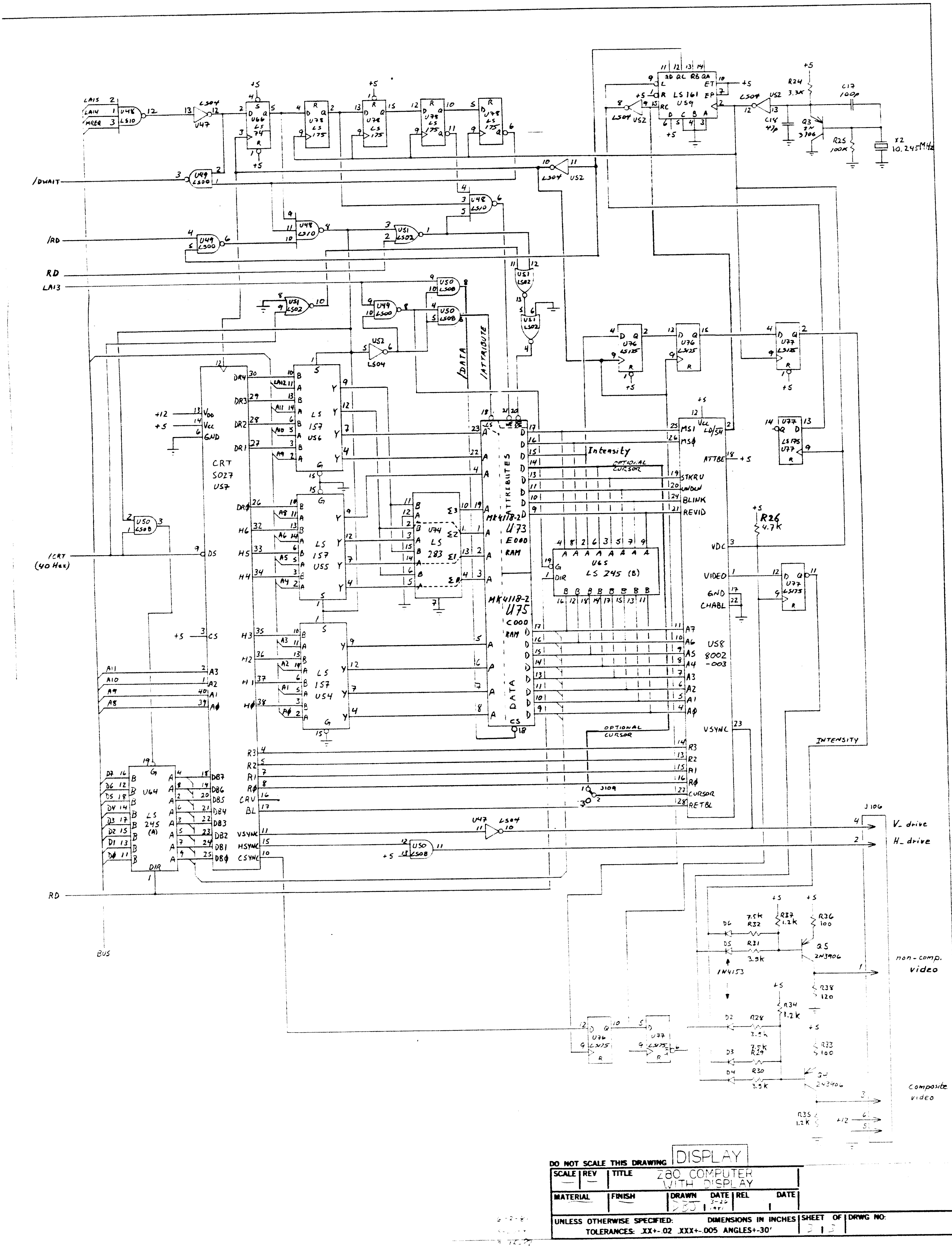



Z80A - CPU U25
U33 LS75
U27 LS 241
U26 LS 241
2 x 2564
LS 244 U63
U72 14532
U70 LS 75
U71 LS 75
U84 555
U13 LS 138
U40 LS 390
7.68 MHZ
1.92 MHZ
19.2 KHZ (1)
19.2 KHZ (2)
/ENABL RAM (1ST 24)
/DWAIT
/IOSB
INT BUS
RCVR
TAPE
VIDEO
/PB RESET
16 x 4116
CAS
WR
-S MEM
/CIA CODE LTH - /STIC
/ELEVATION LTH (DAC) - /ST18
/AZIMUTH LTH (DAC) - /ST14
/RS232 UART
/HARD COPY UART
/PIO 2
/PIO 1
/PIO ϕ
BUS
MEMORY ALLOCATION
F000 - FFFF DISPLAY (ENHANCE)
E000 - EFFF DISPLAY (CHAR)
8000 - BFFF EPROM
ϕ - 7FFF RAM
PROCESSOR, MEMORIES, AND CONTROL LOGIC
DO NOT SCALE THIS DRAWING
TITLE Z80 COMPUTER W/ DISPLAY
DRAWN DBJ DATE 3-24 1981
UNLESS OTHERWISE SPECIFIED: DIMENSIONS IN INCHES
TOLERANCES: XX+-.02 XXX+-.005 ANGLES+-30'
SHEET 1 OF 3



DO NOT SCALE THIS DRAWING PARALLEL INTERFACE

SCALE	REV	TITLE		
—	—	Z80 COMPUTER WITH DISPLAY		
MATERIAL	FINISH	DRAWN DBJ	DATE 3-25-1981	REL / DATE
UNLESS OTHERWISE SPECIFIED: TOLERANCES: .XX+-.02 .XXX+-.005 ANGLES+-30'	DIMENSIONS IN INCHES	SHEET 2 OF 3	DRWG NO:	


DISPLAY
DO NOT SCALE THIS DRAWING
SCALE REV TITLE
Z80 COMPUTER WITH DISPLAY
MATERIAL FINISH DRAWN DATE REL DATE
UNLESS OTHERWISE SPECIFIED: DIMENSIONS IN INCHES
TOLERANCES: .XX+-.02 .XXX+-.005 ANGLES+-30'
SHEET OF DRWG NO:
CRT 5027 U57
LS 157 U56
LS 157 U55
LS 157 U54
LS 283 U74
MK4118-2 U73 E000 RAM
MK4118-2 U75 C000 RAM
LS 245 (B) U65
LS 245 (A) U64
US8 8002-003
LS 161 U59
Intensity
OPTIONAL CURSOR
/DATA
/ATTRIBUTE
/DWAIT
/RD
RD
LA13
/CRT (40 Hex)
BUS
V_drive
H_drive
non-comp. video
composite video
J106
J109
X2 10.245 MHz

Pg. 58 of 109

Z80 Processor Board — Parts List — 82-02-12

Resistors

R 1	22 Ω	
2	22 Ω	
3	22 Ω	
4	22 Ω	
5	4.7 k	
6	560 k	
7	4.7 k	
8	470 k	
9	22 Ω	(4x)
10	22 Ω	(3x)
11	1 k	
12	220 Ω	
13	10 Ω	
14	3.3 k	
15	100 k	
16	10 k	
17	220 Ω	
18	270 k	
19	100 Ω	
20	100 Ω	
21	47 k	
22	100 Ω	
23	4.7 k	
24	3.4 k	
25	100 k	
26	4.7 k	
27	1.2 M	
28	3.9 k	
29	7.5 k	
30	3.9 k	
31	3.9 k	
32	7.5 k	
33	100 Ω	
34	1.2 k	
35	1.2 k	
36	100 Ω	
37	1.2 k	
38	120 Ω	
39	1 kΩ	(4x)
40	27 k	(4x)
41	4.7 kΩ	(4x)
42	4.7 kΩ	(9x)

Capacitors

C 1	100 μF	25V elco
2	100 μF	25V elco
3	100 μF	25V elco
4	4.7 μF	tant.
5	4.7 μF	tant.
6	4.7 μF	tant.
7	4.7 μF	tant.
8	6.8 μF	tant.
9	.01	
10	.01	
11	.1	
12	.01	
13	.001	
14	47 p	
15	100 p	
16	22 μF	6V tant.
17	100 pF	
18	47 pF	
19	.1	
20	.022	
21	.01	
C22 - C65	.1 μF (decoupling)	

Z80 Processor Board   Parts List   82-02-17

Integrated Circuits

U 1	74LS138N	U 48	74LS10
2	74LS138N	49	74LS00
3	TMS4116-20NL	50	74LS08
4	"	51	74LS02
5	"	52	74LS04
6	"	53	MC7805CT
7	"	54	74LS157
8	"	55	74LS157
9	"	56	74LS157
10	"	57	CRT5027
11	MC79L05CP	58	CRT8002-003
12	74LS04N	59	74LS161A
13	74LS138N	60	MC7812CT
14	TMS4116-20NL	61	D8251C
15	"	62	D8251C
16	"	63	74LS244
17	"	64	74LS245
18	"	65	74LS245
19	"	66	74LS74
20	"	67	MC7912CT
21	"	68	P8255A
22	NE555N	69	CD4050B
23	NE555N	70	74LS75
24	P8255A	71	74LS75
25	MK3880N-4(Z80A)	72	CD4532B
26	74LS241	73	MK4118-2
27	74LS241	74	74LS238
28	74LS20	75	MK4118-2
29	74LS00	76	74LS175
30	74LS04	77	74LS175
31	7408	78	74LS175
32	74LS00	79	74LS04
33	74LS75	80	CD4002A
34	74LS04	81	CD4011B
35	74LS00	82	MC1488L
36	74LS00	83	MC1489L
37	74LS20	84	NE555N
38	74LS74		
39	74LS74		
40	74LS390		
41	CD4049B		
42	P8255A		
43	EPROM TMS2564JDL-45		
44	EPROM TMS2564JDL-45		
45	74LS00		
46	74LS02		
47	74LS04		

Transistors

Q 1	2N3906
2	2N3906
3	2N3906
4	2N3906
5	2N3906

Diodes

D 1	IN4153
2	IN4153
3	IN4153
4	IN4153
5	IN4153
6	IN4153

Connectors

J100	34p	3M
J101	11p	Molex
J102	34p	3M
J103	34p	3M
J104	14p	Socket Dualization
J105	9p	Molex
J106	6p	"
J107	3p	"
J108	3p	"
J109	3p	"

Crystals

7.68 MHz
10.245 MHz

Z80 Processor Board — Parts List — 82-02-17

Totals

Integrated Circuits

74LS138	3
TMS4116-20NL	16
MC79L05	1
74LS04	6
NE555N	3
P8255A	3
MK3880N-4 (Z-80A)	1
74LS20	2
74LS20	3
74LS00	6
74LS75	3
7408	1
74LS74	3
74LS390	1
CD4049B	1
74LS02	2
74LS10	1
74LS08	1
MC7805CT	1
74LS157	3
CRT5027	1
CRT8002-003	1
74LS161A	1
MC7812CT	1
D8251C	2
74LS244	1
74LS245	2
MC7912CT	1
CD4050B	1
MK4118-2	2
CD4532B	1
74LS238	1
74LS175	3
CD4002A	1
CD4011B	1
MC1488L	1
MC1489L	1
TMS2564JDL-45	2

Transistors

IN3906	5

Diodes

IN4153	6

Resistors

22 Ω	6
4.7 k	17
560 k	1
470 k	1
1 k	5
220 Ω	2
10 Ω	1
3.3 k	2
10 k	1
270 k	1
100 Ω	5
1.2 M	1
3.9 k	3
7.5 k	2
1.2 k	3
120 Ω	1
27 k	4

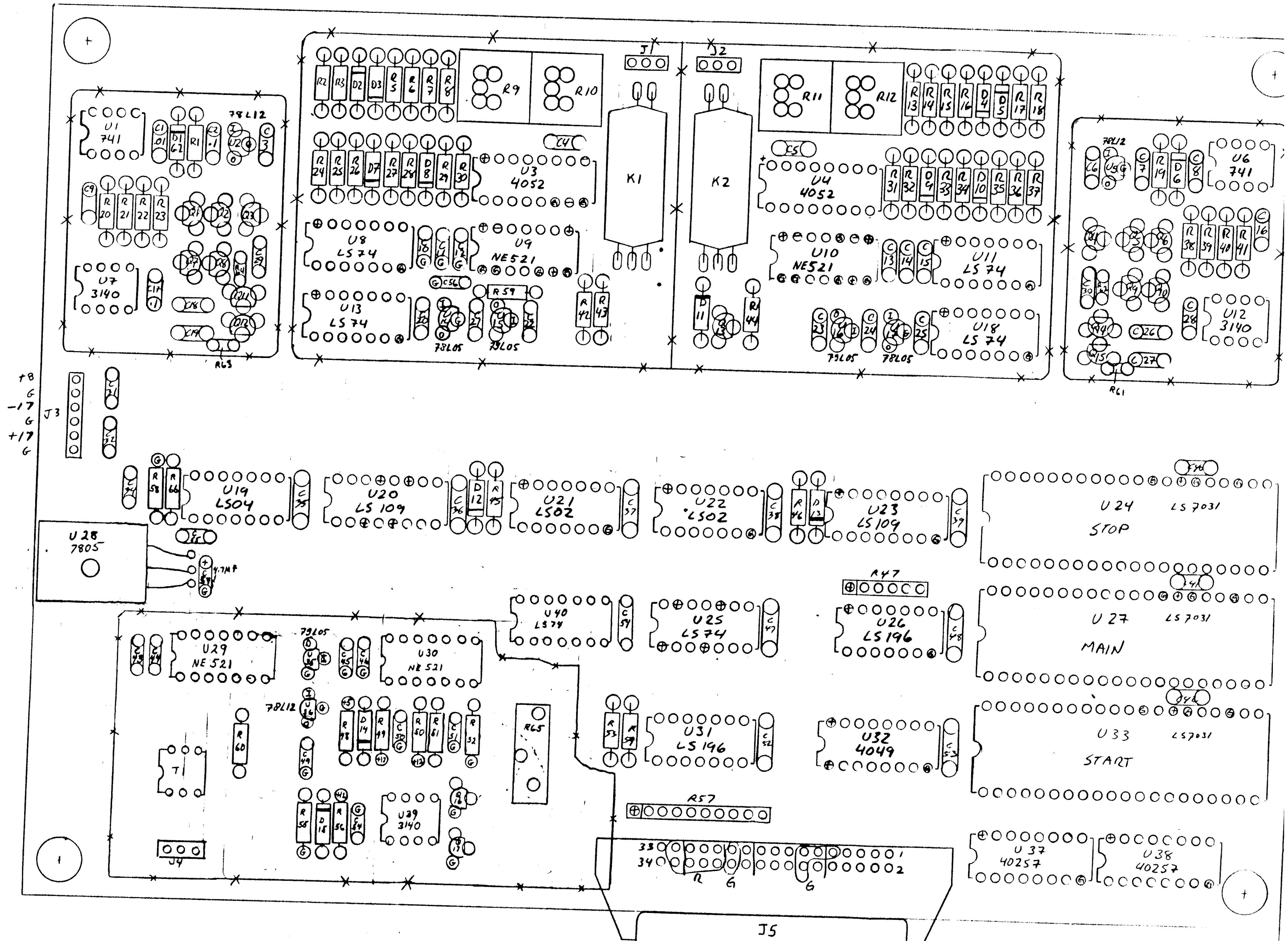
Capicitors

100 μF	25V elco	3
4.7 μF	tant.	4
6.8 μF	tant.	1
.01		3
.1		46
.001		1
47 pF		2
100 pF		2
22 μF	6V tant.	1
.022		1

Connectors

34 p:3M3431-4005	3
11 p:Molex4030-20A	1
14 p:ICsocket	1
9 p:Molex 4030-20A	1
6 p:Molex 4030-20A	1
3 p:Molex 4030-20A	3

COUNTER



NBS/GPS
TIME INTERVAL COUNTER
Rev Feb 16, 1982

Time Interval Counter   Parts List   82-02-17

Integrated Circuits

U1	741
2	78L12
3	4052
4	4052
5	78L12
6	741
7	CA3140
8	74LS74
9	NE521
10	NE521
11	74LS74
12	CA3140
13	74LS74
14	78L05
15	79L05
16	79L05
17	78L05
18	74LS74
19	74LS04
20	74LS109
21	74LS02
22	74LS02
23	74LS109
24	LS7031
25	74LS74
26	74LS196
27	LS7031
28	78L05
29	NE521
30	NE521
31	74LS196
32	4049
33	LS7031
34	
35	79L05
36	78L12
37	CA40257BE
38	CA40257BE
39	CA3140
40	74LS74

Transistors

Q1	MPS3640
2	MPS3640
3	MPS3640
4	MPS3640
5	MPS3640
6	MPS3640
7	MPS3640
8	MPS3640
9	MPS3640
10	MPS3640
11	2N4275
12	2N4275
13	2N3904
14	2N4275
15	2N4275
16	2N4275
17	2N3904

Diodes

D1	IN5230	4.7 V
2	IN4153	
3	IN4153	
4	IN4153	
5	IN4153	
6	IN5230	4.7 V
7	IN4153	
8	IN4153	
9	IN4153	
10	IN4153	
11	IN4004	
12	IN4153	
13	IN4153	
14	IN4153	
15	IN4153	

Time Interval Counter — Parts List — 82-02-17

Resistors

R1	750 Ω
2	10 k
3	2.2 k
4	
5	*
6	*
7	*
8	*
9	1k 20t potm.
10	1k 20t potm. *
11	1K 20t potm.
12	1k 20t potm. *
13	*
14	*
15	*
16	*
17	2.2 k
18	10 k
19	750 Ω
20	100 Ω
21	--
22	~~2.74 k 1%~~ 2.2K
23	2.74 k 1%
24	2.4 k
25	3.9 k
26	1 k
27	11 k
28	11 k
29	562 Ω 1%
30	562 Ω 1%
31	562 Ω 1%
32	562 Ω 1%
33	11 k
34	11 k
35	1 k
36	3.9 k
37	2.4 k
38	2.74 k 1%
39	~~2.74 k 1%~~ 2.2K
40	--
41	100 Ω
42	*
43	*
44	3.6 k
45	1 k
46	1 k
47	10 k (3x)

R48	750 Ω
49	2.2 k
50	100 k
51	~~220 k~~ 100K
52	~~47 k~~ 27K
53	6.8 k
54	6.8 k
55	750 Ω
56	3.3 M
57	10 k (8x)
58	3.9 k
59	470 Ω
60	270 Ω
61	100 Ω
62	220 Ω
63	100 Ω
64	220 Ω
65	100 k 20t potm.
66	3.9 k

* not implemented

Time Interval Counter | Parts List | 82-02-17

Capacitors

C1	.01 μF	ceramic
2	.1	"
3	.1	"
4	.01	"
5	.01	"
6	.1	"
7	.1	"
8	.01	"
9	.01	"
10	.01	"
11	.1	"
12	.1	"
13	.1	"
14	.1	"
15	.01	"
16	.01	"
17	.01	"
18	220 pF	NPO ceramic
19	1 μF	
20	.1 μF	ceramic
21	.1	"
22	.1	"
23	.1	"
24	.1	"
25	.1	"
26	220 pF	NPO ceramic
27	1 μF	
28	.01 μF	ceramic
29		
30	.01	
31	4.7 μF	tant
32	4.7 μF	"
33		
34	4.7 μF	tant
35	.1 μF	ceramic
36	.1	"
37	.1	"
38	.1	"
39	.1	"
40	.1	"
41	.1	"
42	.1	"
43	.01	"
44	.1	"
45	.1	"
46	.01	"
47	.1	"
C48	.1 μF	ceramic
49	.1 μF	
50	220 pF	"
51	.01 μF	ceramic
52	.1	
53	.1	
54	10 μF	tant
55	50 pF	
56	.001 μF	ceramic
57	4.7 μF	tant

Miscellaneous

T1	T1-1	Mini Circuits Lab
J1	3p	Wafer assembly 4030-20A Molex
J2	3p	" " " "
J3	6p	" " " "
J4	3p	" " " "
J5	34p	Scotchflex 3431-4005 3M
K1	Reedrelay	SPDT 5Vcoil,101-001 Triridge
K2	" "	" " " " " " "

or: Electronic Applications Company: S1C5 A HH

Time Interval Counter Parts List 82-02-17

Totals

Integrated circuits

741	2	
78L12	2	
4052	2	
CA3140	3	
74LS75	5	
NE 521	4	
78L05	4	
79L05	3	
74LS04	1	
74LS109	2	
74LS02	2	
LS7031	3	(LSI Computer Systems, Inc.
74LS196	2	1234 Walt Witman Rd.
CD4049 BE	1	Melville, NY 11746
CD40257 BE	2	(516) 271-0400
		TWX 510-226-7833)

Transistors

MPS 3640	10
2N4275	5
2N3904	2

Diodes

IN5230	2
IN4153	12
IN4004	1

Capacitors

.01 μF ceram.	14
.1 μF "	29
220 pF NPO ceram.	3
1 μF	2
10 μF tant.	1
4.7 μF tant.	4
.001 μF ceram.	1
50 pF	1

Reedrelays SPDT 5V	2
T1-1 MiniCirc. Lab	1
3p Molex 4030-20A	3
6p " " "	1
34p 3M 3431-4005	1

Resistors

2.2KΩ	2	
750 Ω	3	
10 k	13	
2.2 k	3	
1 k potm. 20t.	2	Spectrol 64W 102
100 Ω	3	
2.74 k 1%	~~4~~ 2	
2.4 k	2	
3.9 k	4	
1 k	4	
11 k	4	
562 Ω 1%	4	
3.6 k	1	
100 k	1	
~~220~~ k 100K	1	
~~47~~ k 27K	1	
6.8 k	2	
3.3 M	1	
470 Ω	1	
270 Ω	1	
220 Ω	2	
100 k potm. 20t.	1	Bourns "TRIM POT"

FAIL SAFE MEMORY

MODS TO IMPLEMENT FAIL-SAFE MEMORY

ON PROCESSOR CARD:

(1) CUT TRACES + RUN WIRE FROM U61-19 to U82-4 (TX DATA)

(2) CUT TRACE BETWEEN J104-1 + J103-34 (ST 50H)

(3) RUN WIRE FROM J104-1 TO U2-10 (ST 54H)

(4) INSTALL 15-60PF TRIMMER IN 7.68MHZ OSC CKT

SEE PROCESSOR TRACE SCHEMATICS ATTACHED

IN POWER SUPPLY (A VERSION)

(1) REPLACE 24V SUPPLY WITH 6.3VAC XFMR (.2A)

2. RUN 6.3V AC IN PLACE OF 24V TO PINS D, E OF CONNECTORS

ON MULTIPLIER CARD IN RCVR

(1) CUT TRACES TO GND ON PIN 1 OF HP OSC CONNECTOR (-24V)

(2) CONNECT PIN 1 OF OSC CONNECTOR TO -15V (PIN 6 OF MOLEX)

(3) CONNECT PIN 2 OF OSC CONNECTOR TO +8V (PIN 4 OF MOLEX)

(4) REMOVE RUNS TO PINS 1+2 OF MOLEX (ORIGINAL + - 24V)

(5) REMOVE POWER WIRES (RED+BLUE) FROM PINS D, E IN RCVR

IN PROCESSOR CHASSIS:

(1) RUN WIRES FROM PINS D, E OF POWER CONNECTOR TO PINS 9, 10 OF FAIL SAFE MOLEX (6.3VAC)

"A" VERSION ONLY -- ADD 6.3VAC XFMR TO "B" VERSION

(2) REMOVE [illegible] KHZ ON PIN 7 OF FAIL-SAFE MOLEX

(3) INSTALL BATTERY PACK IN PLACE OF TAPE DRIVE (REMOVE TAPE DRIVE CABLE)

(4) CONNECT (+) OF BATT PACK TO PIN 2 OF FS MOLEX

(5) CONNECT (-) OF BP TO PIN 4 OF FS MOLEX

ADJUST 7.68 MHZ XTAL OSC ON PROCESSOR CARD AND 32 KHZ OSC ON FAIL-SAFE CARD.

16K EPROM
2K RAM + CLOCK w/BATTERY | NBS/GPS RCVR | MAR 3, 1982 - D[3] | (S1)

(J1)

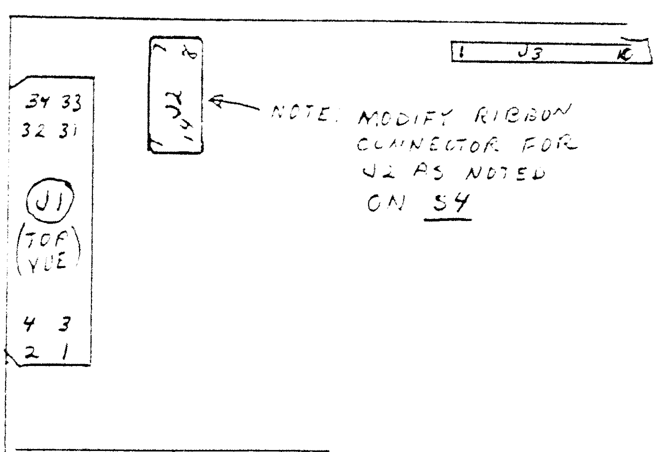
1 GND
2 B0
3 B1
4 B2
5 B3
6 B4
7 B5
8 B6
9 B7
(pins 2–9) TO U1, U2, U4, U5, U6, U7, U8 — PORT 08 (ADDR BUS)
NOTE: 15K PULLUP ON ALL 8 LINES TO +5V * (R29)
10 GND
11 UTC INT/ U15-10
12 —
13 —
14 PRINTER INT/ U14-10
15 —
16 /ST44 (RESET PRINTER INT) U14-(5,6)
17 —
18 VIDEO INT/ U14-11
19 GND
20 19.2 kHZ →
21 GND
22 TX CLOCK ←
23 RX CLOCK ← 4.7K R28 — +5V *
24 —
25 TXRDY U14-(1,2)
26 —
27 —
28 —
29 —
30 — * POLARIZE
31 GND
32 GND
33 /ST34 (RESET UTC INT) U15-(1,2)
34 /ST50 (RESET VIDEO INT) U15-(12,13)

J2

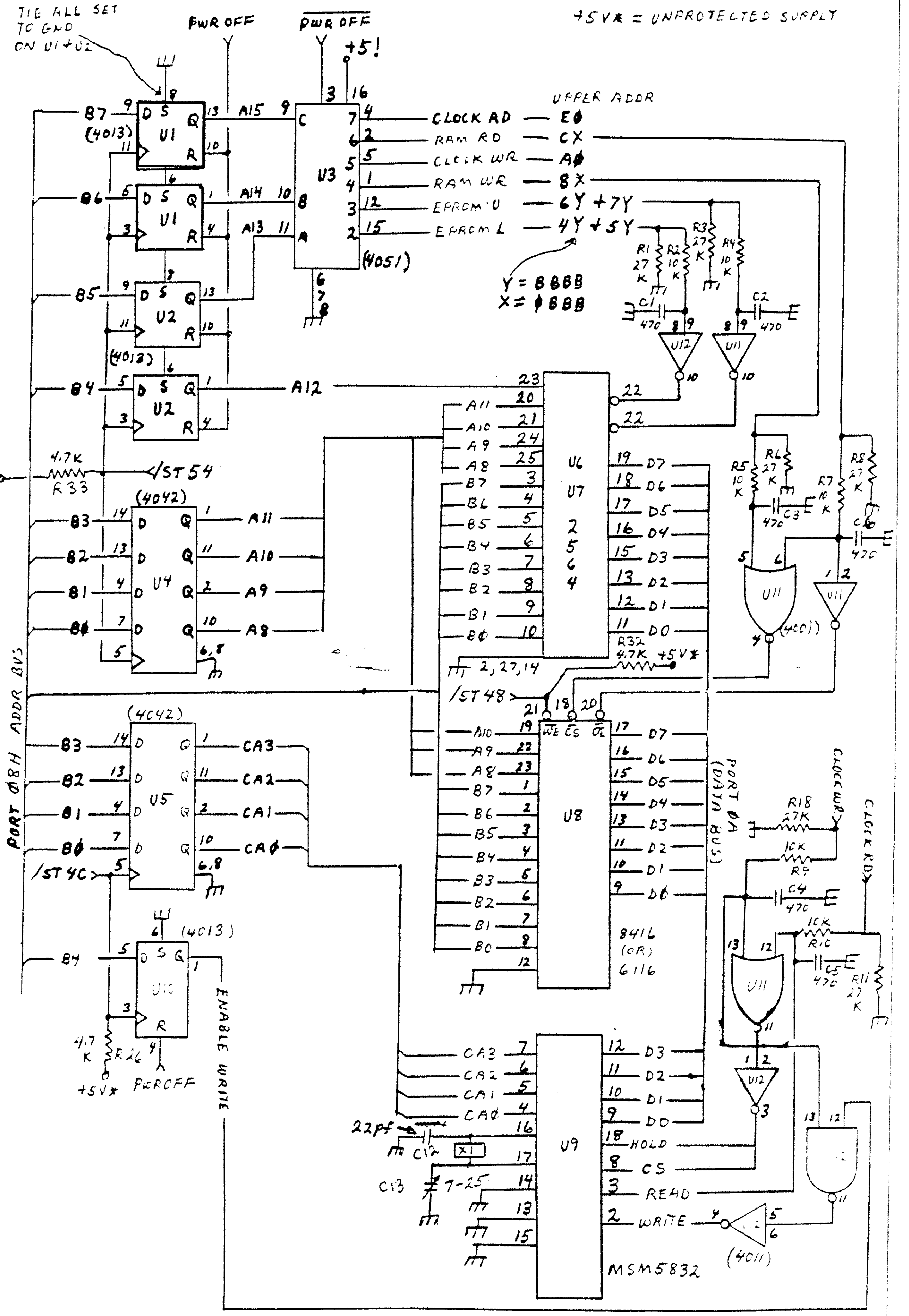
1 /ST54 (LATCH A8-A15)
2 GND
3 D0
4 D1
5 D2
6 D3
7 D4
8 D5
9 D6
10 D7
(pins 3–10) TO U6, U7, U8, U9 — PORT 0A (DATA BUS) ⟷
NOTE: 15K PULLUP RESISTORS ON ALL 8 DATA BUS LINES (TO +5V *) (R30)
11 GND
12 /ST4C (LATCH CLOCK ADDR) U5-5, U10-3
13 /ST48 (WRITE TO RAM) U8-21
14 +5V (NOT USED) * POLARIZE

J3

1 +8V
2 — +4.5V BATT
3 +15V (NOT USED)
4 — -4.5 BAT (GND)
5 GND
6 GND
7 —
8 * POLARIZE
9 —6.3VAC
10 —6.3VAC



NOTE! +5V! = PROTECTED SUPPLY
+5V* = UNPROTECTED SUPPLY

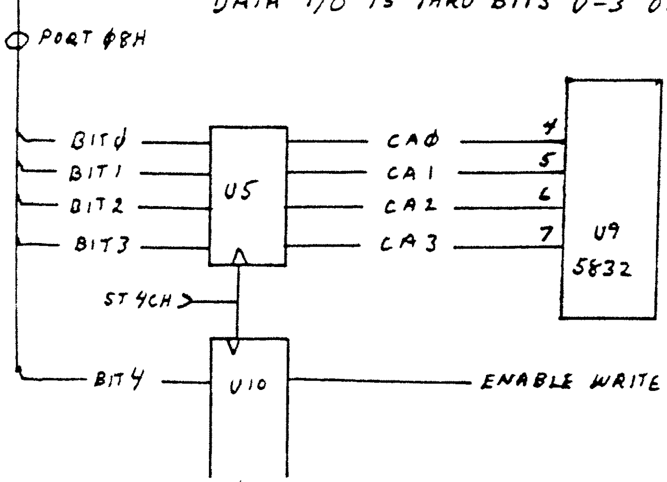


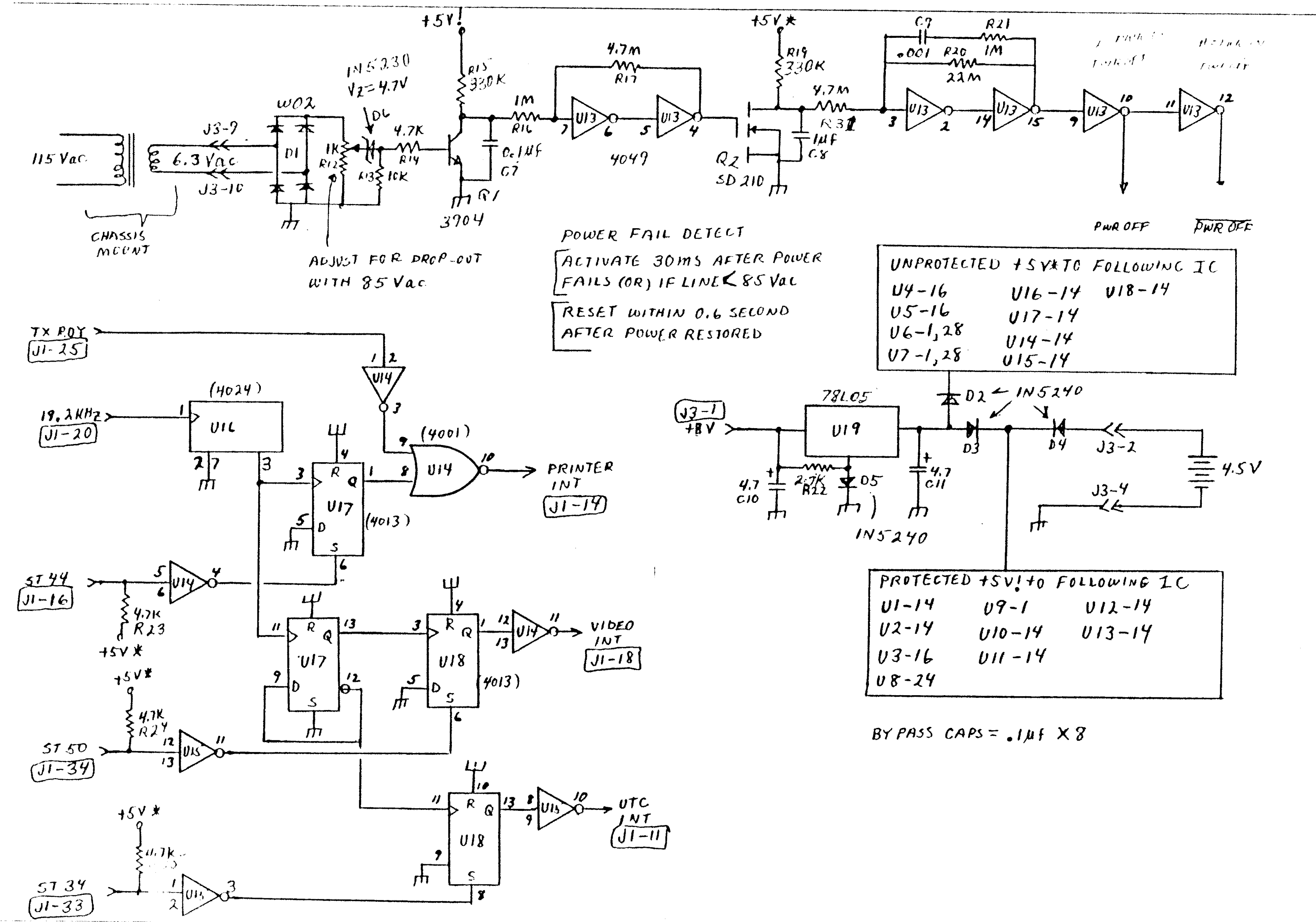
5832 ADDRESS/DATA TABLE

ADDRESS A0	A1	A2	A3	HEX VALUE	INTERNAL COUNTER	DATA D0	D1	D2	D3
0	0	0	0	0	SECOND 1	X	X	X	X
1	0	0	0	1	SECOND 10	X	X	X	d
0	1	0	0	2	MINUTE 1	X	X	X	X
1	1	0	0	3	MINUTE 10	X	X	X	
0	0	1	0	4	HOUR 1	X	X	X	X
1	0	1	0	5	HOUR 10	X	X	a	b
0	1	1	0	6	DAY/WEEK	X	X	X	
1	1	1	0	7	DATE 1	X	X	X	X
0	0	0	1	8	DATE 10	X	X	c	
1	0	0	1	9	MONTH 1	X	X	X	X
0	1	0	1	A	MONTH 10	X			
1	1	0	1	B	YEAR 1	X	X	X	X
0	0	1	1	C	YEAR 10	X	X	X	X
1	1	1	1	F	REFERENCE	e	f	g	h

X. 0 or 1: BCD Digit
a. 0 for AM, 1 for PM
b. 0 for 12 hour, 1 for 24 hour format
c. 1 for 29 days in month 2
d. Seconds reset to 00 by write to clock
e. 1024 Hz square wave
f. 1 Hz pulse
g. 1/60 Hz pulse
h. 1/3600 Hz pulse

NOTE: CLOCK NIBBLE IS ADDRESSED BY LATCHING DATA BITS 0-3 OF PORT Ø8H. LATCHING IS BY STROBE 4CH. DATA I/O IS THRU BITS 0-3 OF PORT ØAH





16K EPROM 2K RAM & CLOCK W/BATTERY

NBS/GPS RCVR

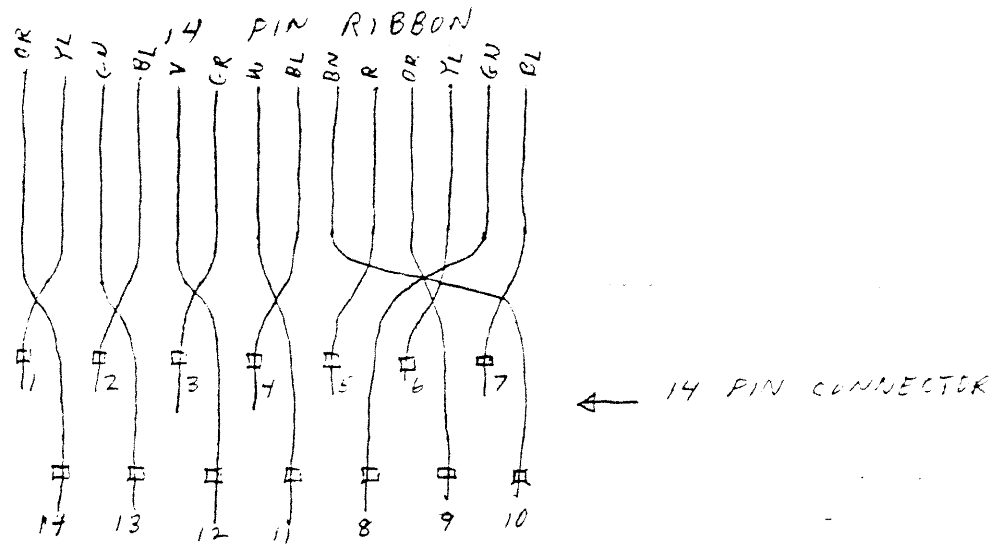
MAR 3 1982 - D3

4/12/82 - R³

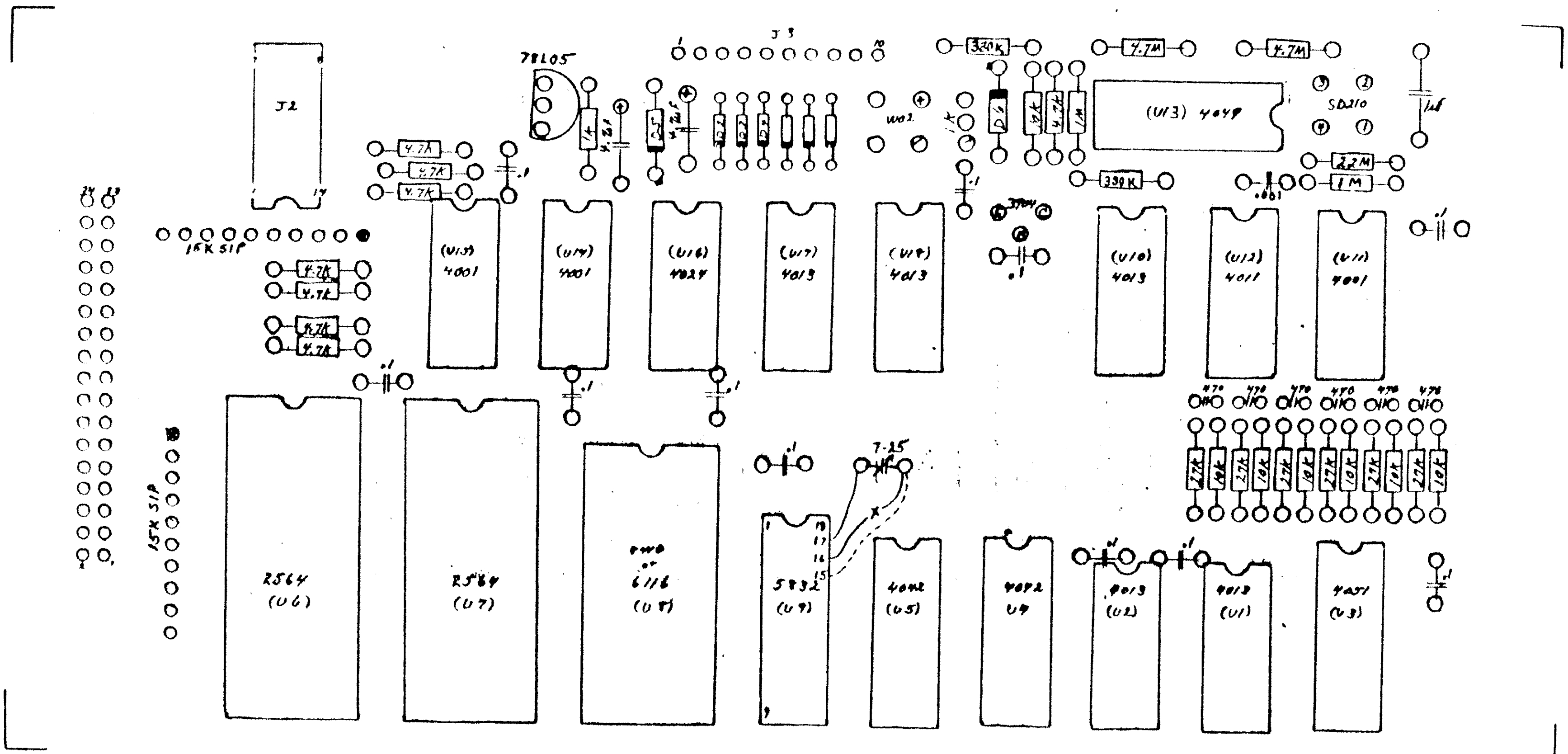
(54)

14 PIN DIP CONN TO FAILSAFE CARD

1. SPLIT RIBBON WIRES APART FOR 1 INCH
2. PRESS WIRES INDIVIDUALLY INTO 14 PIN RIBBON CONNECTOR
3. PRESS ON CAP FOR CONNECTOR



THIS MOD CORRECTS ERROR IN SPECIFYING PINOUT FOR CONNECTOR



NOTE: CUT RUN FROM 7-25PF TO U9-16 --- GND 7-25PF TO U9-15
MOUNT XTAL ON BACK OF BD BETWEEN U9-17 + U9-16
MOUNT 15PF ON BACK OF BD BETWEEN U9-16 + U9-14 (GND)

16K EPROM - 2K RAM + CLOCK w/Battery

3/24/82 F.C. REV 4/12/82 - R3

PARTS LIST, FAIL-SAFE 16K EPROM, 2K RAM, CLOCK BOARD

INTEGRATED CIRCUITS

U1 CD 4013
U2 4013
U3 4051
U4 4042
U5 4042
U6 TMS 2564
U7 2564
U8 MB 8416-20 (FUJITSU, 2K RAM)
U9 MSM 5832 (OKI CLOCK CHIP)
U10 CD 4013
U11 4001
U12 4011
U13 4049
U14 4001
U15 4001
U16 4024
U17 4013
U18 4013
U19 78L05

RESISTORS (1/8 W)

R1 - 27K
2 - 10K
3 - 27K
4 - 10K
5 - 10K
6 - 27K
7 - 10K
8 - 27K
9 - 10K
10 - 10K
11 - 27K
12 - 1K POT
13 - 10K
14 - 47K
15 - 330K
16 - 1M
17 - 4.7M
18 - 27K
19 - 330K
20 - 22M
R21 - 1M
22 - 2.7K
23 - 4.7K
24 - 4.7K
25 - 4.7K
26 - 4.7K
27 - NOT ASSIGNED
28 - 4.7K
29 - 9 x 15K SIP
30 - 9 x 15K SIP
31 - 4.7M
32 - 4.7K
33 - 4.7K

XTAL - 32KHZ, FOR MSM5832

CAPACITORS

C1 - 470 PF CERAMIC
2 - 470PF "
3 - 470PF "
4 - 470PF "
5 - 470PF "
6 - 470PF "
7 - 0.1MF "
8 - 1MF POLYSTYRENE
9 - .001 CERAMIC
10 - 4.7MF TANT
11 - 4.7MF TANT
(10 ea UN-NUMBERED 0.1MF BYPASS)
12 - 15PF SILVER MICA
13 - 7-25PF TRIMMER

TRANSISTORS

Q1 - 2N3904
Q2 - SD210 - (SIGNETICS MOS)

XFMR - 6.3VAC, .2A (EXTERNAL TO PC BD)

DIODES

D1 - W02 BRIDGE
D2 - 1N5240 (VZ=10V)
D3 - 1N5240
D4 - 1N5240
D5 - 1N5240
D6 - 1N5230 (VZ = 4.7V)

BATTERY PACK - 3 ea, "AA" ALKALINE CELLS

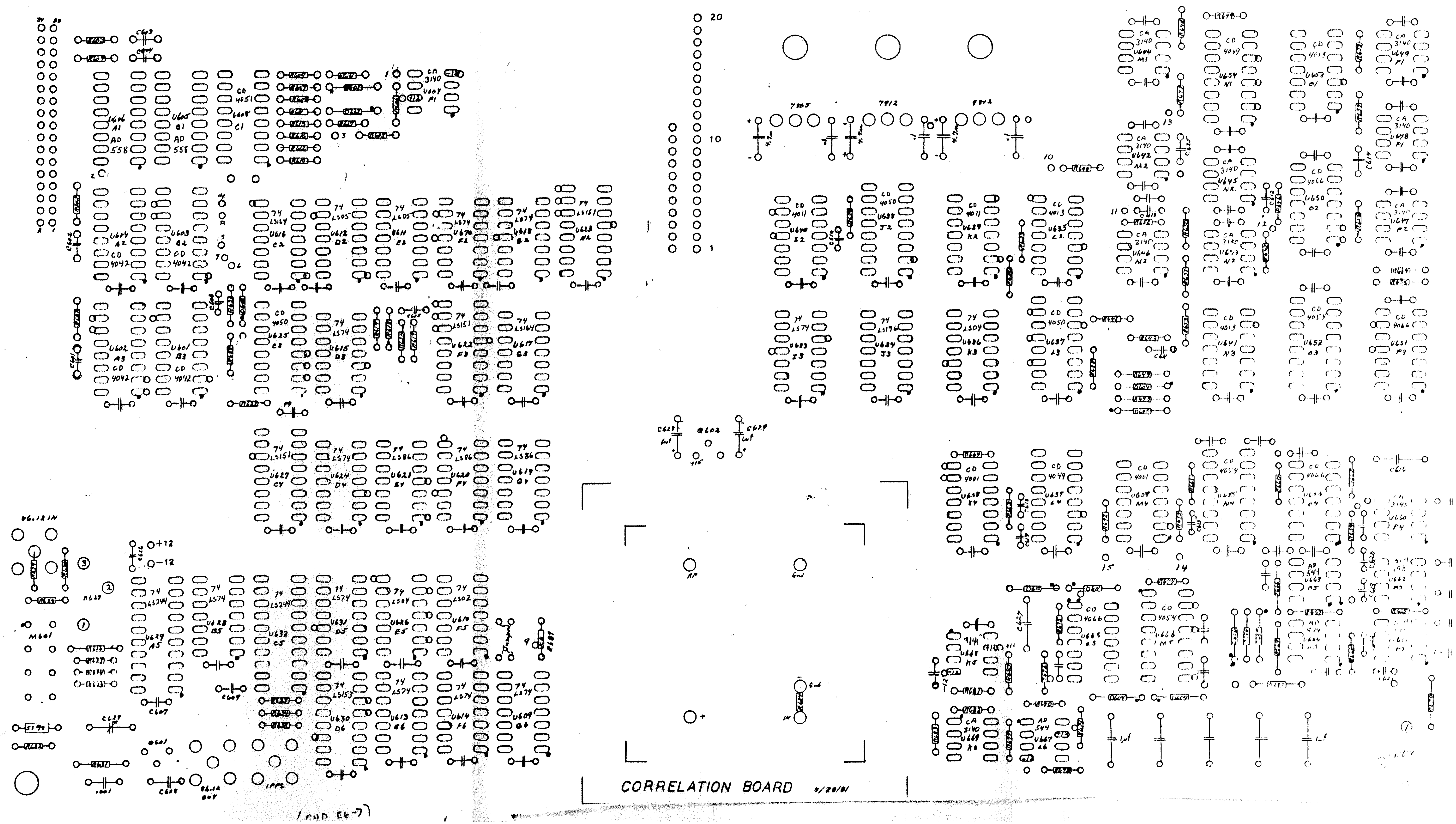
SOCKETS

2 ea - 28 PIN
1 ea - 24 PIN
1 ea - 18 PIN
4 ea - 16 PIN
11 ea - 14 PIN

CONNECTORS

3M 3431-4005 (34 PIN RIBBON)
MOLEX 4030-10A (10 PIN HEADER)

CORRELATION


CORRELATION BOARD
4/20/81

GPS RECEIVER — PORT ASSIGNMENTS — 10/18/80 D3 3/2/82

5-1

STROBE	PORT	
1C	Ø1	
(BIT) 7	1 = INHIBIT PN CODE/ENABLE CODE	
6	1 = OUTPUT 1 KHZ/OUT IPPS	
5	4 (Y1+1)	C/A CODE SELECT
4	2 (Y1+1)	C/A CODE SELECT
3	1 (Y1+1)	C/A CODE SELECT
2	4 (Y1+3)	C/A CODE SELECT
1	2 (Y1+3)	C/A CODE SELECT
0	1 (Y1+3)	C/A CODE SELECT

STROBE	PORT	
3C	Ø1	
(BIT) 7	1 = ~~ENABL CORR OFFSET~~	
6	0 = NON-COHD CORR (ENV DET)	
5	0 = NARROW CORR LOOP	
4	5	CARRIER SYNTHESIZER $\pm$4800 HZ STEP=400 HZ
3	4	
2	3	
1	2	
0	1	

RCVR OUT
PORT ØØ

BIT 7, 6, 5 — NOT ASSIGNED
4 – Ø = 10 MHz PLL LOCK
3 – Ø = CARRIER LOCK
2 – 1 = CORRELATION HIT
1 – 1 KHz DATA
Ø – 50 Hz DATA

STROBE	PORT
38	Ø1
(BITS) (7-0)	HIT THRESHOLD
	ØØ = MIN (ØV)
	FF = MAX (-2.55V)

STROBE	PORT
2Ø	Ø1
(BITS) (7-0)	IF GAIN
	ØØ = MAX GAIN (+28 dB)
	FF = MIN GAIN (Ø dB)

(N/A) — Ø2 (NON-MPX PORT)

BIT	
7	1 HZ
6	RESET INT=1
5	RESET ÷ = Ø
4	INHIBIT 1 KHZ = 0
3	SLEW PN SEQUENCE; (.25 µs STEPS)--LEAVE @ Ø
2	RESET CORR SERVO=1=SEARCH;ENABL CS=Ø=DITHER
1	GAIN SW MAX=Ø MIN=1
0	ENABL CARRIER LOOP=1; SYNTHESIZE CARRIER=Ø

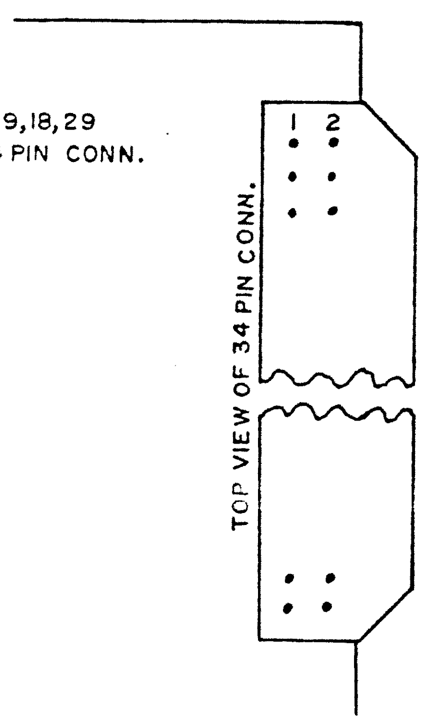
(PORT 02) 34 PIN CONN.

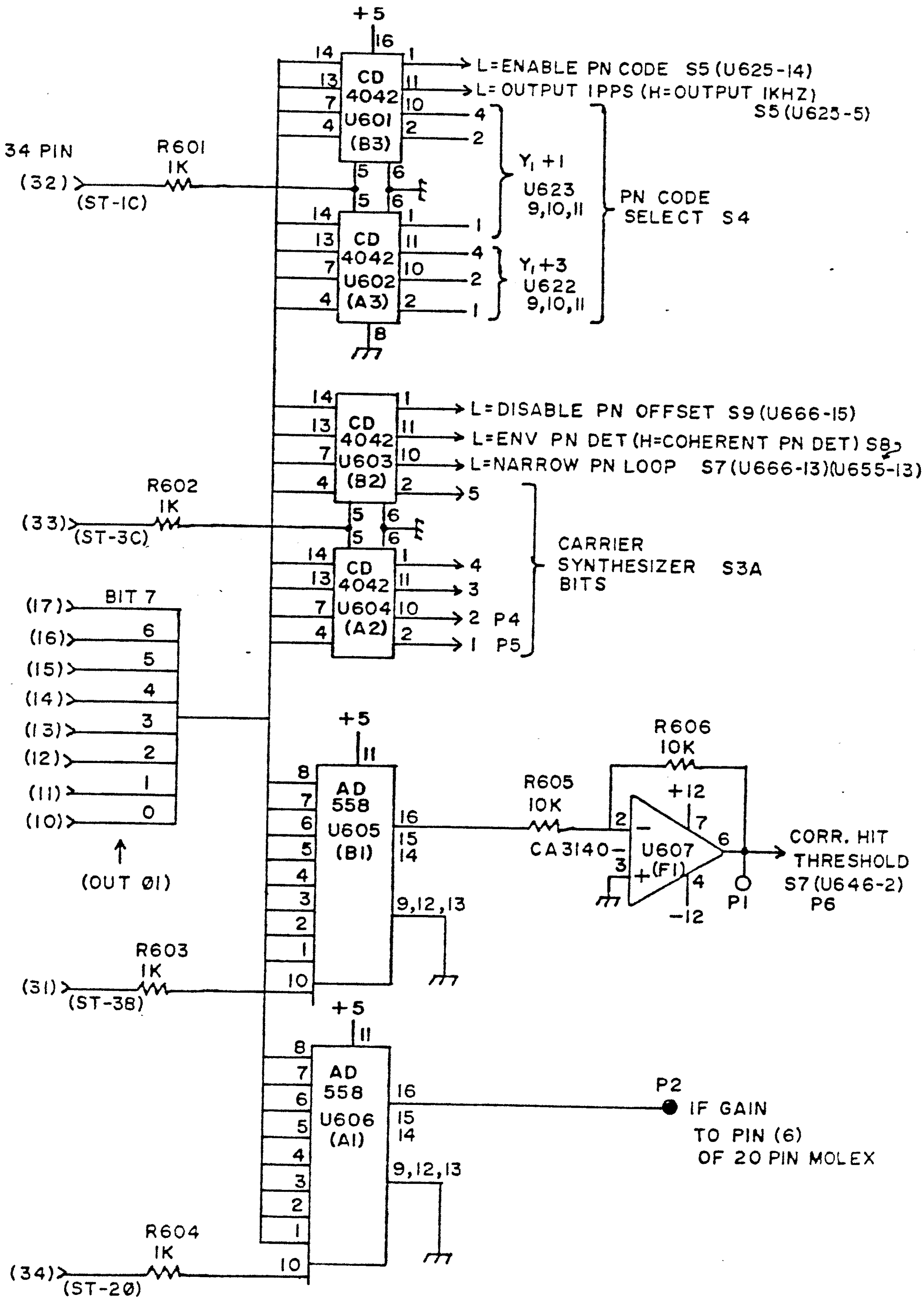
BIT	PIN		Signal	Destination
7	(26)	>	IPPS	→ S5 (U625-3)
6	(25)	>	RESET INT/	→ S6 (U635-4/8)
5	(24)	>	/RESET 50 HZ	→ S6 (U637-3/14)
4	(23)	>	/INHIBIT 1KHZ INTRPT	→ S6 (U639-2)
3	(22)	>	DELETE PULSE	→ S4 (U609-11) (P-7)
2	(21)	>	RESET CORR. SERVO	→ S9 (U666-9)
			SEARCH	→ S5 (U625-11) (P-8)
1	(20)	>	/GAIN SW. MAX	PIN (9) OF 20 PIN MOLEX
0	(19)	>	ENABLE CARRIER/SYNTHESIZE CARR	PIN (8) OF 20 PIN
	(27)	←	CPU INTERRUPT/	< S6 (U638-2)

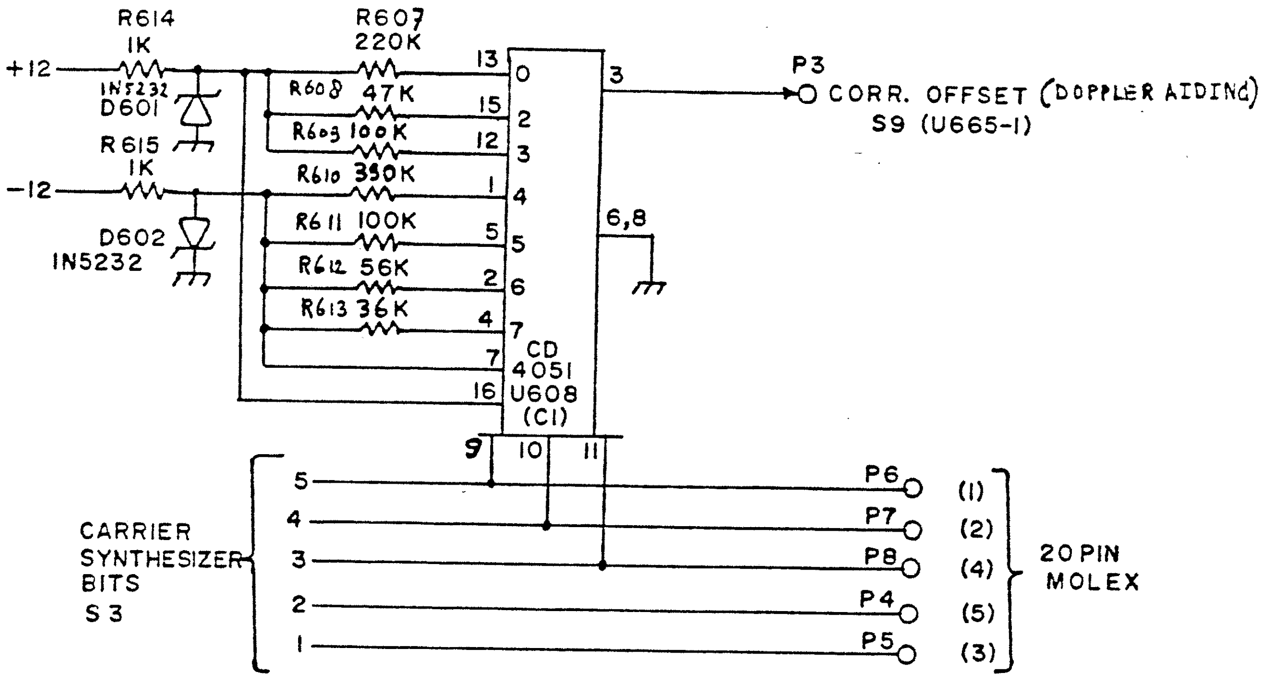
(PORT ØØ)

BIT	PIN		Signal	Destination
7	(8)		NOT ASSIGNED	
6	(7)		NOT ASSIGNED	
5	(6)		NOT ASSIGNED	
4	(5)		NOT ASSIGNED	
3	(4)	←	/CARRIER LOCK	PIN (7) OF 20 PIN
2	(3)	←	CORRELATION HIT/	< S7 (U654-2)
1	(2)	←	1KHZ DATA	< S7 (U654-6)
0	(1)	←	50HZ DATA	< S7 (U654-4)

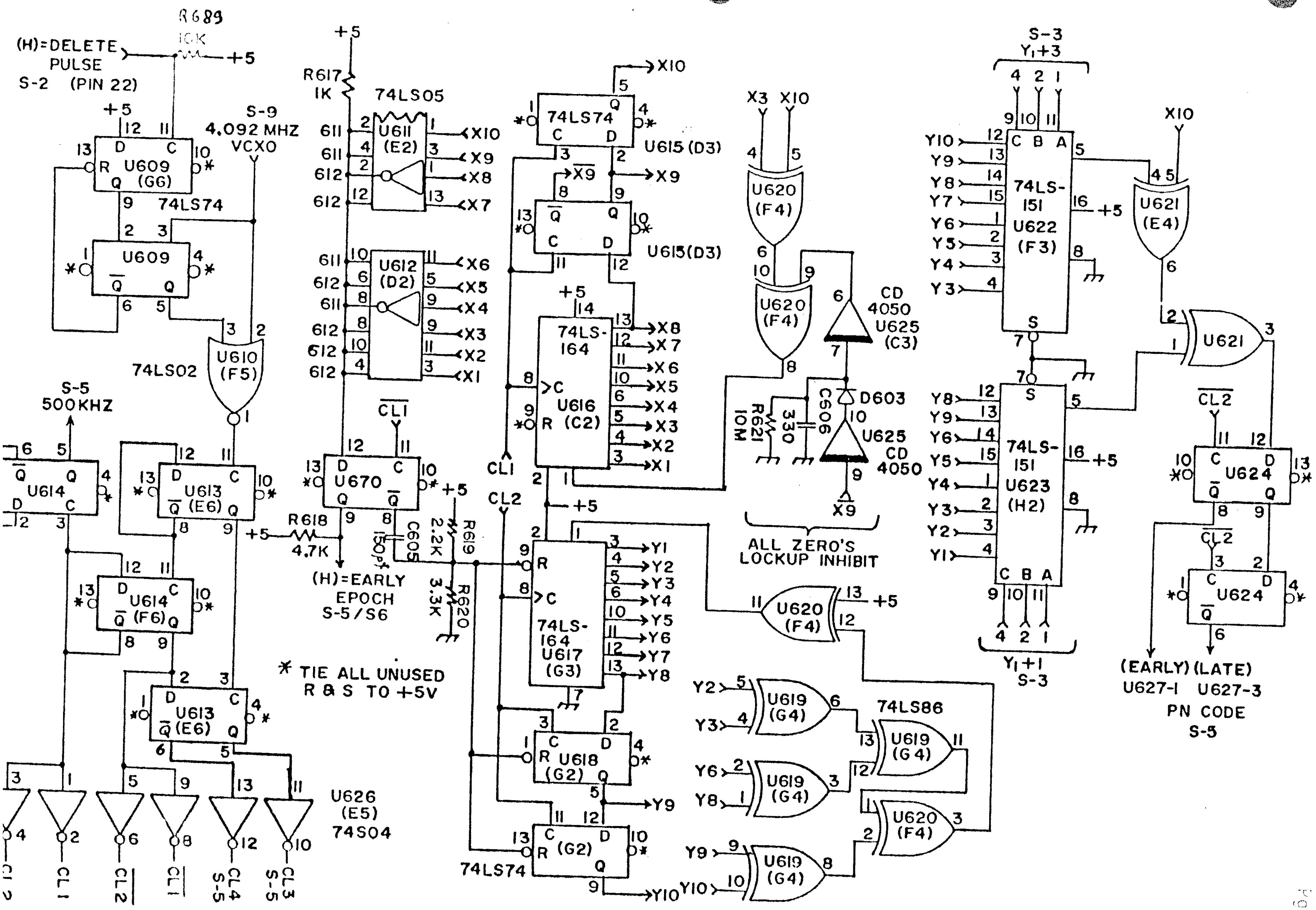
GND PINS 9,18,29
OF 34 PIN CONN.




+5
CD 4042 U601 (B3)
L=ENABLE PN CODE S5 (U625-14)
L=OUTPUT 1PPS (H=OUTPUT 1KHZ)
S5 (U625-5)
34 PIN
(32)
(ST-1C)
R601 1K
Y₁ +1
U623 9,10,11
PN CODE SELECT S4
CD 4042 U602 (A3)
Y₁ +3
U622 9,10,11
CD 4042 U603 (B2)
L=DISABLE PN OFFSET S9 (U666-15)
L=ENV PN DET (H=COHERENT PN DET) S8
L=NARROW PN LOOP S7 (U666-13)(U655-13)
R602 1K
(33)
(ST-3C)
CD 4042 U604 (A2)
CARRIER SYNTHESIZER BITS S3A
P4
P5
(17) BIT 7
(16) 6
(15) 5
(14) 4
(13) 3
(12) 2
(11) 1
(10) 0
(OUT Ø1)
AD 558 U605 (B1)
R606 10K
R605 10K
+12
CA3140 U607 (F1)
-12
P1
CORR. HIT THRESHOLD S7 (U646-2) P6
R603 1K
(31)
(ST-38)
AD 558 U606 (A1)
P2
IF GAIN TO PIN (6) OF 20 PIN MOLEX
R604 1K
(34)
(ST-20)
9,12,13



CHANGE
R608 47K → 56K
R609 100K → 91K
R613 36K → 51K



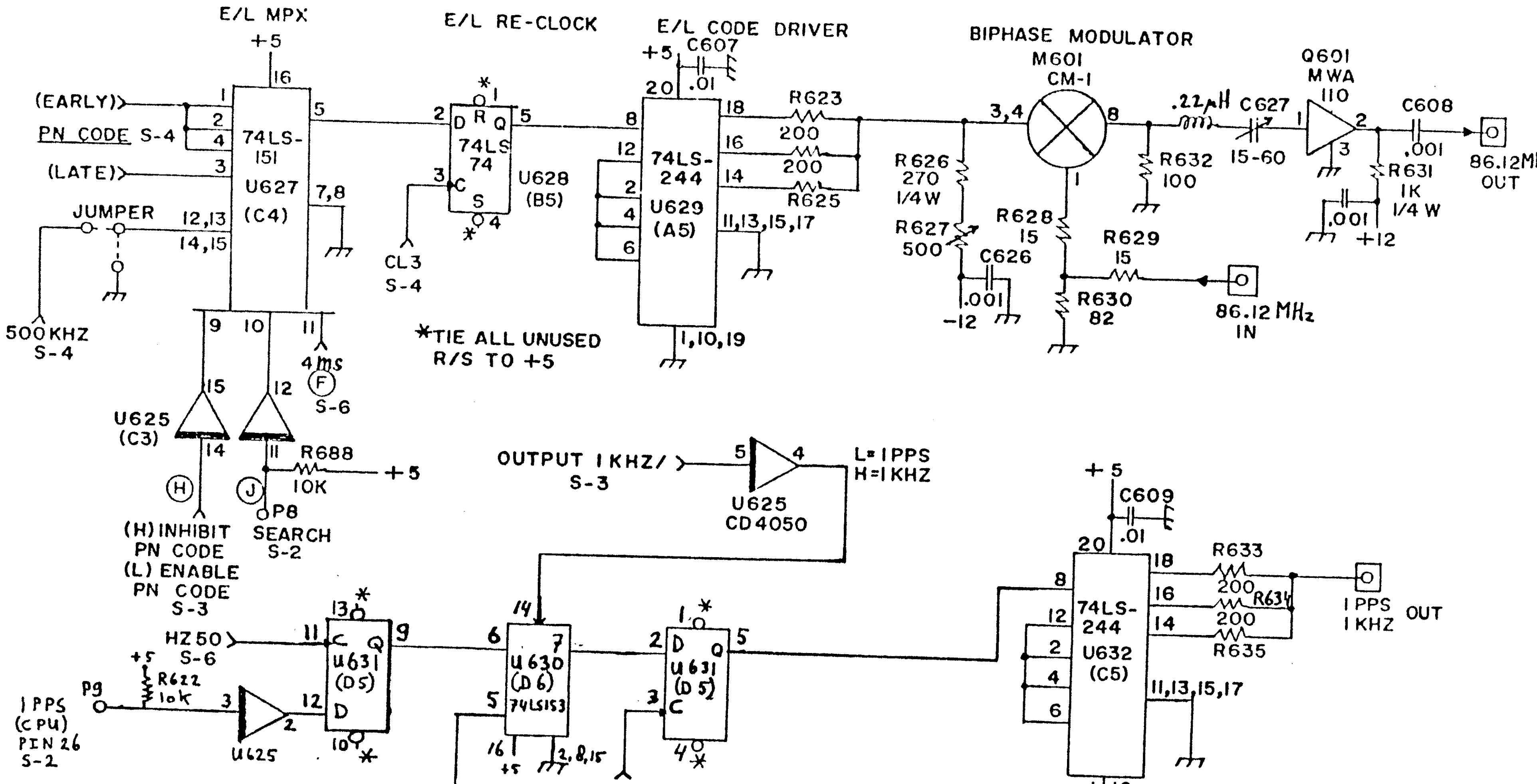
PN CODE GENERATOR

GPS RECEIVER

11/29/80 Rev 3/1/82

S-4

Pg. 84 of 180



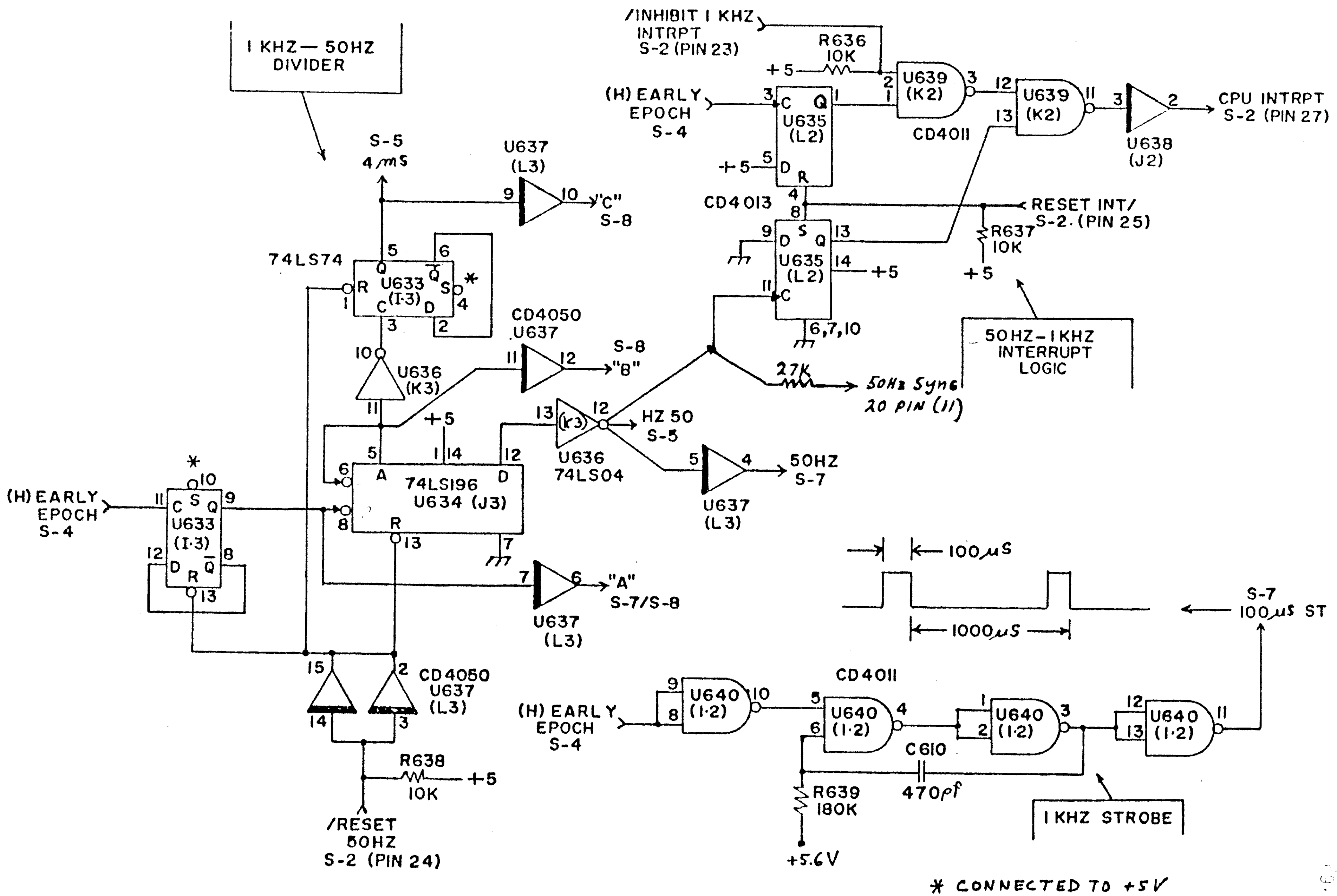
(H)	(J)	(F)	MPX-code:
0	0	0	EARLY
0	0	1	LATE
0	1	X	SEARCH (EARLY)
1	X	X	INHIBIT PN CODE

1kHz/1pps multiplex, Reclock + Line driver

GPS RECEIVER

11/30/80 Rev. 3/2/82

S-5



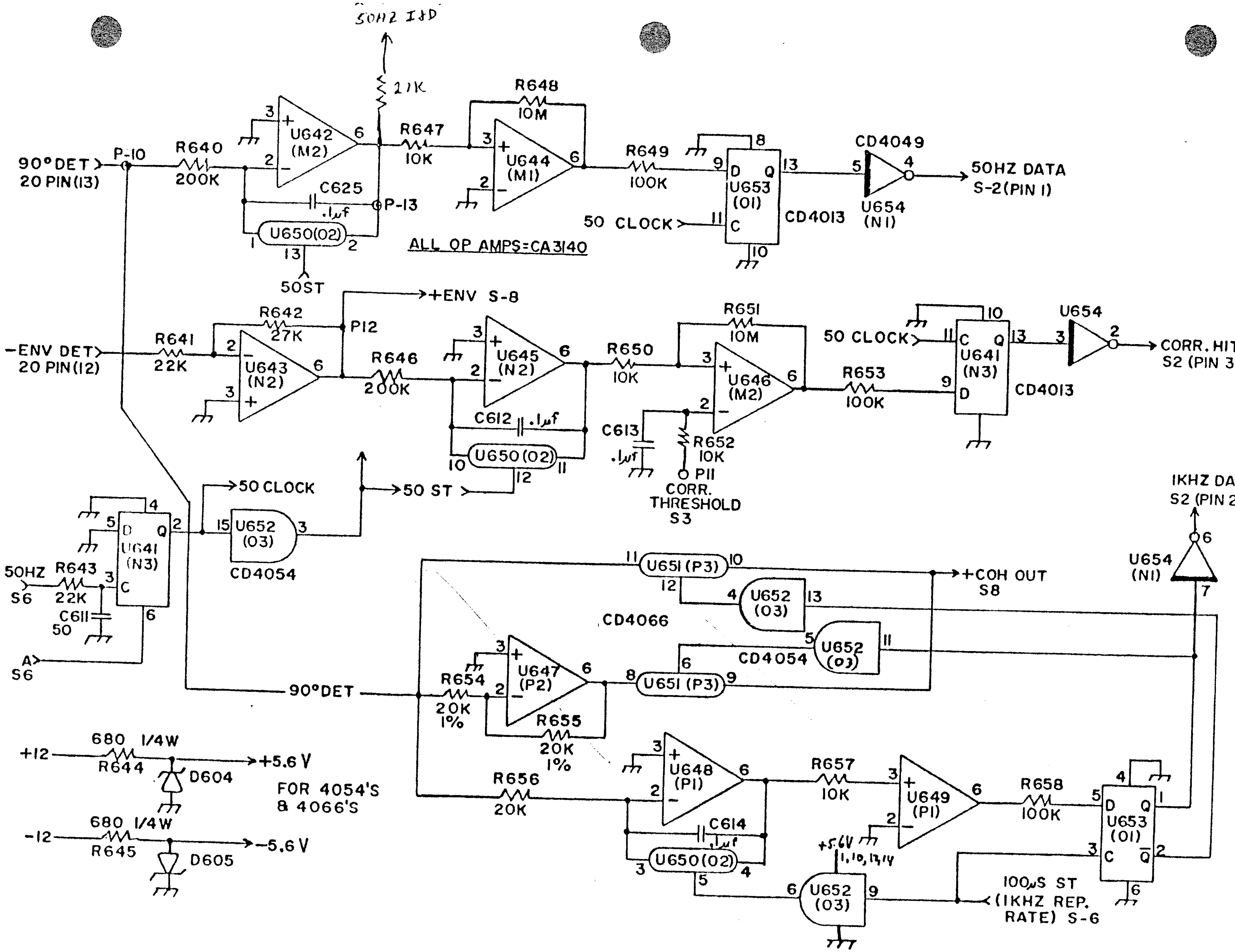
50 HZ DIVIDER
1 KHZ STROBE

GPS RECEIVER

11/30/80 Rev. 3/2/82

S-6

Pg. 86 of 180

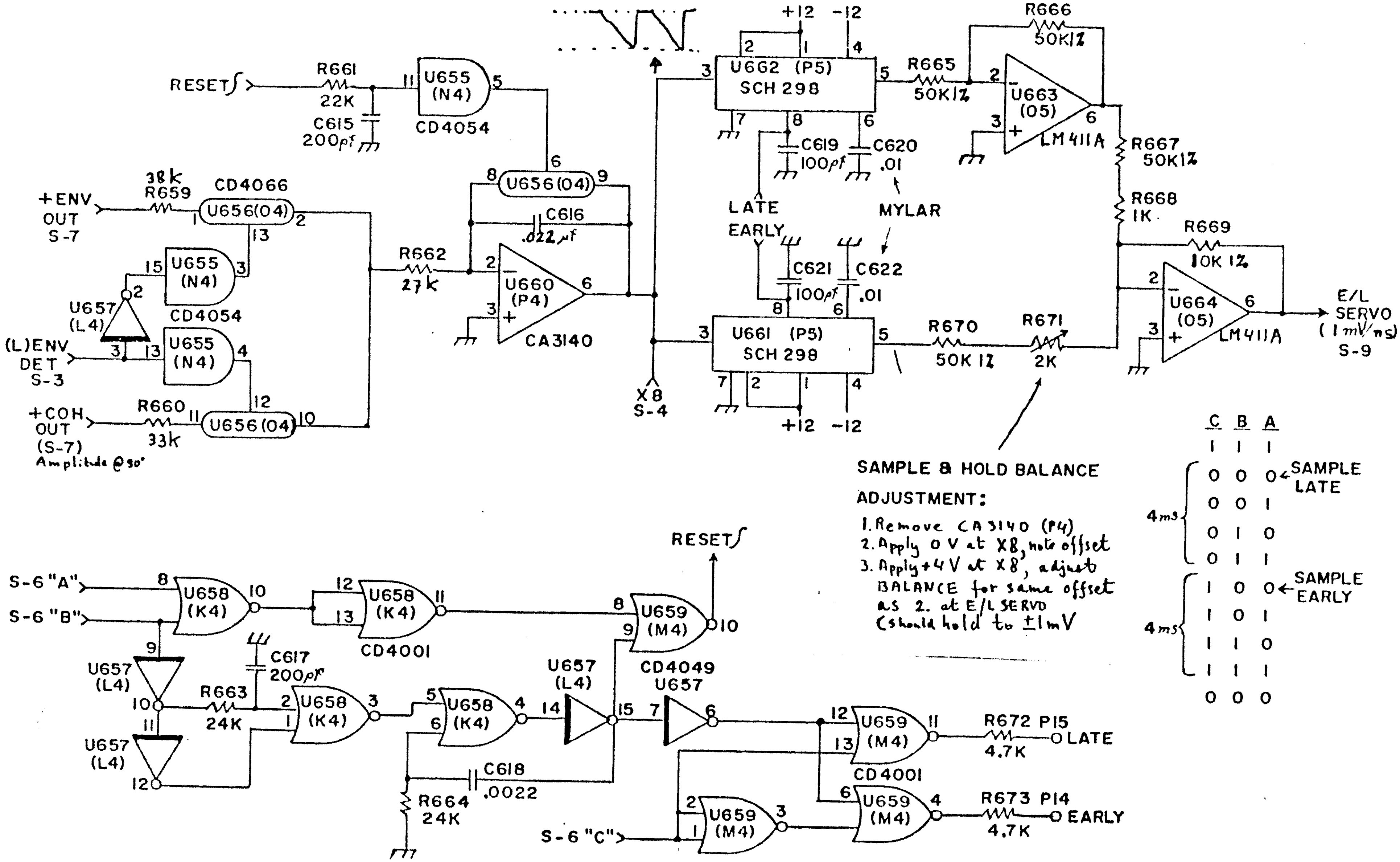


ENV. DET. CORRELATION HIT
50HZ-1KHZ I&D

GPS RECEIVER

11/30/80 Rev. 3/2/82

S-7

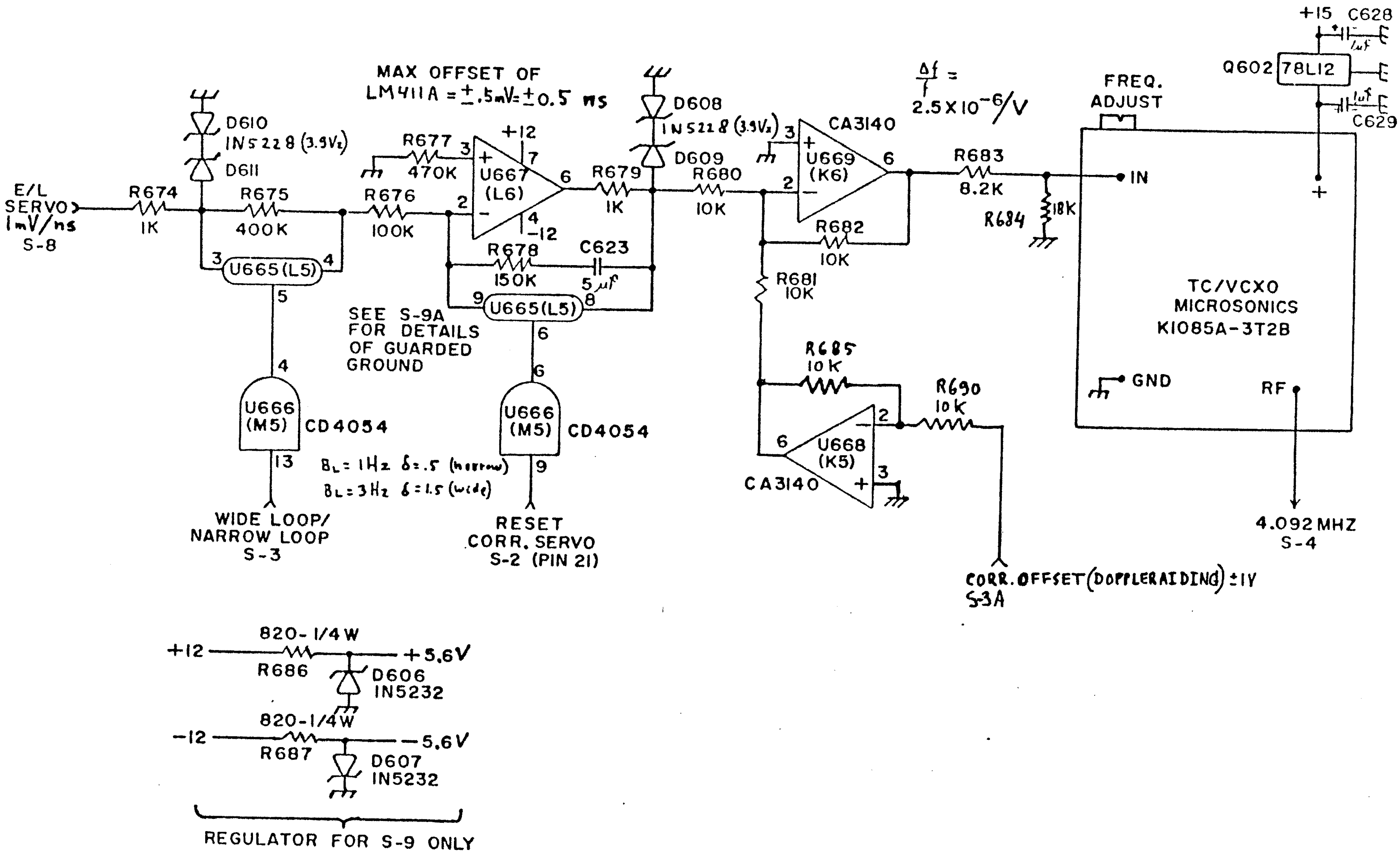


E/L CORR. S&H

GPS RECEIVER

11/9/80 Rev 3/2/82

S-8



CORRELATION SERVO

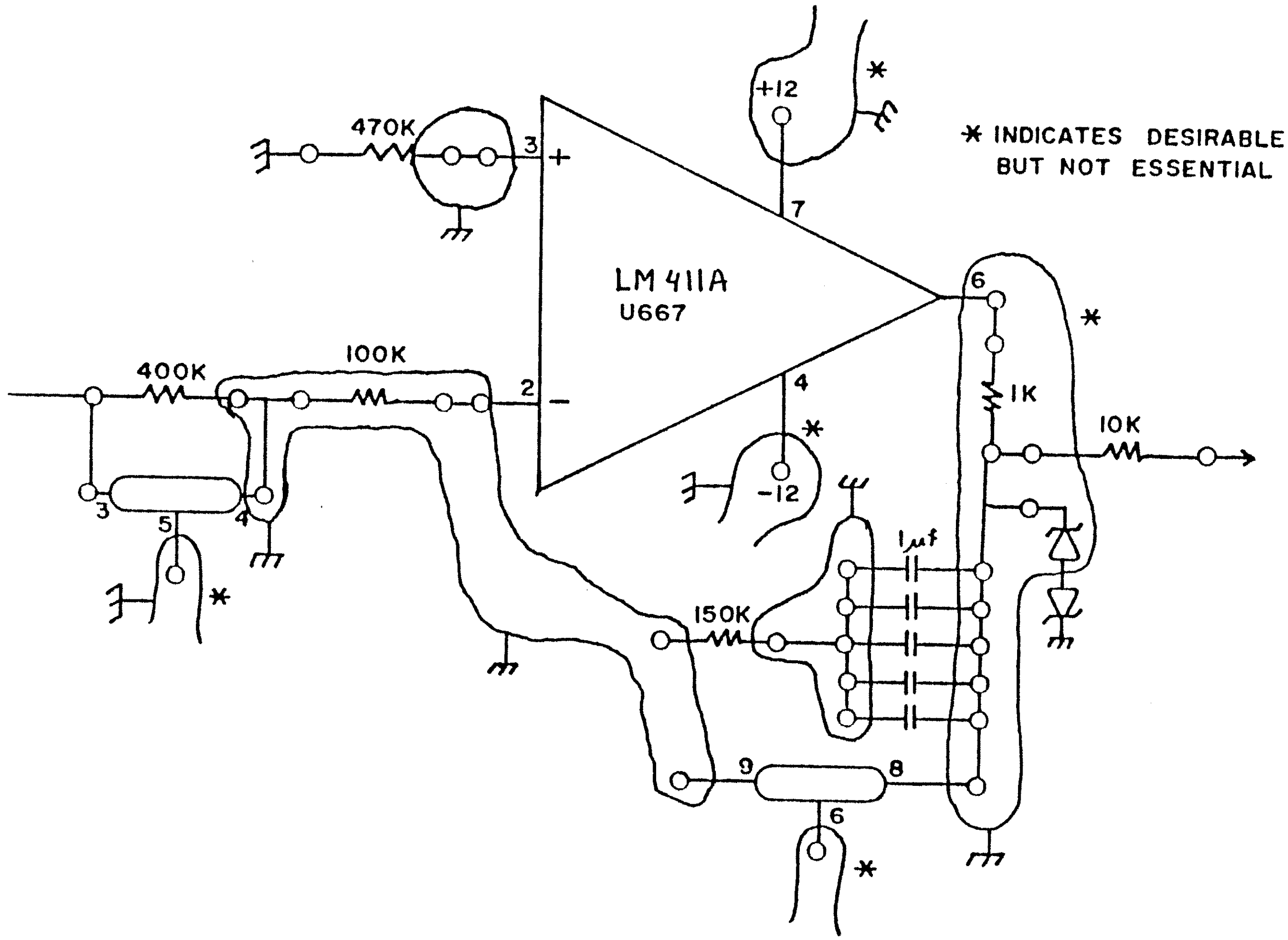
GPS RECEIVER

11/30/80 Rev. 3/2/82

S-9

GROUNDED "GUARD RINGS" MUST ENCLOSE INDICATED CIRCUITS ON BOTH SIDES OF CIRCUIT BOARD TO MINIMIZE LEAKAGE CURRENTS

* INDICATES DESIRABLE BUT NOT ESSENTIAL



Rev 3/2/82

RECEIVER CORRELATION BOARD

CAPACITORS

C-601 - deleted
C-602 - " "
C-603 - " "
C-604 - " "
C-605 - 150pf
C-606 - 330pf
C-607 - .01
C-608 - .001
C-609 - .01
C-610 - 470pf
C-611 - 50pf
C-612 - .luf
C-613 - .luf
C-614 - .luf
C-615 - 200pf
C-616 - .luf
C-617 - 200pf
C-618 - .0022
C-619 - 100pf
C-620 - .01
C-621 - 100pf
C-622 - .01
C-623 - luf (5x parallel) non-polar
C-624 - deleted
C-625 - .luf
C-626 - .001
C-627 - 15-60pF trimmer
C-628 - luf tant
C-629 - luf tant

RESISTORS

R-601 - 1K
602 - 1K
603 - 1K
604 - 1K
605 - 10K
606 - 10K
607 - 220K
608 - 47K
609 - 100K
610 - 390K
611 - 100K
612 - 56K
613 - 36K
614 - 1K
615 - 1K
616 - deleted
617 - 1K
618 - 4.7K
R-619 - 2.2K
620 - 3.3K
621 - 10M
622 - 10K
623 - 200
624 - 200
625 - 200
626 - 270 ¼w
627 - 500 Pot, 20t
628 - 15
629 - 15
630 - 82
631 - 1K-¼w
632 - 100
633 - 200
634 - 200
635 - 200
636 - 10K
637 - 10K
638 - 10K
639 - 180K
640 - 200K
641 - 22K
642 - 27K
643 - 22K
644 - 680 ¼w
645 - 680 ¼w
646 - 200K
647 - 10K
648 - 10M
649 - 100K
650 - 10K
651 - 10M
652 - 10K
653 - 100K
654 - 20K-1%
655 - 20K-1%
656 - 20K-1%
657 - 10K
658 - 100K
659 - 38 k
660 - 33 k
661 - 22K
662 - 27 K
663 - 24K
664 - 24K
665 - 50K-1%
666 - 50K-1%
667 - 50K-1%
668 - 1K
669 - 10K-1%
670 - 50K-1%
R-671 - 2K-Pot, 20t
672 - 4.7K
673 - 4.7K
674 - 1K
675 - 400K
676 - 100K
677 - 470K
678 - 150K
679 - 1K
680 - 10K
681 - 10K
682 - 10K
683 - 8.2K
684 - 18K
685 - 10K
686 - 820 ¼w
687 - 820 ¼w
688 - 10K
689 - 10K
690 - 10k

DIODES

D-601 - IN5232
D-602 - IN5232
D-603 - IN4153
D-604 - IN5232
D-605 - IN5232
D-606 - IN5232
D-607 - IN5232
D-608 - IN5228
D-609 - IN5228
D-610 - IN5228
D-611 - IN5228

Rev 3/2/82

RECEIVER CORRELATION BOARD

U601	(B3)	4042
602	(A3)	4042
603	(B2)	4042
604	(A2)	4042
605	(B1)	AD558
606	(A1)	AD558
607	(F1)	CA3140
608	(C1)	CD4051
609	(G6)	74LS74
610	(F5)	74LS02
611	(E2)	74LS05
612	(D2)	74LS05
613	(E6)	74LS74
614	(F6)	74LS74
615	(D3)	74LS74
616	(C2)	74LS164
617	(G3)	74LS164
618	(G2)	74LS74
619	(G4)	74LS86
620	(F4)	74LS86
621	(E4)	74LS86
622	(F3)	74LS151
623	(H2)	74LS151
624	(D4)	74LS74
625	(C3)	CD4050
626	(E5)	74S04
627	(C4)	74LS151
628	(B5)	74LS74
629	(A5)	74LS244
630	(D6)	74LS153
631	(D5)	74LS74
632	(C5)	74LS244
633	(I3)	74LS74
634	(J3)	74LS196
635	(L2)	CD4013
636	(K3)	74LS04
637	(L3)	CD4050
638	(J2)	CD4050
639	(K2)	CD4011
640	(I2)	CD4011
641	(N3)	CD4013
642	(M2)	CA3140
643	(N2)	CA3140
644	(M1)	CA3140
645	(N2)	CA3140
646	(M2)	CA3140
647	(P2)	CA3140
648	(P1)	CA3140
649	(p1)	CA3140
650	(O2)	CD4066
651	(P3)	CD4066
652	(O3)	CD4054
653	(O1)	CD4013
654	(N1)	CD4049
655	(N4)	CD4054
656	(O4)	CD4066
U657	(L4)	CD4049
658	(K4)	CD4001
659	(M4)	CD4001
660	(P4)	CA3140
661	(P5)	SCH293
662	(P5)	SCH293
663	(O5)	LM411A
664	(O5)	LM411A
665	(L5)	CD4066
666	(M5)	CD4054
667	(L6)	LM411A
668	(K5)	CA3140
669	(K6)	CA3140
670	(F2)	74LS74

Rev. 3/2/82

PARTS LIST

RECEIVER CORR. BOARD

50pf	1
100pf	2
150pf	1
200pf	2
330pf	1
470pf	1
.001	2
.0022	1
.01	4
.1	7
.1 non-polar.	1
1uf nonpolar	5
1uf tant	2
15-60pF	1 trimmer Erie
4.7uf tant.	3
Bypass Caps. .1μF	73
IN5232	6 (5.6Vz)
IN5228	4 (3.9Vz)
7805	1
7812	1
7912	1
78L12	1
MWA-110	1
SRA-1	1 Mini Circuits Lab
4.092 MHz TCXO	1 Microsonics K1085A-3T2B
20Pin	1 Molex 4030-20A
34PIn	1 3M
RFConn	3
Choke 0.22μH	1
W/W pins	125

SOCKETS

8Pin	17
14Pin	32
16Pin	19
20Pin	2

1/8 W

15	2
82	1
100	1
200	6
1K	10
2.2K	1
3.3K	1
4.7K	3
8.2K	1
10K	15
18K	1
22K	3
24K	2
27K	2
47K	1
56K	1
36K	1
100K	6
150K	1
180K	1
200K	2
220K	1
400K	1
390K	1
470K	1
33k	1
39k	1
10M	3

1/4 W

270	1
680	2
820	2
1K	1
20K-1%	3
50K-1%	4
10k-1%	1
500 -Pot	1 "Trimpot" type 3006W
2K -Pot	1 " " "

 Rev 3/2/82

WIRE WRAPS - CORRELATION BD.

Pin 1 - Pin 11
2 - 20 pin 6
3 - U665-14
4 - 20 pin 5
5 - 20 pin 3
6 - 20 pin 1
7 - 20 pin 2
8 - 20 pin 4
9 - 34 pin 22
10 - U651-11 (P3)
12 - U656-1 (O4)
13 - U650-2 (O2)
~~14 - U661-8~~
~~15 - U662-8~~

34 Pin-1 - U654-4 (N1)
2 - U654-6 (N1)
3 - U654-2 (N1)
4 - 20 Pin 7
~~19 " 8~~
~~20 " 9~~
21 - U625-11 (C3) - U666-9 (M5)
23 - U639-2 (K2)
24 - U637-14 (L3)
25 - U635-8 (L2)
26 - U625-3 (C3)
~~27 - U638-2~~

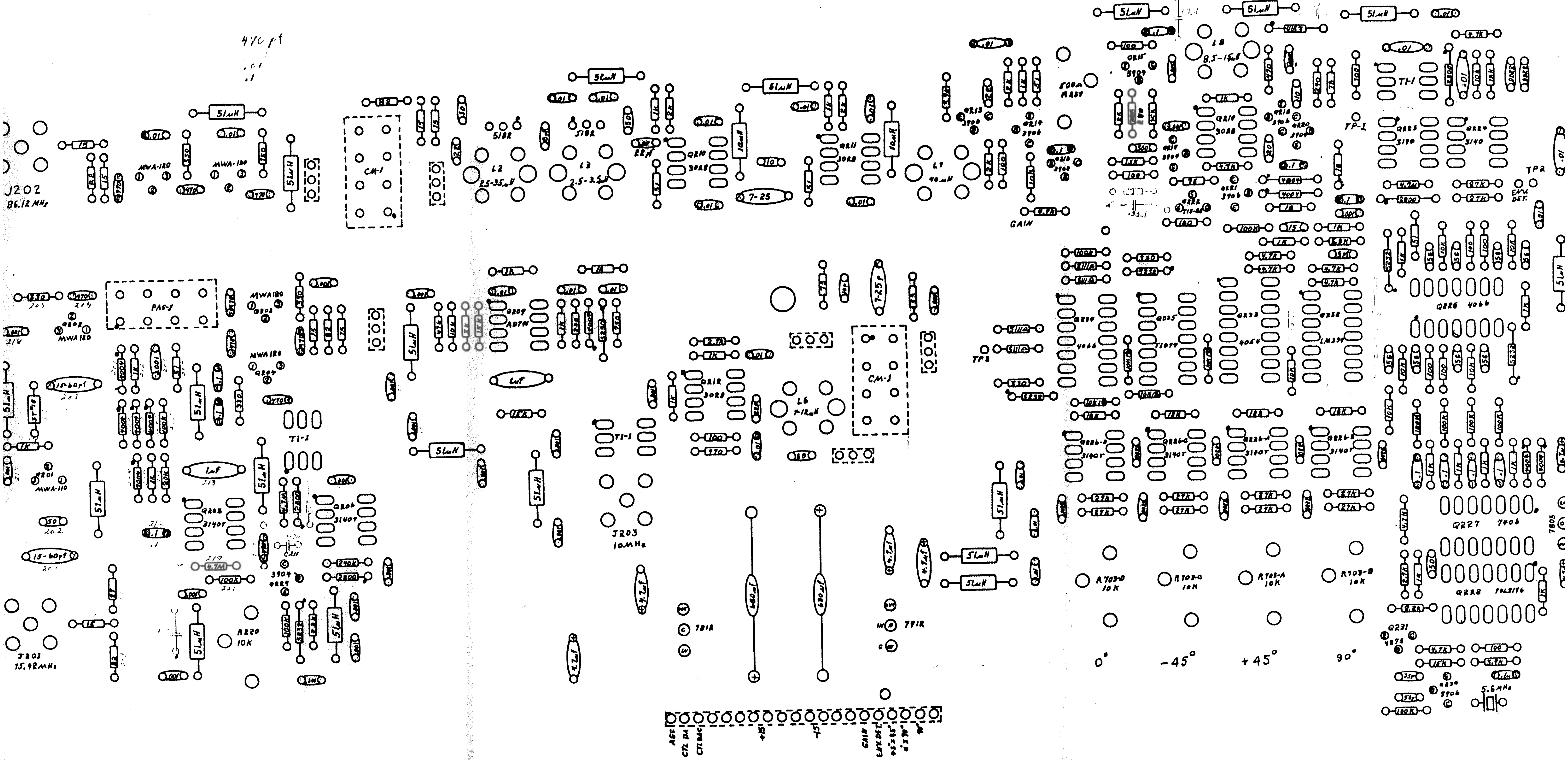
U640-11 (I2) - U653-3 (O1)
U637-6 (L3) - U641-6 (N3) - U658-8 (K4)
U637-10 (L3) - U659-2 (M4)
~~U637-12 U658-9~~
~~U651-9 - U656-11~~
~~U642-2 - U650-1~~

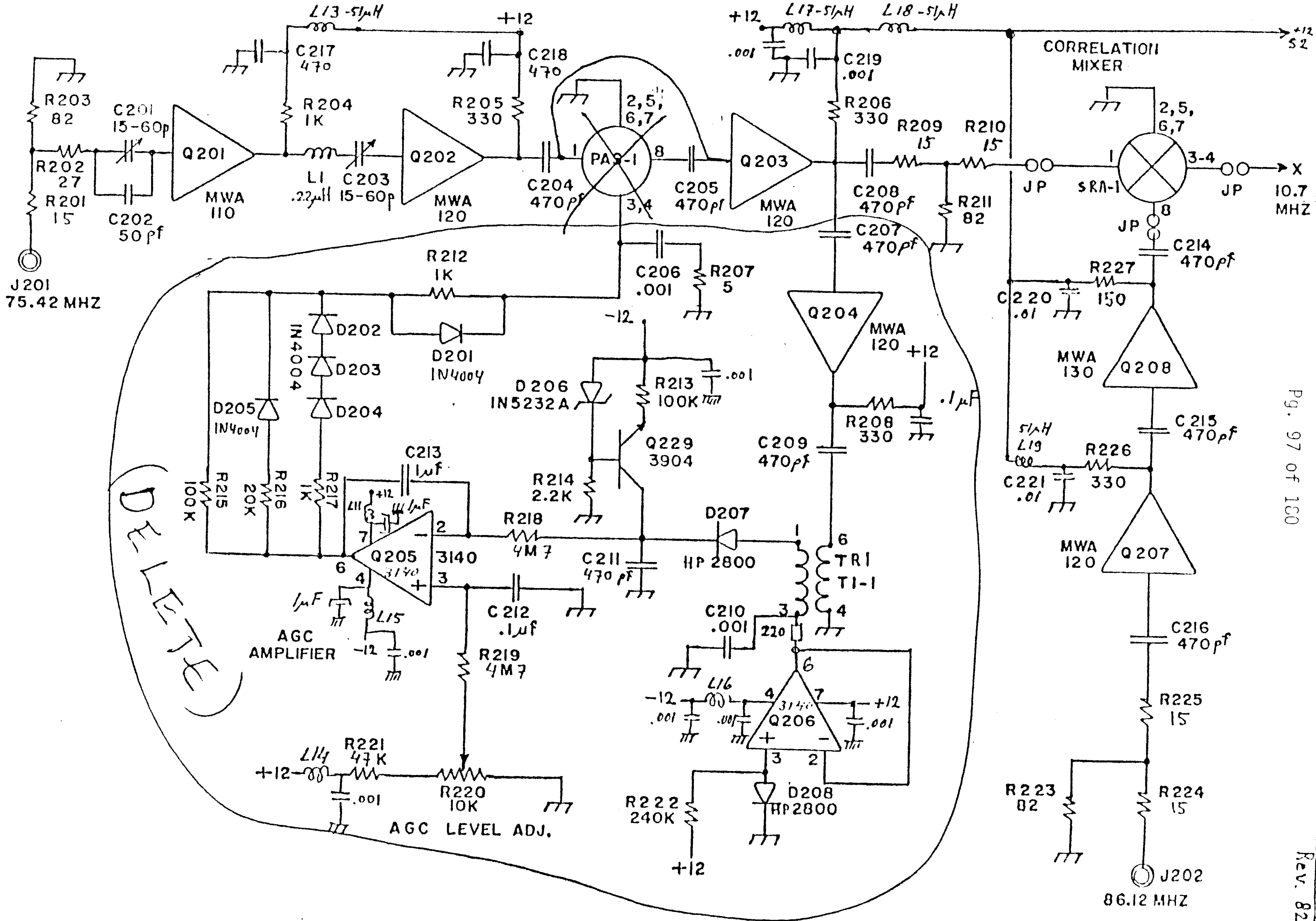
~~U612-1 - U660-5~~
U601-10 (B3) - U623-9 (H2)
U601-2 (B3) - U623-10 (H2)
U602-1 (A3) - U623-11 (H2)
U602-11 (A3) - U622-9 (F3)
U602-10 (A3) - U622-10 (F3)
U602-2 (A3) - U622-11 (F3)
U603-1 (B2) - U666-15 (M5)
U603-10 (B2) - U666-13 (M5)
U603-11 (B2) - U657-3 (L4)
U616-8 (E2) - U615-3 (D3) - U626-2 (E5)
U670-11 (F2) - U626-8 (E5)
U670-9 (F2) - U630-5 (D6) - U633-11 (I3) -
U635-3 (L2) - U640-9 (I2)
U618-11 - U626-4 (E5)
~~U624-3 - U626-6~~
U616-1 - U620-8 (F4)
U612-9 - ~~U620-12~~ (F4) - 4
U621-4 - U622-5 (F3)
U621-1 - U623-5 (H2)
U627-11 - U633-5 (I3)
U630-6 - U636-12 (K3)
U625-4 - U630-14 (D6)
U625-2 - U631-12 (D5)

+12V → E1-7 → +12 at A5
-12V → E1-4 → -12 at A5

I.F. AMP

IF AMP - GPS RECEIVER



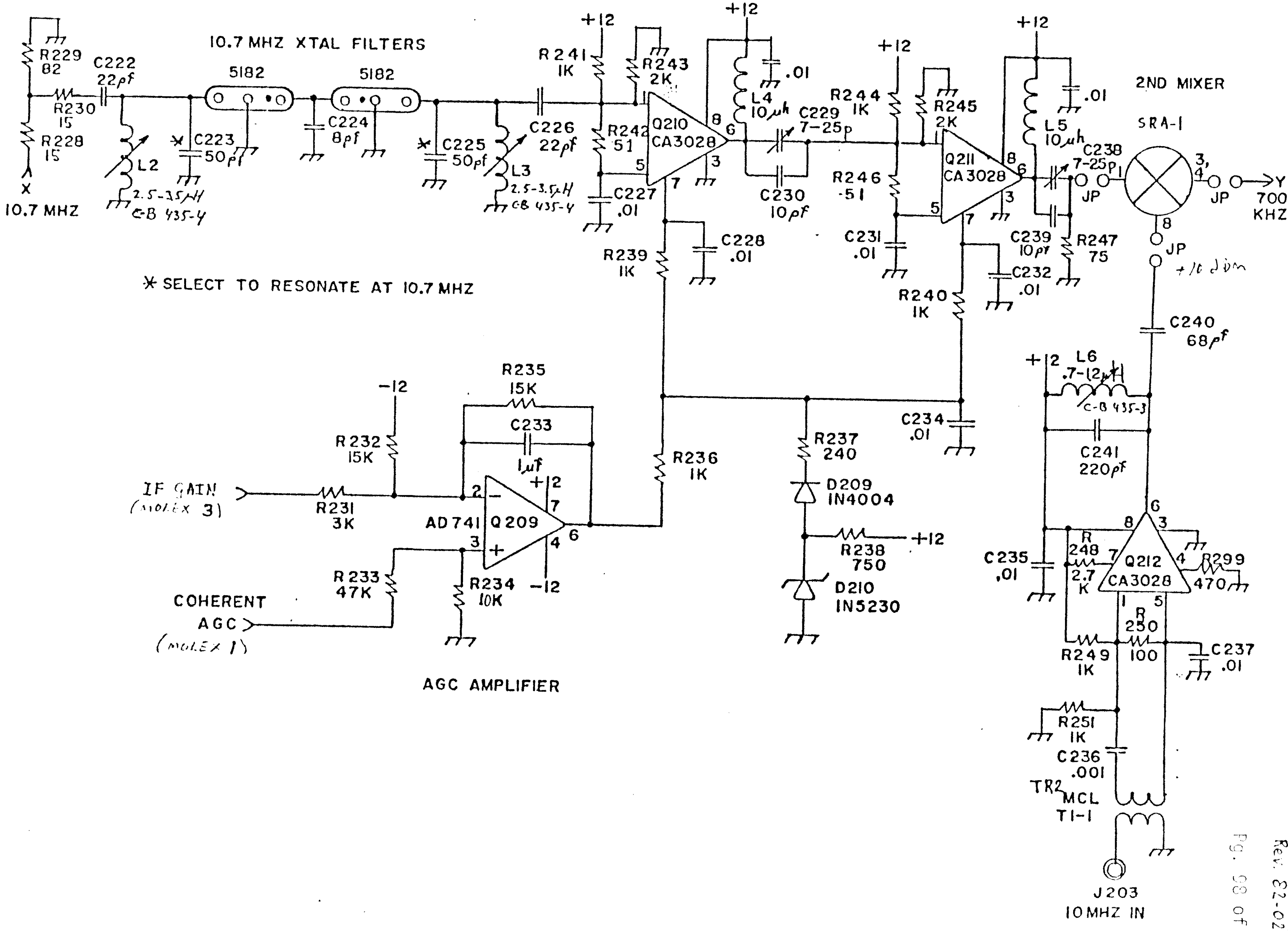


GPS RECEIVER

Pg. 97 of 180

Rev. 82-02-05

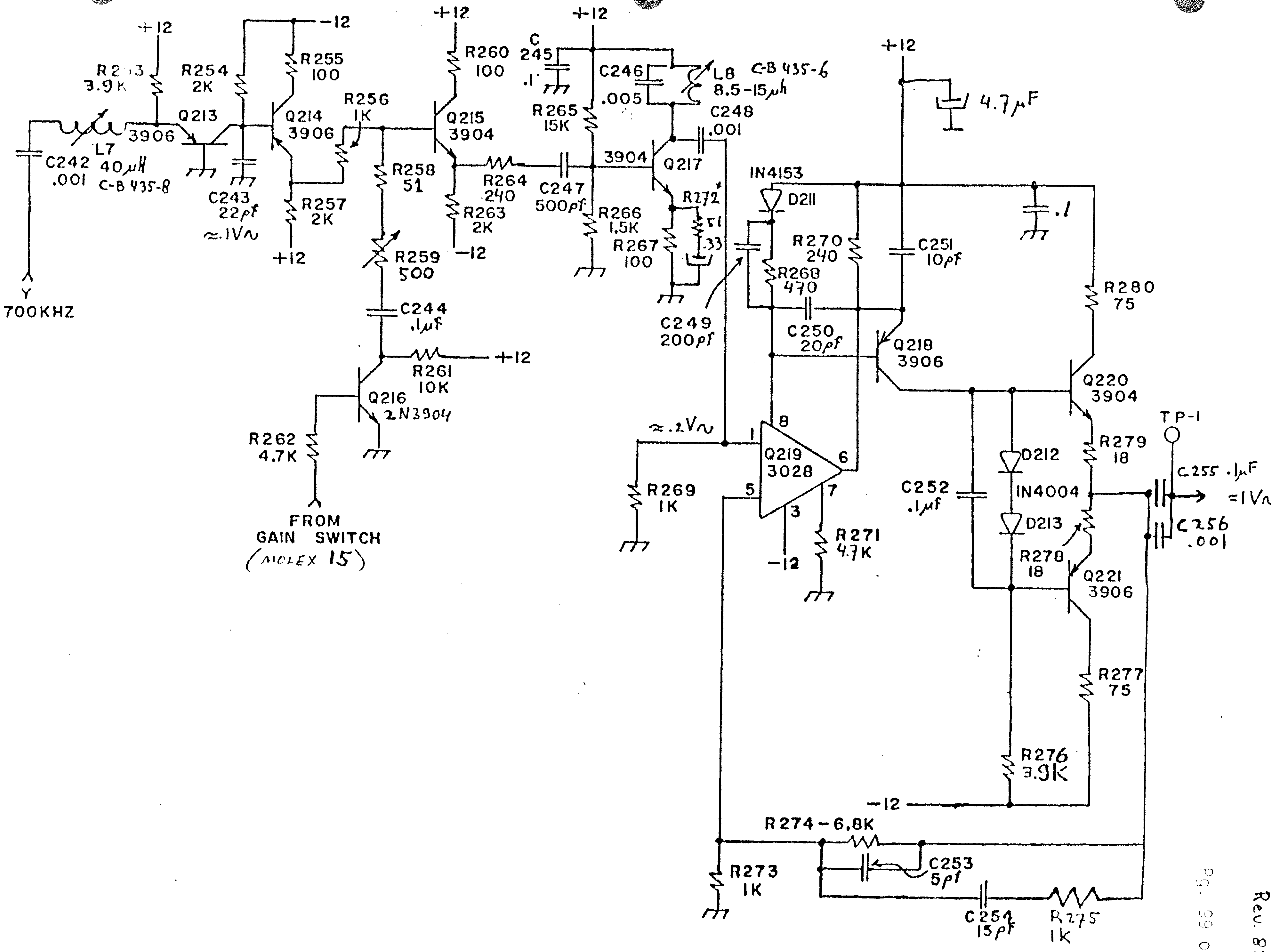
S-1



IF AMP
GPS RECEIVER

S-2

Rev. 82-02-09

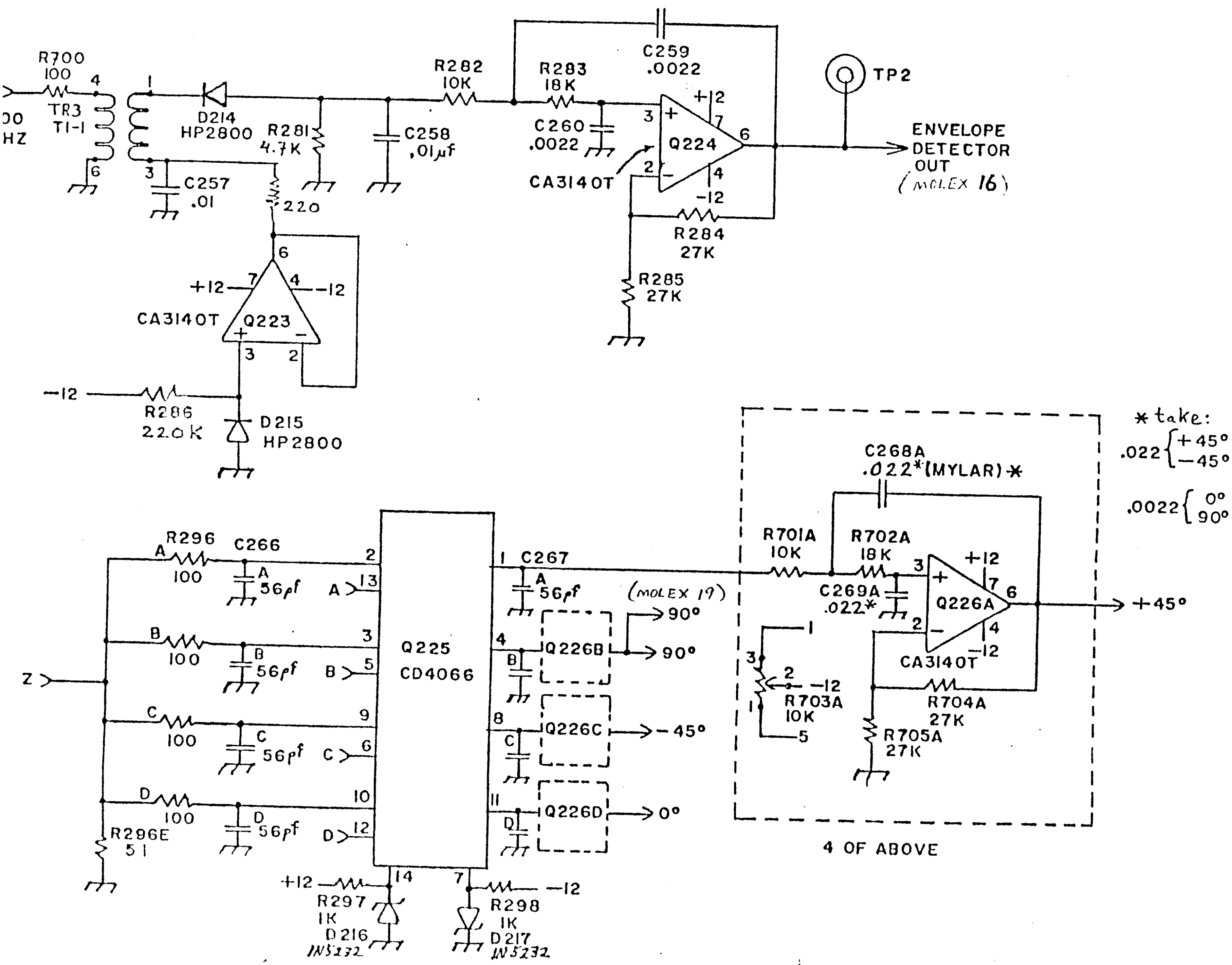


GPS RECEIVER

IF AMP

S-3

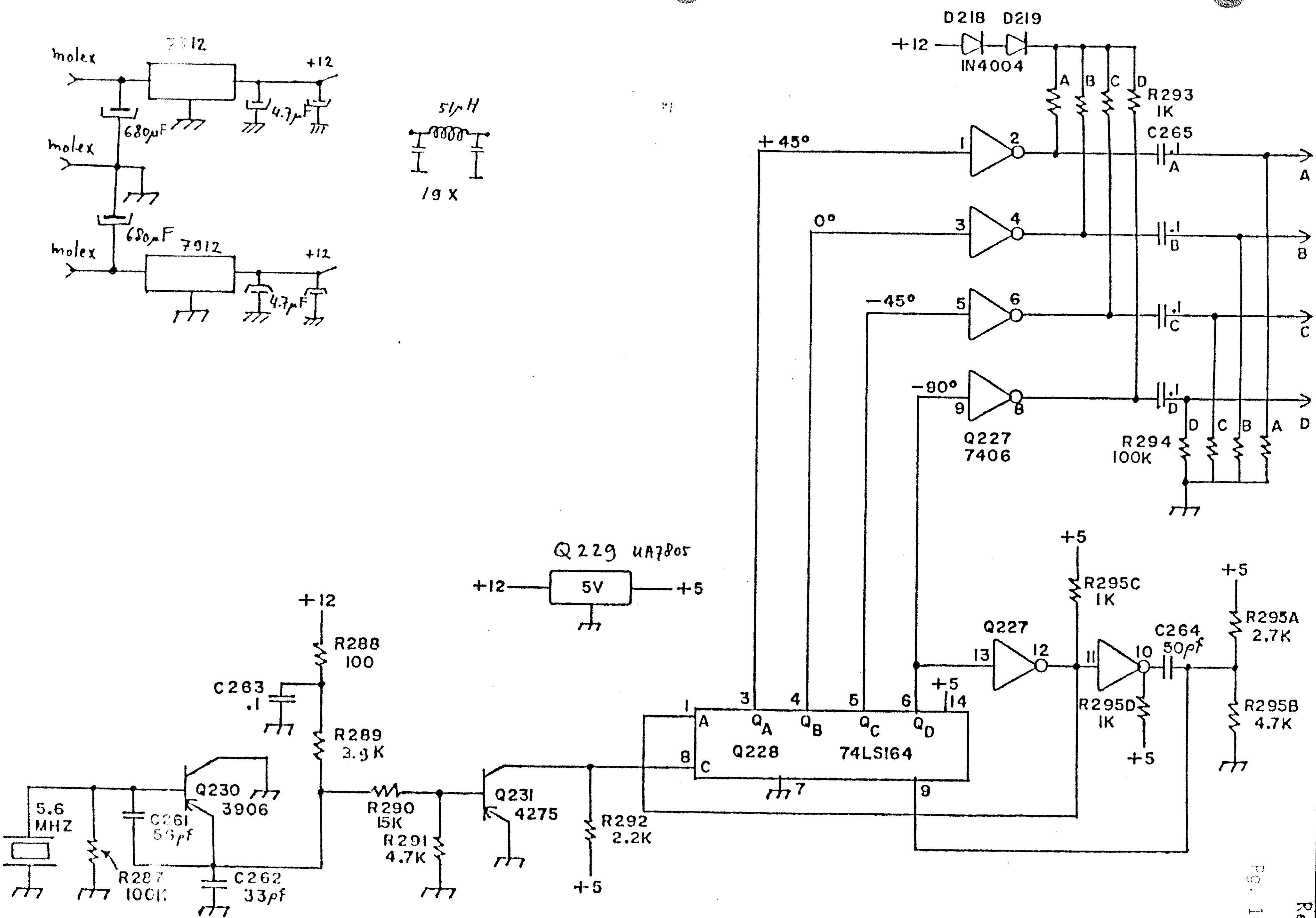
Rev. 82-02-09



IF AMP
GPS RECEIVER

S-4

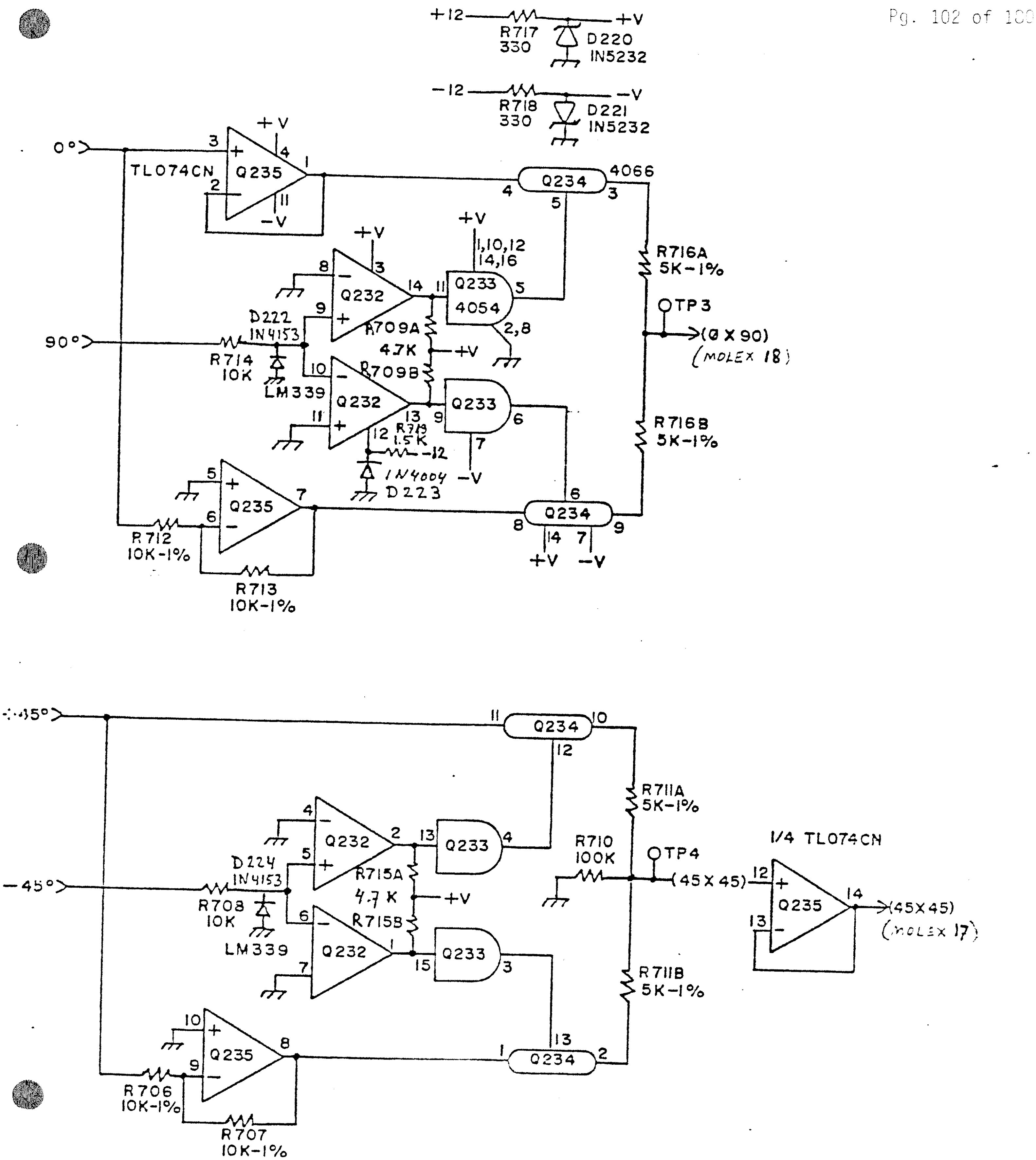
Rev. 82-02-05



IF AMP
GPS RECEIVER

S-5

Rev. 82-02-[illegible]


+12
R717
330
D220
IN5232
+V
-12
R718
330
D221
IN5232
-V
0°
TL074CN
Q235
Q234
4066
90°
R714
10K
D222
IN4153
LM339
Q232
R709A
4.7K
R709B
Q233
4054
1,10,12
14,16
R719
1.5K
-12
IN4004
D223
R716A
5K-1%
R716B
5K-1%
TP3
(0 X 90)
(MOLEX 18)
R712
10K-1%
R713
10K-1%
±45°
-45°
R708
10K
D224
IN4153
R715A
4.7 K
R715B
R711A
5K-1%
R711B
5K-1%
R710
100K
TP4
(45 X 45)
1/4 TL074CN
(MOLEX 17)
R706
10K-1%
R707
10K-1%

IF-Amplifier Board Parts List 82-02-12

Capacitors

C201	15-60 pF trim Erie
202	50 p
203	15-60 pF trim Erie
204	470 p
205	470 p
206	.001
207	470 p
208	470 p
209	470 p
210	.001
211	470 p
212	.1
213	1 µF
214	470 p
215	470 p
216	470 p
217	470 p
218	470 p
219	.001
220	.01
221	.01
222	22 p
223	50 p (tune 10.7 MHz)
224	8 p
225	50 p (tune 10.7 MHz)
226	22 p
227	.01
228	.01
229	7-25 pF trim Erie
230	10 p
231	.01
232	.01
233	1 µF
234	.01
235	.01
236	.001
237	.01
238	7-25 pF trim Erie
239	10 p
240	68 p
241	220 p
242	.001
243	22 p
244	.1

Parts List | IF Amplifier Card | 82-02-12

Capacitors

C 245	.1			
246	.005			
247	500 pF (470 pF)			
248	.001			
249	200 pF			
250	20 pF			
251	10 pF			
252	.1			
253	5 pF			
254	15 pF			
255	.1			
256	.001			
257	.01			
258	.01			
259	.0022			
260	.0022			
261	56 pF			
262	33 pF			
263	.1			
264	50 pF			
265	.1	(4x)		
266	56 pF	(4x)		
267	56 pF	(4x)		
268	.0022	(2x)	.022 (2x)	
269	.0022	(2x)	.022 (2x)	

Decoupling Capacitors:

2x680 μF elco
7x4.7 μF tat
2x1 μF tat
20x0,01 μF ker.
20x0,001 μF ker.

Total 2	trimmer 15-60 pF Erie
2	trimmer 7-25 pF Erie
1	5 pF
1	8 pF
3	10 pF
1	15 pF
1	20 pF
3	22 pF
1	33 pF
4	50 pF
9	56 pF
1	60 pF
1	200 pF
1	220 pF
11	470 pF
1	500 pF
7	.001
6	.0022
11	.01
4	.022

10	.1 μF
2	1 μF
1	.005
20	.001
20	.01
2	1 μF tat
7	4.7 μF tat
2	680 μF elco

Parts List IF Amplifier 82-02-12

Resistors

R 201	15	
202	27	
203	82	
204	1 k	
205	330	
206	330	
207	51	
208	330	
209	15	
210	15	
211	82	
212	1 k	
213	100 k	
214	2.2 k	
215	100 k	
216	20 k	
217	1 k	
218	4.7 M	
219	4.7 M	
220	10 k	20 turn
221	47 k	
222	240 k	
223	82	
224	15	
225	15	
226	330	
227	150	
228	15	
229	82	
230	15	
231	3 k	
232	15	
231	3 k	
232	15 k	
233	47 k	
234	10 k	
235	15 k	
236	1 k	
237	240	
238	750	
239	1 k	
240	1 k	
241	1 k	
242	51	
243	2 k	
244	1 k	
245	2 k	
246	51	
247	75	
R 248	2.7 k	
249	1 k	
250	100	
251	1 k	
253	3.9 k	
254	2 k	
255	100	
256	1 k	
257	2 k	
258	51	
259	500	20 turn
260	100	
261	10 k	
262	4.7 k	
263	2 k	
264	240	
265	15 k	
266	1.5 k	
267	100	
268	470	
269	1 k	
270	240	
271	4.7 k	
272*	51	
273	1 k	
274	6.8 k	
275	1 k	
276	3.9 k	
277	75	
278	18	
279	18	
280	75	
281	4.7 k	
282	10 k	
283	18 k	
284	27 k	
285	27 k	
286	220 k	
287	100 k	
288	100	
289	3.9 k	
290	15 k	
291	4.7 k	
292	2.2 k	
293	1 k	(4x)
294	100 k	(4x)
R 295A	2.7 k	
295	4.7 k	
295	1 k	
R 295	1 k	
296	100	(4x) R296E 51
297	1 k	
298	1 k	
299	470	
R 700	100	
701	10 k	(4x)
702	18 k	(4x)
703	10 k	20 turn (4x)
704	27 k	
705	27 k	
706	10 k	1%
707	10 k	1%
708	10 k	
709A,B	4.7 k	
710	100 k	
711A,B	5 k	1%
712	10 k	1%
713	10 k	1%
714	10 k	
715A,B		
716A,B	5 k	1%
717	330	
718	330	
719	1.5 k	

extra: 220 Ω is series with T2-2
220 Ω in series with T1-1

Parts List IF Amplifier 82-02-12

Resistors

Total	15 Ω		7 x
	18		2
	27		1
	51		6
	75		3
	82		4
	100		10
	150		1
	240		3
	330		6
	470		2
	500	20 turn	1
	750		1
	1 k		22
	1.5 k		2
	2 k		5
	2.2 k		2
	2.7 k		2
	3 k		1
	3.9 k		3
	4.7 k		9
	5.1 k	1%	4
	6.8 k		1
	10 k		9
	10 k	1%	4
	10 k	20 turn	5
	15 k		5
	18 k		4
	20 k		1
	27 k		7
	47 k		2
	100 k		8
	220 k		1
	240 k		1
	4.7 M		2
	220 Ω		2

Parts List IF Amplifier 82-02-12

Active Devices

Q 201	MWA110
202	MWA120
203	MWA120
204	MWA120
205	CA3140E
206	CA3140E
207	MWA120
208	MWA130
209	AD741CP
210	CA3028A
211	CA3028A
212	CA3028A
213	2N3906
214	2N3906
215	2N3904
216	2N3904
217	2N3904
218	2N3906
219	CA3028A
220	2N3904
221	2N3906
222	deleted
223	CA3140E
224	CA3140E
225	CD4066AE
226	CA3140E (4x)
227	SN7406N
228	SN74LS164
229	7805
230	2N3906
231	2N4275
232	LM339N
233	CD4054BE
235	TL074CN
234	CD4066AE

Diodes

D 201	IN4004
202	"
203	"
204	"
205	"
206	IN5232A
207	HP2800
208	HP2800
209	IN4004
210	IN5230
211	IN4154
212	IN4004
213	IN4004
214	HP2800
215	HP2800
216	IN5232
217	IN5232
218	IN4004
219	IN4004
220	IN5232
221	IN5232
222	
223	IN4004
224	

Total:

MWA110	1	x
MWA120	4	
MWA130	1	
CA3140E	8	
AD741CP	1	
CA3028A	4	
2N3906	5	
2N3904	4	
CD4066AE	2	
SN7406N	1	
74LS164	1	x
7805	1	x
2N4275	1	
LM339N	1	
CD4054BE	1	
CD4054BE	1	
TL074CN	1	
LM7812	1	
MC7912CT	1	

Parts List | IF Amplifier | 82-02-12

Coils, Transformers

L1	.22 μH	(rf ferrite coil)
L2	2.5-3.5 μH	C-B 435-4
L3	2.5-3.5 μH	C-B 435-4
L4	10 μH	(rf ferrite coil)
L5	10 μH	(rf ferrite coil)
L6	.7-1.2 μH	C-B 435-3
L7	40 μH	C-B 435-8
L8	8.5-15 μH	C-B 435-6

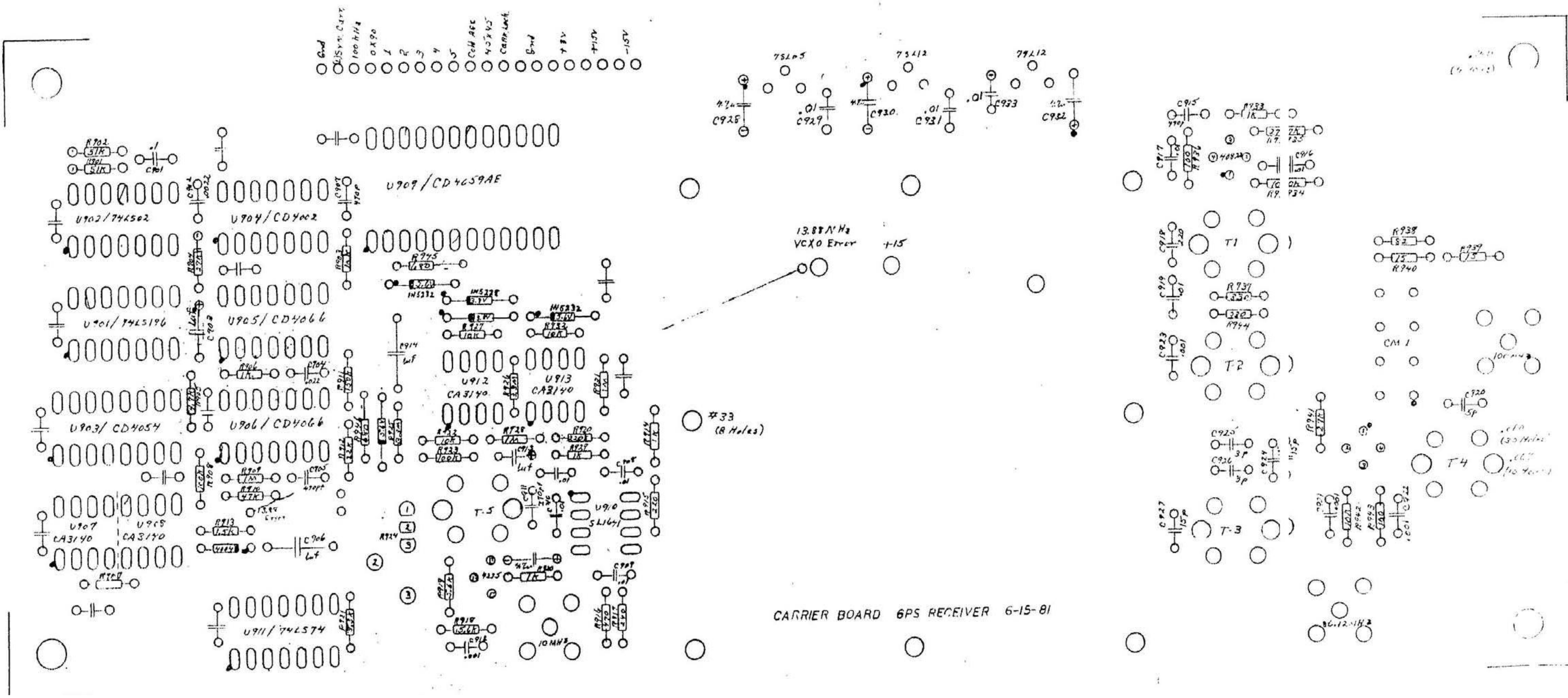
L9...L28 51 μH rf ferrite choke

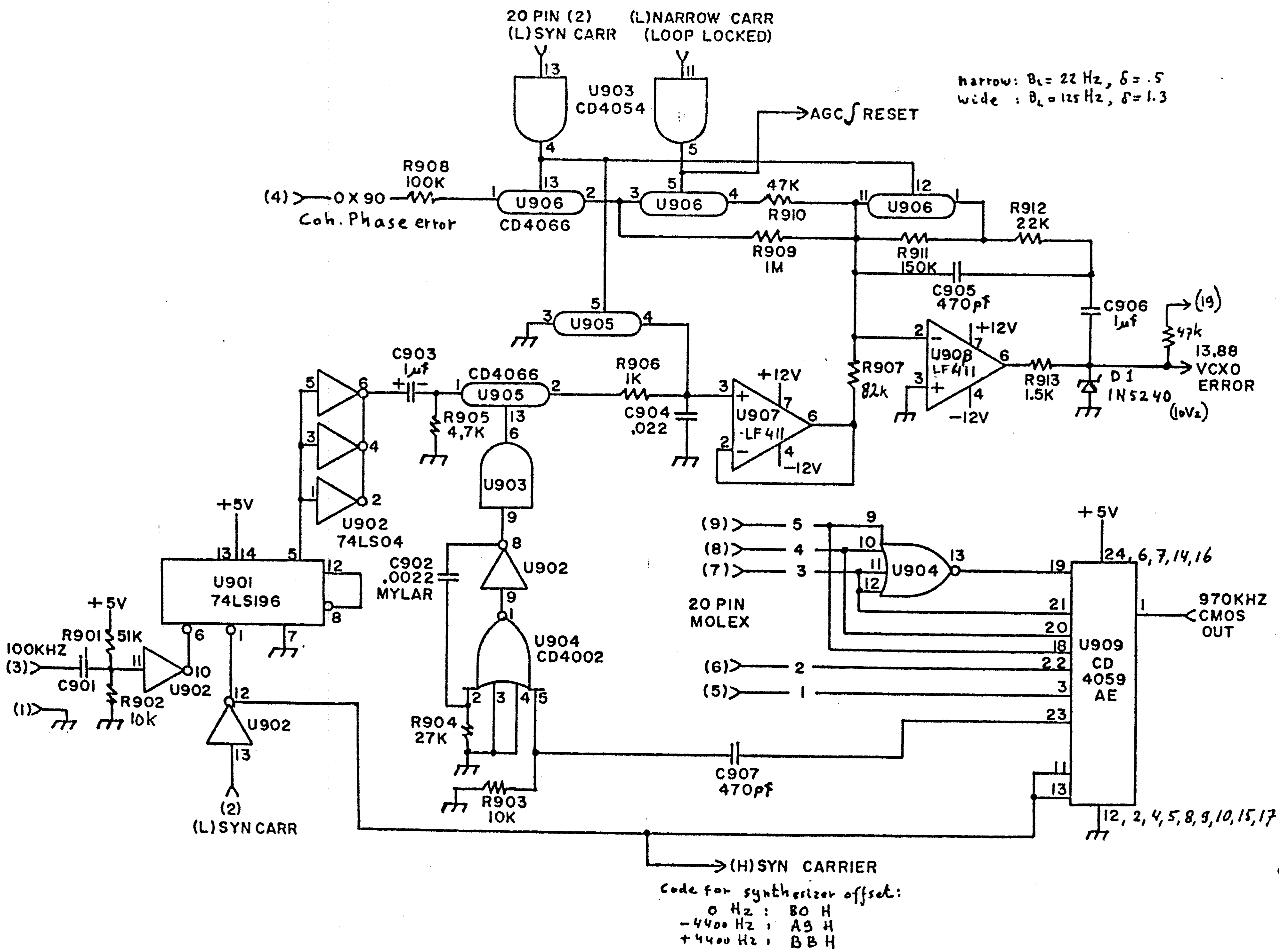
TR1 MCL T1-1
TR2 MCL T1-1
TR3 MCL T1-1

Miscellaneous

~~rf attenuator PAS-1 Mini Circuits Lab~~
rf mixer SRA-1 " " "
rf mixer SRA-1 " " "
10.7 MHz X-tal filter 5182
10.7 MHz X-tal filter 5182
1 X-tal 5.6 MHz
3 PC board coaxial connectors J201 - J203
10 pin wirewrap-type connector, 0.1" pitch + mating female Molex 4030-20A
6 3-pin " " " " " = mating females Molex 4030-20A

CARRIER


CARRIER BOARD 6PS RECEIVER 6-15-81
U909/CD4059AE
U902/74LS02
U904/CD4002
U901/74LS196
U905/CD4066
U903/CD4054
U906/CD4066
U907 CA3140
U908 CA3140
U911/74LS74
U912 CA3140
U913 CA3140
U910 SL1641
13.88 MHz VCXO Error
+15
#33 (8 Holes)
T1
T2
T-3
T4
T-5
10MHz
CM1
C928
C929
C930
C931
C933
C932

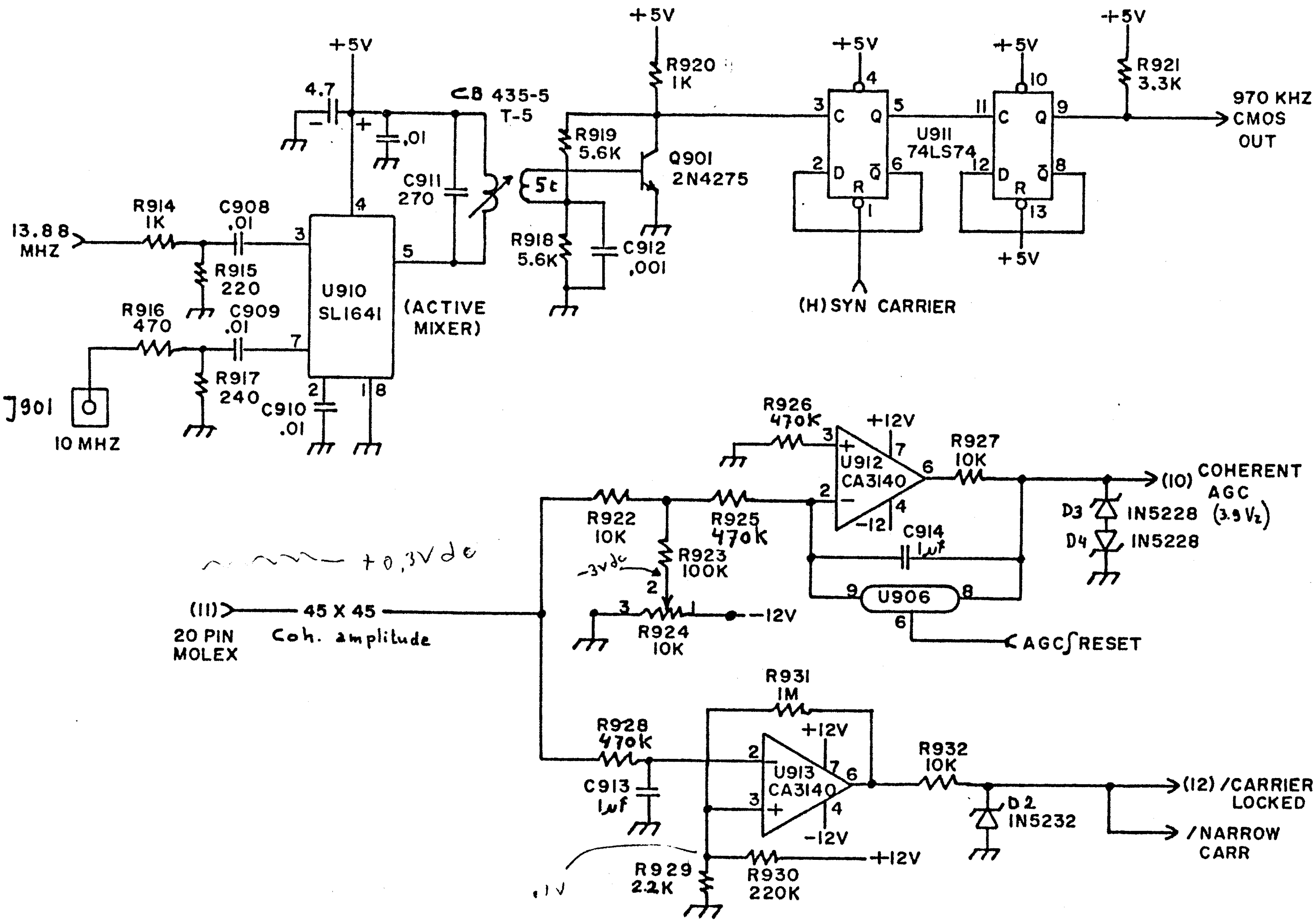


CARRIER SYNTHESIZER
COSTAS LOOP

CARRIER
GPS RECEIVER

11/5/80 Rev. 3/1/82

S-1

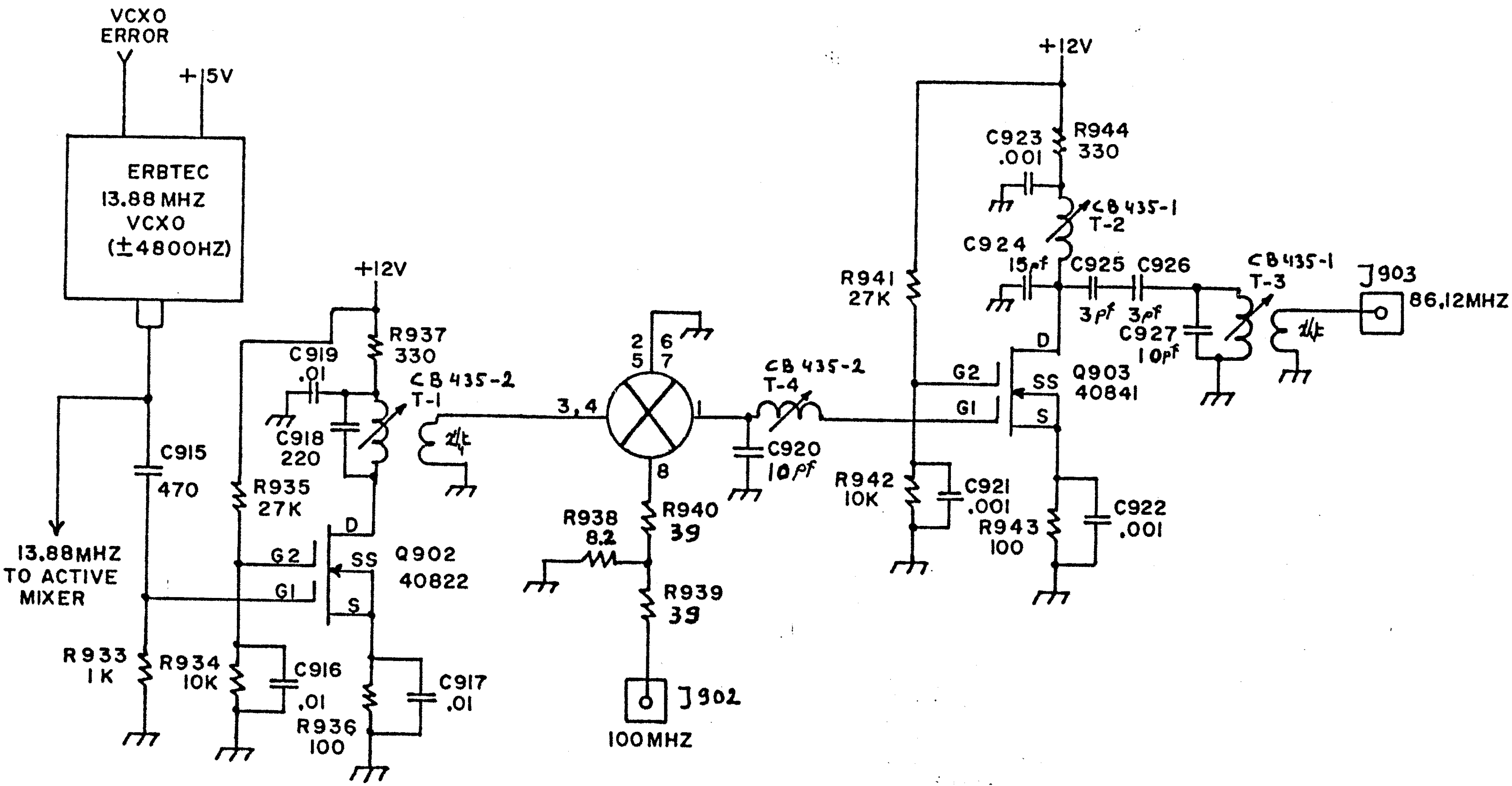


10MHZ X 13.88 MHZ ACTIVE MIXER
3.88MHZ—970KHZ DIVIDER
COHERENT AGC
CARRIER LOCK INDICATOR

CARRIER
GPS RECEIVER

11/5/80 Rev. 3/1/82

S-2

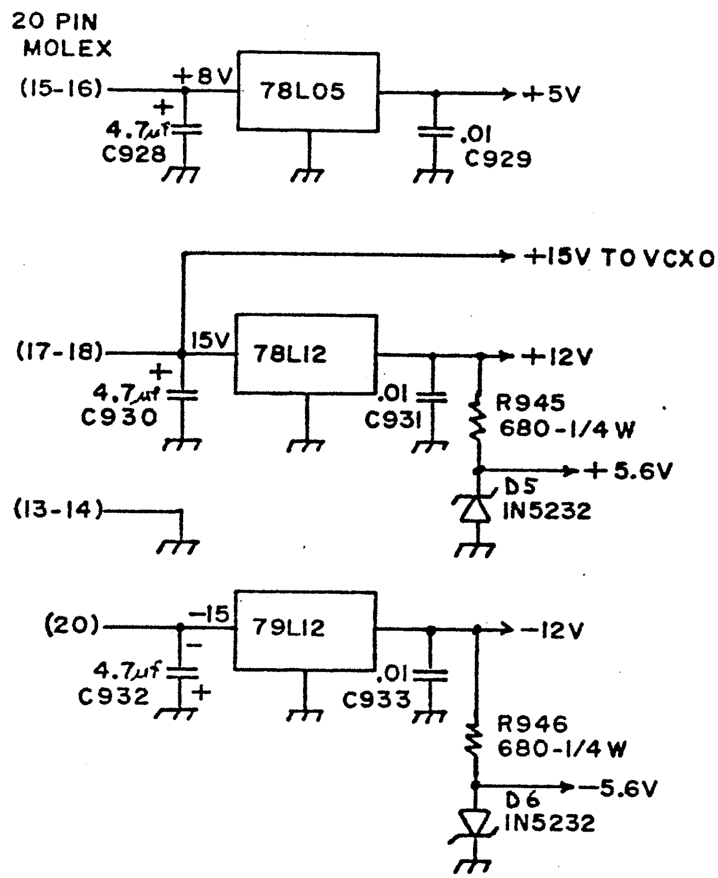


13.88→86.12MHZ MIXER

CARRIER
GPS RECEIVER

12/1/80 Rev. 3/1/82

S-3



±5.6V TO U903, U905, U906

Parts Placement - Carrier Board   S5   Rev 3/1/82

Resistor	Value
R901	51K
902	10K
903	10K
904	27K
905	4.7K
906	1K
907	82K
908	100K
909	1K
910	47K
911	150K
912	22K
913	1.5K
914	1K
915	220
916	470
917	240
918	5.6K
919	5.6K
920	1K
921	3.3K
922	10K
923	100K
924	10K (Pot)
925	470k
926	470k
927	10K
928	470k
929	1K
930	220K
931	1K
932	10K
933	1K
934	10K
935	27K
936	100
937	330
938	8.2
939	39
940	39
941	27K
942	10K
943	100
944	330
945	680-½W
946	680-½W

Capacitor	Value
C901	.1
902	.0022Mylar
903	1uf tant.
904	.022
905	470pf
906	1uf non-polar.
907	470p
908	.01
909	.01
910	.01
911	270pf
912	.001
913	1uf tant.
914	1uf non-polar.
915	470p
916	.01
917	.01
918	220p
919	.01
920	5p
921	.001
922	.001
923	.001
924	15p
925	3p
926	3p
927	10p
928	4.7uf tant
929	.01
930	4.7uf tant.
931	.01
932	4.7uf tant.
933	.01

IC	Type
U901	74LS196
902	74LS04
903	CD4054
904	CD4002
905	CD4066
906	CD4066
907	LF411ACN
908	LF411ACN
909	CD4059AE
910	SL1641
911	74LS74
912	CA3140
913	CA3140

Part	Type
Q901	2N4275
Q902	40322
Q903	40841
D 1	IN5240 (10Vz)
2	IN5232 (5.6Vz)
3	IN5228 (3.9Vz)
4	IN5228 "
5	IN5232 (5.6Vz)
6	IN5232 "
T 1	CB435-2, sec. 2¼t
2	CB435-1
3	CB435-1, sec. 2¼t
4	CB435-2
5	CB435-5, sec 5 t
J901	PCB coax connector
902	" " " "
903	" " " "
M901	Double Bal. Mixer SRA-1

PARTS LIST - CARRIER BOARD S6

Rev 3/1/82

Resistors ½W

82	1
[illegible]	2
100	2
220	1
240	1
330	2
470	1
1K	5
1.5K	1
3.3K	1
4.7K	1
5.6K	2
10K	7
10KPot	1
22K	1
27K	3
47K	1
51K	1
100K	2
150K	1
220 K	1
470 K	3
1 M	2
680 - ¼W	2
82k	1

Capacitors

3pf	2
5pf	1
15p	1
220p	1
270p	1
470p	3
.001	4
.0022(Mylar)	1
.01	9
.022	1
.1	1
10p	1
1 uf(Non-pol)	2
1 uf tant.	2
4.7 uf tant.	3

Semiconductors

IN5240	1
IN5228	2
IN5232	3
2N4275	1
40822	1
40841	1

Integrated Circuits

SL1641	1
CA3140	2
CD4002	1
CD4054	1
CD4059	1
CD4066	2
74LS04	1
74LS74	1
74LS196	1
LF 411ACN	2
78L05	1
78L12	1
79L12	1

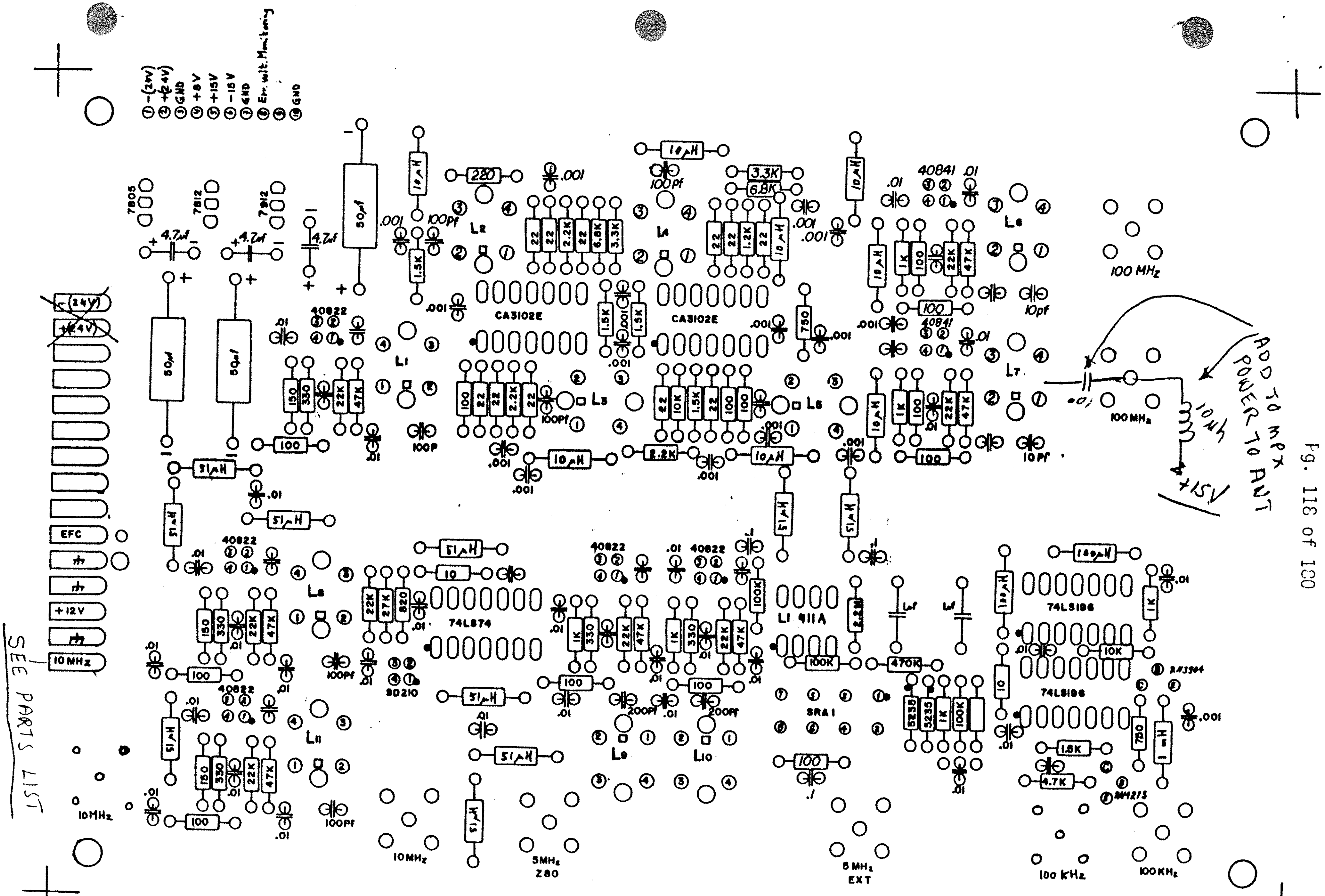
Coils, Transformers

CB 435-1	2
CB 435-2	2
CB 435-5	1

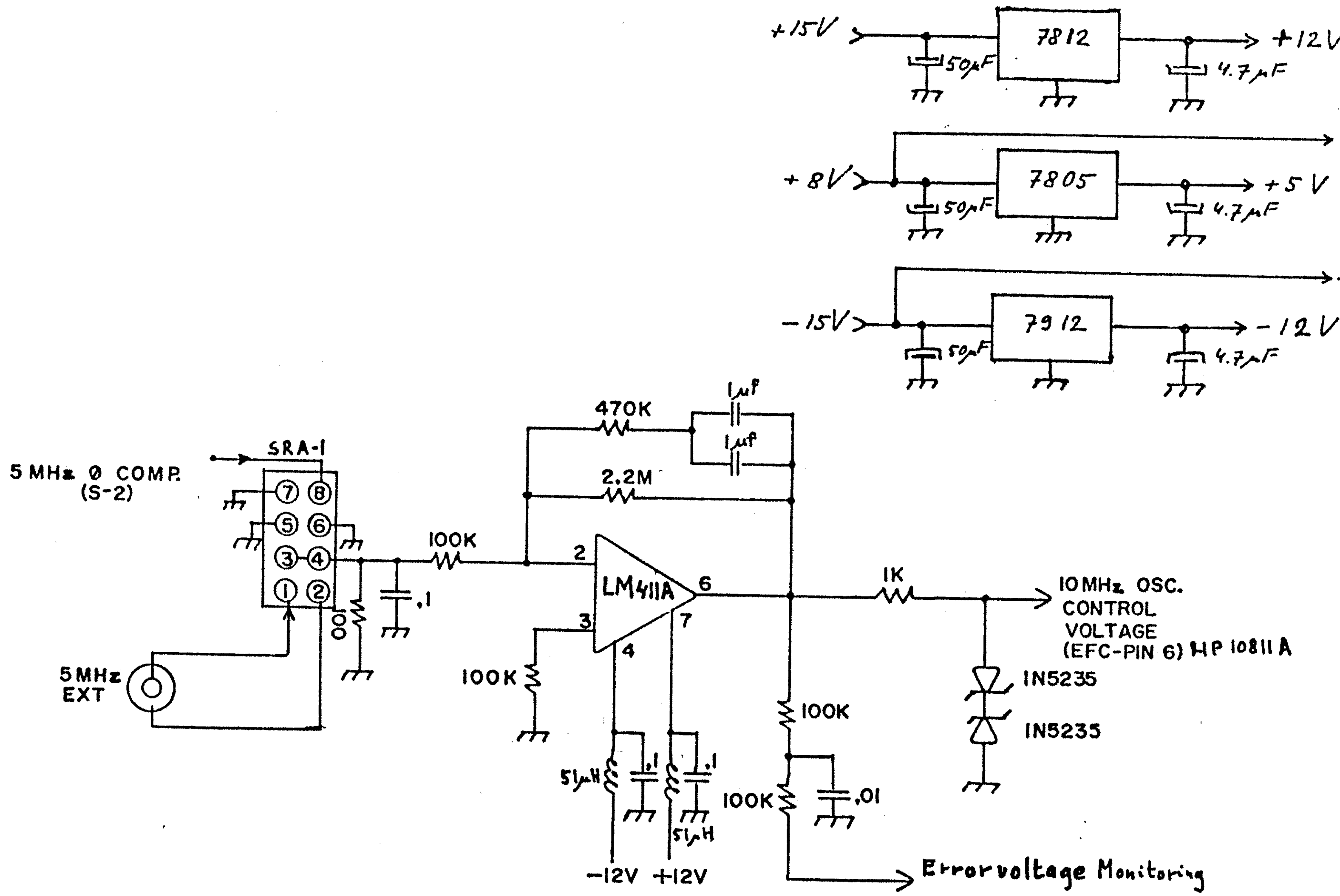
Miscellaneous

SRA-1 mixer	1
VCXO 13.88MHz	1
20p Molex conn. (4030-20A)	1
Coax. print conn.	3

MULTIPLIER



MULTIPLIER CARD (1018/1019)



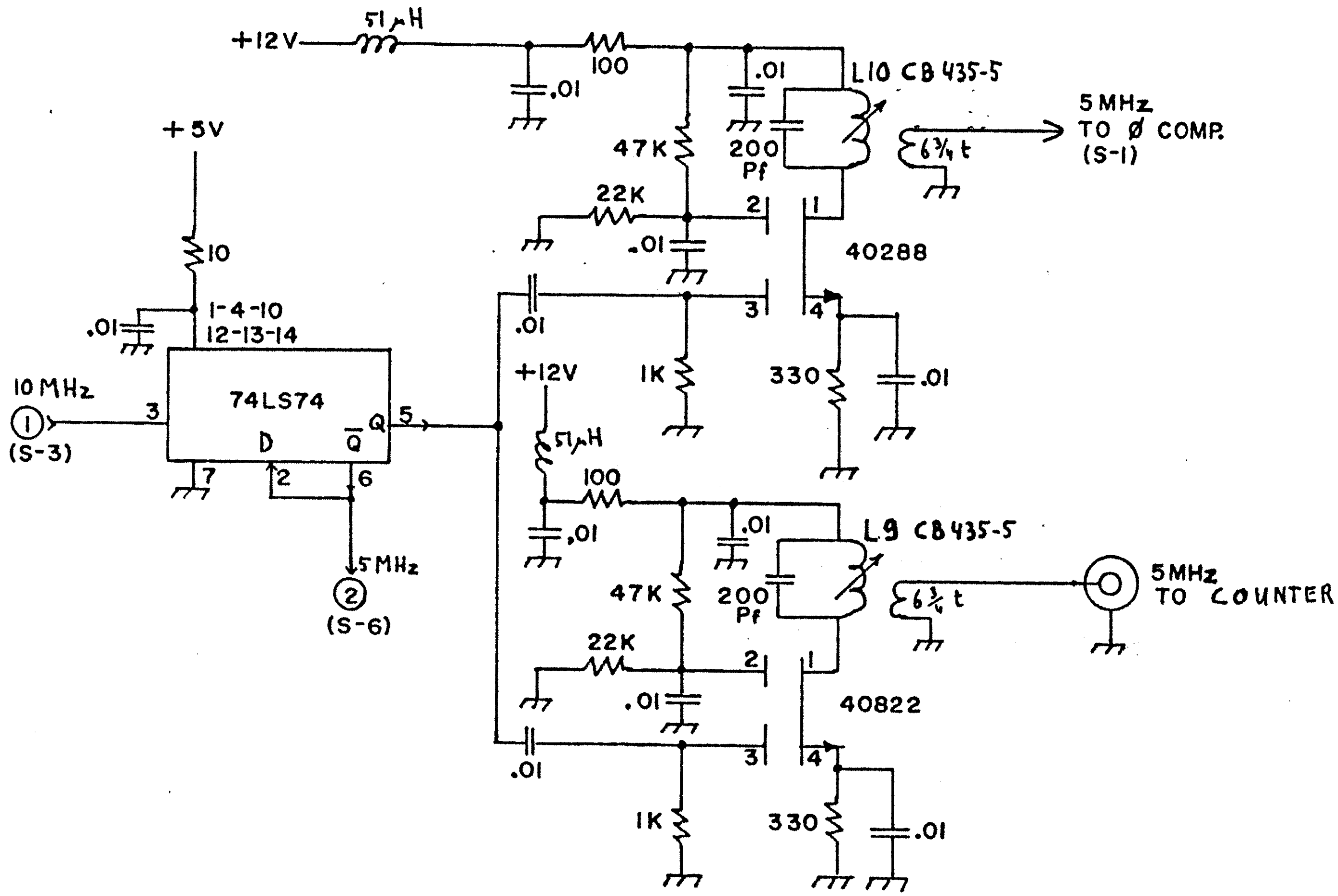
5 MHz PLL

MULTIPLIER GPS-Z80

Rev 3/2/82

S1

Davis

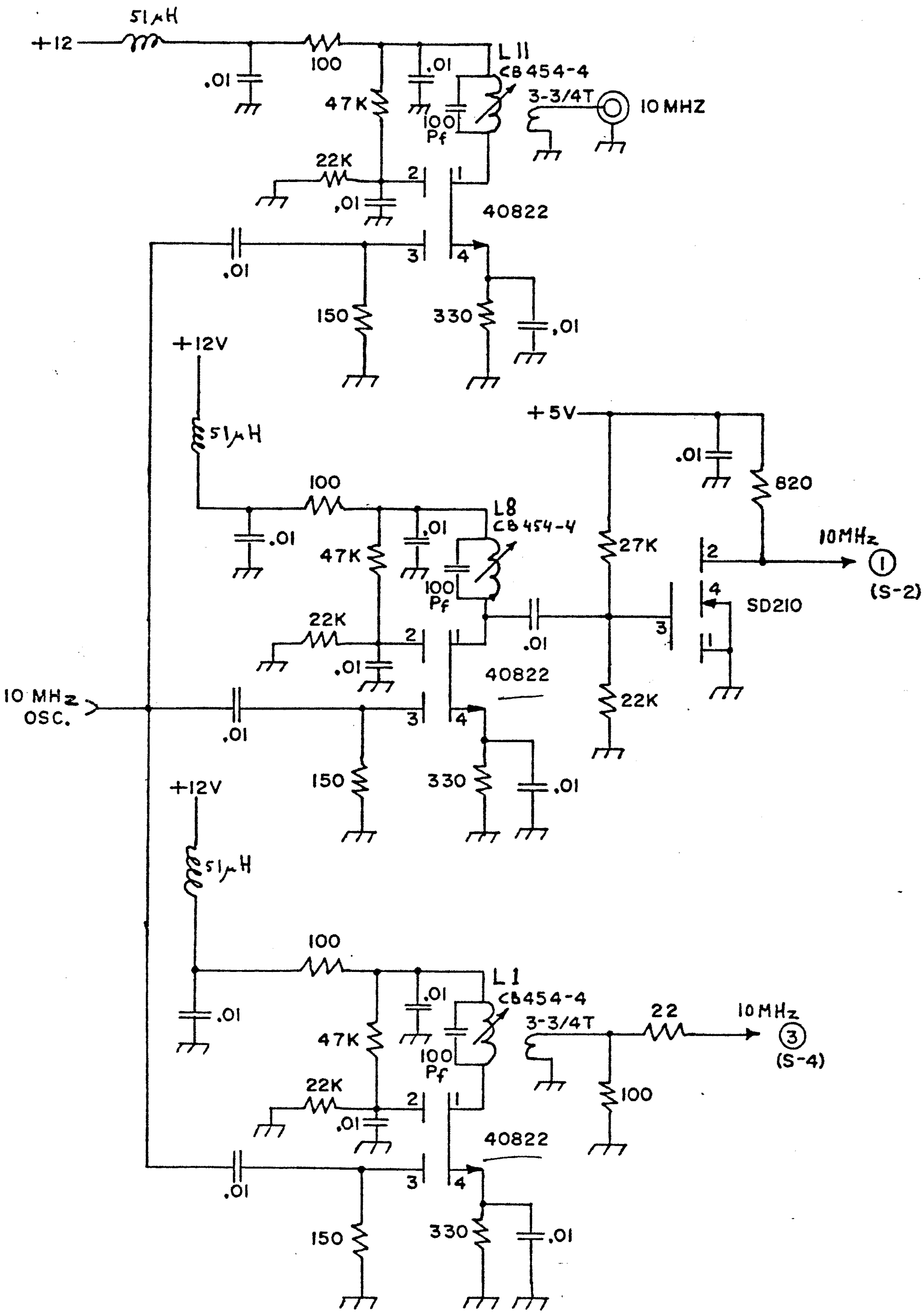


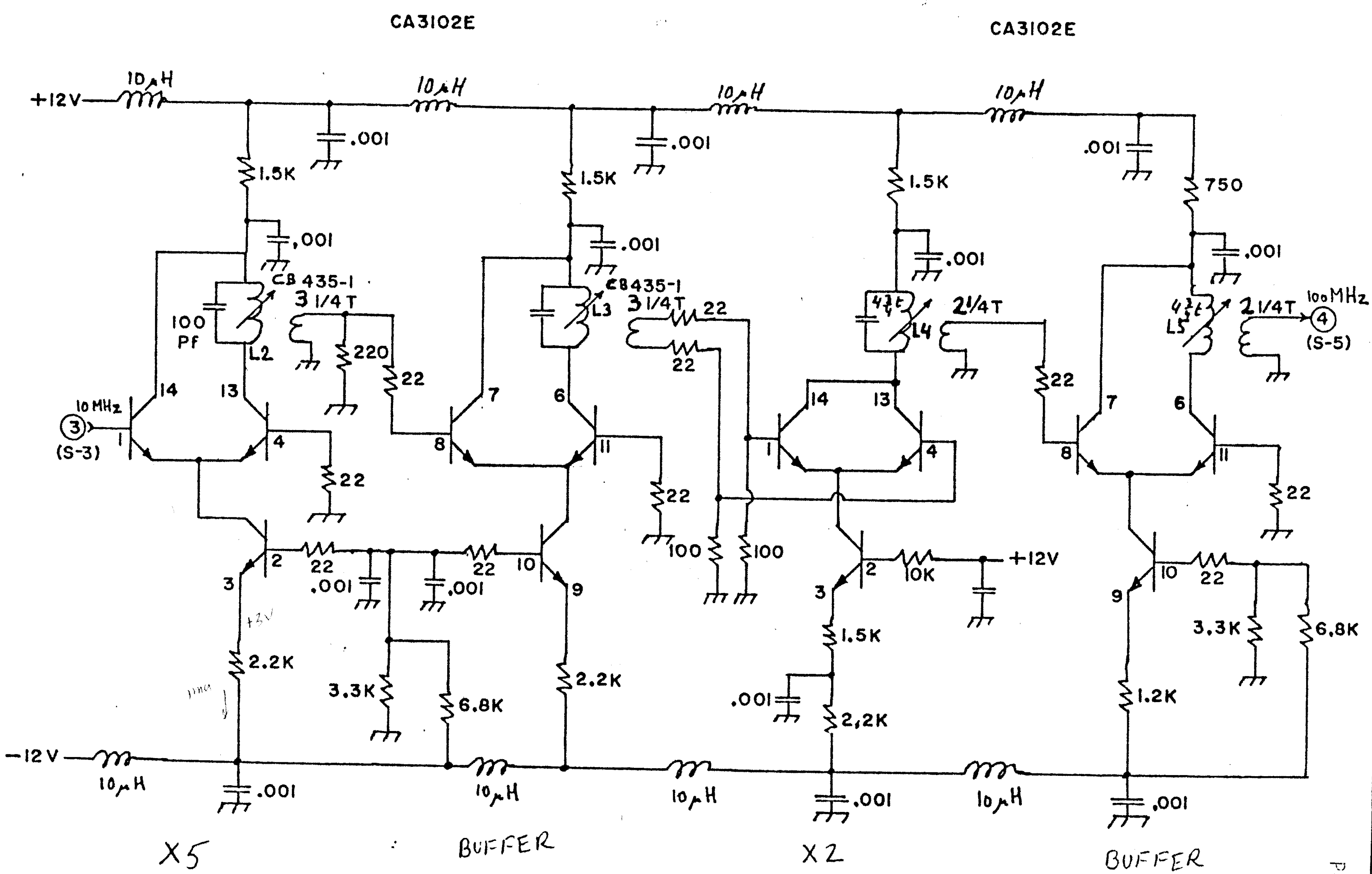
5 MHZ GEN. & BUFFER

MULTIPLIER
GPS Z-80

Rev 3/2/82

S2


+12
51µH
.01
100
47K
.01
L11
CB454-4
100 Pf
3-3/4T
10 MHZ
22K
.01
40822
.01
150
330
.01
+12V
51µH
100
.01
47K
.01
L8
CB454-4
100 Pf
+5V
.01
820
27K
10MHz
1
(S-2)
SD210
22K
.01
40822
10 MHz OSC.
.01
150
330
.01
22K
+12V
51µH
100
.01
.01
L1
CB454-4
3-3/4T
22
10MHz
3
(S-4)
47K
100 Pf
100
22K
.01
40822
.01
150
330
.01

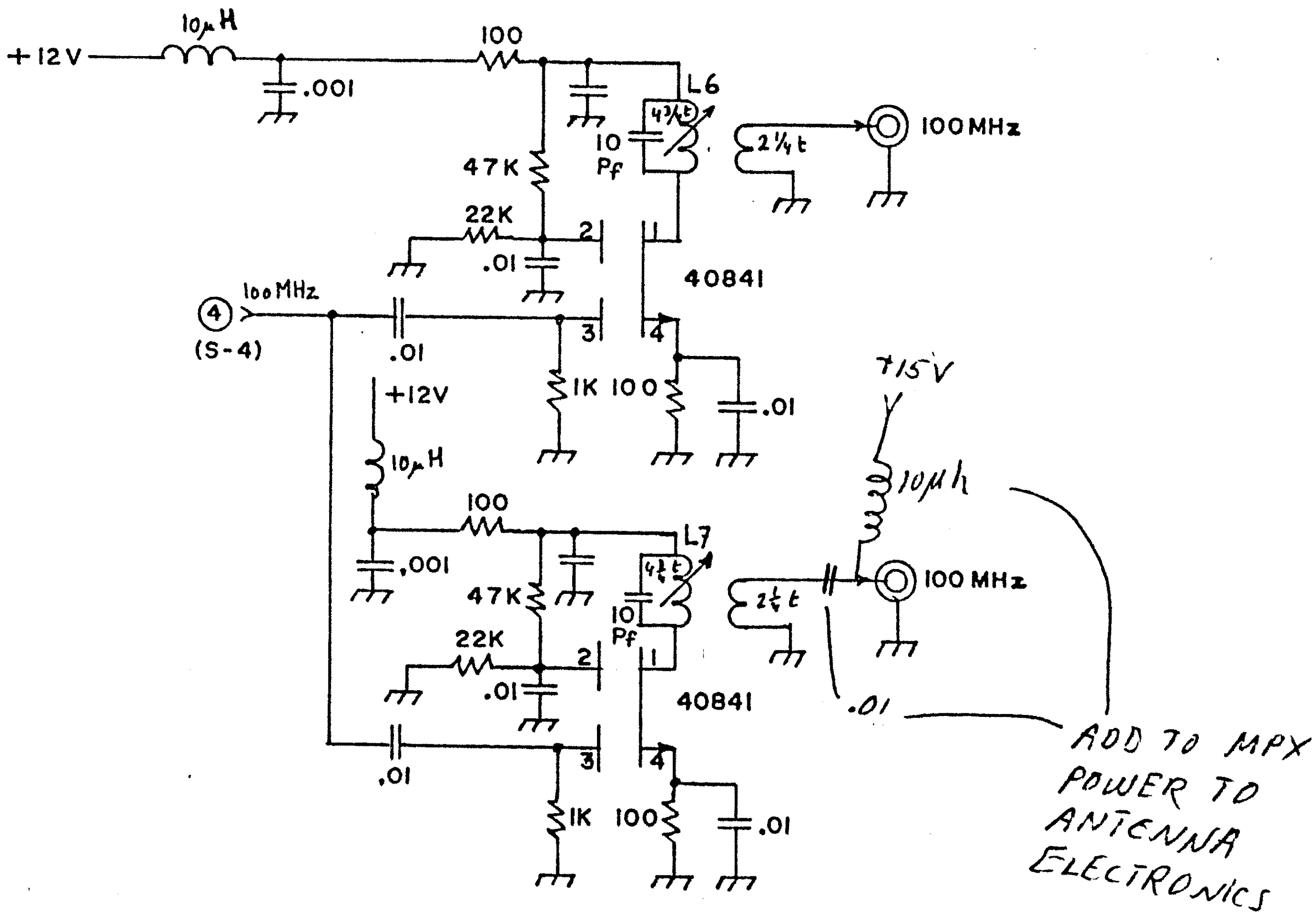


10-100 MULTIPLIER

MULTIPLIER GPS-Z80

Rev 3/2/82

S4

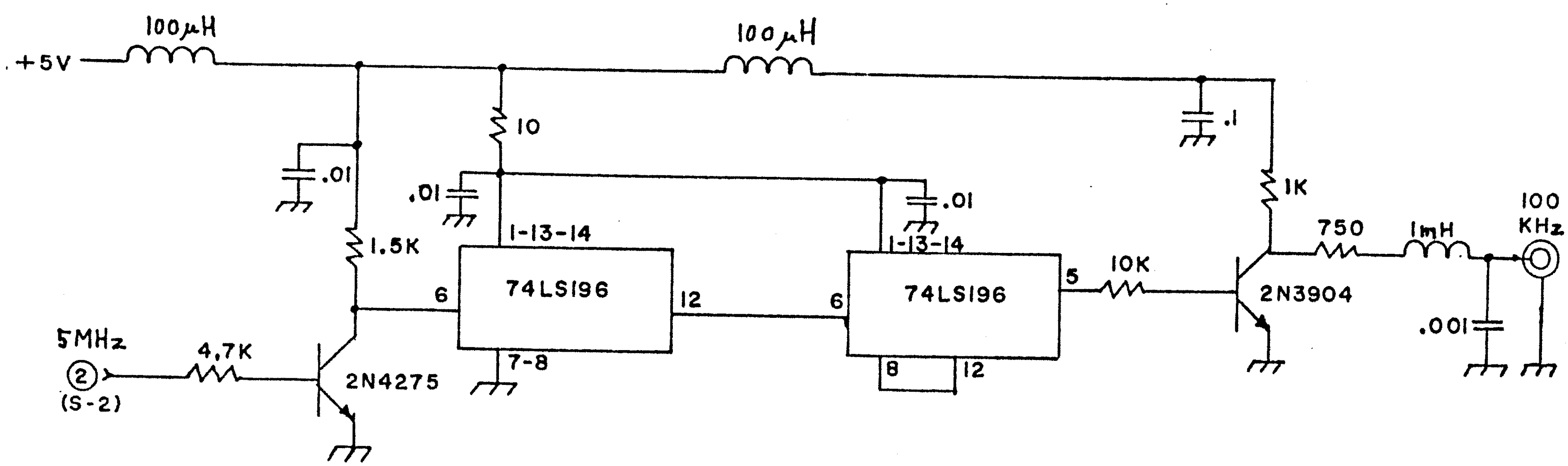


100 MHZ AMPLIFIER

MULTIPLIER GPS-Z80

Rev 3/2/82

S5



100KHZ

MULTIPLIER
GPS-Z80

Rev. 3/2/82

S6

PARTS LIST - MULTIPLIER CARD

CAPACITOR

10 pf	2
200 pf	2
100 pf	7
.001	16
.01	34
.1	3
1 uf	2
4.7 uf	3
50 uf	3

MSC.

7805	1
7812	1
7912	1
1MH Choke	1
Choke	20
SD210	1
40822	5
40841	2
CA3102E	2
AD544	1
74LS74	1
74LS196	2
SRA1	1
3904	1
4275	1
5235	2
Molex 10 pin	1
Min Coax Conn	6

RESISTORS

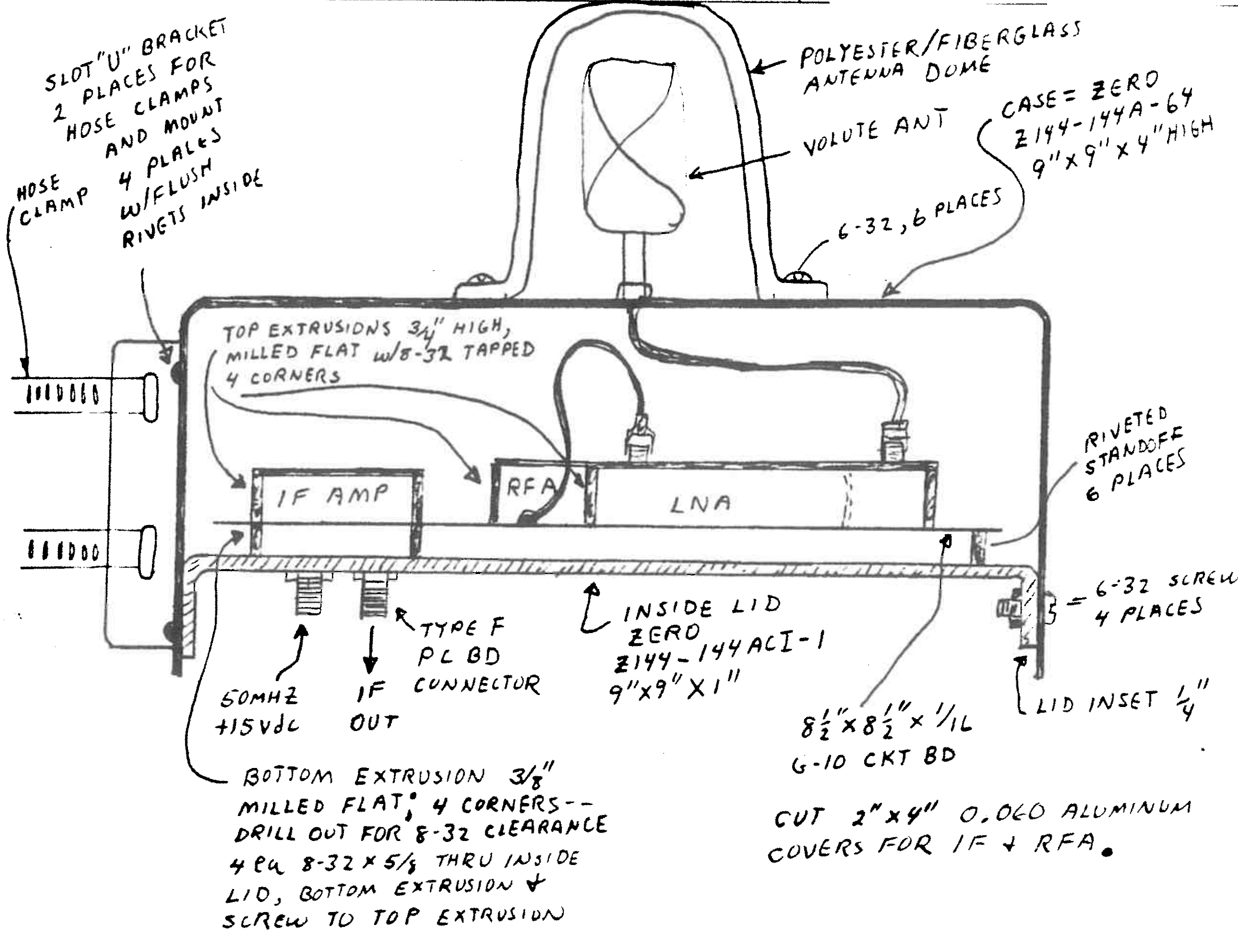
10	2
22	11
100	13
150	3
220	1
330	5
750	21
820	1
1K	6
1.2K	1
1.5K	5
2.2K	3
3.3K	2
4.7K	1
6.8K	2
10 K	2
22 K	8
27 K	1
47 K	7
100 K	4
470 K	1
2.2 Meg	1

HP 10811A
10 MHz OSCILLATOR

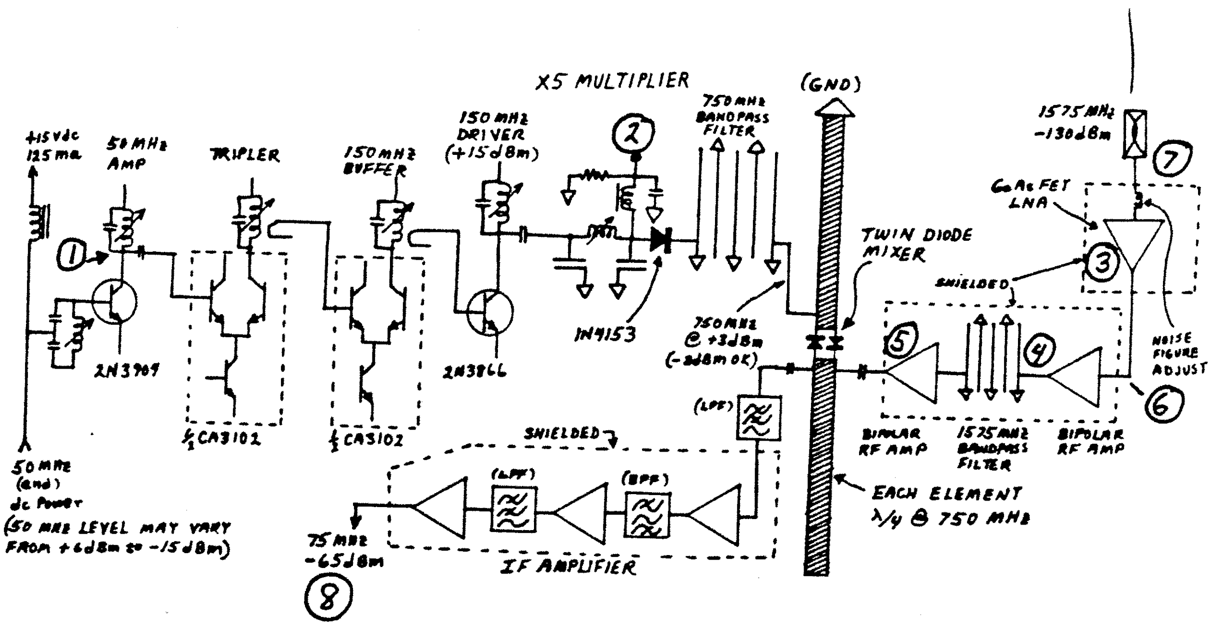
EQUIVALENT:

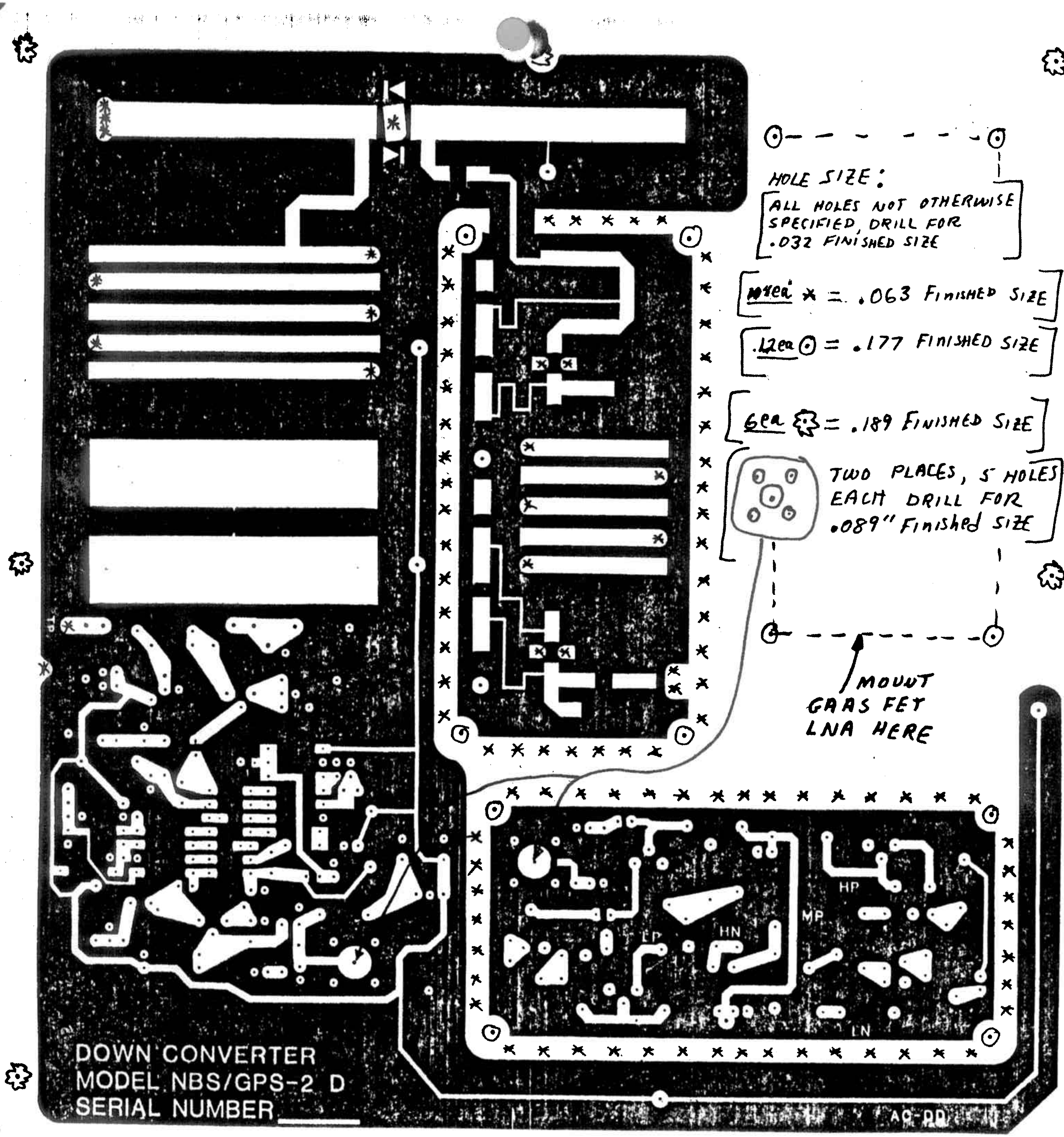
PIEZO SYSTEMS - PART # 2810007-4
100 K STREET
Carlisle Pa 17013
(717) 249-2151

ANTENNA ELECTRONICS



ELECTRICAL BLOCK DIAGRAM



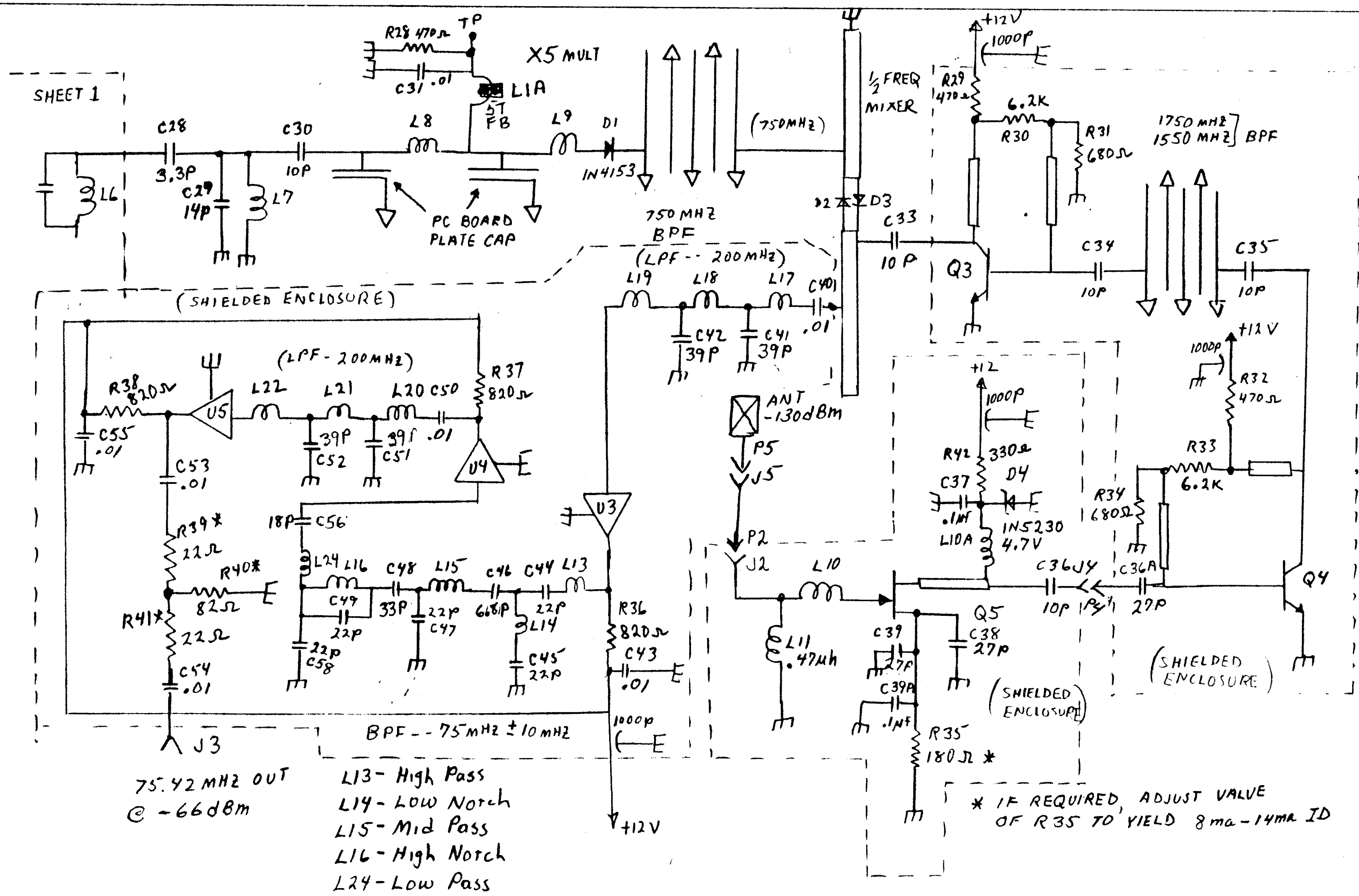


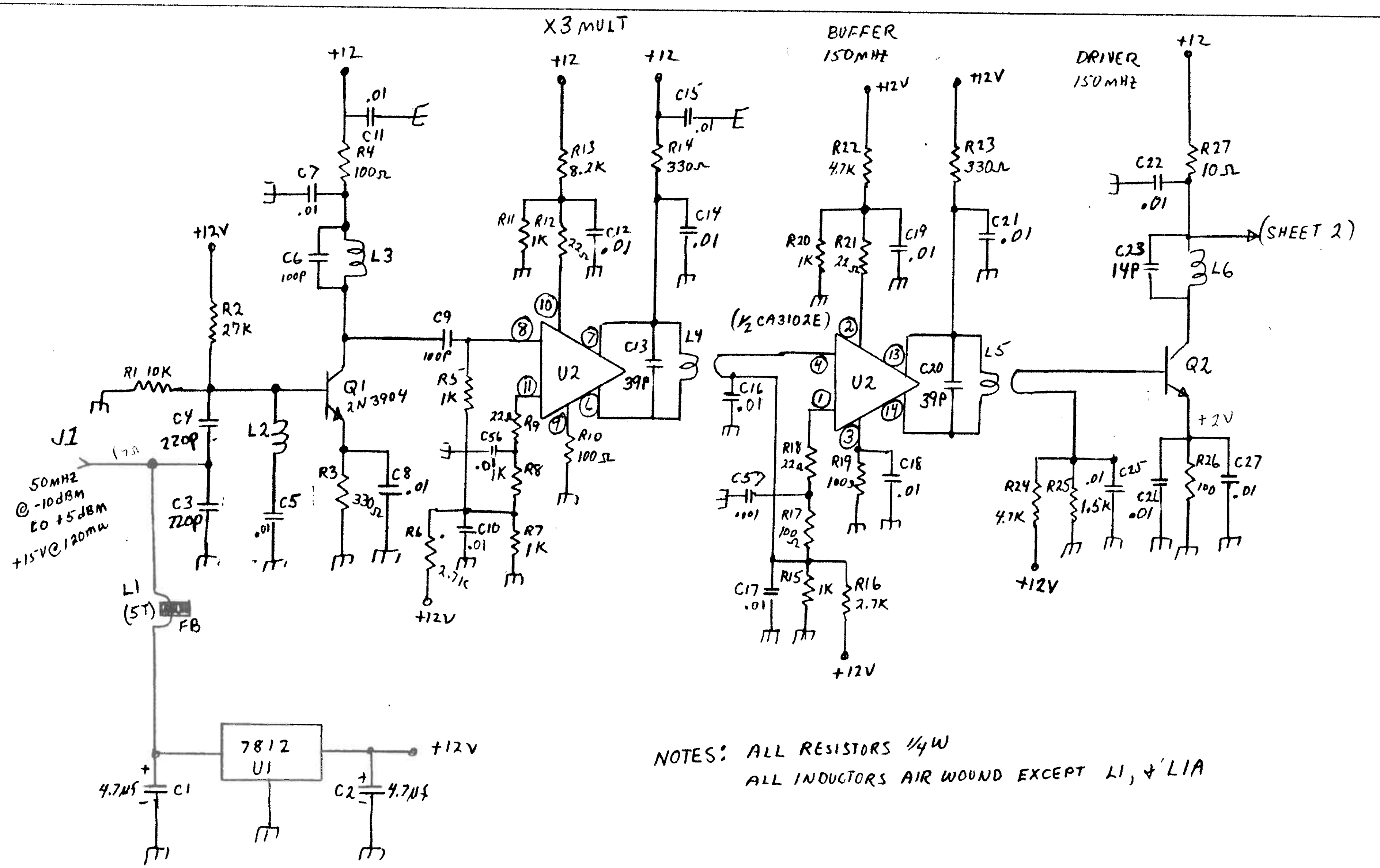
HOLE SIZE:
ALL HOLES NOT OTHERWISE SPECIFIED, DRILL FOR .032 FINISHED SIZE
40ea * = .063 FINISHED SIZE
12ea ⊙ = .177 FINISHED SIZE
6ea ✿ = .189 FINISHED SIZE
TWO PLACES, 5 HOLES EACH DRILL FOR .089" Finished SIZE
MOUNT GAAS FET LNA HERE
HP
MP
HN
LP
LN
DOWN CONVERTER
MODEL NBS/GPS-2 D
SERIAL NUMBER____
AC-DD

NBS/GPS ANT PKG

REV 10/16/84

8/31/84 - D Davis





NOTES: ALL RESISTORS ¼W
ALL INDUCTORS AIR WOUND EXCEPT L1, + L1A

NBS/GPS ANT PKG
REV 10/16/84
8/31/84 – D Dow

C1, C2	4.7uf/35V TANT		(BEST SOURCE)	
C6	120P	ELMENCO SILVER MICA		
C9	100P	CN15A101K	CENTRALAB	15¢/100
C3, C4	220P	CN15A221K		
C5, 7, 8, 10, 11, 12, 14, 15, 16, 17, 18, 19, 21, 22, 24, 25, 26, 27, 31, 32, 40, 43, 53, 54, 55, 56, 57,	.01uf	CY15A103Z		
C 48	33P	ELM S MICA		
C51, 52	39P	"	"	
C37, C39A	0.1uf	CERAMIC		
C28	3P	-(QC)-- QUALITY COMPONENTS ST MARYS PA (814) 834-2817		7⁰⁰/100
C33	6.8P	(QC)		
C30, 34, 35, 36, 46	10P	(QC)		
C23, C29	14P			
C44, 45, 47, 49	22P	(QC)		
C13, 20, 41, 42, 51, 52	27P	(QC)		

FEED-THRU CAPS

3 ea 1000 PF THREADED

1 ea 1000 PF SOLDER-IN

RESISTORS: ALL 1/4W CARBON, 5% NON INDUCTIVE

R27	10Ω
R9, R12, R18, R21, R39, R41	22Ω
R40	82Ω
R4, R10, R17, R19, R26	100Ω
R35	180Ω
R3, R14, R23, R42	330Ω
R28, R29, R32	470Ω
R31, R34	680Ω
R36, R37, R38	820Ω
R5, R7, R8, R11, R15	1K
R25	1.5K
R6, R16	2.7K
R22, R24	4.7K
R30, R33	6.2K
R13	8.2K
R1	10K
R2	27K

TEFLON COAX - RG 188 A/U $98.03/160ft - NEWARK STK 37F2086 WA
APPROX 12" REQUIRED FOR EACH ANT PKG

J2, J4	SMA FEMALE, PC MOUNT	JOHNSON	142-0298-001
P2, P4	SMA MALE, FOR RG 188	JOHNSON	142-0221-001
J5	SMA BULKHEAD	JOHNSON	142-0233-001
J1, J3	TYPE F FEMALE PC MOUNT, 3/8 SHOULDER # AF 61 PC ($61.00/100)	AVA ELECT CORP 400 BRIDGE ST DREXEL HILL PA 19026	

SEMICONDUCTORS

D1 12¢ 1N4153

D2, D3 (1^{10} ea) MA4883 MA/COM ASSOCIATES INC, BURLINGTON MASS.
D4 10¢ 1N5232 4.7V ZENER

U1 (1^{20}) 7812 - 3T REGULATOR

U2 (3^{80} ea) CA3102E

U3, U4, U5 (7^{50} ea) MWA110 - MOTOROLA GAIN BLOCK

Q1 15¢ 2N3904

Q2 (1^{60} ea) 2N3866

Q3, Q4 (7^{40} ea) NE64535 CALIFORNIA EASTERN LABORATORIES (CEL)
SCOTTSDALE AZ (602) 945-1381

Q5 (13^{00} ea) NE72089A (CEL)

MISC.

FERRITE BEADS (J W MILLER)
MOUSER ELECT STOCK # 542-FB43-110 ($$12^{00}$/100)

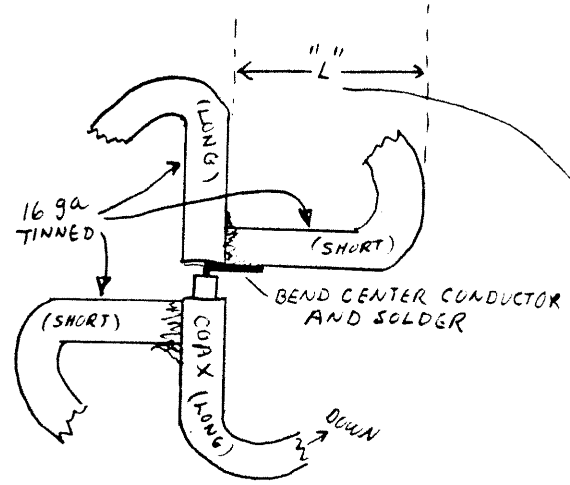
		(PRICE BREAKS) (1)	(10)	(25)	
CASE	Z144-144A-64	30^{22}	24^{17}	18^{13}	Zero Corp 777 Front St
LID	Z144-144ACI-1	18^{11}	14^{49}	10^{87}	Burbank (818)-846-4191

STANDOFF, RIVETED/4-40THREAD
1651-2 3/8"
(955/100)

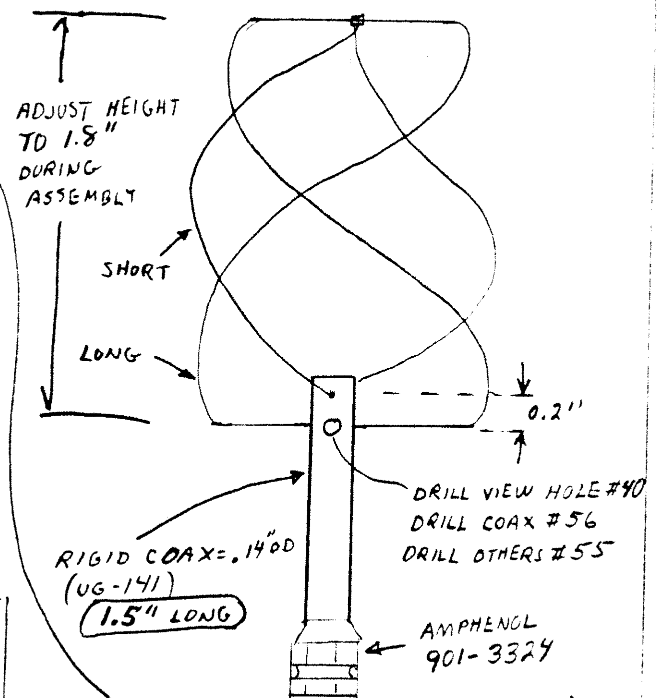
KEYSTONE ELECTRONICS CORP
49 BLEECKER ST
NY 10012
(212) - 475 - 4600

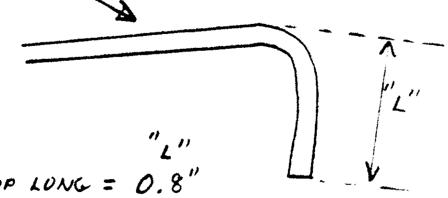
Aluminum Extrusion # 6303
6 ft Bar - $70^{48}
(FOR SHIELD COVERS, RF + IF)
(CUT + MILL FLAT PER DETAIL)

AHAM TOR INC.
Attn: Vickie Schilling
27901 Front St
Rancho CA 92390
(714) 676-4151



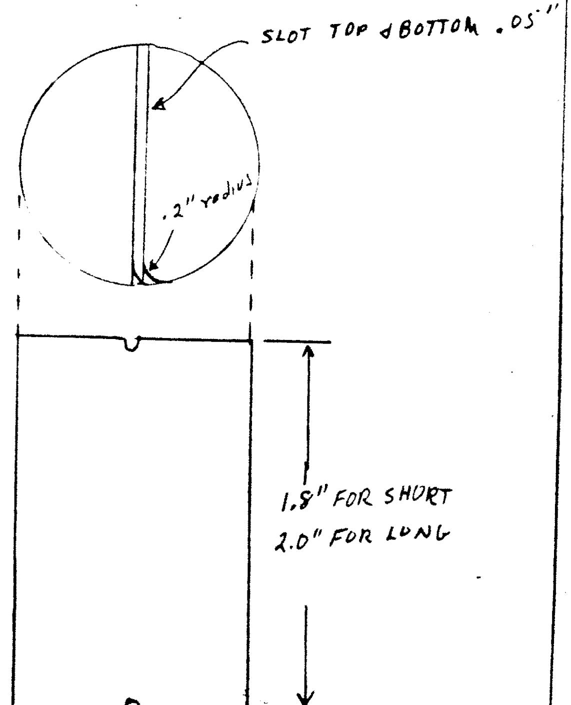
TOP VIEW OF ANT

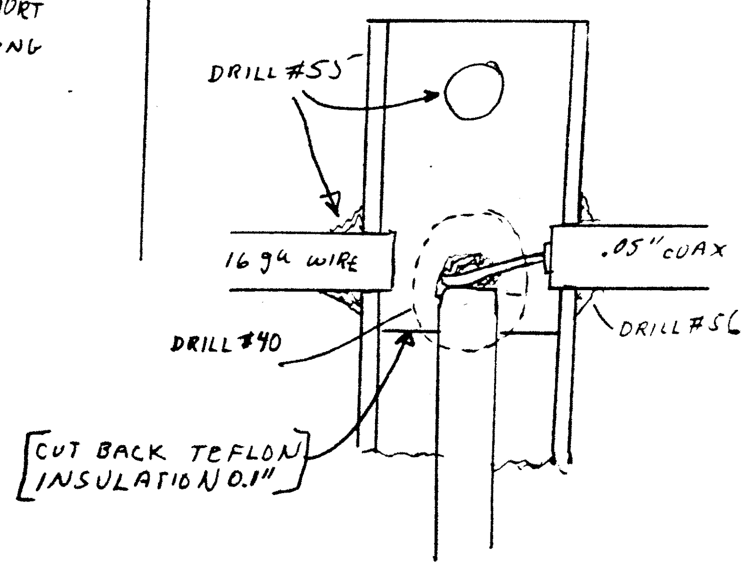




"L"
TOP LONG = 0.8"
BOTTOM LONG = 0.7"
TOP SHORT = 0.7"
BOTTOM SHORT = 0.63"

(2) MANDRELS FOR FORMING ELEMENTS
DIA = 1.25"





0.05" COAX = CA50047
MFR: PRECISION TUBE
N WALES, PA ($300 MIN)
SMALL QTY:
WALTRONIC SALES
(408) 727-1200
ELECTRONIC RESOURCES
(408) 745-1240
MICRO MODE
(619) 449-3844

NOTES ON CONSTRUCTION OF QUADRAFILAR ANTENNA (PAGE 1)

CUT LENGTHS OF UG-141 COAX TO 2" WITH JEWELERS SAW AND FORCE OUT TEFLON INSULATION AND CENTER CONDUCTOR. IF TEFLON CANT EASILY BE PUSHED OUT, HEAT COAX WITH HEAT GUN AND TRY AGAIN. (COEFFICIENT OF EXPANSION OF TEFLON IS MUCH GREATER THAN COPPER SLEEVE -- THIS WILL BREAK BOND.)

CUT OUTER COPPER SLEEVE OF 141 TO EXACTLY 1.5" AND DRILL HOLES AS SPECIFIED. CUT BACK TEFLON ABOUT 0.04" AT TOP, SQUARE END OF CENTER CONDUCTOR AND TIN. FORCE TEFLON BACK INTO TUBE, POSITIONING SO THAT CENTER CONDUCTOR IS SLIGHTLY BELOW HOLE WHERE 0.050" COAX ANTENNA ELEMENT IS TO BE INSERTED. CRIMP UG-141 IN 2 PLACES WITH DIAGONAL PLIERS, AS SHOWN. DONT BE TOO CONSERVATIVE WITH THE CRIMPS -- THEY ARE NECESSARY TO HOLD THE TEFLON FIRMLY IN PLACE AND THEY DONT SIGNIFICANTLY AFFECT VSWR.

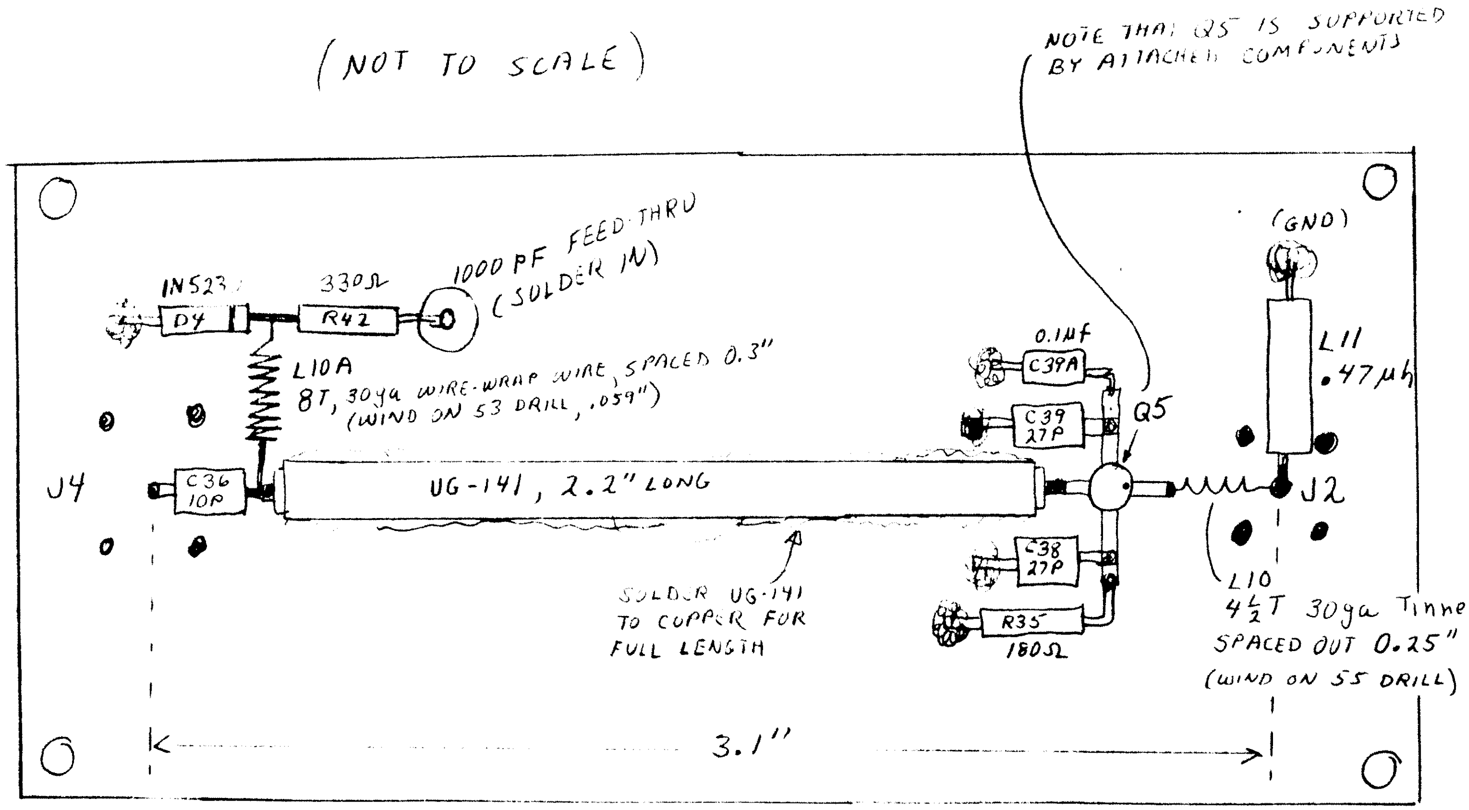
CUT BACK BOTTOM END OF TEFLON IN PREPARATION FOR CONNECTOR, BUT DONT INSTALL CONNECTOR AT THIS TIME.

FORM ANTENNA ELEMENTS BY BENDING THEM OVER MANDRELS, CONSTRUCTED AS SHOWN. BOTTOM ENDS OF 3 WIRE ELEMENTS SHOULD BE CUT SLIGHTLY LONGER THAN "L" TO ALLOW FOR INSERTION INTO COAX. WIRE ELEMENTS CAN BE CUT WITH DIAGONAL PLIERS AND SQUARED OFF WITH A FILE. THE COAX ELEMENT CAN BE CUT BY CUTTING AROUND SHIELD WITH A SCALPEL OR VERY SHARP KNIFE, (NICK, DONT CUT THRU) THEN SNAP OFF OUTER SHIELD. CUT BACK TEFLON INSULATION ON BOTH ENDS TO WITHIN ABOUT 0.03" OF SHIELD, LEAVING ABOUT 0.1" OF CENTER CONDUCTOR PROTRUDING. WHEN THE COAX ELEMENT IS SOLDERED, THE TEFLON INSULATION WILL EXPAND (A LOT!!), SO "CONDITION" THE TEFLON BY HEATING BOTH ENDS OF THE COAX + CUTTING BACK EXCESS TEFLON TO 0.03" OF SHIELD.

"RE-FORM" THE ANTENNA ELEMENTS BY HAND TO ACHIEVE A 180° TWIST -- PLACE BACK ON MANDREL TO CHECK. MOUNT UG-141 TUBE IN A MACHINIST'S VISE AND INSERT COAX ELEMENT. MAKE SURE CENTER CONDUCTOR OF COAX ELEMENT IS PROPERLY POSITIONED, AND SOLDER COAX ELEMENT TO UG-141. AT THIS POINT, THE CENTER CONDUCTOR OF THE COAX ELEMENT IS READY TO BE SOLDERED TO THE CENTER CONDUCTOR OF THE UG-141. CAREFULLY BEND THE TOP OF THE COAX ELEMENT OUT OF THE WAY, AND SOLDER CENTER CONDUCTOR AS SHOWN ON NEXT PAGE.

BEND COAX ELEMENT SO IT IS CENTERED AND PUSH IT DOWN SO IT IS 1.8" HIGH, RATHER THAN THE 2" IT STARTED OUT TO BE ON THE MANDREL.

(NOT TO SCALE)



NOTES: BUILD LNA ON 4" X 2" 2 SIDED G-10 BOARD
DRILL CORNER HOLES TO MOUNT ON 6063 EXTRUSION, 0.75" HIGH.

COIL WINDING DATA

WIND FOLLOWING ON #1 DRILL (0.228" DIA)
(20 ga TINNED WIRE)

L4 - 1 3/4 T } CLOSE COUPLE 3/4 TURN LINK TO EACH
L5 - 1 3/4 T } OF THESE COILS, USING BELDEN 8251 22 AWG SELF STRIPPING WIRE.

L6 - 2 3/4 T } SPACE APPROX 0.25"
L7 - 2 3/4 T }
L8 - 4 3/4 T SPACE APPROX 0.5"

L9 - NOT USED, D1 MOUNTED WITH SHORTEST LEADS, 0.6" FROM SHORTED END OF BANDPASS FILTER.

WIND FOLLOWING ON #8 DRILL (0.201" DIA)
WITH BELDEN 8051 22 AWG SELF-STRIPPING WIRE

L17, L18, L19, L20, L21, L22 - 3 3/4 T, SPACED OUT 0.3" (LPF, NOT CRITICAL)

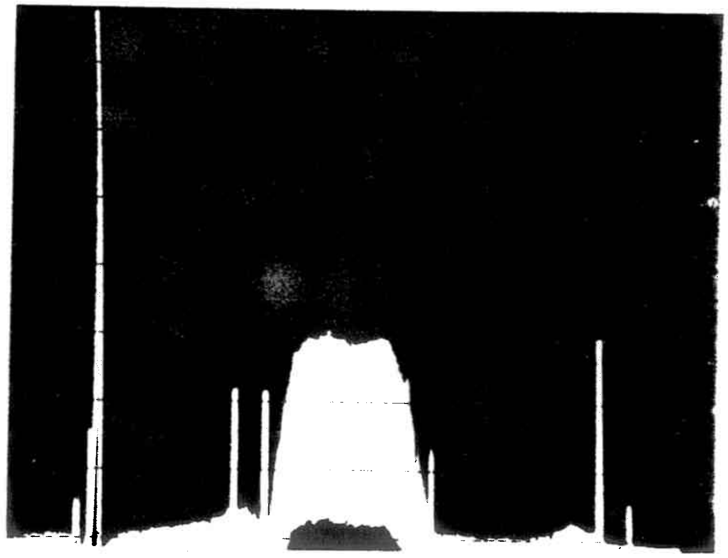
L13 5 3/4 T HIGH PASS
L14 15 3/4 T LOW NOTCH
L15 17 3/4 T MID PASS
L16 5 3/4 T HIGH NOTCH
L24 18 3/4 T LOW PASS

ADJUST FOR BEST BANDPASS, CENTERED AT 75 MHZ.
(FLAT, 75 MHZ ± 10 MHz, WITHIN 2 dB)

L2 - 5 3/4 T, SPACED 0.2"
L3 - 3 3/4 T, SPACED 0.15"

TYPICAL NOISE SPECTRUM AT IF OUTPUT
V= 10dB/CM
H=20MHz/CM

-50dBm →
-60dBm →



THIS NOISE SPECTRUM WITH ANTENNA CONNECTED AND UNIT SEALED PER NORMAL OPERATION

↑ Φ freq ↑ 75MHZ ↑ 150MHZ
↓

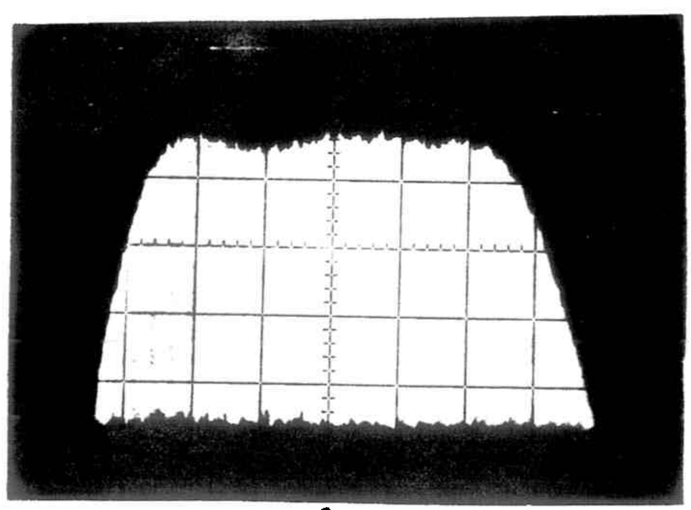
spurs seen at NIST Feb 14? 1993

-55 to -60dBm
300KHz BW

SAME AS ABOVE EXCEPT
H = 5 MHz/cm

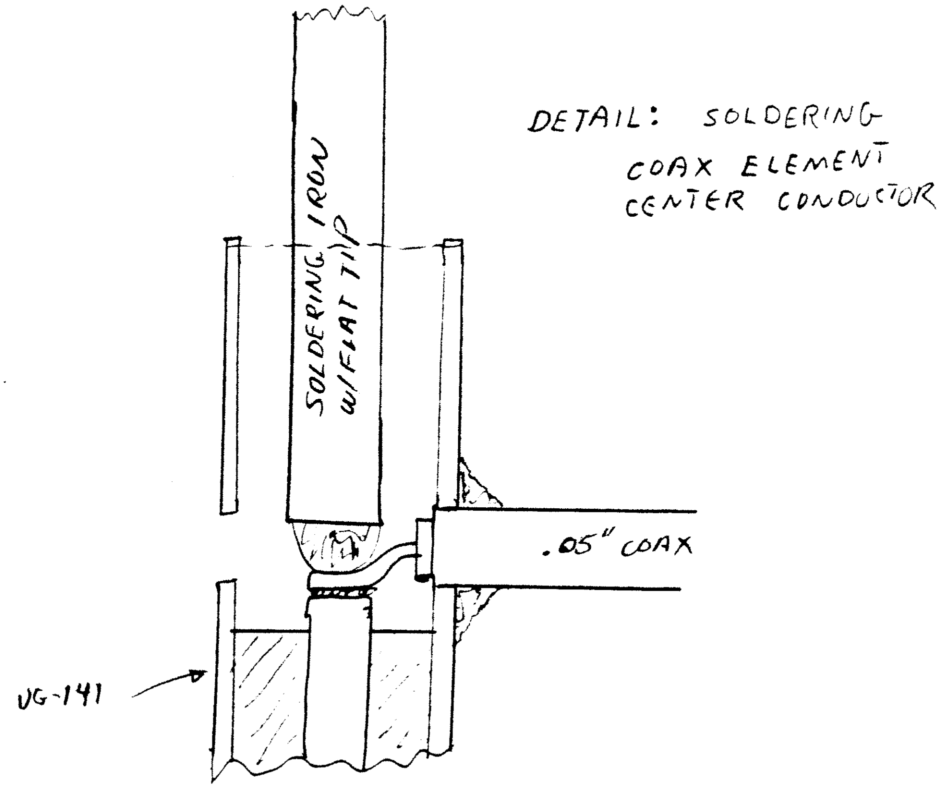
spur

SWEEP FREQ RESPONSE
SIGNAL GEN TO ANT INPUT
V=2dB/cm
H= 5MHz/cm



↑ 75MHz

NOTES ON CONSTRUCTION OF QUADRAFILAR ANTENNA (PAGE 2)



NOW INSERT AND SOLDER THE 3 WIRE ELEMENTS, HAND ADJUSTING THEM TO MEET COAX AS SHOWN IN TOP VIEW OF ANTENNA. (ALLIGATOR CLIPS ON ELEMENTS IN PLACE WILL KEEP SOLDER FROM MELTING AS NEXT ELEMENT IS PUT ON AND SOLDERED)

DO NOT SOLDER TOP OF ELEMENTS UNTIL THEY ARE EXACTLY POSITIONED AND HOLD THEIR POSITION WITHOUT PUSHING AGAINST EACH OTHER.

SOLDER TOP ELEMENTS AND MOUNT COAX CONNECTOR.

BE PREPARED TO THROW AWAY (OR REWORK) ABOUT 1 IN 3 ANTENNAS IF THEY DONT MEET FOLLOWING SPEC;

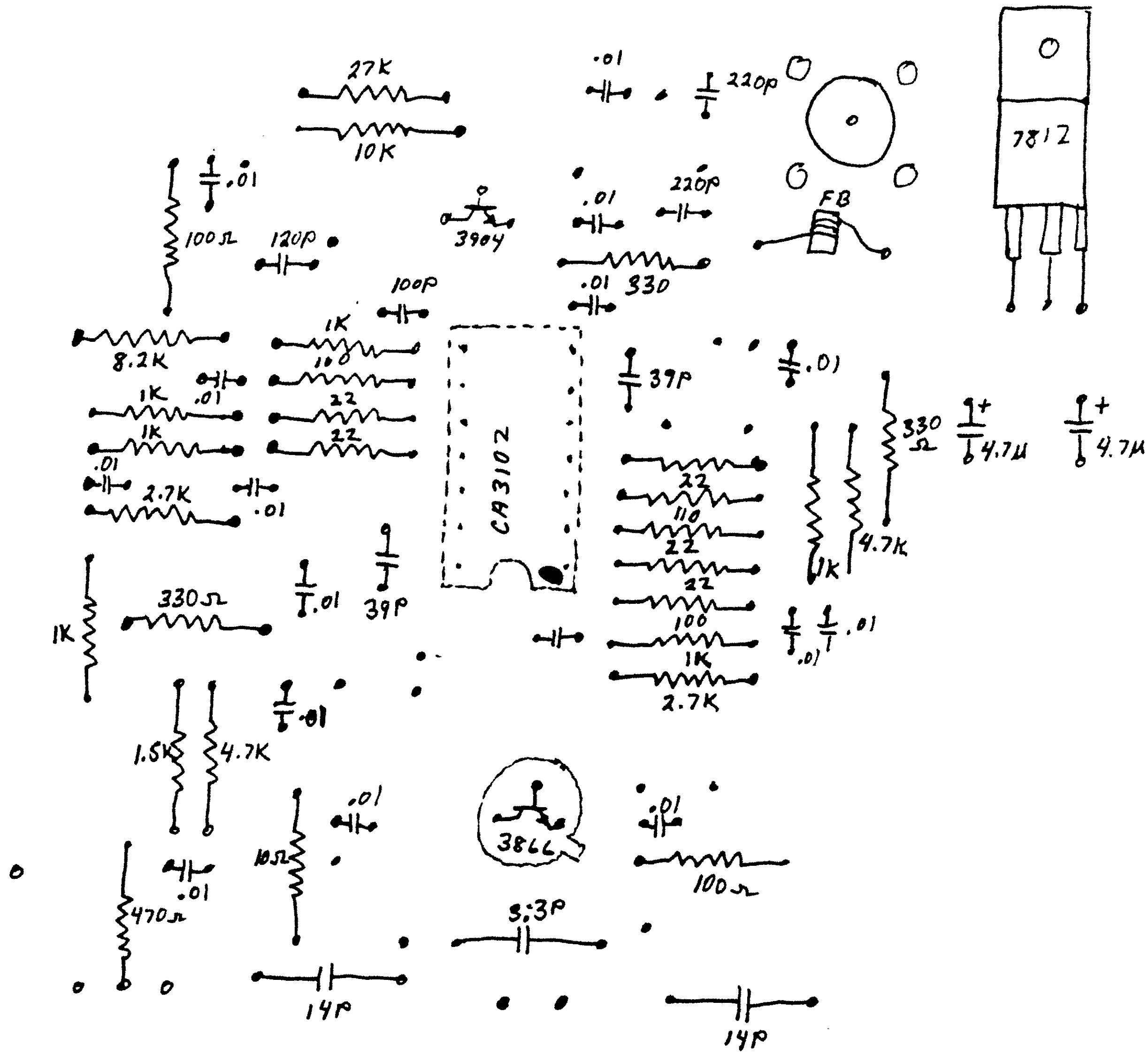
VSWR (1565-1585 MHZ), < 1.4

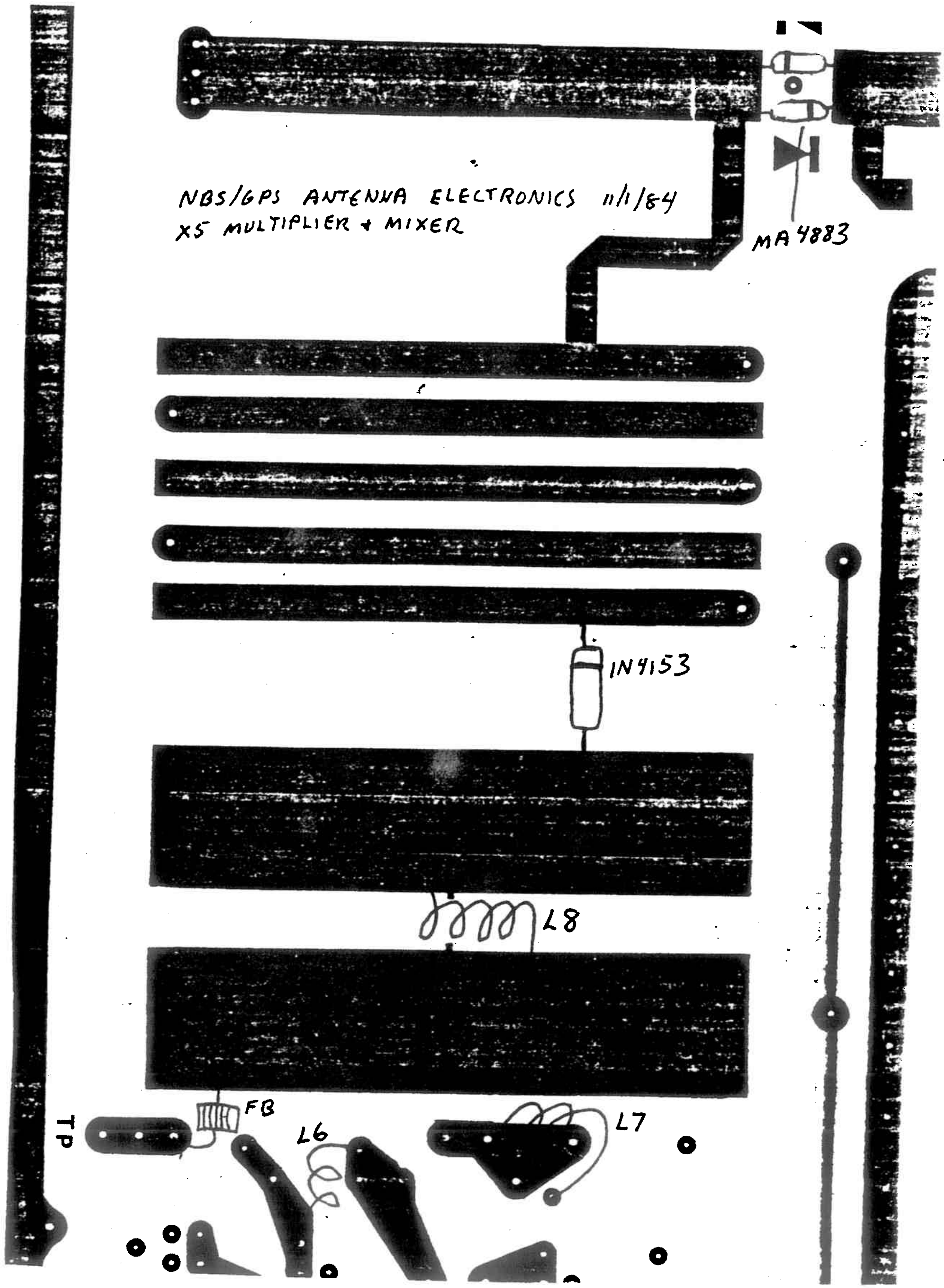
GAIN: WITHIN 2 dB OVER 1565-1585 MHZ, WHEN EXCITED WITH SIGNAL SOURCE @ 30° ELEVATION.

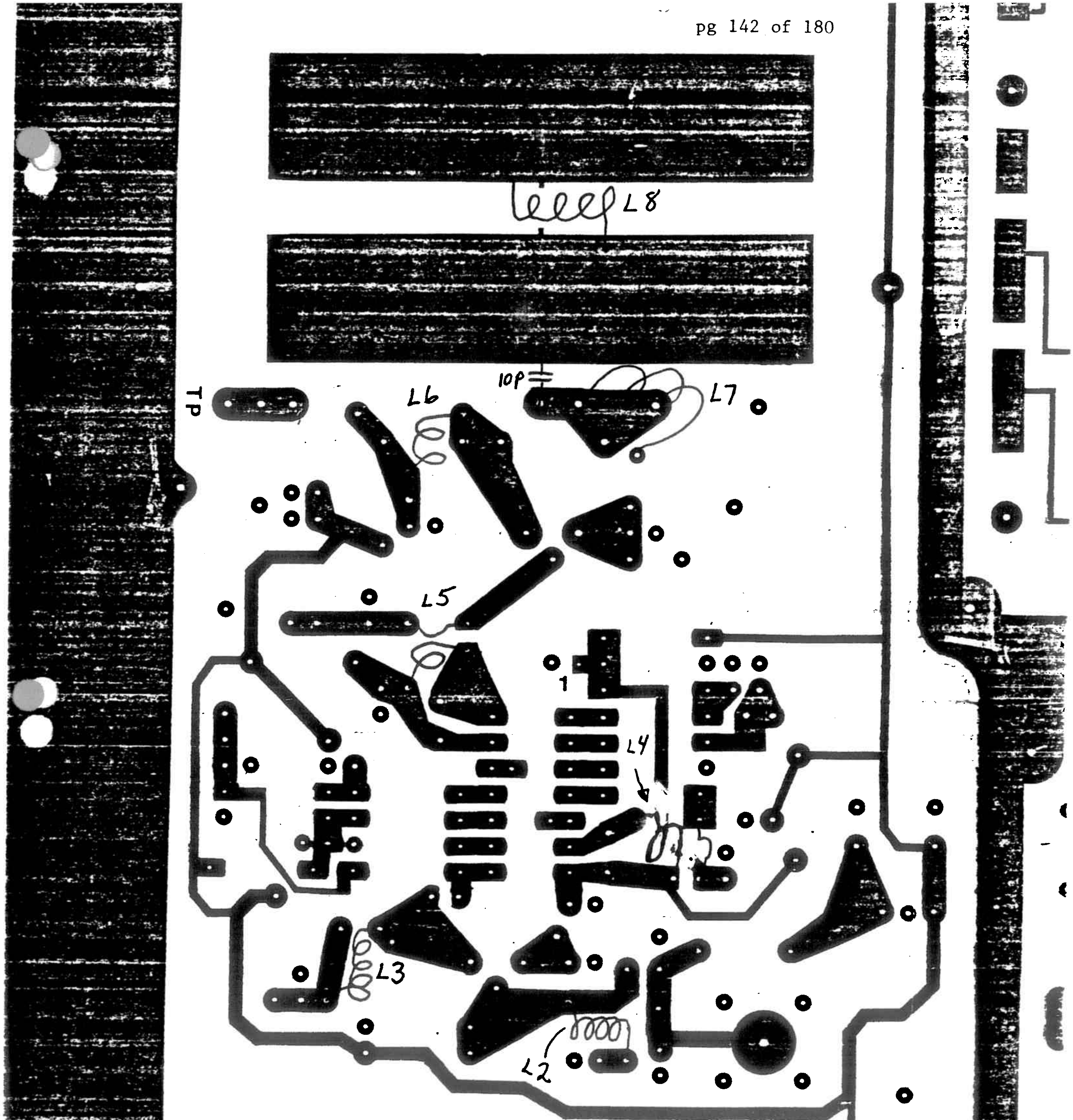
GAIN: UNIFORM WITHIN 2 dB WHEN ANTENNA IS ROTATED WITH SIGNAL SOURCE @ 30° ELEVATION.

TIME REQUIRED TO BUILD + TEST ANTENNAS IN QUANTITIES OF 5: APPROX 1 DAY. (SLOW WORKER)

NBS/GPS ANT ELECTRONICS 11/1/84
PARTS LOCATION, X3 MULTIPLIER + BUFFER



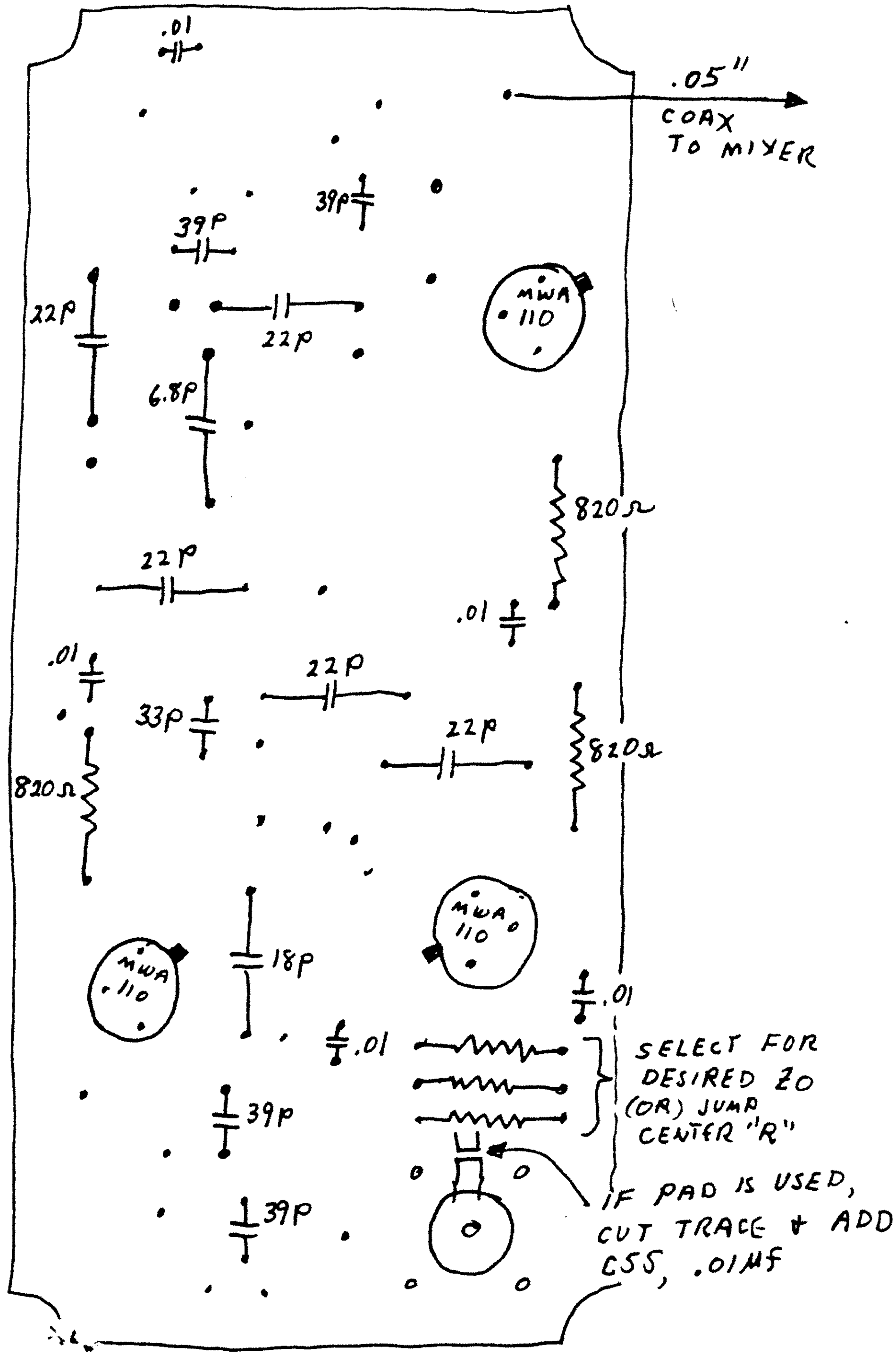

NBS/GPS ANTENNA ELECTRONICS 11/1/84
X5 MULTIPLIER + MIXER
MA 4883
IN4153
L8
FB
L6
L7
TP



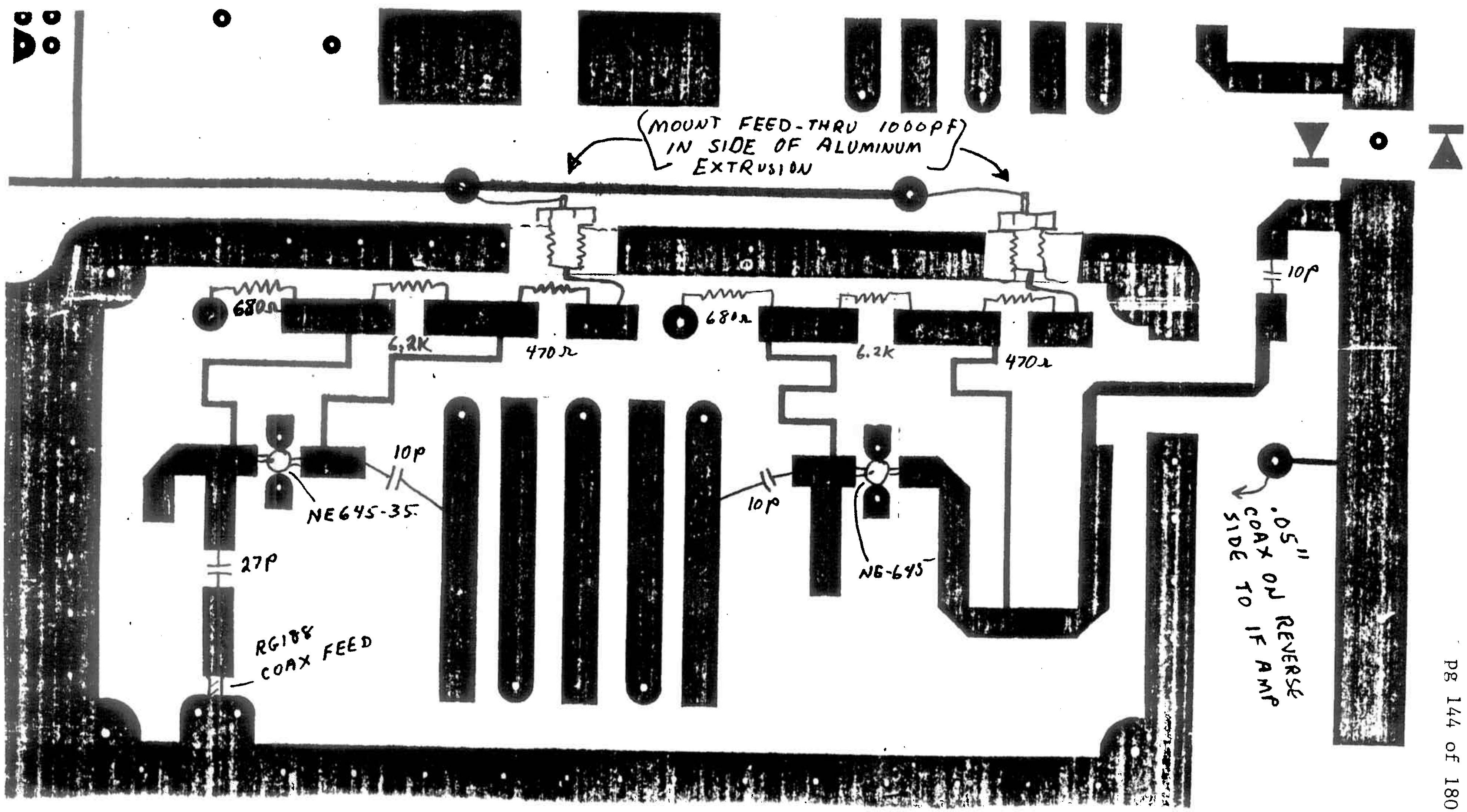
X3 MULTIPLIER CKT SIDE COMPONENTS

DOWN CONVERTER
MODEL NBS/GPS-2 D
SERIAL NUMBER ________

NBS/GPS ANT ELECTRONICS 11/1/84
IF AMP COMPONENT LOCATION

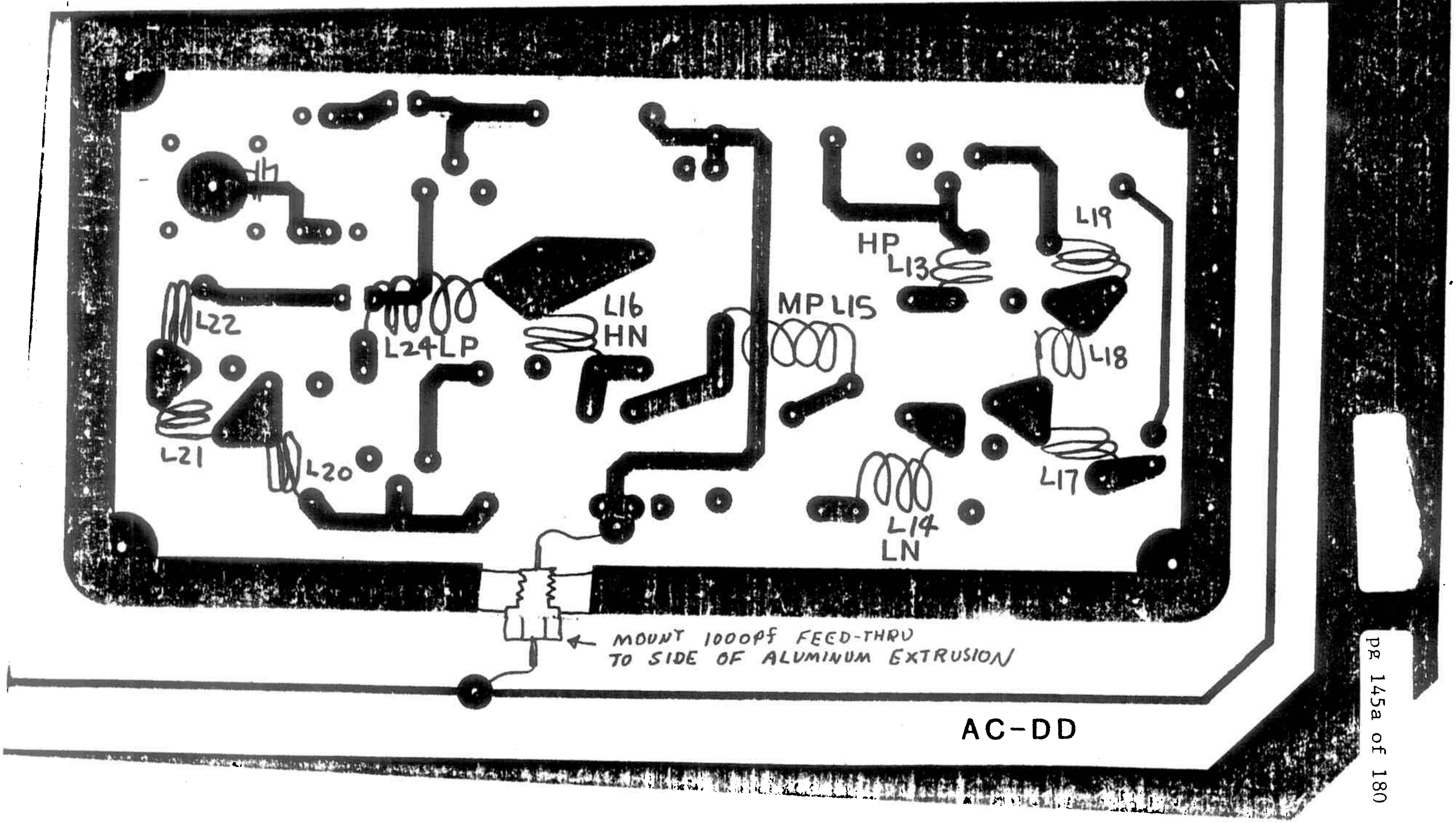


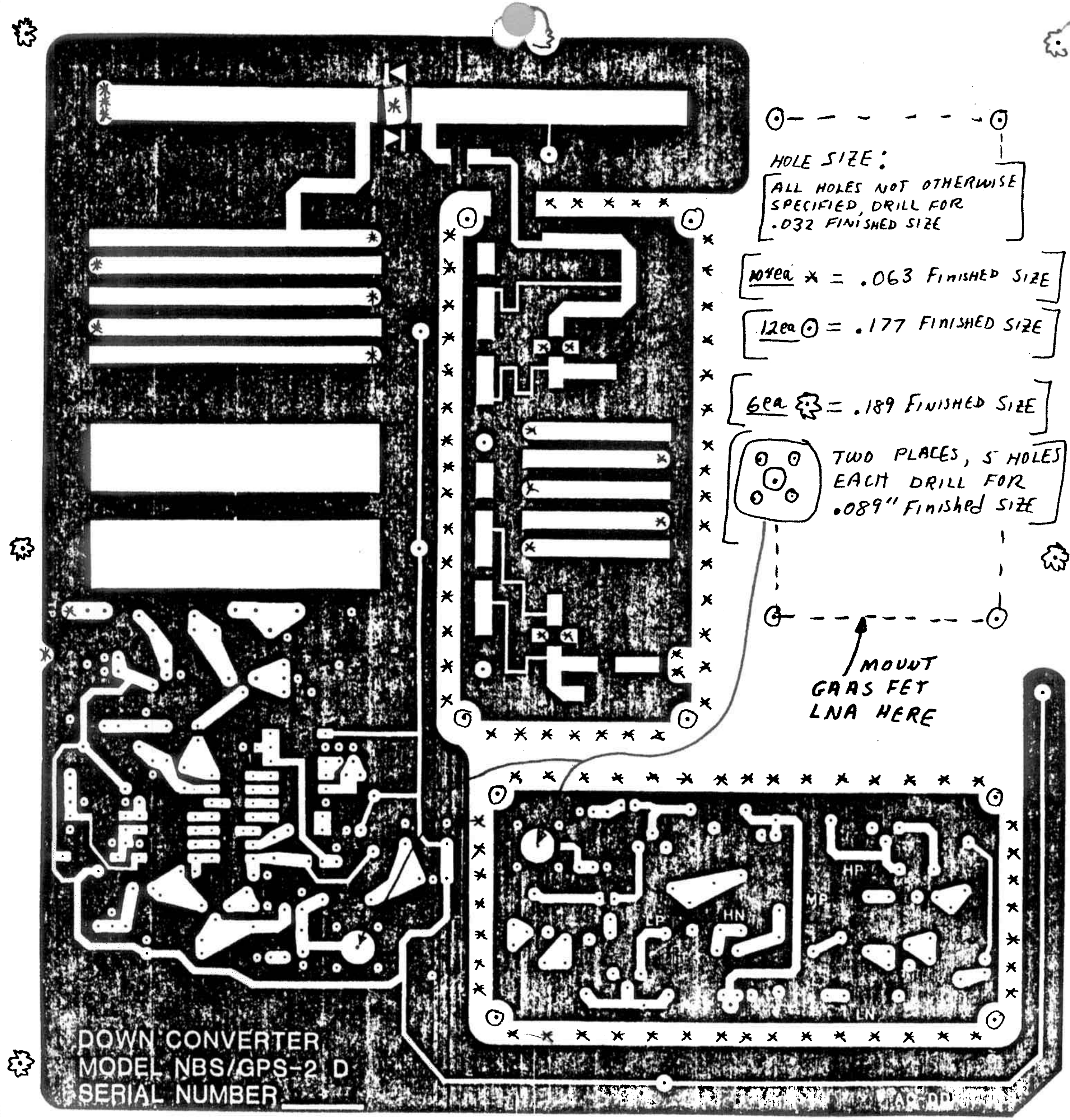
NBS/GPS ANTENNA ELECTRONICS
PARTS LAYOUT - BIPOLAR RF AMP -11/1/84-



NBS/GPS ANTENNA ELECTRONICS - 11/1/84
IF AMP COIL LOCATIONS

NOTE: REFER TO COIL WINDING LIST
FOR # TURNS AND DIAMETER




HOLE SIZE:
ALL HOLES NOT OTHERWISE SPECIFIED, DRILL FOR .032 FINISHED SIZE
104ea ✳ = .063 FINISHED SIZE
12ea ⊙ = .177 FINISHED SIZE
6ea ✿ = .189 FINISHED SIZE
TWO PLACES, 5 HOLES EACH DRILL FOR .089" Finished SIZE
MOUNT GAAS FET LNA HERE
HP
MP
HN
LP
LN
DOWN CONVERTER
MODEL NBS/GPS-2 D
SERIAL NUMBER

SET UP

NBS/GPS TIME TRANSFER RECEIVER

INITIAL SET-UP

After unpacking the equipment, inventory to make sure all items are included.

1. Antenna Electronics Package (Metal Drum, approximately 10 1/4" in diameter and 22" high, including fiberglass antenna dome, three BNC Connectors are on bottom end, labelled "100 MHZ", "MIX BIAS", and antenna".) (NO) - SEE ANT
2. Receiver - 5"H x 16 1/2"D x 16 1/2" wide, Rack mount
3. Microprocessor, Counter - 7" H X 16 1/2" D X 16 1/2" wide, Rack Mount
4. Keyboard, RCA VP601
5. Printer, EPSON MX80
6. Miscellaneous cables as follows:
   - A. dc Power, RCVR to processor, braided, with 9 pin Amphenol conn, (Approx. 4 ft. long)
   - B. 34 PIN ribbon, Approximately 4 ft. long (RCVR to processor)
   - C. 20 pin ribbon, approx. 4 ft. long (KBD to processor)
   - D. BNC, BNC - 4 ft. long, IPPS RCVR to IPPS CTR STOP
   - E. BNC, BNC - 4 ft. long, 5 MHZ RCVR out to 5 MHZ CTR IN
   - F. BNC, BNC - 150 ft. Ant to RCVR*
   - G. BNC, BNC - 150 ft., 100 MHZ RCVR out to MHZ Ant Electronics IN*
   - H. BNC, 9 PIN Amphenol - 150 ft., processor dcpwr to ANT +15 vdc
7. Rack Mount Hardware
   - A. 1 set for 5" RCVR
   - B. 1 set for 7" Processor
8. Rack Slide Drawer for MX80 Printer

* Antenna Cable may have Thru-line Attenuator on one end. If so, the end with the attenuator should be connected to the receiver.

INSTALLATION OF RACK MOUNT EQUIPMENT

Figure 1 indicates a suggested rack mount arrangement of the equipment. If other mounting configurations are used, the following should be considered:

> At least 1 1/2" of clearance should be provided above and below the microprocessor and receiver for adequatp ventilation.
>
> The keyboard should be immediately below the microprcessor for ease of use of the KBD/Video display.

Make all connections as shown in Figure 2, paying particular attention not to reverse connections on the two ribbon cables.

Do not apply power to the microprocessor until the printer is loaded with paper and powered up! (The printer supplies error messages if anything goes wrong on power-up.)

If desired, the rack mount may be powered up before the antenna package is installed, but the
the microprocesser is operating.

INSTALLATION OF ANTENNA PACKAGE

The antenna barrel is equipped with a flat metal plate that may be attached to a metal pipe with muffler clamps (or) screwed to a wood pole or flat surface.

The antenna should be mounted with no obstructions above it or equal in height with it. (Multipath reflections can degrade performance if the delay of the reflected signal is less than 1 microsecond, relative to the direct signal)

Attach the BNC connectors to the antenna electronics barrel.

INITIAL POWER-UP

As soon as power is applied to the microprocessor, the printer should output the following message:

```
PORTS INITIALIZED
READY
```

As soon as the CRT heats up, the video display should appear with the UTC clock running and showing the correct time (within a few seconds)
(The GPS clock runs only while the receiver is tracking a satellite.)

The complete video display should appear as shown in Figure #1, Page 8 of the User's Manual (except) no time will be shown for the GPS clock until the receiver has tracked a satellite.

If all indications are normal, refer to the User's Manual for the correct procedure to set up a tracking schedule and for normal receiver operating procedures.

If the printer has output error messages or there is any other indication of receiver malfunction, contact Dick Davis at NBS Boulder (303) 497-3639, FTS: 320-3639.

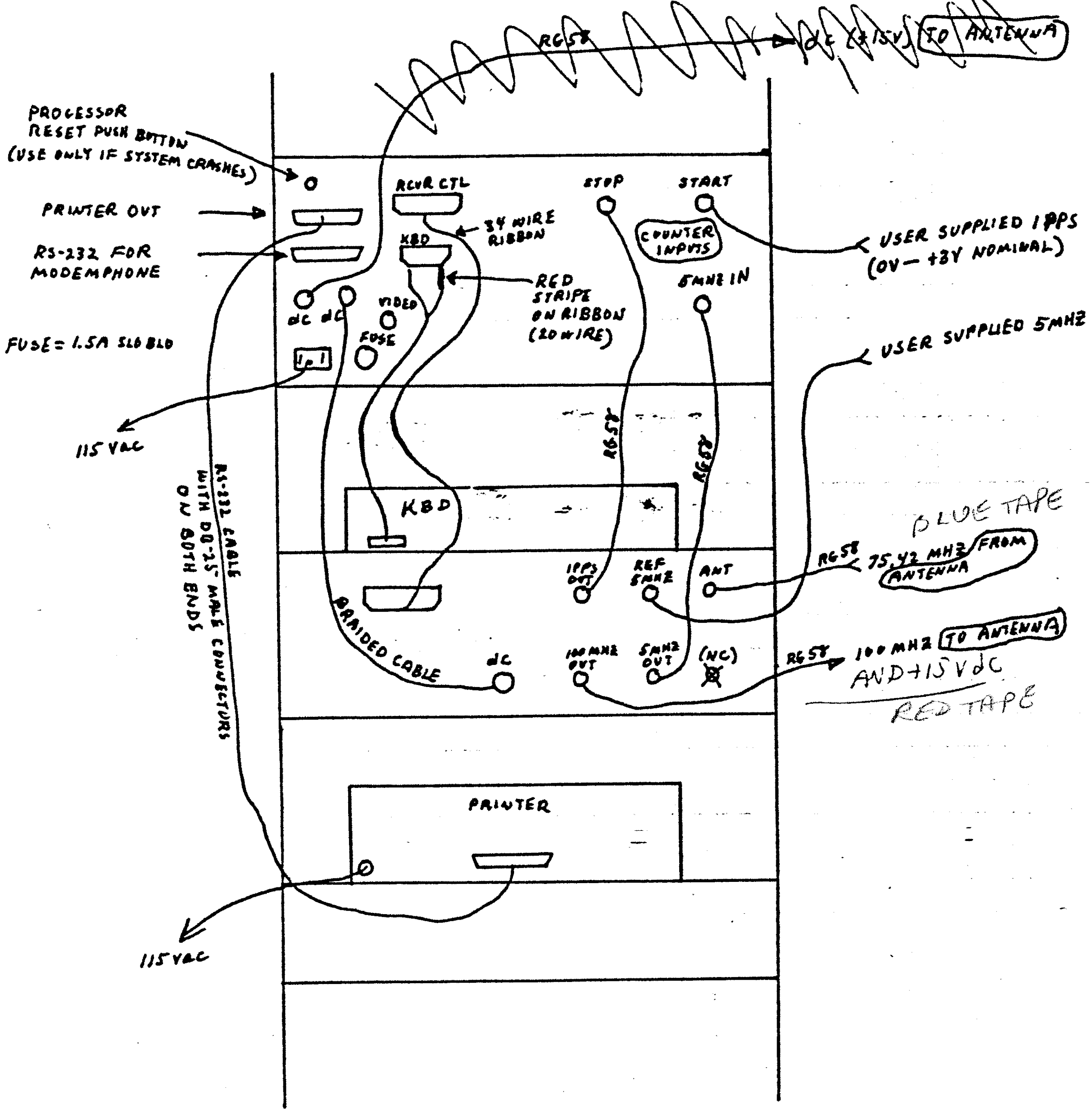


FIGURE 2.
REAR VIEW OF INTERCONNECTIONS TO NBS/GPS TIME TRANSFER SYSTEM

1. ALL CABLES ARE SUPPLIED EXCEPT USER 1PPS + USER 5MHZ
2. USE MARKED CABLES FROM (RCVR 1PPS TO COUNTER STOP) + (5MHZ OUT TO CTR 5MHZ IN)
3. 34 WIRE RIBBON CABLE IS NOT POLARIZED! INSTALL SO IT DOES NOT HAVE 180° TWIST
4. 20 WIRE KBD CABLE SHOULD BE INSTALLED WITH RED STRIPE AS SHOWN
5. ALL CABLES SHOULD BE INSTALLED BEFORE APPLYING POWER
6. USER SUPPLIED 1PPS SHOULD BE 0V → +3V, POSITIVE GOING "ON TIME"
   IF LEVEL IS GREATER THAN +4V, USE "IN LINE" ATTENUATOR.
   (BOTH START + STOP COUNTER INPUTS ARE INTERNALLY TERMINATED IN 50Ω.)
7. USER SUPPLIED 5MHZ SHOULD BE 1V rms (NOMINAL) -- NOT CRITICAL
8. A STANDARD 525 LINE VIDEO MONITOR MAY BE CONNECTED TO
   THE VIDEO OUT BNC ON MICROPROCESSOR IF A LARGER DISPLAY IS DESIRED. (TERMINATE IN 75Ω)

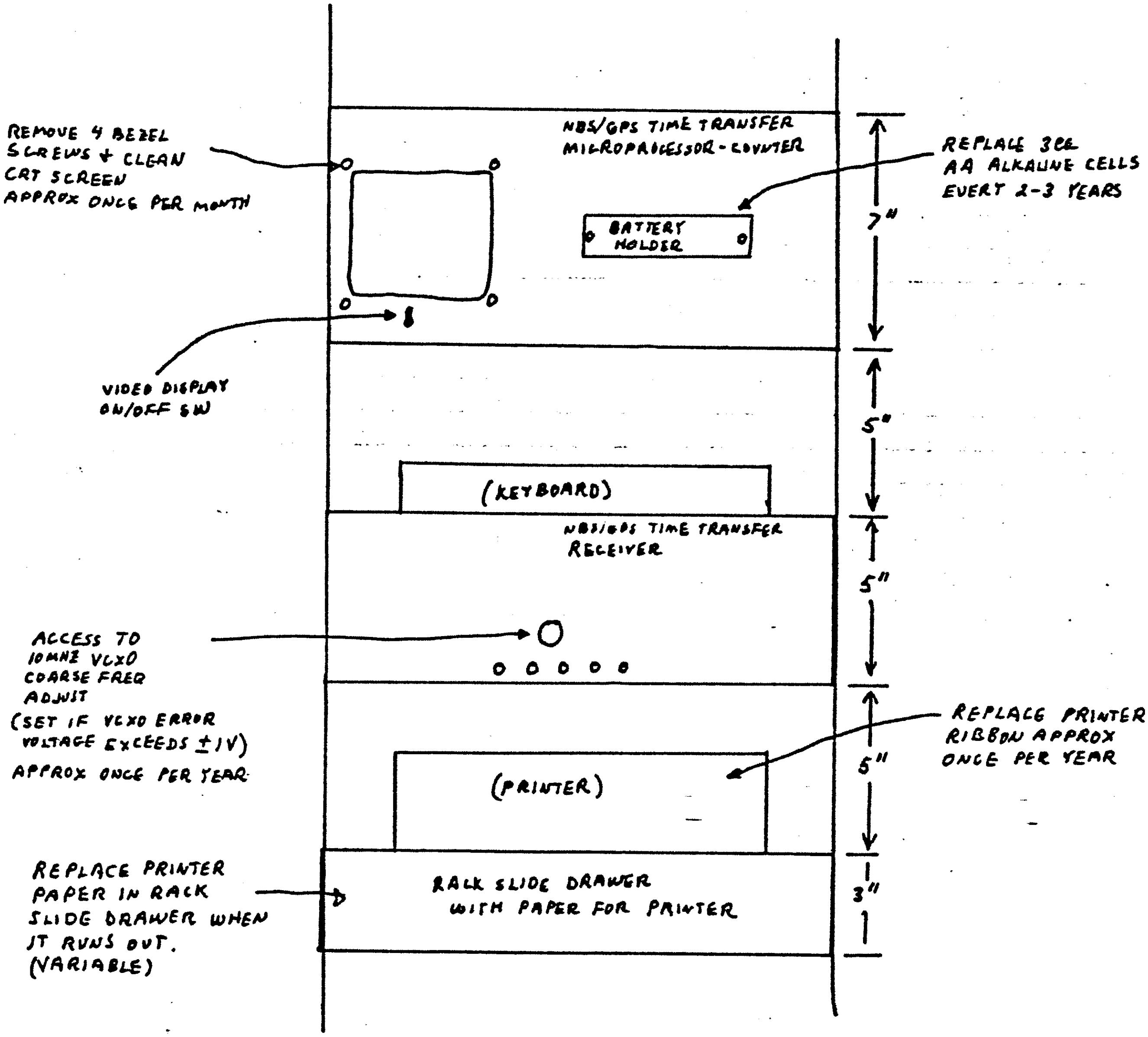
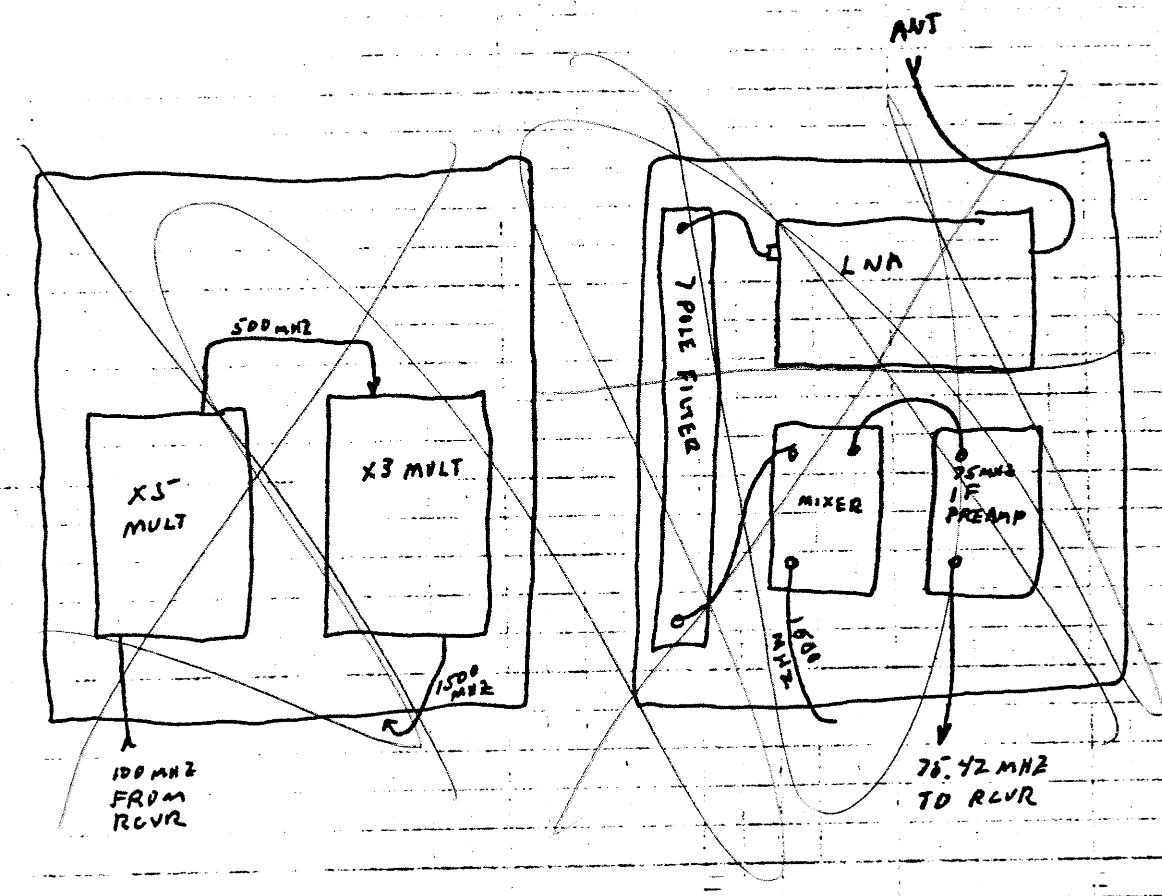
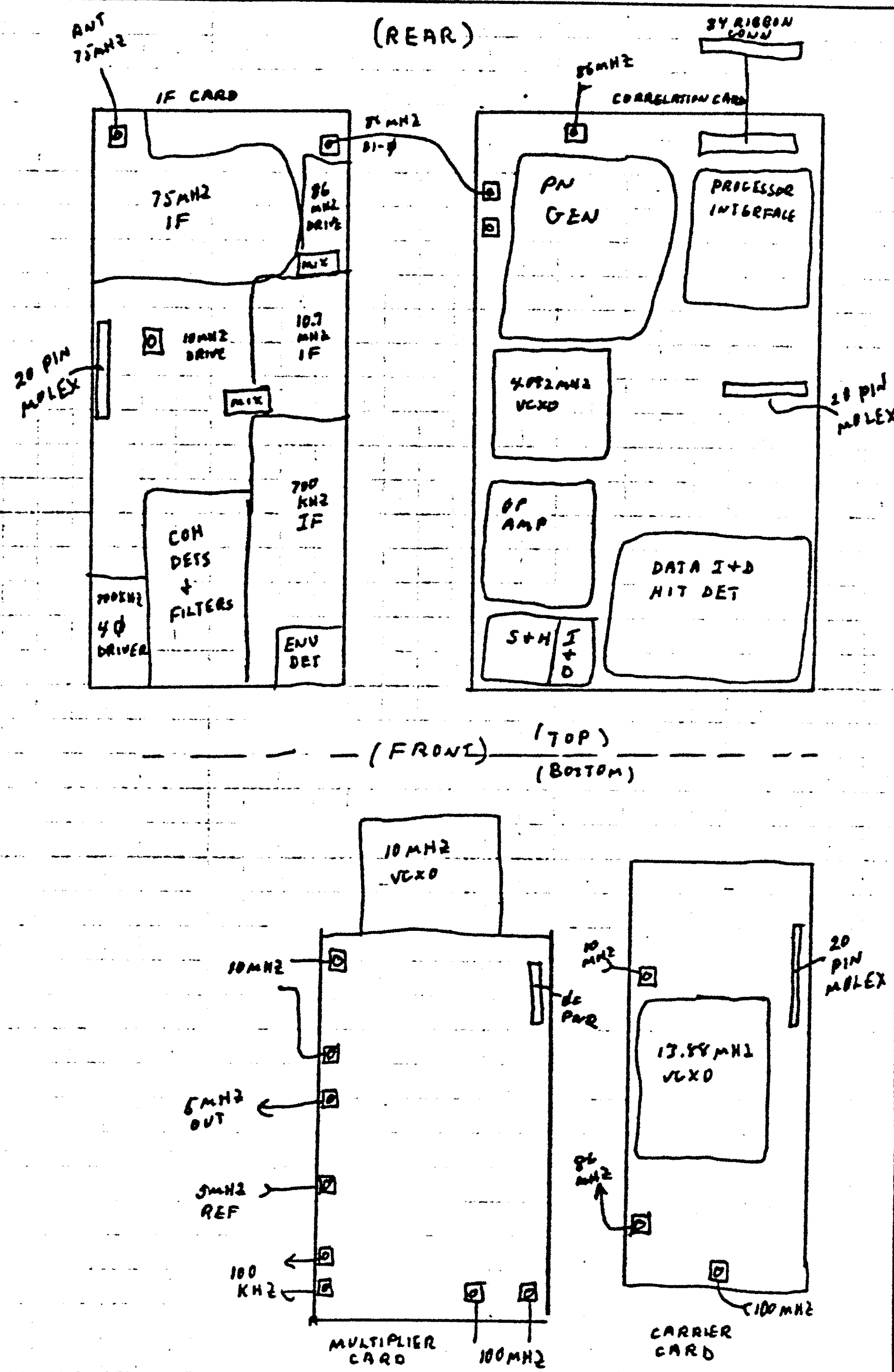


FIGURE 1.
SUGGESTED RACK MOUNTING (FRONT VIEW)

ANTENNA ELECTRONICS

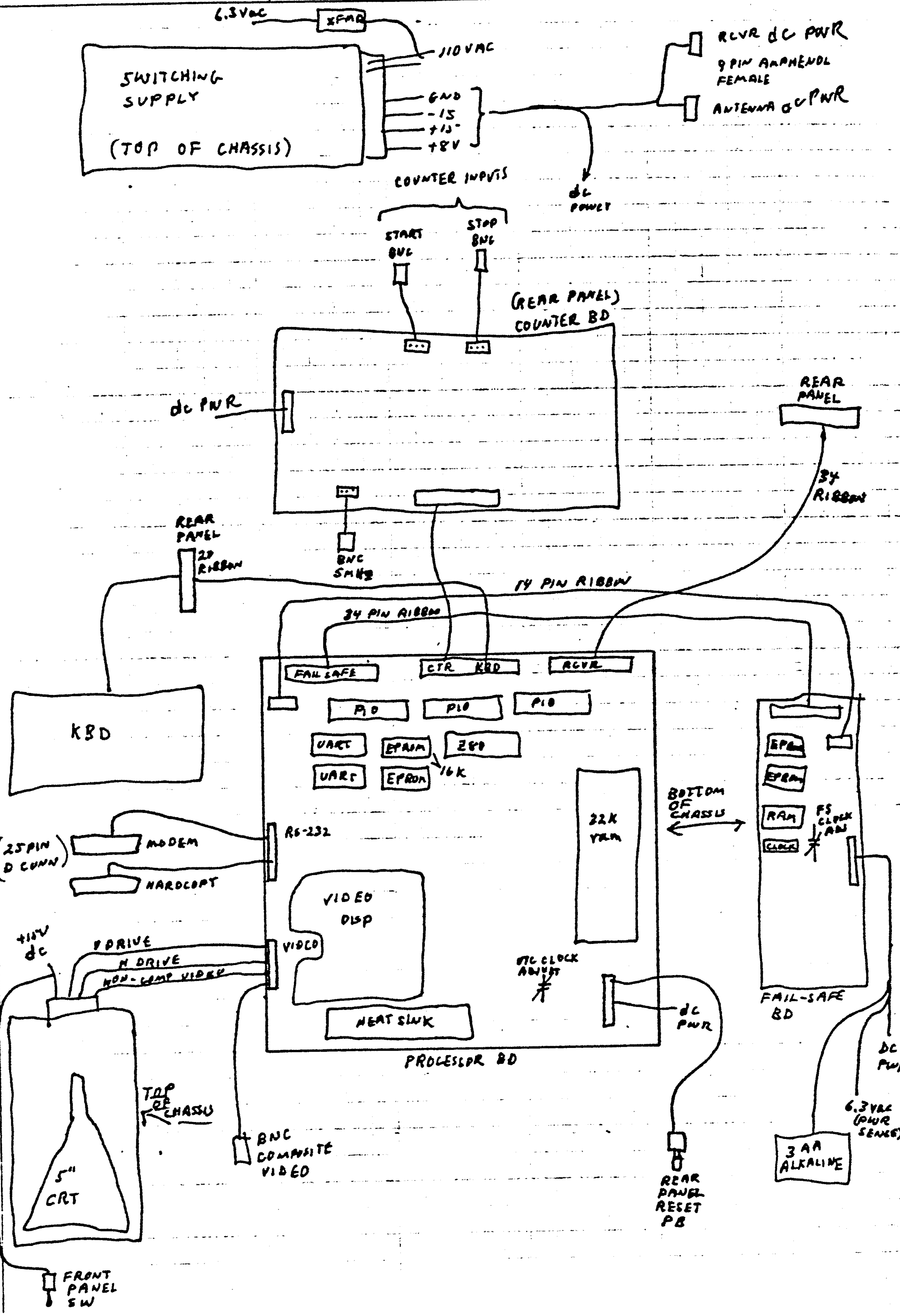


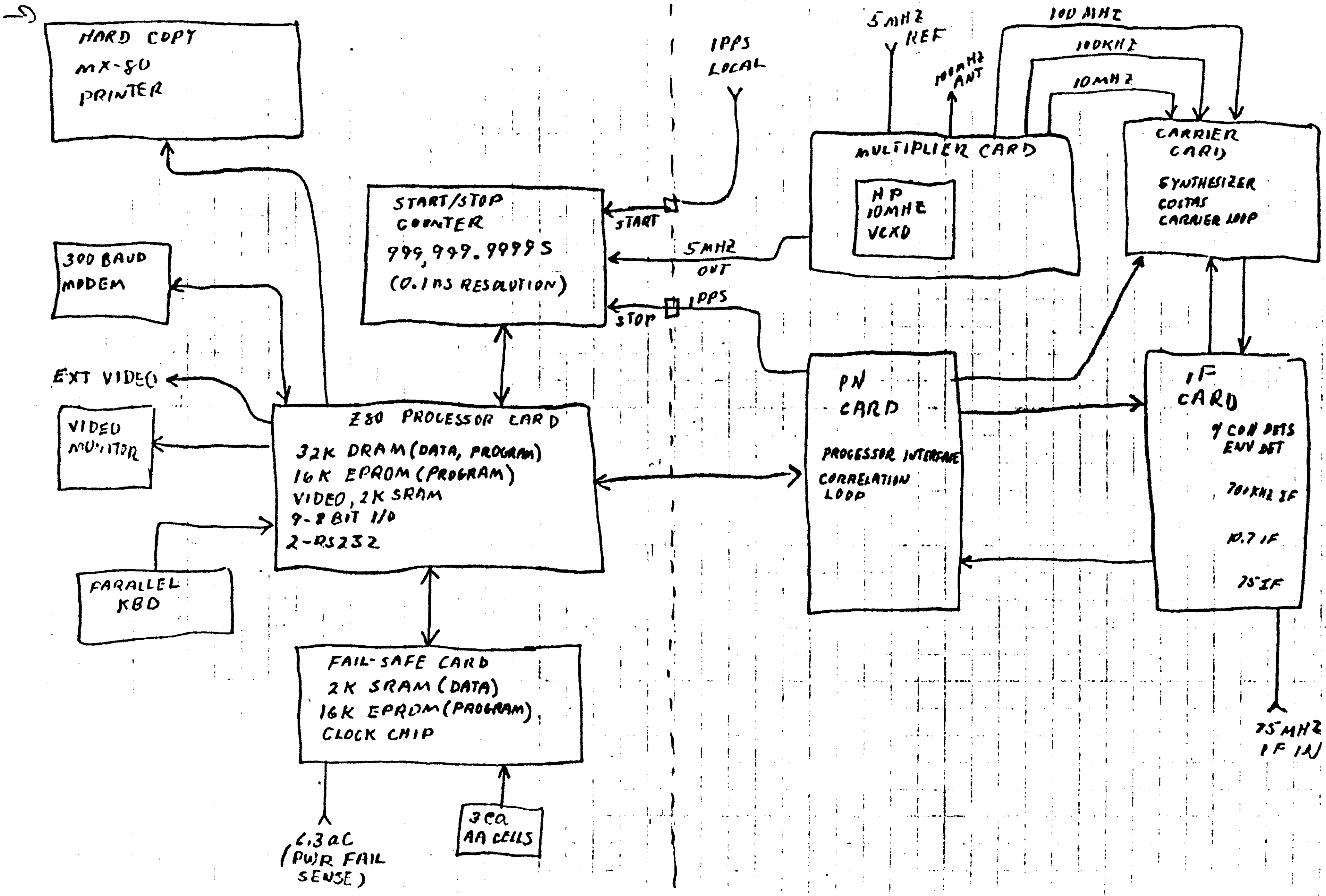
RECEIVER CHASSIS



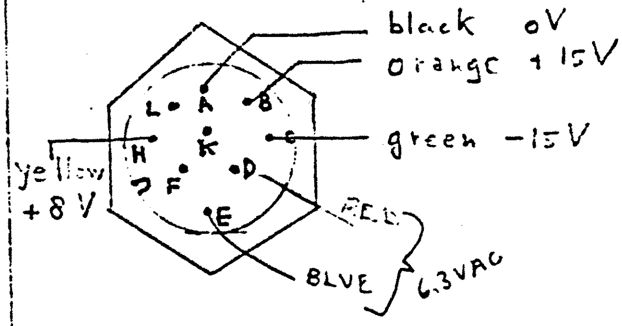
7

PROCESSOR CHASSIS




HARD COPY
MX-80
PRINTER
300 BAUD
MODEM
EXT VIDEO
VIDEO
MONITOR
PARALLEL
KBD
START/STOP
COUNTER
999,999.9999 S
(0.1 nS RESOLUTION)
Z80 PROCESSOR CARD
32K DRAM (DATA, PROGRAM)
16K EPROM (PROGRAM)
VIDEO, 2K SRAM
9-8 BIT I/O
2-RS232
FAIL-SAFE CARD
2K SRAM (DATA)
16K EPROM (PROGRAM)
CLOCK CHIP
6.3 AC
(PWR FAIL
SENSE)
3 ea.
AA CELLS
1PPS
LOCAL
START
5 MHZ
OUT
1PPS
STOP
5 MHZ
REF
100 MHZ
ANT
MULTIPLIER CARD
HP
10 MHZ
VCXO
100 MHZ
100 KHZ
10 MHZ
CARRIER
CARD
SYNTHESIZER
COSTAS
CARRIER LOOP
PN
CARD
PROCESSOR INTERFACE
CORRELATION
LOOP
IF
CARD
4 COH DETS
ENV DET
700 KHZ IF
10.7 IF
75 IF
75 MHZ
IF IN

POWER SUPPLY CONNECTOR



Power needed:		Switching Power Supply:
+15V	2.5A	2.5A
-15V	1 A	1.5A
+8V	1.5A	2A

OSC. oven: 24V 0.4A max, (43Ω @ cold start)
supplied by -15V and +8V:
23V, 0.5A

RECEIVER CHASSIS WIRING | (MOLEX CONNECTORS) | 5/7/82 – D³

IF CARD

(FCN)	Ⓐ	(TO)
AGC	1	Ⓒ-10 (BROWN)
GND	2	✓
IF GAIN	3	✓
(NC)	4	POLARIZE
GND	5	✓
GND	6	✓
+15V	7	+15V (ORANGE)
+15V	8	+15V (ORANGE)
GND	9	PWR GND (BLACK)
GND	10	✓
-15V	11	-15V (GN)
-15V	12	-15V (GN)
GND	13	✓
GND	14	Ⓒ-13 (RED)
GAIN SW	15	✓
ENV DET	16	✓
45×45	17	Ⓒ-11 (OR)
0×90	18	Ⓒ-4 (YL)
90 DET	19	✓
GND	20	✓

PN CARD

(FCN)	Ⓑ	(TO)
CARRIER SYNTHESIZE BITS 5	1	Ⓒ-9 (BLUE)
CARRIER SYNTHESIZE BITS 4	2	Ⓒ-8 (GN)
CARRIER SYNTHESIZE BITS 1	3	Ⓒ-5 (YL)
CARRIER SYNTHESIZE BITS 3	4	Ⓒ-7 (OR)
CARRIER SYNTHESIZE BITS 2	5	Ⓒ-6 (R)
IF GAIN	6	Ⓐ-3 (WH)
CARRIER LOCK	7	Ⓒ-12 (BN)
SYN CARR	8	Ⓒ-2 (BLACK)
GAIN SW	9	Ⓐ-15 (GRAY)
DATA I+D	10	P-(FRONT PANEL)(WHITE)
50 HZ SYNC	11	P-(FRONT PANEL)(RED)
ENV DET	12	Ⓐ-16 (VIOLET)
90 DET	13	Ⓐ-19 (BLUE)
GND	14	Ⓐ-13 (GN)
+8V	15	+8V (YELLOW)
NC	16	NC
-15V	17	-15V (GN)
NC	18	POLARIZE
+15V	19	+15V (ORANGE)
GND	20	POWER GND (BLACK)

CARRIER CARD

(FCN)	Ⓒ	(TO)
GND	1	→ MULTIPLIER SMA CONN
SYN CARR	2	✓
100 kHz	3	→ MULTIPLIER SMA CONN
0×90	4	✓
CARRIER SYNTHESIZE BITS 1	5	✓
CARRIER SYNTHESIZE BITS 2	6	✓
CARRIER SYNTHESIZE BITS 3	7	✓
CARRIER SYNTHESIZE BITS 4	8	✓
CARRIER SYNTHESIZE BITS 5	9	✓
AGC	10	✓
45×45	11	✓
LOCK	12	✓
GND	13	✓
GND	14	POWER GND (BLACK)
+8V	15	+8V (YELLOW)
+8V	16	+8V (YELLOW)
+15V	17	+15V (ORANGE)
+15V	18	+15V
CARR VCXO	19	P-(FRONT PANEL) (BROWN)
-15V	20	

MULTIPLIER CARD

(FCN)	Ⓓ	(TO)
(NC)	1	✓
(NC)	2	POLARIZE
VCXO 10 MHZ	3	P-(FRONT PANEL)(GRAY)
GND	4	P-FRONT PANEL) (BLACK)
-15V	5	-15V (GREEN)
+15V	6	+15V (ORANGE)
+8V	7	+8V (YELLOW)
GND	8	PWR GND (BLACK
(NC)	9	✓
(NC)	10	✓

NOTES:

1- SIGNAL RUNS ARE IDENTIFIED BY DESTINATION ONLY ON ONE END, BY CHECK (✓) ON OTHER.

2- SIGNAL RUNS ARE 26GA

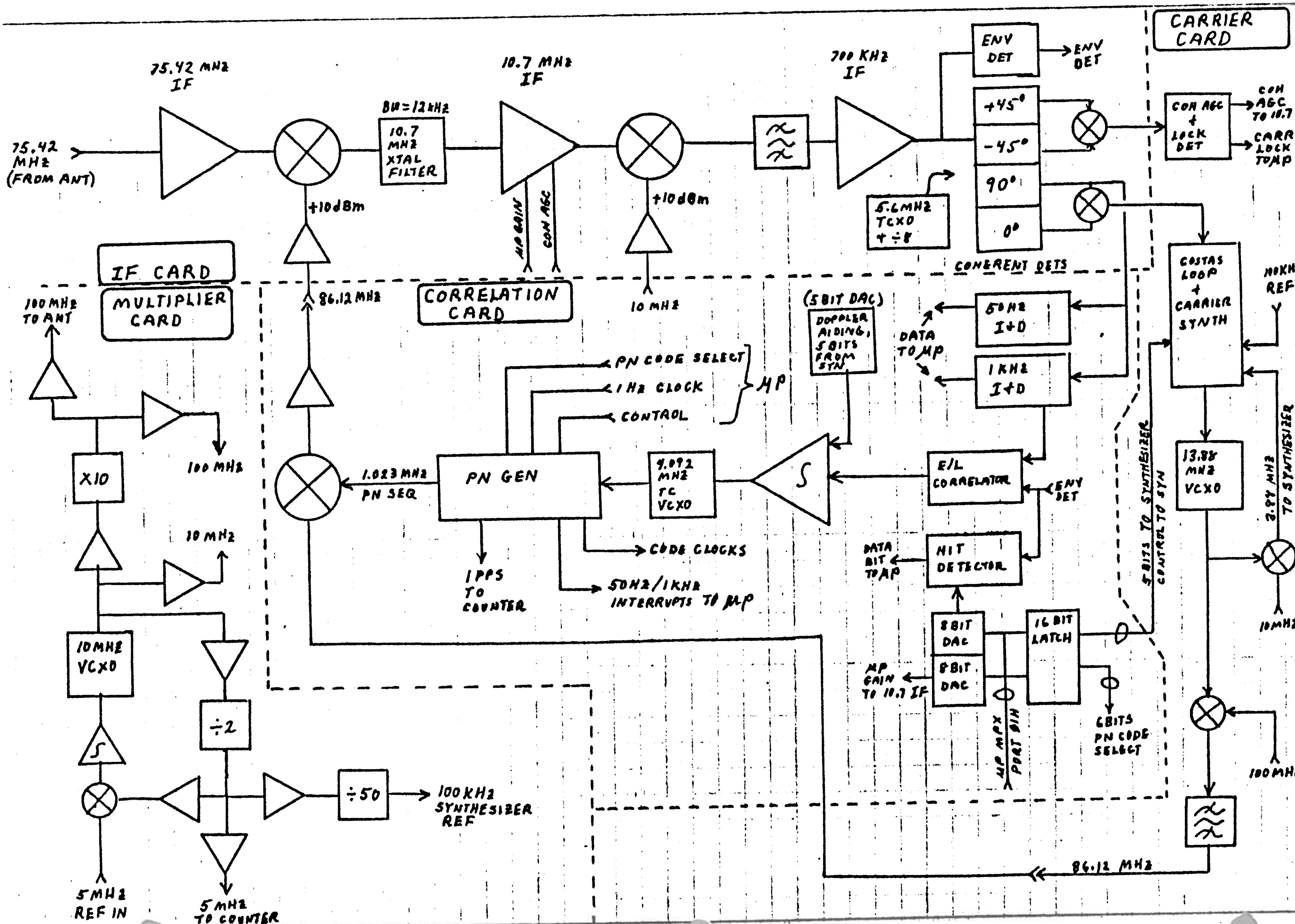
3- POWER RUNS ARE 22 GA

11

BLOCK DIAGRAM

NBS/GPS RCVR

MAR 3, 1982 – P3



PROCESSOR/COUNTER ADJUSTMENTS

1. 7.68 MHZ OSC ADJUST (UTC CLOCK)

2. 32 KHZ OSC ADJUST (FAIL-SAFE CLOCK)

3. TIME INTERVAL COUNTER ADJUSTMENTS.
   - A. START-STOP THRESHOLD
   - B. CROSSOVER MARGIN
   - C. MULTIPLE CALIBRATE TEST

RECEIVER ADJUSTMENTS

1. MULTIPLIER CARD TUNE-UP
   - A. ALIGNMENT SEQUENCE
   - B. OUTPUT LEVELS
   - C. SPECTRUM CHECKS

2. CARRIER CARD
   - A. VERIFICATION OF SYNTHESIZER OPERATION
   - B. RF ALIGNMENT
   - C. AGC ADJUST

3. IF AMPLIFIER
   - A. 75 MHZ ALIGNMENT, GAIN TEST
   - B. 86 MHZ LEVEL TEST
   - C. 10.7 MHZ ALIGNMENT, GAIN TEST
   - D. 10 MHZ LO ALIGNMENT, LEVEL TEST
   - E. 700 KHZ ALIGNMENT, GAIN TEST
   - F. COHERENT DET OFFSET ADJUST
   - G. HIGH-LOW GAIN SW ADJUST
   - H. 4 QUADRANT MULTIPLIER OFFSET CHECK

4. CORRELATION CARD
   - A. BI-PHASE MODULATOR CARRIER NULL
   - B. BI-PHASE MOD TUNING
   - C. SAMPLE/HOLD BALANCE
   - D. CORRELATION VCXO CENTER FREQ ADJUST
   - E. CORRELATION SERVO INTEGRATOR TEST

ADJUSTMENT OF 7.68 MHZ OSCILLATOR (UTC CLOCK) (on μ processor board)

THE 7.68 MHZ XTAL OSCILLATOR ON THE PROCESSOR CARD IS USED TO DERIVE 19.2KHZ FOR THE TWO UARTS, 3.84 MHZ FOR THE Z80, AND 75HZ FOR THE UTC SOFTWARE CLOCK.

TO SET THE 7.68 MHZ OSCILLATOR, CLIP SCOPE PROBE TO U16 PIN 6 ON THE FAIL-SAFE CARD (1200HZ). SYNC SCOPE WITH THE 1PPS NORMALLY APPLIED TO THE COUNTER START INPUT. ADJUST THE 7.68MHZ TRIMMER CAPACITOR UNTIL THE 1200 HZ IS MOVING LESS THAN 1μS/SEC.

ADJUSTMENT OF THE 32KHZ OSCILLATOR IN THE FAIL-SAFE CLOCK.

CONFIGURE THE CLOCK CHIP (U9) ON THE FAIL-SAFE CARD TO GENERATE 1KHZ TIMING PULSES BY ISSUING THE FOLLOWING COMMANDS TO THE RS-232 MODEM PORT:

(DONT ACTUALLY TYPE QUOTES)
CARRIAGE RETURN KEY

PRIVILEDGED CMD: "QWERDXCMD"(CR) (RESPONSE IS "OK")
CONFIGURE 8255 PORT: "8B0B5CSCMD"(CR) (RESPONSE IS "DONE")
CONFIGURE U9 TO READ: "FF084CSCMD"(CR) (RESP IS "DONE")
"E00854SCMD"(CR) (RESP IS "DONE")

CLOCK CHIP ON FAIL-SAFE CARD IS NOW GENERATING 1KHZ PULSES SO CLIP SCOPE PROBE TO U9;PIN9 ON FAIL SAFE CARD. SYNC SCOPE WITH 1PPS + ADJUST C13 ON FAIL-SAFE CARD UNTIL 1KHZ IS MOVING LESS THAN 1μS/SECOND.

REMOVE SCOPE PROBE + RE-CONFIGURE CLOCK CHIP FOR NORMAL OPERATION WITH THE FOLLOWING COMMAND SEQUENCE:

"QWERDXCMD" (CR)
"000854SCMD"(CR)
"00084CSCMD"(CR)

SINCE NORMAL OPERATION OF THE CLOCK CHIP HAS BEEN INTERRUPTED DURING THE TIME IT WAS GENERATING 1KHZ TIMING PULSES, DO A UTC CLOCK SET OPERATION UNDER "COLD START" COMMANDS.

TIME INTERVAL COUNTER ADJUSTMENTS

START - STOP THRESHOLD

① CLIP DIGITAL VOLTMETER TO IC U9-11, (-) LEAD TO GROUND. ADJUST R9 FOR +0.5V @ U9-11.

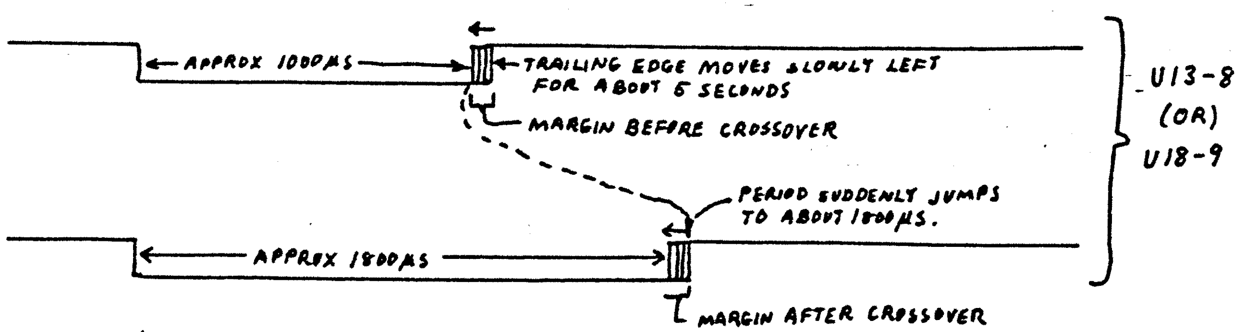
② REPEAT, IC U10-11, ADJUST R13 FOR +0.5V @ U10-11.

CALIBRATE CROSSOVER MARGIN

① CLIP SCOPE PROBE TO U13-8 (START INTERPOLATOR)

② FORCE A COUNTER CALIBRATE CYCLE + OBSERVE THE DURATION OF (-) WAVEFORM. (SET SCOPE FOR "NORMAL", NOT "AUTO TRIGGER + ADJUST FOR TRIGGERING ON (-) TRANSITION.

③ ADJUST R65 SO MARGIN BEFORE CROSSOVER APPROXIMATELY EQUALS MARGIN AFTER CROSSOVER DURING THE 10 SECOND FAST MEASUREMENT PORTION OF THE CALIBRATE CYCLE. (SEE BELOW)



(IT MAY BE NECESSARY TO FORCE SEVERAL CALIBRATE CYCLES TO COMPLETE + CHECK THIS ADJUSTMENT)

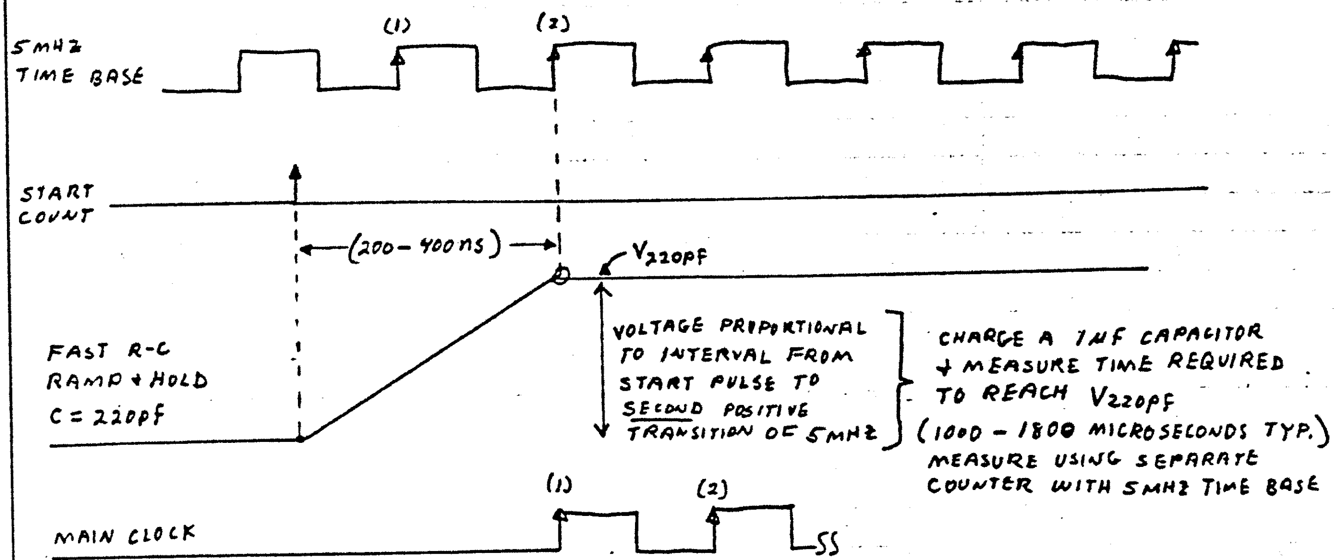
④ CHECK WAVEFORM AT U18-9 + IF NECESSARY, READJUST R65 FOR BEST COMPROMISE.

(THIS ADJUSTMENT DOES NOT AFFECT THE ACCURACY OF THE COUNTER AS LONG AS BOTH THE START + STOP INTERPOLATORS ACTUALLY MAKE THE CROSSOVER JUMP.)

TIME INTERVAL COUNTER – DESCRIPTION OF OPERATION

The time interval counter in the NBS/GPS receiver utilizes analog interpolators to resolve the 200ns ambiguity normally inherent in a counter with a 5MHz time base.

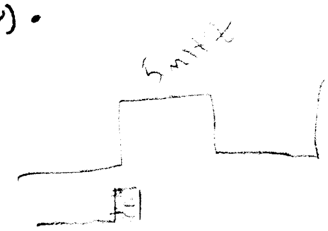
The basic technique is illustrated below.

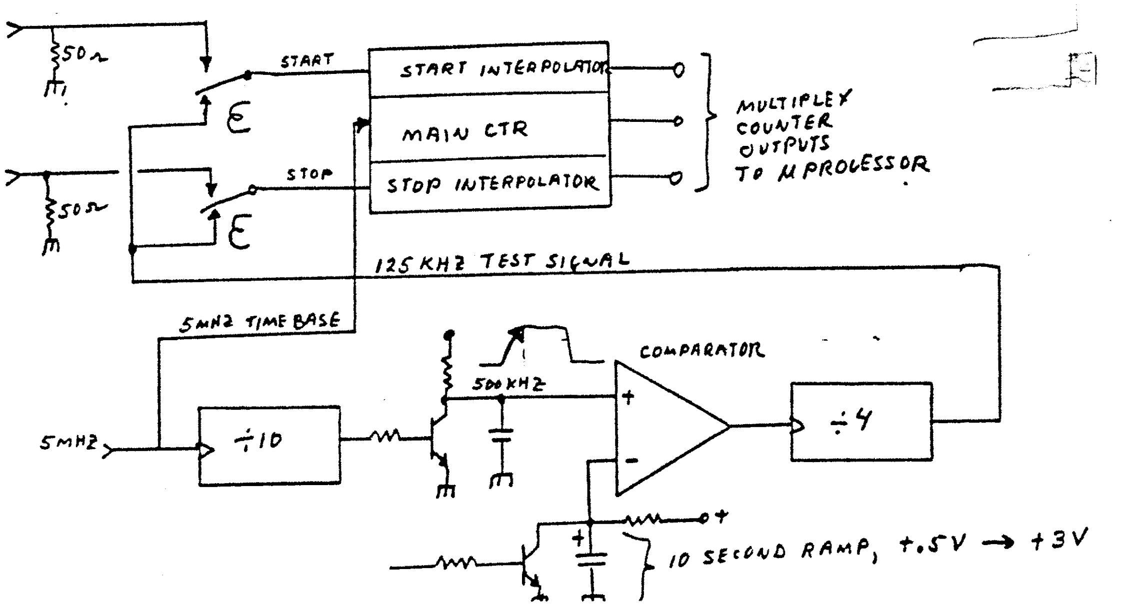


DO SAME THING WITH STOP PULSE, USING A STOP RAMP + HOLD.
THE TOTAL TIME BETWEEN THE START + STOP PULSES (T) IS:

MAIN + (START) – (STOP) + (DELAY CORRECTION)

THE ONLY PROBLEM IS COMPUTING THE SCALING FACTORS FOR THE (START) AND (STOP) ANALOG CIRCUITS AND DETERMINING THE (DELAY CORRECTION).
THIS IS AN IDEAL TASK FOR A MICROPROCESSOR.





THE MICROPROCESSOR SWITCHES A PAIR OF RELAYS TO SELECT A 125KHZ TEST SIGNAL TO THE COUNTER. THE TEST SIGNAL IS DERIVED FROM THE 5MHZ TIME BASE USED BY THE COUNTER. A COMPARATOR + RAMP IS USED TO SLOWLY VARY THE PHASING OF THE TEST SIGNAL RELATIVE TO THE 5MHZ TIME BASE. THE PHASE IS CHOSEN SO THAT THE START + STOP PULSES "BRACKET" A POSITIVE GOING TRANSITION OF THE 5MHZ TIME BASE, +- 25ns.

THIS RESULTS IN THE START + STOP INTERPOLATOR COUNTS GOING THRU THEIR CROSSOVER POINT FROM A MINIMUM TO MAXIMUM AT SOME TIME DURING THE 10 SECOND CALIBRATE INTERVAL. A TOTAL OF 640 START-STOP MEASUREMENTS IS MADE IN 10 SECONDS TO DETERMINE THE HIGH + LOW READINGS FOR THE START + STOP INTERPOLATORS

TYPICALLY, THE LOW INTERPOLATOR READINGS ARE AROUND 5000, CORRESPONDING TO A TIME INTERVAL OF 1000μS WITH THE 5MHZ TIME BASE. THE HIGH READINGS ARE USUALLY AROUND 9000, CORRESPONDING TO A TIME INTERVAL OF 1800μS. AT THIS POINT WE MUST BE CAREFUL TO POINT OUT THAT THE THING WE ARE TRYING TO DETERMINE IS THE <u>DIFFERENCE</u> BETWEEN THE HIGH + LOW COUNTS (9000-5000) AND THE ACTUAL LOW COUNT. THIS DIFFERENCE BETWEEN HIGH + LOW (4000) IS THE SCALING FACTOR FOR THE INTERPOLATOR, AND IS EQUAL TO EXACTLY 200ns, THE PERIOD OF THE TIME BASE. FOR THIS EXAMPLE, THE SCALING FACTOR IS 20 COUNTS/NS (4000 COUNTS/200ns) THE MICROPROCESSOR STORES 1/(SCALING FACTOR) AND (LOW COUNT) FOR BOTH THE START + STOP INTERPOLATORS.

LATER, WHEN MAKING COUNTER MEASUREMENTS, THE μPROCESSOR "READS" THE START, STOP, + MAIN COUNTERS. FOR SIMPLICITY, LETS ASSUME THE START INTERPOLATOR READING IS 7000 COUNTS. TO CONVERT THIS READING TO NANOSECONDS, WE MUST TAKE

$$\underset{\text{ACTUAL COUNT}}{7000} - \underset{\text{LOW COUNT}}{5000} = 2000(1/SF) = \frac{2000}{20} = 100\text{ ns}$$

THIS SAYS THE TIME INTERVAL BETWEEN THE START PULSE + THE NEXT POSITIVE TRANSITION OF THE 5MHZ TIME BASE THAT CAN BE COUNTED BY THE MAIN COUNTER IS 100ns

IF THE STOP INTERPOLATOR HAS A READING OF 6980 COUNTS WITH THE SAME SCALING FACTOR, THEN THE STOP CORRECTION IS 99ns. THE ACTUAL TIME INTERVAL READING WILL BE!

MAIN + (START) − (STOP) + (DELAY CORRECTION)

= MAIN + (100ns) − (99ns) + (DELAY) = (MAIN) + 1ns + (DELAY)

BUT ALAS! WE AT THIS POINT DONT KNOW WHAT THE DELAY CORRECTION IS SUPPOSED TO BE! THIS IS ACTUALLY TAKEN CARE OF DURING THE SECOND HALF OF THE CALIBRATE CYCLE,

DURING THE SECOND HALF OF THE CALIBRATE CYCLE, THE TEST SIGNAL RAMP IS INITIALIZED & A TOTAL OF 10 MEASUREMENTS ARE MADE IN 10 SECONDS. SINCE BOTH START & STOP INPUTS ARE TIED TO THE TEST SIGNAL, THE TIME INTERVAL READING SHOULD EQUAL ZERO:

ϕ = ~~MAIN~~ + START − STOP + (DLY CORR)

(ACTUALLY, THE MAIN COUNTER WILL HAVE A COUNT OF 8.0 MICROSECONDS SINCE THE STOP INTERPOLATOR IS INHIBITED UNTIL THE START INTERPOLATOR IS TRIGGERED)

DLY CORR = STOP − START
= 99ns − 100ns
DLY CORR = −1.0 ns

(ASSUMING THE PRECEEDING EXAMPLE WAS A CALIBRATE DELAY READING.)

AS MENTIONED ABOVE, 10 MEASUREMENTS ARE MADE DURING THE SECOND HALF OF THE CALIBRATE CYCLE AND THE MEAN OF THE 10 DELAY CORRECTION VALUES IS COMPUTED & STORED AS THE DELAY CORRECTION.

THE MICROPROCESSOR ALWAYS PERFORMS A COUNTER CALIBRATE AT THE BEGINNING OF EACH SATELLITE TRACK. OPTIONALLY THE USER CAN FORCE A COUNTER CALIBRATE CYCLE AT ANY TIME BY SELECTING (6) "COUNTER CMDS" ON THE MAIN MENU AND (3) "CALIBRATE" FROM THE SUB-MENU. (BUT DONT FORCE A CALIBRATE CYCLE WHILE THE RECEIVER IS TRACKING & MAKING COUNTER MEASUREMENTS EACH SECOND!!)

TO OBTAIN A HARD COPY OF THE RESULTS OF A CALIBRATE CYCLE, SELECT (5) "TRACK HDCPY CMDS" ON THE MAIN MENU AND (2) "EACH 1 SECOND GPS MEASUREMENT" ON THE SUB-MENU. MULTIPLE CALIBRATE CYCLES CAN BE FORCED (UP TO 15) BY TYPING 6 3 6 3 6 3 - - - .

FOR EACH CALIBRATE CYCLE YOU WILL GET A PRINTOUT LIKE

DELTA / START LOW / DELTA / END LOW — (HIGH-LOW) / LOW COUNT — HIGH-LOW (DELTA COUNT) / LOW COUNT

DEL, SLO, DEL, ELO   3937 5104   3920 5096

START INTERPOLATOR — STOP INTERPOLATOR

DELAY 0002, 00

DELAY 0.2ns — SIGN 00 = + FF = −

IN THIS EXAMPLE, THE START INTERPOLATOR SCALING FACTOR IS 3937/200ns = 19.685 COUNTS/ns. THIS CORRESPONDS TO 0.0508 ns/COUNT (50.8 PS/COUNT) (THE MICROPROCESSOR WILL ACTUALLY STORE THE FIXED POINT SEQUENCE OF DIGITS "5080" AS 1/SF)

FORTUNATELY, THE USER DOESNT HAVE TO REALLY BE CONCERNED ABOUT SCALING FACTORS AND LOW/HIGH COUNTS SINCE THIS IS ALL HANDLED AUTOMATICALLY. THE PROVISION TO PRINT THE RESULTS OF A CALIBRATE CYCLE IS HOWEVER A USEFUL DIAGNOSTIC AID IN CASE OF COUNTER HARDWARE FAILURES.

```
                        START        STOP
DEL,SLO,DEL,ELO 3873 4994 3557 4692
DELAY 000100
DEL,SLO,DEL,ELO 3872 4994 3558 4691
DELAY 000100
DEL,SLO,DEL,ELO 3874 4994 3554 4690
DELAY 000300
DEL,SLO,DEL,ELO 3871 4992 3556 4690
DELAY 000100
DEL,SLO,DEL,ELO 3872 4995 3559 4689
DELAY 000200
```

MAX Δ = 3 COUNTS

MAX Δ = 5 COUNTS

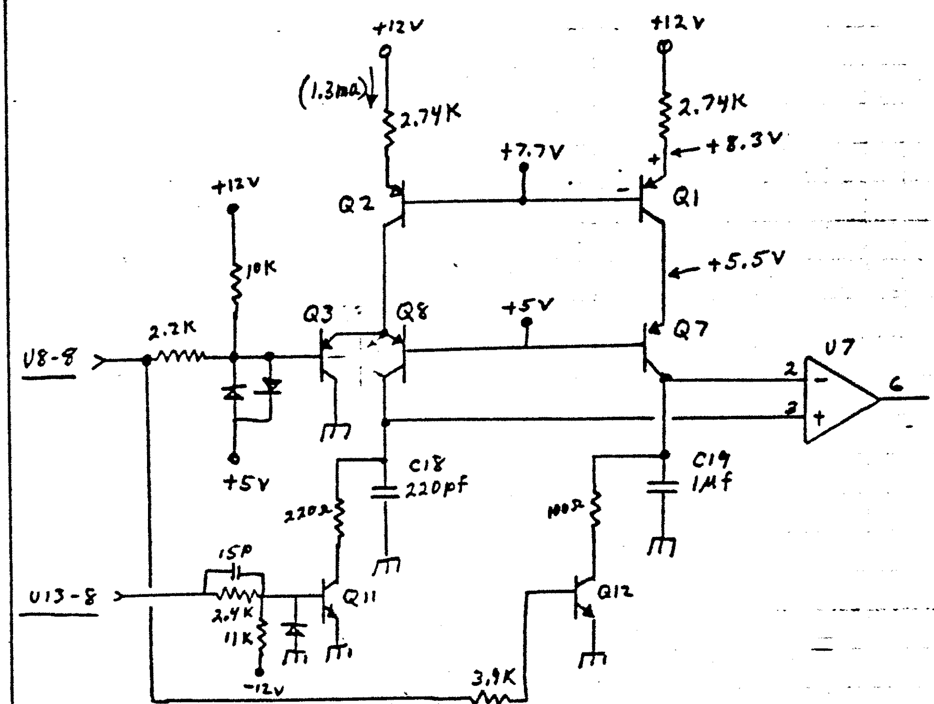
THE PRINTOUT ABOVE IS OF 5 SUCCESSIVE CALIBRATE CYCLES. NOTE THAT THE LOW COUNT FOR THE STOP INTERPOLATOR VARIES FROM 4692 – 4689 OR A MAX OF 3 COUNTS. THE DELTA COUNT FOR THE STOP INTERPOLATOR IS FROM 3559 TO 3554, A VARIATION OF 5 COUNTS. SINCE THE SCALING FACTOR IS ABOUT 18 COUNTS/NS, A VARIATION OF 5 COUNTS WOULD INDICATE A NOISE JITTER OF ABOUT 5/18 ns (OR) 0.280 ns. THIS REPRESENTS TYPICAL PERFORMANCE FOR THE COUNTER. IF THE VARIATION FROM 1 CALIBRATE CYCLE TO THE NEXT WERE TO APPROACH 18 COUNTS (1ns) WE WOULD SUSPECT SOMETHING IS WRONG, (NOISY TRANSISTOR, LEAKY CAPACITOR, BAD VOLTAGE REGULATOR.)

TOTAL FAILURE OF EITHER THE START OR STOP INTERPOLATOR WILL RESULT IN EITHER A "COUNTER FAILED" MESSAGE (OR) LARGER THAN NORMAL SIGMA (RMS) OF SV DATA. (FOR EXAMPLE, 40ns TO 80ns RMS RATHER THAN THE MORE TYPICAL 3 – 15ns FOR THE 15 SECOND DATA POINTS.

IF THE LOW COUNT IN A HARDCOPY PRINTOUT IS 6000, THIS INDICATES THAT THE CROSSOVER POINT WAS NOT REACHED FOR THE INTERPOLATOR. (THE MICROPROCESSOR INITIALIZES THE HIGH & LOW COUNTS TO 6000 BEFORE COMMENCING A CALIBRATE CYCLE)

A QUICK LOOK AT THE COUNTER CIRCUITS.

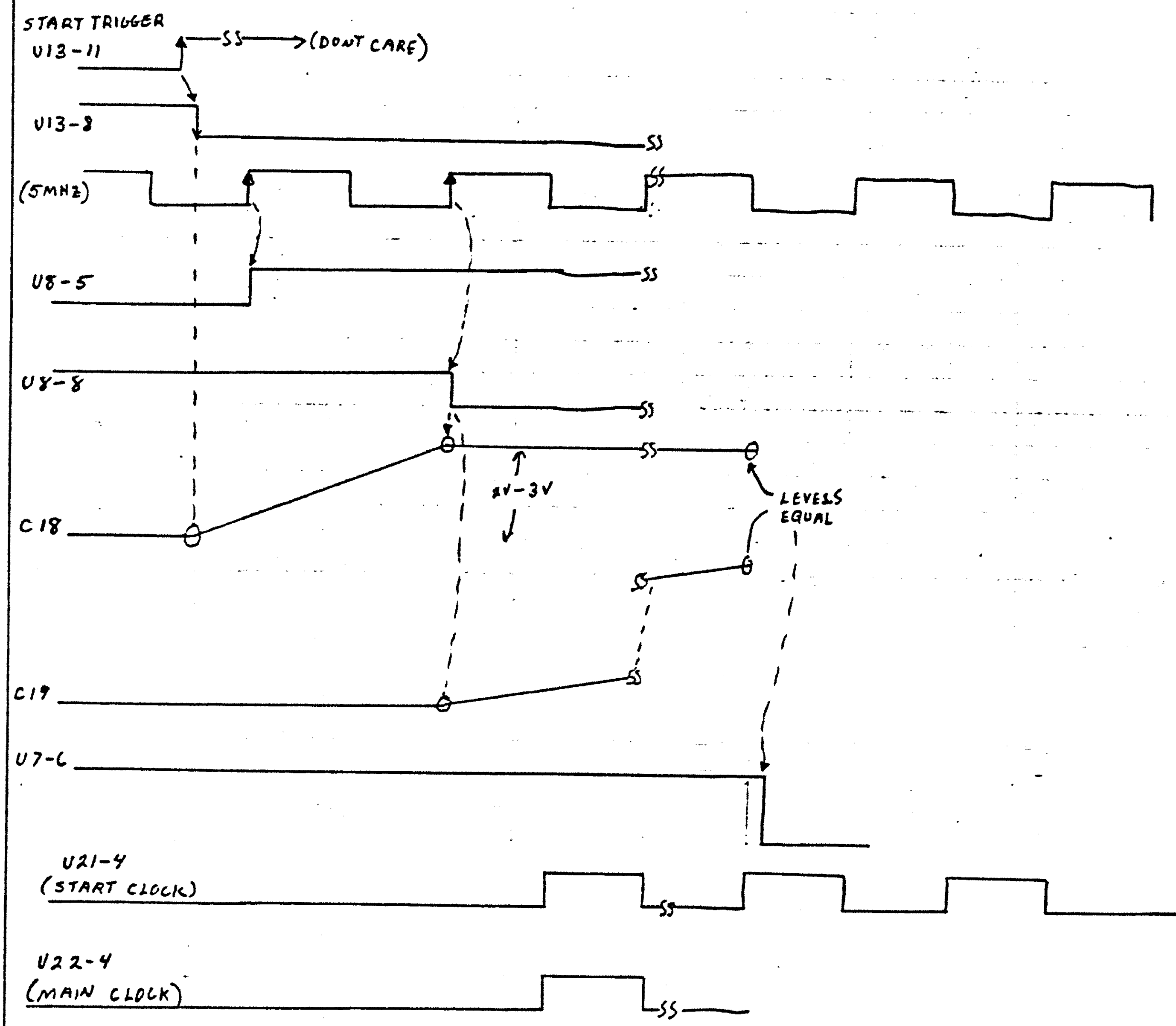
SEVERAL SPECIAL PRECAUTIONS MUST BE TAKEN IN A COUNTER OF THIS TYPE TO INSURE 1ns ACCURACY. FOR EXAMPLE, THE RAMP GENERATORS IN THE INTERPOLATORS MUST HAVE GOOD LINEARITY, SO NON-SATURATING CURRENT SWITCHES ARE USED TO CHARGE THE INTEGRATING CAPACITORS.



TRANSISTORS Q1 + Q2 SUPPLY CONSTANT CURRENTS OF ABOUT 1.3 ma TO THEIR RESPECTIVE INTEGRATING CAPACITORS C18 + C19. BOTH CONSTANT CURRENT SOURCES ARE FURTHER BUFFERED BY Q3-Q8 AND Q7. Q3-Q8 IS A NON-SATURATING CURRENT SWITCH FOR THE SAMPLE + HOLD RAMP GENERATED BY C18. C19 IS NOT REQUIRED TO HOLD A CONSTANT LEVEL + THEREFORE DOES NOT REQUIRE A CURRENT SWITCH.

IN THE QUIESCENT STATE, BOTH INPUTS CONTROLLING THE ANALOG CURRENT SWITCHES (U8-8 + U13-8) ARE HIGH. Q11 + Q12 ARE CONDUCTING + SATURATED AND BOTH C18 + C19 ARE DISCHARGED. Q8, THE CURRENT SWITCH FOR C18 IS CONDUCTING SO BOTH Q11 + Q12 ARE SINKING A CURRENT OF ABOUT 1.3 ma. THE 220Ω RESISTOR IN THE COLLECTOR OF Q11, VS THE 100Ω RESISTOR IN THE COLLECTOR OF Q12 INSURES THAT C18 HAS A VOLTAGE SLIGHTLY MORE POSITIVE (+.2V) THAN C19 (+.15V). THIS GUARANTEES THAT THE VOLTAGE COMPARATOR OUTPUT U7-6 IS POSITIVE.

THE WAVEFORMS BELOW ILLUSTRATE WHAT HAPPENS WHEN A START PULSE IS RECEIVED. THE POSITIVE TRANSITION OF THE START PULSE AT U13-11 (CLOCK INPUT) CAUSES U13-8 ($\overline{Q}$ OUTPUT) TO GO LOW, TURNING OFF Q11 AND ALLOWING C18 TO CHARGE.



THE START PULSE TO U13-11 CAN HAVE ANY PHASE RELATIONSHIP TO THE 5 MHZ CLOCK. THE NECESSARY "INTERLOCKING" IS PROVIDED BY U8. 5 MHZ IS APPLIED TO THE CLOCK INPUTS (PINS 3 & 11) OF U8. PIN 2 (D INPUT) OF U8 IS DRIVEN HIGH BY THE START TRIGGER, THRU U13-9. IF SUFFICIENT TIME HAS ELAPSED FROM THE TIME U8-2 GOES HIGH TO SATISFY THE SET-UP REQUIREMENTS OF THE D LATCH, (APPROX 20ns), THEN THE NEXT + TRANSITION OF THE 5MHZ CLOCK WILL FORCE U8-5 HIGH. U8-5 CONNECTS TO THE "D" INPUT U8-12, SO THE SECOND 5MHZ + TRANSITION WILL SWITCH U8-9 HIGH, ENDING THE CHARGE TIME FOR C18. THE MINIMUM CHARGE TIME FOR C18 IS THEREFORE $200ns + t_{SU}^{(+)}$ (SETUP TIME OF D LATCH), OR ABOUT 220ns THE MAXIMUM CHARGE TIME IS $400ns + t_{SU}^{(-)}$ OR 420ns, WHERE WE JUST MISS THE SETUP TIME FOR THE D LATCH.

BOTH THE START CLOCK AND MAIN CLOCK BEGIN COUNTING IMMEDIATELY AFTER THE END OF THE C18 UP-RAMP TIME. THE START CLOCK WILL STOP COUNTING 2 CLOCK CYCLES AFTER THE RAMP ON C19 EQUALS THE LEVEL OF C18, PLUS SOME ADDITIONAL BUT FIXED DELAY THRU THE THRESHOLD COMPARATOR U7. (REMEMBER, THE ACTUAL READING OF THE INTERPOLATION COUNTERS IS NOT IMPORTANT, AS LONG AS THEY ARE STABLE FROM THE TIME THE HIGH, LOW + DELTA VALUES ARE DETERMINED DURING THE CALIBRATE CYCLE UNTIL THE END OF THE MEASUREMENT SEQUENCE SOME TEN MINUTES LATER)

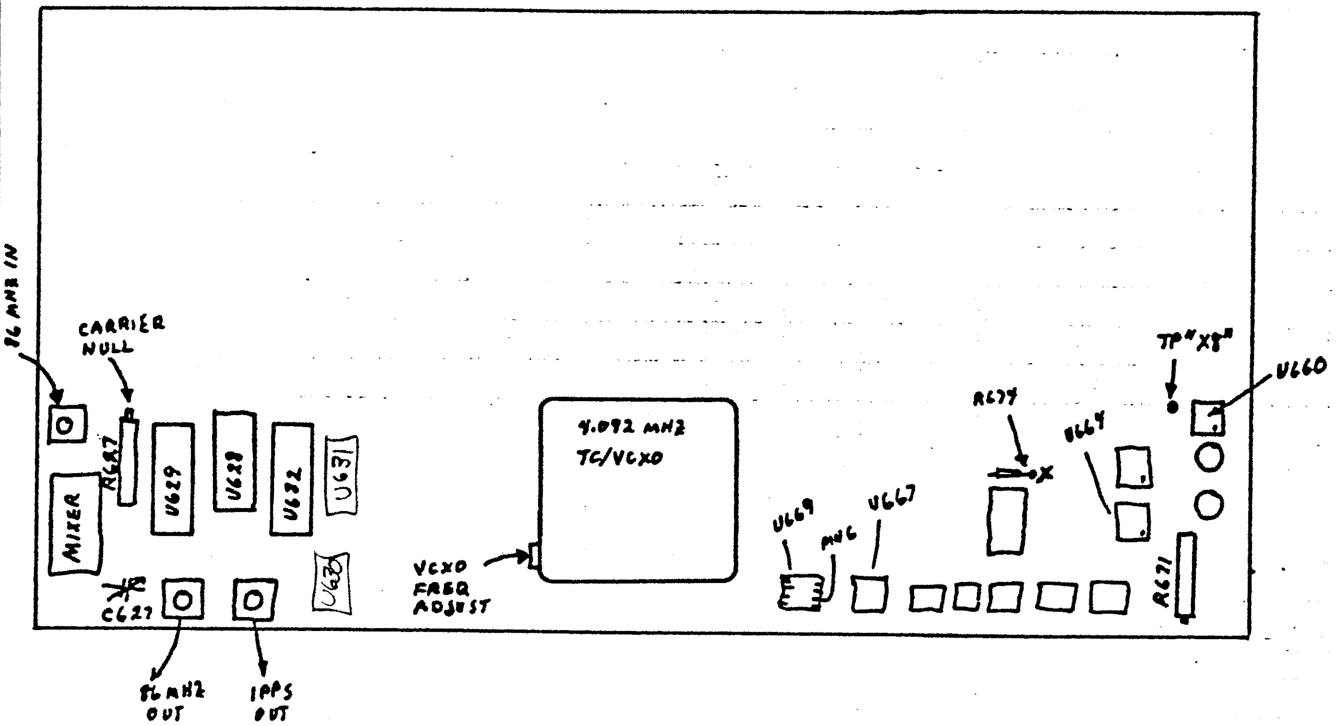
THE MAIN CLOCK IS INTERLOCKED WITH THE STOP INTERPOLATOR LOGIC SO IT'S COUNT IS EXACTLY CONTROLLED. (NO ERRORS OF EXACTLY 200 nS IN THE COUNTER READINGS)

A SPECIAL INTERLOCK IS PROVIDED TO INSURE THAT THE STOP INTERPOLATOR CANNOT START BEFORE THE START INTERPOLATOR (START + STOP TRIGGERS SIMULTANEOUS).
THIS INTERLOCK IS PROVIDED BY DERIVING THE INPUT TO U18-12 FROM U21-10. THE STOP INTERPOLATOR WILL NOT TRIGGER UNLESS U21-10 IS LOW, WHICH REQUIRES THAT EITHER U21-9 IS HIGH (START DONE) OR U21-8 IS HIGH (START BEGUN).

AN ADDITIONAL INTERLOCK IS ON THE START INTERPOLATOR THAT IS ACTIVATED ONLY DURING A CALIBRATE CYCLE. THE START INTERPOLATOR CANNOT TRIGGER AS LONG AS U13-12 IS HELD LOW. EACH TIME THE COUNTER IS ARMED, U40-5 IS FORCED LOW BY THE RESET PULSE. CLOCKING PULSES FOR U40 ARE DERIVED FROM THE 125 KHz TEST SIGNAL, INSURING THAT AT LEAST 8 μs HAS ELAPSED FROM THE END OF THE RESET PULSE UNTIL THE START INTERPOLATOR IS ARMED. WITHOUT THIS INTERLOCK, IT IS POSSIBLE TO GET ERRORS IN THE START INTERPOLATOR COUNT ABOUT 1 TIME IN EACH 100 MEASUREMENTS. DURING NORMAL 1PPS MEASUREMENTS, THE ARM/RESET AND START SEQUENCES BECOME SYNCHRONIZED + THERE IS NO CHANCE FOR THIS TYPE ERROR.

THAT PORTION OF THE COUNTER THAT YOU DONT SEE IN THE SCHEMATICS IS THE SOFTWARE. APPROXIMATELY 1300 BYTES OF MACHINE LANGUAGE PROGRAM IS REQUIRED TO CONTROL THE CALIBRATE AND NORMAL MEASUREMENT FUNCTIONS.
THE COUNTER PROGRAM IS CONTAINED IN PROGRAM SECTION "EG1" WITH SUB-TITLE "COUNTR".

CORRELATION CARD ALIGNMENT - TESTS

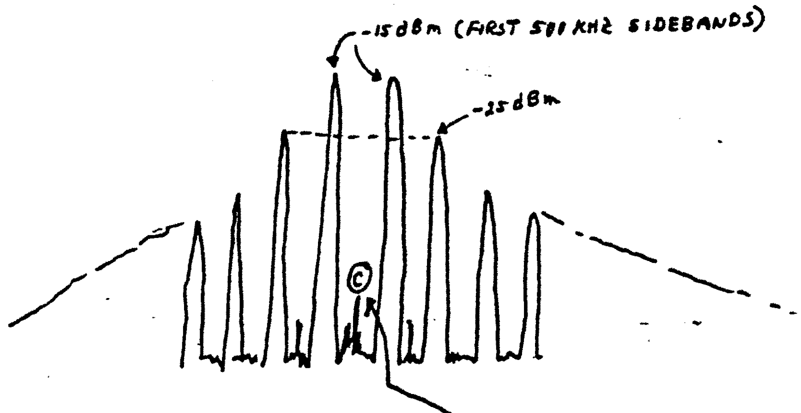


A. BI-PHASE MODULATOR TUNING

1. CONNECT SPECTRUM ANALYZER TO 86.12 MHz OUT SMA CONNECTOR.

2. FORCE 500 KHz BIPHASE MODULATION RATHER THAN PN CODE MODULATION BY QWERDXCMD + "AØ Ø11C SCMD"(CR)

3. ADJUST C627 FOR MAX OUT WITH SYMMETRICAL SIDEBANDS. (SPECTRUM ANALYZER = 2MHz/cm, BW = 100KHz.) OUTPUT SHOULD LOOK SIMILAR TO BELOW.

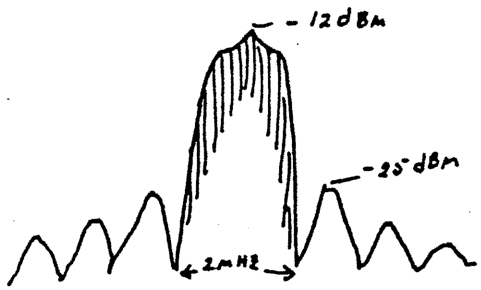


B. BI-PHASE MOD CARRIER NULL

1. ADJUST R627 FOR BEST NULL OF CARRIER ©, AT LEAST 40dB BELOW FIRST 500KHz SIDEBANDS.

B.

2. FORCE PN CODE MODULATION BY QWERDX CMD(CR) + "2ØØ11C SCMD"(CR) WITH SPECTRUM ANALYZER = 1MHZ/CM + 300KHZ BW, OUTPUT SHOULD BE SIMILIAR TO FIGURE BELOW.



C. SAMPLE + HOLD BALANCE.

1. REMOVE U660 FROM IT'S SOCKET + CONNECT dc POWER SUPPLY (+) TO TP"X8", (-) TO GROUND.

2. SET dc SUPPLY TO +4V + MONITOR PIN 6 OF U664 WITH A DIGITAL VOLTMETER.

3. ADJUST R671 FOR Ømv OUT AT U664-6.

4. SET dc SUPPLY TO -4V @ TP"X8" — U664-6 SHOULD READ ØmV ±1mV.

5. REMOVE dc SUPPLY FROM TP"X8" + REPLACE U660.

D. CORRELATION VCXO CENTER FREQUENCY ADJUST.

1. CLIP SCOPE PROBE TO IC D-6 PIN 5 (U631) + SYNC TO THE 1KHZ EARLY EPOCH PULSES OUT.

2. CONNECT OTHER SCOPE PROBE TO THE 100KHZ OUT OF THE MULTIPLIER CARD. (MAINTAIN SCOPE SYNC TO EARLY EPOCH OUT). THE 100 KHZ OUTPUT SHOULD BE MOVING SLOWLY ACROSS SCOPE SCREEN AT A RATE UP TO ± 3μS/S.

3. FORCE CORRELATION SERVO RESET BY QWERDXCMD(CR) + "24Ø25C SCMD"(CR) FORCE SERVO CENTER FREQUENCY BY "BØØ13C SCMD"(CR).

4. THE 100KHZ WAVEFORM SHOULD NOW BE SLOWLY MOVING ACROSS SCOPE SCREEN FROM <u>RIGHT TO LEFT</u> AT A RATE OF 0.4μS/S. IF THIS IS NOT THE CASE, ADJUST VCXO FREQ ADJUST. TOLERANCE OF INITIAL ADJUSTMENT IS 0.4μS/S ± 0.2μS/S. MAX TOLERANCE OF CENTER FREQ IS 0.4μS/S ± 0.4μS/S.

5. VERIFY THAT OTHER CORRELATION OFFSETS ARE CORRECT BY FORCING "XXØ13C SCMD"(CR), WHERE XX REPRESENTS VALUES IN FOLLOWING TABLE.

TABLE OF SYNTHESIZER BYTES VS CORRELATION SERVO OFFSETS (μS/S)

SYNTHESIZER BYTE (XX)	VCXO OFFSET μS/S	
A9	+2.7	100KHZ MOVING LEFT TO RIGHT
A0	+1.7	
A1	+0.6	
B∅	−0.4	100KHZ MOVING RIGHT TO LEFT
B5	−1.4	
B9	−2.4	
BC	−3.0	

E. CORRELATION SERVO INTEGRATOR TEST.

THIS TEST VERIFIES THAT THE LEAKAGE CURRENT/OFFSET VOLTAGE OF THE CORRELATION SERVO INTEGRATOR IS LOW ENOUGH TO INSURE ± 1mS TRACKING ACCURACY.

1. LIFT END OF R674 INDICATED ON PARTS PLACEMENT DIAGRAM.

2. FORCE PROPER CORRELATION LOOP STATE BY: QWERDX CMD(CR)
   "9∅∅13C6CMD"(CR) (NARROW LOOP) (NO DOPPLER AIDING)
   "2∅∅26C5CMD"(CR) (ENABLE TRACKING)
   ~~[illegible]~~

3. CLIP DVM TO PIN 6 OF U669. (CORR SERVO OUTPUT)

4. FORCE OUTPUT OF INTEGRATOR TO +1V BY TOUCHING OPEN END OF R674 WITH ONE FINGER WHILE TOUCHING OUTPUT OF EITHER +12V OR −12V REGULATOR (AS NECESSARY) WITH ANOTHER FINGER.

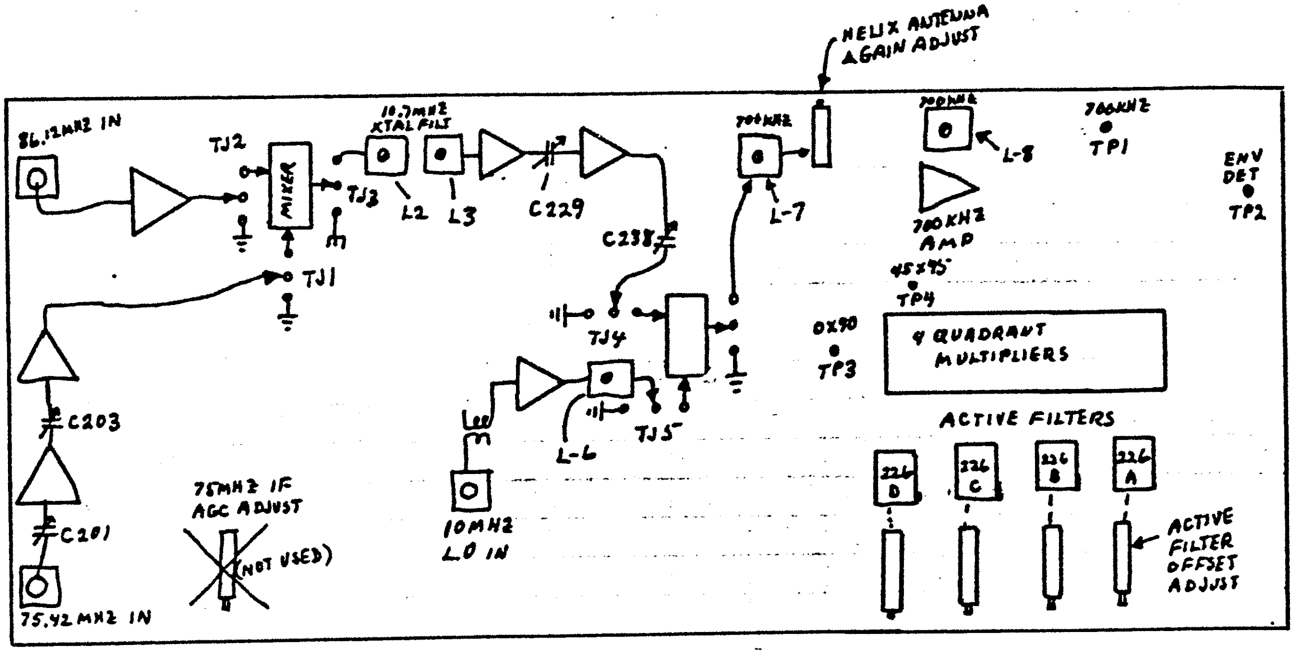
5. AFTER INTEGRATOR IS CHARGED TO APPROX +1V, GROUND OPEN END OF R674 WITH A CLIP LEAD. THIS WILL SIMULATE NORMAL OPERATION, SINCE R674 IS NORMALLY DRIVEN FROM A LOW IMPEDANCE SORCE, i.e., THE OUTPUT OF U664.

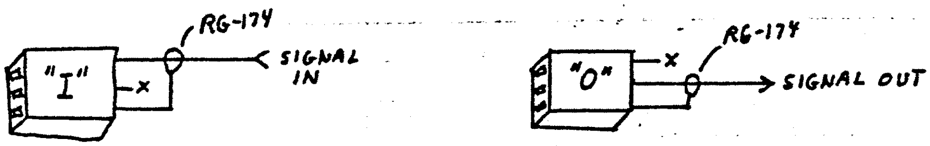
6. MONITOR THE VOLTAGE CHANGE AT PIN 6 OF U669 WITH THE DVM. MAXIMUM RATE OF CHANGE IS ± 10mV/MINUTE. TYPICAL SHOULD BE LESS THAN ± 5mV/min. IF RATE OF CHANGE IS > 10mV/MIN, REPLACE COMPONENTS IN SERVO AS REQUIRED, (U667, U665, C623, ect) AND THOUROUGHLY CLEAN BOARD WITH SOLVENT + BAKE DRY.

7. REPEAT STEPS 4−6 WITH INTEGRATOR CHARGED TO −1V.

8. RE-CONNECT R674.

IF CARD ALIGNMENT - TESTS



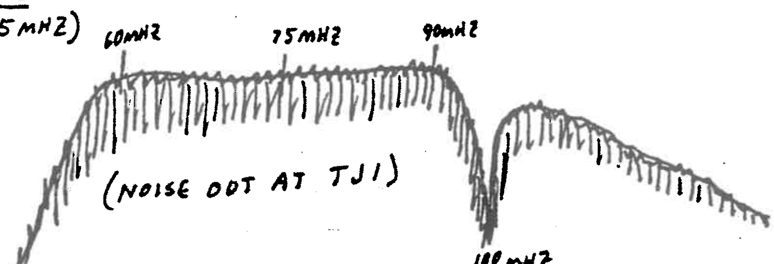


ADAPTERS FOR TJ1 - TJ6 (4' LONG, BNC ON OPPOSITE END)

A. 75MHZ IF ALIGNMENT + GAIN TEST (SIGNAL GEN + SPECTRUM ANALYZER)

1. FEED 75MHZ TO ANTENNA INPUT ON REAR OF RECEIVER (LEVEL = -50dBm)
   MEASURE 75MHZ LEVEL AT TJ1, USING AN "O" ADAPTER.
   ADJUST C-201 + C203 FOR MAX OUTPUT. GAIN OF 75MHZ IF SHOULD BE AT LEAST 28dB. (OUTPUT LEVEL = -22dBm)

2. CONNECT RECEIVER TO ANTENNA. MONITOR OUTPUT AT TJ1 WITH SPECTRUM ANALYZER. (SWEEP = 10MHZ/DIVISION. BANDWIDTH = 300KHZ)
   ADJUST C203 FOR BEST FLATNESS OF NOISE OUT FROM 60MHZ TO 90MHZ. (75MHZ ± 15MHZ)



3. VERIFY THAT OUTPUT LEVEL AT TJ1 FROM 60-90MHZ IS APPROX -30dBm ± 5dB ON SPECTRUM ANALYZER (ANALYZER BW = 300KHZ)
   ALTERNATIVELY, VERIFY THAT OUTPUT OF TJ1 IS BETWEEN -10dBm + -20dBm ON POWER METER READING TOTAL NOISE POWER FROM 5MHZ TO 100MHZ(+).
   IF LEVEL IS NOT BETWEEN THESE LIMITS, ADD OR REMOVE PADS AT ANTENNA INPUT CONNECTOR ON RECEIVER. (REPLACE TJ1 JUMPER PLUG)

IF CARD ALIGNMENT-TESTS

B. 86 MHZ LEVEL TESTS

NOTE: CARRIER BALANCE AND BI-PHASE MODULATOR TUNING ADJUSTMENTS MUST BE COMPLETE BEFORE SETTING 86MHZ LEVEL - SEE CORRELATION CARD ADJ)

1. MEASURE 86.12 MHZ OUTPUT LEVEL AT TJ2 USING AN "O" ADAPTER CONNECTED TO POWER METER. ADJUST T-1 ON THE CARRIER CARD TO OBTAIN A LEVEL OF +10dBm TO +13dBm.

C. 10.7 MHZ ALIGNMENT, GAIN TEST

1. INJECT 10.7 MHZ TEST SIGNAL AT TJ3, USING AN "I" ADAPTER. (FREQUENCY MUST BE 10.7 MHZ ± 300HZ, LEVEL = -20 dBm (MAX))

2. CONNECT TJ4 TO SPECTRUM ANALYZER USING AN "O" ADAPTER

3. SET IF GAIN TO MAXIMUM BY EXECUTING QWERDXCMD (AND) "ØØØ12Ø5CMD"(CR)

4. TUNE L2, L3, C229 + C238 FOR MAXIMUM OUTPUT AT 10.7 MHZ. (REDUCE INPUT LEVEL AS NECESSARY)

5. VERIFY CRYSTAL FILTER BANDWIDTH BY VARYING 10.7 MHZ TEST SIGNAL FREQUENCY UNTIL OUTPUT DROPS 3dB. BANDWIDTH SHOULD BE ± 8 KHZ (MAX). RESET CENTER FREQUENCY.

6. VERIFY MAXIMUM IF GAIN BY SETTING TEST SIGNAL LEVEL IN TO -50dBm. OUTPUT AT TJ4 SHOULD BE APPROX -22dBm, (28 dB GAIN)

7. FORCE MINIMUM IF GAIN BY QWERDXCMD + "FFØ12Ø5CMD", OUTPUT AT TJ4 SHOULD BE APPROX -50dBm. (ØdB GAIN) SET IF GAIN TO MID-POINT WITH "80Ø12Ø5CMD". REPLACE TJ4 JUMPER.

D. 10 MHZ LOCAL OSCILLATOR/MIXER

1. CONNECT "O" ADAPTER TO TJ5 + AND ADJUST L-6 FOR MAXIMUM OUTPUT. OUTPUT LEVEL SHOULD BE AT LEAST +10 dBm ON POWER METER. REPLACE TJ5 JUMPER.

E. 700 KHZ ALIGNMENT

1. WITH TEST SIGNAL AT 10.7 MHZ APPLIED TO TJ3 <u>AND</u> THE OTHER (5) TEST JUMPERS IN PLACE, CLIP SCOPE PROBE TO TP1, 700 KHZ OUT.

IF CARD ALIGNMENT-TESTS

E. 700 KHZ ALIGNMENT (CONTINUED)

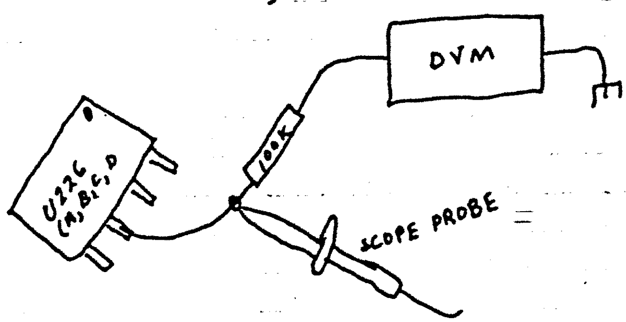
2. TUNE L7 + L8 FOR MAX OUTPUT. TOUCH UP L2, L3, C229 + C228. (ADUST TEST SIGNAL FOR 1V (PEAK), 2V(PP) AT TP1.)

F. COHERENT DETECTOR(S) OFFSET ADJUST.

1. ADJUST TEST SIGNAL FOR 2V(PP) AT TP1 (10.7MHZ INPUT TO TJ3)

2. TOUCH SCOPE PROBE TO PIN 6 OF U226(A), COHERENT DET OUTPUT, AND ADJUST FREQUENCY OF 10.7MHZ TEST GENERATOR TO OBTAIN A 200HZ SINE WAVE OUTPUT. (FREQ APPROXIMATE, NOT CRITICAL)

3. CONNECT 100K RESISTOR, SCOPE PROBE AND DVM AS SHOWN BELOW. ADJUST ACTIVE FILTER OFFSET POTS FOR 226 A, B, C, D WHILE MONITORING PIN 6 OF CORRESPONDING IC, UNTIL <u>DC</u> OUT = ØV ± 2MV. (AC OUT IS APPROX 2VPP)



4. REPEAT ADJUSTMENTS UNTIL ALL DC OFFSETS ARE LESS THAN ± 3MV

G. 4 QUADRANT MULTIPLIER OFFSET TEST

1. USING SAME SCOPE PROBE-RESISTOR-DVM CONFIGURATION, TOUCH SCOPE PROBE TO TP3 (ØX90 MULTIPLIER). DC OFFSET SHOULD BE LESS THAN ±15MV.

2. REPEAT FOR TP4 (45X45 MULTIPLIER). DC OFFSET SHOULD BE LESS THAN ± 30MV.

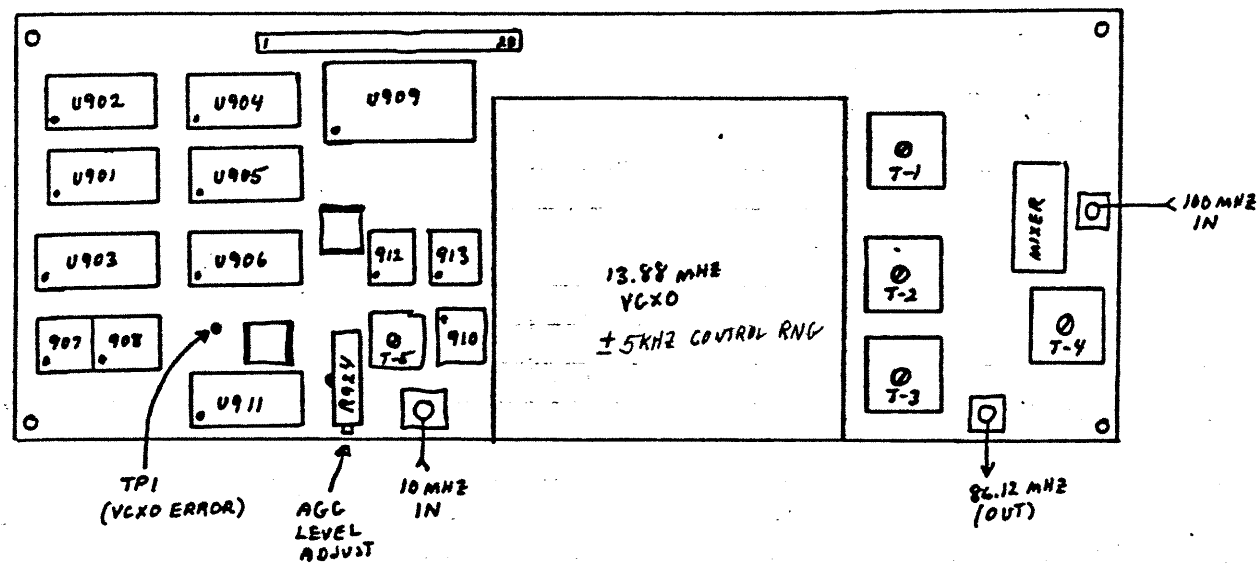
H. HIGH-LOW GAIN SWITCH ADJUST.

1. CLIP SCOPE PROBE TO TP1 — LEVEL SHOULD STILL BE 2 V(PP).

2. FORCE GAIN SWITCH BY QWERDXCMD + "26Ø25CSCMD" ADJUST HELIX Δ GAIN POT UNTIL TP1 LEVEL IS REDUCED TO 0.5 V (PP) (A 12 dB GAIN REDUCTION)

3. FORCE GAIN SWITCH TO HIGH BY "24Ø25CSCMD". OUTPUT AT TP1 SHOULD AGAIN BE 2 V(PP)

CARRIER CARD ALIGNMENT-TESTS



A. VERIFICATION OF SYNTHESIZER OPERATION (SEE * NOTE BELOW)

1. CLIP SCOPE PROBE TO TP1 (VCXO ERROR)
2. CONNECT PRINTER/KBD SUCH AS TELETYPE MODEL 43 TO MODEM INPUT ON PROCESSOR. (KBD/PRINTER SHOULD BE 300 BAUD, EVEN PARITY, 7 BITS, 1 START, 1 STOP)
3. ISSUE PRIVILEDGED CMD "QWERDXCMD" (CR) - CORRECT RESPONSE IS "OK" - (IF NO "OK" IS RECEIVED, REPEAT "QWERDXCMD" (CR))
4. FORCE SYNTHESIZE MODE BY "24Ø25CSCMD" (CR) - CORRECT RESPONSE IS "DONE"
5. FORCE CENTER FREQUENCY SYNTHESIS BY "BØØ13CSCMD" (CR) (CORRECT RESPONSE IS "DONE")
6. dc OUTPUT AT TP-1 SHOULD BE APPROXIMATELY +5V (±1V)
7. VERIFY THAT THE SYNTHESIZER OPERATES OVER THE FULL RANGE ±4800HZ BY ISSUING IN TURN "XXØ13CSCMD" (CR), WHERE "XX" IS ONE OF THE VALUES IN THE TABLE BELOW.

XX	VCXO ERROR	XX	VCXO ERROR
A8	APPROX ØV	BØ	APPROX 5V
A9	VOLTAGE INCREASES FOR EACH STEP	B1	VOLTAGE INCREASES FOR EACH STEP
AA		B2	
AB		B3	
AC		B4	
AD		B5	
AE		B6	
AF		B7	
AØ		B8	
A1		B9	
A2		BA	
A3	APPROX 5V	BB	
		BC	APPROX 10V

NOTE: THE SYNTHESIZER LOOP MAY NOT BE ABLE TO JUMP FROM "BC" (+10V) TO "A8" (ØV) IN A SINGLE STEP. THE MICROPROCESSOR ALWAYS FORCES THE SYNTHESIZER TO MID-RANGE "BØ" BEFORE GOING TO THE DESIRED VALUE IN NORMAL OPERATION.

* NOTE: IF THIS IS THE FIRST TIME TEST OF THE CARRIER CARD, T-5 MUST BE ALIGNED BEFORE PERFORMING THE SYNTHESIZER TEST.
IF SO, GO TO RF ALIGNMENT BELOW.

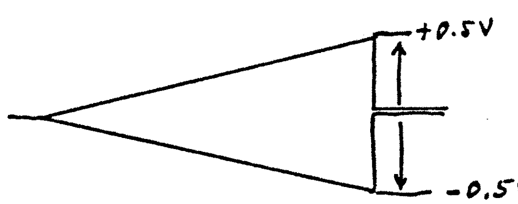
B. RF ALIGNMENT

1. ALIGNMENT OF T-5, 3.88 MHZ ACTIVE MIXER OUT.
   CLIP SCOPE PROBE TO U911-3, AND ADJUST T-5 FOR MAX OUTPUT.
   (U911-3 SHOULD SWING FROM ØV TO ABOUT +4V TO RELIABLY DRIVE THE 74LS74 CLOCK INPUT)

2. ALIGNMENT OF 86.12 MHZ MIXER/FILTER
   CONNECT SPECTRUM ANALYZER TO 86.12 MHZ OUT.
   ADJUST T-1 FOR MAX OUTPUT AT 86 MHZ
   ADJUST T-2, T-3, T-4 FOR MAX OUT AT 86 MHZ WITH MINIMUM SPURIOUS OUT AT 100 MHZ AND 113 MHZ.
   (SPURIOUS AT LEAST 30 dB down)
   NOTE: LATER, WHEN ADJUSTING THE DRIVE LEVEL TO THE CORRELATION MIXER (IF AMPLIFIER TESTS), T-1 WILL BE DE-TUNED TO PROVIDE THE CORRECT MIXER DRIVE. THIS WILL ALSO REDUCE LEVEL OF SPURIOUS OUT.

C. AGC LEVEL ADJUST.
NOTE: IF THIS IS A FIRST TIME ADJUSTMENT, PRESET THE WIPER OUT OF R924 TO +3V.

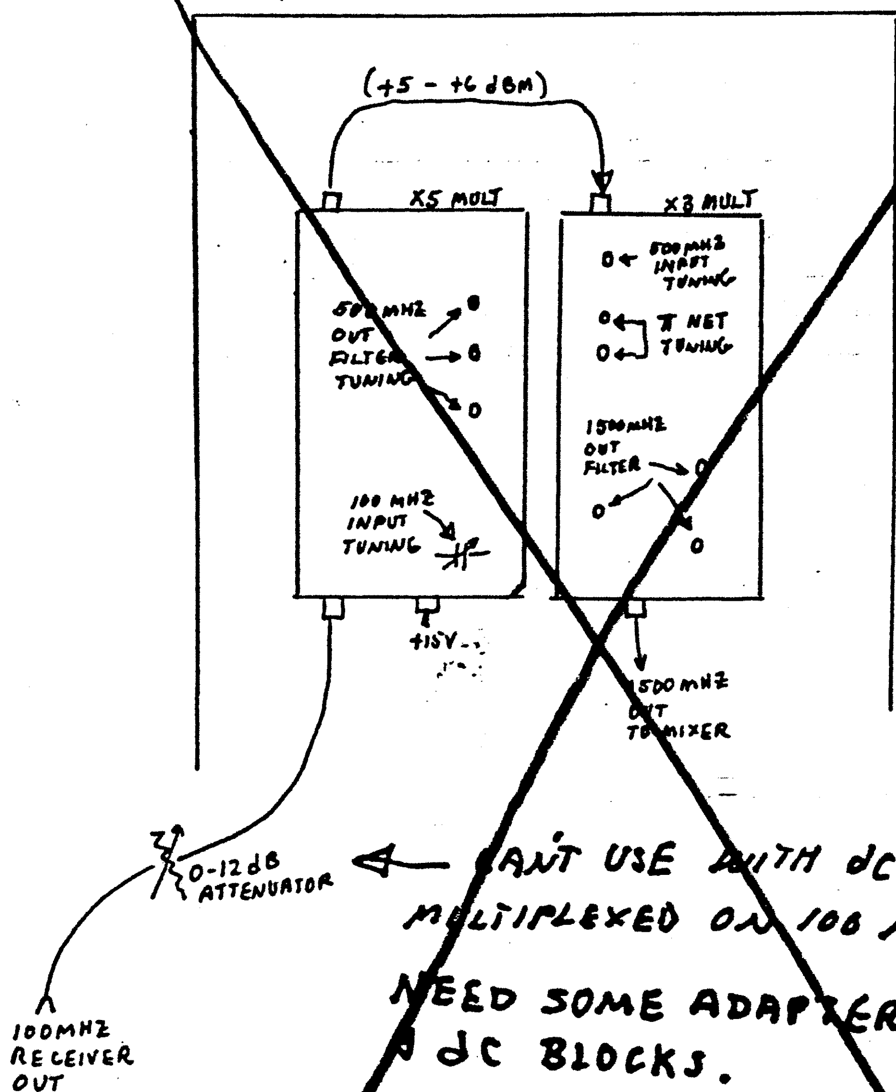
WHILE TRACKING A SATELLITE, MONITOR THE "DATA I+D" FRONT PANEL OUTPUT OF THE RECEIVER. (USE 50HZ SYNC)
ADJUST R924 TO OBTAIN ±0.5V SWING AT "I+D"



(DATA I+D OUT)

MULTIPLIER CHAIN - ALIGNMENT

PAGE INVALID



CAN'T USE WITH dc +15V MULTIPLEXED ON 100 MHZ

NEED SOME ADAPTERS & dc BLOCKS.

1. CONNECT 100MHZ FROM RECEIVER TO INPUT OF X5 MULTIPLIER, THRU 0-12dB VARIABLE ATTENUATOR. (HP-355A OR EQUIVALENT). SET ATTENUATOR TO 6dB, SIMULATING 100ft OF RG-58 CABLE. CONNECT OUTPUT OF X5 MULTIPLIER TO SPECTRUM ANALIZER.

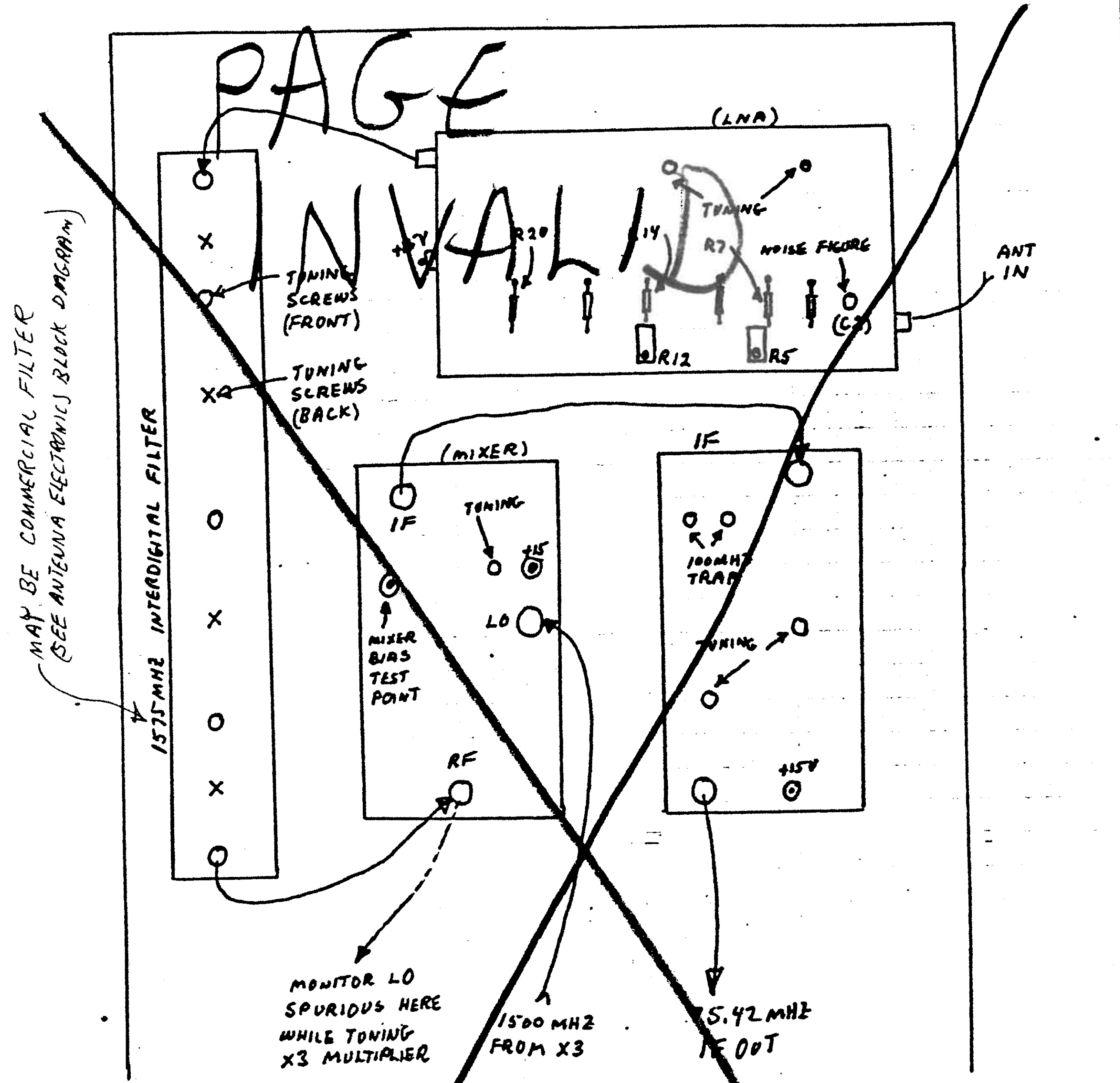
2. TUNE X5 MULTIPLIER FOR MAX OUT AT 500 MHZ, WITH MIN SPURIOUS.

3. SWITCH ATTENUATOR OVER RANGE OF 0-12dB. OUTPUT LEVEL SHOULD BE +5dBm ±1dB OVER RANGE. IF NOT, TOUCH UP 100 MHZ INPUT TUNING.

4. CONNECT X5 OUT TO X3 IN, X3 OUT TO MIXER LO IN, (NEXT PAGE)

10-14-82-A3

PAGE INVALID



MULTIPLIER CHAIN - ALIGNMENT (CONTINUED)

5. CONNECT SPECTRUM ANALIZER TO RF IN (TO MONITOR LO SPURIOUS)
CONNECT DVM TO MIXER BIAS CURRENT TEST POINT.

6. ADJUST X3 MULTIPLIER TUNING, ALONG WITH LAST PISTON TRIMMER OF X5 MULTIPLIER FOR MAX OUT + BEST SPECTRUM TO MIXER. BIAS CURRENT TEST POINT SHOULD READ AT LEAST 40MV (ON DVM) OVER FULL 0-12dB RANGE OF INPUT ATTENUATOR. THE π NETWORK TRIMMERS SHOULD BE ADJUSTED FOR MAX C OF TOP TRIMMER, CONSISTENT WITH MULTIPLIER STABILITY. BOTH π TRIMMERS SHOULD END UP ABOUT 1/2 MESHED.

10-14-82-D7

75 MHZ PREAMP - ALIGNMENT

1. PRE-ALIGN 100 MHZ TRAP BY APPLYING 100MHZ IN & ADJUSTING TWO TRAP COILS FOR BEST NULL. (AT LEAST 40dB).

2. SWEEP IF 75MHZ ±30MHZ & ADJUST 2 TUNING TRIMMERS FOR BEST FLATNESS.

INTERDIGITAL FILTER ALIGNMENT (REQUIRES FULL ANT SYSTEM CONFIGURATION)

1. CONNECT SIGNAL GENERATOR TO ANT INPUT OF LNA. (-90dBm, 1575 MHZ, ± 30MHZ SWEEP)

2. CONNECT SPECTRUM ANALIZER TO MIXER (IF) OUT.

3. ADJUST FILTER FOR BEST FLATNESS @ 75MHZ ± 20MHZ

4. TOUCH UP 15-60PF TRIMMER IN MIXER OUT FOR BEST FLATNESS

5. ADD IF AMP TO CHAIN & VERIFY THAT BANDPASS FROM 55MHZ TO 95MHZ IS FLAT TO ±1dB. (CENTER 20MHZ FROM 65MHZ TO 85MHZ SHOULD BE WITHIN ±1/2 dB) IF NOT TOUCH UP 2 IF TRIMMERS & REPEAT STEPS 3 & 4 ABOVE.

6. VERIFY THAT RESPONSE IS DOWN AT LEAST 40dB AT 1600 MHZ. IF NOT, TOUCH UP 100 MHZ TRAP IN IF AMP.

LOW NOISE AMPLIFIER

1. FET BIAS
   (A) ADJUST R5 TO OBTAIN 100 MV ACROSS R7 (10mA ID FOR Q1)

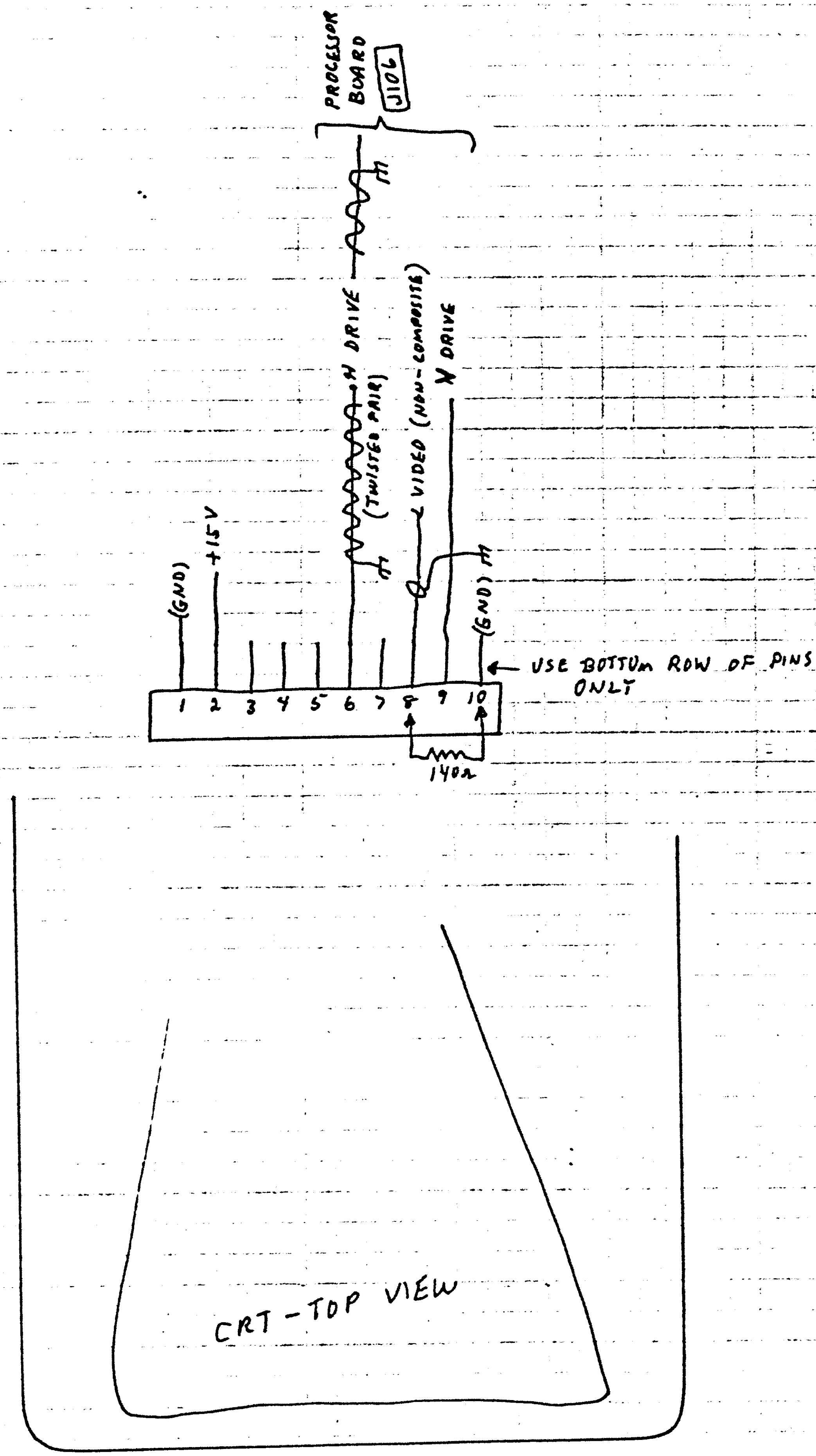
   (B) ADJUST R12 TO OBTAIN 100 MV ACROSS R14 (10 mA ID FOR Q3)

2. BIPOLAR BIAS - VERIFY DROP ACROSS R20 IS APPROX 70 MV (7mA IC FOR Q5)

3. RF ALIGNMENT - APPLY 1575 MHZ TO LNA INPUT (-90dBm) AND ADJUST 2 TRIMMERS FOR MAX OUT. (DO NOT ADJUST C2) - ADJUSTMENT OF C2 FOR MAX OUT WILL SERIOUSLY DEGRADE NOISE FIGURE!!!

4. NOISE FIGURE ADJUST (REQUIRES COMPLETE ANT PACKAGE)
   CONNECT AILTECH 7514 NOISE FIGURE METER TO LNA INPUT.
   CONNECT 75 MHZ IF OUT TO NF RF IN THRU 20 dB PAD.
   SELECT 70 MHZ IF ON NF METER - CALIBRATE NF METER TO 15.5dB SET POINT.
   ADJUST C2 IN LNA FOR BEST NOISE FIGURE -- TYPICALLY 1.5dB TO 1.8dB.

5. LNA GAIN TEST - WITH 1575 IN, VERIFY THAT GAIN OF LNA IS 34-38dB.


PROCESSOR BOARD
J106
H DRIVE
(TWISTED PAIR)
VIDEO (NON-COMPOSITE)
V DRIVE
(GND)
+15V
(GND)
1 2 3 4 5 6 7 8 9 10
USE BOTTOM ROW OF PINS ONLY
140Ω
CRT - TOP VIEW