Welcome to the 20th Annual Central States VHF Society Conference. We hope that you will enjoy the Technical programs, sightseeing activities and of course, your visit to the St. Louis area in general. It is certainly a privilege and an honor for me to serve as President of this prestigious group of amateurs. As it has now become a tradition, the proceedings of this years conference are again being published for the benifit of all those involved. It not only relieves the speaker of the problem of handouts pertaining to his talk, but also makes it possible to distribute the material to those attending and to those not able to attend. Also in this manner we are able to fully document and credit the work and accomplishments of the CSVHF Society.

This years conference is made possible through the dedicated efforts of the conference committee:

Al Ward, WB5LUA	Program/Wilson Award Chmn
Carol Sluder	Ladies Programs/Prizes
Jan Abernathy	Ladies Programs
Mike Abernathy, WB0SIL	Registration
Marc Thorsen, WB0TEM	Antenna Measurements
Mike Watson, W5UC	Prizes
John Fox, W0LER	Chambers Award Chmn
Rick Fogle, WA5TNY	Noise Figure Meas
Kent Britian, WB5VJB	Noise Figure Meas

I now wish to take special notice of those listed on the program whose diligent work and efforts make up our technical program.

Your CSVHF Society Officers and Board of Directors are:

Bob Sluder, N0IS - Pres
Al Ward, WB5LUA - Vice Pres
ED Fitch, W0OHU - Sec
Joe Muscanere, WB5HNK - Treas
Charlie Calhoun, W0RRY
Tom Clark, W3IWI
Charles Chennault, WA5YOU
Roger Cox, WB0DGF

Tony Bickel, K5PJR
Marshall Williams, K5MB
Louis Anciuax, WB6NMT
John Fox, W0LER
Terry VanBenschoten, W0VB
Russ Wicker, W4WD
Rod Blocksome, K0DAS

Very 73's

Bob, NØIS

20th Annual CSVHF Conference Schedule, 1986

Thursday, July 24

5:00 - 9:00PM	Registration on the upper patio
7:00 - 10:00PM	Cash Bar and snacks on the upper patio
9:00 - 10:00PM	Board of Directors Meeting

Friday, July 25

7:00 - 2:00PM	Registration on the upper patio
7:30AM	Coffee and Donuts (milk and juice) on the upper patio
8:00AM	Welcome and General Info
8:15AM	W5UN - Getting started on 2 Mtr EME
9:15AM	K1FO - High Performance Yagis for 432 Mhz
10:15AM	Break
10:30AM	W0PW - Using MMIC's in a 902 Mhz Transverter
11:15AM	KF4JU - Computer analysis of Yagi Antennas with some useful results
12:00PM	Lunch Break
1:00PM	Hewlett Packard Seminar on Noise Figure
2:00PM	WB0TEM/WB5LUA - Antenna Measuring
5:00PM	Dinner Break
7:00PM	W7CNK - 2304 Mhz Power Amplifier
7:30PM	WB0DRL/WA0TKJ - YU-129 1296 Mhz KW Amplifier
8:00PM	NO0Y - Feb 8 Aurora Opening
8:30PM	Flea Market
	Noise Figure Measurements

Saturday, July 26

7:30AM - Noon	Registration
7:30AM	Coffee and Donuts (Juice and Milk) on the upper patio
8:00AM	K0RZ - Amsat Mode S Transponder Development
8:45AM	W1JR - Radio Propagation on 50 Mhz and above
9:45AM	Break
10:00AM	KL7WE - A New Dimension in Meteor Communications
11:00AM	K5PJR/W5UGO - 5760 Mhz Operation
Noon	Lunch
1:00PM	W0VB - VUAC Update
	W0SD - 220 Mhz Happenings
	W3XO - ARRL Happenings
2:00PM	Business Meeting
2:30PM	N6TX - Who is Mr. Smith and why is everyone afraid of his Charts?
3:30PM	WA5DBY/WA5TNY - 3456 Mhz Operation
4:15PM	WB8IFM - Noise from the Stars
5:00PM	Close of Technical Sessions
6:00 - 7:00PM	Social Hour - Cash Bar and Free Hors D'Oeuvres
7:00 - 10:00PM	Banquet Dinner; Speaker: Bob Cox

Sunday, July 27

9:00AM - Till?	So, You Want To Show Your Slides, etc........

Family Program Schedule

Thursday, July 24

5:00 - 10:00PM	Tour and Banquet Registration
7:00 - 10:00PM	Time to get acquainted - Cash Bar and Snacks on the Upper Patio

Friday, July 25

7:30 - 8:15AM	Coffee and Donuts - Upper patio area
8:30 - 2:00PM	Trip to Arch and Riverboat ride Lunch on the Riverboat McDonald's
2:00 - 5:15PM	Afternoon break
5:30 - 12:00AM	Trip to The Muny. A Backstage tour and Broadway Show

Saturday, July 26

7:30 - 8:15AM	Coffee and Donuts - Upper patio area
8:30 - 1:00PM	Tour of old St. Charles
1:00 - 6:00PM	Afternoon break
6:00 - 6:50PM	Social Time - Cash Bar and Hors D'oeuvres
6:00 - 8:00PM	Childrens Banquet Magic Show - Mary Bright
7:00 - 10:30PM	Banquet - Speaker: Bob Cox Many nice prizes for all

Please Note:

Free babysitting will be available during all tours and the banquet. Any additional time required will be between you and the babysitters. You will find the babysitters in rooms 114 and 115. Please note that children left with the sitters must remain in rooms provided until parents return.

Please meet in the lobby 15 minutes prior to tour departure time.

Table of Contents

2 METER EME
A PRIMER FOR GETTING STARTED

EVALUATING YOUR PRESENT STATION

The first step to take to determine if you can make an eme contact is to evaluate your station equipment set-up and known performance. Stations using as little equipment as a single, good performance Yagi, and a solid state 150 watt amplifier (such as the Mirage 1016B) with built-in preamp have made random EME contacts when the moon was near the horizon at their QTH. The above type of station is probably the absolute minimun with which one would want to try for a QSO, but it can be done with large EME stations at the other end.

You probably remember hearing the phrase in your early days of operating that "if you can't hear em, you can't work em". This is absolutely true in EME work. The big difference is that you can usually hear something on the regular bands, even when everything at your end is not working up to snuff. Odds are that you will not hear anything on EME unless everything is performing quite well at your station. This includes your antenna, the coax connecting it to your receiver, and your receiver front end. All three of these items play an important part in determining your receiving system noise figure performance. A defect in any one of these can utterly destroy the required station performance. How can you tell if things are OK? The best way is to, first,correctly install an antenna with known performance (eg. Cushcraft Boomer types, KLM 16LBX types, well constructed homebrew Quagi or NBS types). I have included a Quagi design in appendix A which has given proven performance at W5UN in past years, and which is a good "poor man's" way to get started.

The connecting coax is critical to good performce. Excessive loss here will utterly destroy your ability to hear EME stations, especially if you are not using an antenna mounted preamp. For attempting to hear EME stations with shack mounted preamp, a piece of Beldin 9913 coax, well fitted with N connectors, and no longer than 50 feet gives about the maximum tolerable loss when connected to a single antenna. If you mount the preamp at the antenna, it is another story, and much longer runs of lower grade coax will get you by, at least for receiving. But in any event it is good practice to keep the cable system high quality to prevent signal loss during reception, and, later during transmission.

Receiving front end must have low noise to hear the weak EME signals of other stations. At present I know of no receiver manufacturer who makes an adequate front ended receiver. The way to remedy this deficiency is to install a preamp. The best place for the preamp is at the antenna (this sets the front end noise figure and eliminates the effects of coax line loss on noise performance). However, it is possible to hear EME signals with the preamp in the shack as a start. The preamp should have a noise figure of less than 1 db. This is easily obtained in this modern day by using a GaAs FET device such as the MGF 1400 series. The Preamp can be bought already built, or more cheaply home brewed from excellent articles in the ARRL handbook. Stay away from low noise bi-polar transistor preamps since their poor ability to handle large signals without overloading can result in a raft of unwelcome problems (such as a band full of TV and FM station birdies).

:STENING FIRST

If you use a Mirage 1016 or 3016 you know that it contains a Bi-polar preamp internally. Even though this device does not have the lowest of noise figures (typically 2 db), and is a bi-polar device,it is so much better than most receiver front ends alone that it can be used in your first attempt to hear EME stations, if there are no birdies present when it is switched on, or if the birdies aren't so bad that they swamp the weakest of signals your ear is capable of hearing. Other brick amplifiers may have similar useable preamps. One would probably not want to use these when the EME effort becomes more serious, since maximum performance will not be had.

Having fulfilled the requirements stated thus far, you are ready to aim your antenna at the moon when it rises or begins to set. If you are west of Europe (i.e. USA) Your time window is about 60 minutes maximum from rise to before the moon elevates out of your antenna path, and before you loose whatever ground gain assistance is available at your QTH (typicallly 1 to 2 db). It works similarly except in reverse on moon set. Usually, best signals will be heard 10 to 15 minutes before set or after rise. Highest EME station activity will be during prime times (weekends as, the moon rises, and is in a northerly, that is, positive, declination). Activity will be found more often than not on 144.000 to 144.020 mhz cw. W5UN has had greatest success working small stations to the east. This is probably due to better ground gain in that direction for W5UN, and the fact that there is more ham activity in that direction.

OPERATING TECHNIQUE

Where its happening Two meter random EME operation normally takes place between 144.000 and 144.025 mhz. This is the best place to begin listening if you have never heard an EME signal. Schedules are made routinely between EME stations all the way to 144.099 mhz. SSB work is usually found on 144.105 when it occurs, which is infrequent.

The 2 minute sequence

Since EME signals are usually extremely weak, a method has been devised which lets stations know when to expect to hear signals from other stations which they are scheduling. Each station transmits and receives alternating every two minutes. The conventional practice is for the Eastern most station to begin transmitting at the top of the hour. Appendix G contains a working guide, printed from the WA1JXN moon tracking program, which will assist a station in knowing when to listen and when to transmit. To use it, determine if you are east or west of the desired station, choose the appropriate transmit interval, and then mark alternate intervals to stay in the proper sequence.

The operating sequence is outlined in detail in the ARRL Handbook. In summary, our transmitting station will begin a schedule by alternately sending his call and the station's call who he is in schedule with for the full two minutes. This is continued for each sequence until he hears the other station's call.

When our station hears both sets of calls, but no O's are heard, our station will send alternating calls for the first 1-1/2 minute of the sequence followed by O's the last half minute.

If the other station's call and O's have been received, our station will respond with RO's for the full two minutes. This is continued each sequence until our station hears R's from the othe station, at which time our station will send R's and 73's.

If our station hears RO's in response to O's sent, then our station would send R's for the full two minutes for each sequence until such time that he has confirmed that the other station has received the R's by hearing R's and 73's.

This may seem complicated but is really quite simple in practice. The main thing is to set your clock with WWV and be on the correct sequence.

Appendix H contains a quick reference example of the sequence message outline as shown in the ARRL Handbook.

Random QSO's

Stations operating random may or may not be using the two minute sequence, but most likely will be on some kind of definite sequencing time frame. Here at W5UN the one minute sequence is routinely used. So if you are hearing this station, you should expect to hear one minute transmissions. There are times during peak conditions that no sequencing is used by the larger stations. QSO's are conducted much like you would expect to hear at the low end of 20 meters.

The best time to hear random stations via EME is in the evenings and on weekends when the moon is in a northerly (positive) declination, still visible in Europe, and the signal degradation is less than 3 db (as defined in the 2 METER EME Bulletin or the WA1JXN moon program).

You may have heard of the Universal Window (UW). This period only occurs when the moon is in a positive declination. The UW is defined as the two hour period of time beginning two hours before the moon sets and ending when the moon sets, in Frankfurt, Germany. This is a good time to listen for random activity. There are other times, especially before the UW, when reception is equally good and often better.

Contests

There are currently two EME contests. The ARRL EME contest occurs in the Fall and takes two weekends (usually one in October and one in November). It starts at 0000 GMT on Saturday and ends at 2400 GMT on Sunday. Most activity is via random QSO's. This is an especially good time to listen and try for first EME QSO's. Contest dates are published in QST several months prior to the start of the contest. Contest results are published in early Spring.

A second contest, sponsored by the French REF is held in the Spring (usually March and April). It has a similar time and operating format. Dates and Details are published in the EME Bulletin before the contest.

ATTEMPTING YOUR FIRST EME CONTACT

So you've heard a couple of stations off the moon, and were able to get their call letters; You are now ready to try for a QSO. Your best bet is to telephone one of the stations who you have identified and ask for an immediate schedule. All EME'ers that I know are more than thrilled to receive such a request, as it means there is an immediate possibility to add another station to the worked list. You will probably have already studied up on the EME QSO sequencing procedure (which is explained in the ARRL Handbook). If not, the EME station operator will be happy to give you some guidance over the phone before beginning on-air transmissions. Another method is to write the EME station which you heard and request a schedule. If you do this, it is good to know your moon positions and path degradation before hand, and to recommend schedule times. It is best to set 2 or more schedules starting 60 minutes before moonset (if the EME station is west of you) or starting with moonrise for 60 minutes (if the EME station is east of you).

Some hardy souls who have never made an EME QSO before, and who have only the barest of capable but unproven equipment, perfer to try their first one via the random contact route. That is, to call the EME station on the air without prior arrangements. This is possible, and success can be absolutely thrilling, but do not expect results immediately if you choose this approach. It may take several weeks of stalking to hit peak conditions, and even then success is rare. W5UN has worked a few such adventursome types.

UPGRADING YOUR STATION FOR SERIOUS EME WORK

Once you have heard another EME station, and particularly after you have made your first QSO the hard way, you will probably want to graduate to a more reliable and consistant method of making QSO's. This calls for a bigger station; that is, larger antenna, more power, and convenient ways to operate it all. I have included in appendix C some typical station configurations being used today, along with information about where to start looking for the required pieces you will need to make your station more capable for EME work.

A typical, modern day, station assembled for a serious EME effort consists of the following equipment (listed in the order of importance).

4 to 6 very good Yagi's (KLM 17LBX, large Cushcraft), or 8 to 12 good antennas (Boomers, quagi's, F9FT'S)

Low noise figure GaAs FET preamp mounted at the antenna

Coax relay switching box with switch timing interlocks for send receive switching of the preamp

800-1200 watt output amplifier

CW receiver/transmitter or transceiver

Moon position printout or computer with tracking program

Remote control of antenna AZ-EL position

Adjustable audio filter

Some stations, such as VE7BQH, still use collinear array antennas successfully. VK5MC uses a fixed high gain rhombic which works very well, but cannot be re-aimed. A few, such as W7FN and YU3AW use parabolic dishes successfully. Some of these systems can even be polarity rotated, which may or may not be an advantage. However, the multiple Yagi array is currently the most popular antenna system in use among EME stations. Appendix B gives details of a typical stacking and phasing arrangment for grouping 4 quagi antennas. These can be further grouped for 8 or 12 total antennas using similar phasing line and power divider hardware.

The best preamps are probably home brew because once you build and tune a preamp in your system, you begin to understand how tuning can affect overall system noise figure. The problem with commercial preamps, besides being expensive, is that we tend to connect them up without questioning whether they are tuned properly. However any considered preamp should use a low noise GaAs FET device as its active element, and most any specified for low noise at 144 mhz will probably give all the performance needed (any noise figure less than about 0.8 db is gold plating). Tuning the preamp on a noise bridge is a good tarting point. This service is often available at the various VHF nfrences during preamp noise figure competitions.

Most stations use a different coax for receive than for transmit. This permits the elimination of one of the tower mounted coax relays, but requires additional coax line be run between the antenna and shack. At W5UN a DPDT coax relay is used to permit single feedline operation. It is a matter of personal preference as to which way is best. Some different methods of connection are diagrammed in appendix D.

Some stations run power below 800 watts output and have reasonably satisfactory success in making QSO's. For the ranges shown, a linear amplifier using the new Eimac 3CX800 or a pair of 4CX250B's will yield adequate output at the low end, while an 8877 amplifier will easily loaf at the high power output end. Either type of amplifier can be built or purchased, depending on the size of one's pocketbook. Again, the ARRL Handbook is an excellent resource for one who wishes to roll his own.

Using either a transceiver or transmitter-receiver combination is, again a matter of personal preference. The key requirement is that both must be capable of handling cw. More expensive models will give more bells and whistles, if you are in to that sort of thing. At W5UN an IC251 is used. The outboard preamp makes up for the poor front end performance of most such rigs.

There are plenty of Moon position computer programs available for almost any of the popular home computers. W5UN uses an HP-41 calculator for this purpose. For those who do not have any type of computer, printouts of AZ-EL for your location, covering one year, and based on 15 minute intervals, can be purchased for a nominal cost. Appendix E lists some sources for programs and printouts.

Remote AZ-EL control permits aiming the antenna from the operating position as opposed to going outside to manually sight and point the antenna. AZ-EL control involves three concerns. First, knowing the direction in which the antenna is aimed, second, knowing where you want to aim, and third, aiming the antenna in the desired direction. The larger the antenna, the more acurate the AZ-EL readout must be. Analog readouts, such as surplus sylsens are probably adequate for 2X2 or 2X3 antenna arrays where the antenna pattern lobes are still relatively wide. For larger antennas, I recommend digital readouts that can be read to within one degree, for both azimuth and elevation. At W5UN surplus multiturn potentiometers with high linearity (+/- 0.05%) are used. These give readings with errors of less than 0.2 degrees. Potentiometers with linearity error of 0.25% can also be used. Worse case errors using these will be less than one degree, which is adequate for any 2 meter ham antenna I know of. Appendix F contains a bridge circuit and readout circuit designed by W7IUV which can easily be built for use with the potentiometers.

An adjustable audio filter will greatly assist you in copying the eak EME signals. I recommend a filter that has variable width and andpass center frequency, such as the Autek. At W5UN the filter is not used until the weak signal is detected on the normal IF bandpass (2.1 khz in my case). Here, the filter is normally used in its sharpest setting, about 80 hz. Practice is the key to success here since each of our ear/brain filters will be slightly different. There have been many times that I have heard absolutely nothing while in the wideband mode, but could get a call when using the filter in this way. More often though, something is first heard in wideband, and then I attempt to tune the center of the filter to this something (hopefully a signal) and begin to narrow down the bandpass to bring the signal out of the noise.

WHERE TO FIND MORE INFORMATION ABOUT EME

PUBLICATIONS

ARRL HANDBOOK

QST: WORLD ABOVE 50 MHZ

CQ MAGAZINE VHF COLUMN

HAM RADIO MAGAZINE

2 METER EME BULLETIN: 417 STAUDAHER ST. BOZEMAN MT. 59715

VHF/UHF AND ABOVE: P.O. BOX 270, W. TERRE HAUTE, IN. 47885

DUBUS: D. DEMAW, 4061 N. DOUGLAS ROAD, LUTHER, MICH. 49656

NETS

2 METER EME NET: SATURDAY AND SUNDAY, BEGINNING 1700 GMT ON 14,345 MHZ.

3818 MHZ INFORMAL GATHERINGS, WHEN HELD.

DETAILS AND PHOTOS OF W5UN's EME STATIONS

Stations using 16 or more very good Yagi's (or equivalent) and high power, and whose signal and operation seem to be ever-present on the low end of 2 meters, should probably be included in this category. These are the stations who are most capable of furnishing first EME contacts to modestly equipped non-EME stations. Some calls which come to mind are K1WHS, KB8RQ, WA1JXN, DL8DAT, F6BSJ, K6MYC, K9HMB, UA1ZCL, and W5UN. Since I am most familiar with my own station, W5UN, let me describe the station equipment being used.

OVERVIEW 1 (Early conceptual sketch of the EME array from W5UN design notebook)

SLIDE 1 (The old W5UN array in Midland Texas, before moving to Manvel)

SLIDE 2 (The new homesite of W5UN in Manvel)

SLIDE 3 (Clearing at the new homesite for the future EME array)

SLIDE 4 (The assembled support structure)

SLIDE 5 (The assembled support structure; testing the design premise)

SLIDE 6 (The Fully assembled array)

The antenna at W5UN consists of 32 KLM 17LBX Yagi antennas which have been customized for 75 ohm feed impedence. The boom length of each antenna is about 31 feet. Antennas are spaced 13 feet, 10 inches apart in the horizontal (E) plane, and 12 feet, 6 inches apart in the vertical (H) plane. The mounting structure consists of 8 cross arms made from 38 feet lengths of 3 inch diameter aluminum irrigation tubing. Four Yagi's are mounted on each cross arm.

SLIDE 7 (3 inch crossarm with braces and struts)

Each cross arm is braced and strutted to provide sufficient rigidity and strength. The entire array displaces a physical volume of 116,000 cubic feet, and is believed to have a gain in escess of 30 db compared to a dipole.

SLIDE 8 (main boom, with braces and struts)

The main boom holding the crossarms is made from 97 feet of Rhon 25 tower sections. It is braced with struts to remove sagging and provide additional wind loading strength.

SLIDE 9 (main pivot mast)

The array is supported by two masts. A pivotal mast made from a 35 foot length of 8 inch pipe, freely rotates in a ground mounted bearing assembly.

A 10 inch cylindrical spacer was slipped over the bottom 6 inches of this mast and welded in place in order to hold the mast centered in the bottom of the foundation tube assembly.

SLIDE 10 (foundation assembly, before installation)

The foundation tube and bearing assembly is made from a 6 foot length of 10 inch pipe. It was capped at the bottom, and encased in 6 yards of concrete.

SLIDE 11 (split flange assembly)

A split flange assembly bolts on to a flange welded on the top of the tube, and holds the rotating mast in a centered position. Before the mast was installed , flat, circular pieces of Teflon sheet were attached to its bottom and to the inside bottom of the 10 inch foundation assembly. These provide the bearing surfaces on which the mast rests and rotates. Teflon sheet is also affixed between the mast and the split flange at the top of the foundation in order to provide a good bearing surface for the mast to turn against, and to keep out moisture. After the mast was installed, the void between the mast and the 10 inch foundation tube was filled with anti-freeze to further protect against moisture entrance and to provide additional lubrication when rotating the mast.

SLIDE 12 (moving mast)

SLIDE 13 (old pickup truck frame chassis)

The moving mast is a 30 feet high Rhon 45 tower mounted on an old, stripped down Ford pickup chassis.

SLIDE 14 (rigid radius arm)

The moving mast assembly is rigidly attached to the rotating mast with a 56 foot long arm made from Rhon 25 tower sections. Because it is entirely rigid, this arm insures that a constant radius of rotation will always be maintained as the chassis rolls and the mast moves.

SLIDE 15 (radial arm stabelizing struts)

Cable struts are affixed between the pivoting mast and the mobil platform to hold proper front and rear wheel alignment and to provide additional radial rigidity.

SLIDE 16 (mobil mast guy cables)

The mobil mounted tower is held vertical by guy wires attaching to the pickup chassis.

SLIDE 17 (chassis sitting on concrete track runners)

Original wheels with rubber tires travel freely on a level track. The track has two parallel concrete paths, spaced at wheel center width Each path is 14 inches wide. The track center is 110 feet in diameter (346 foot circumfrence).

SLIDE 18 (gearmotor mounting, coupling and drive)

Azimuth rotation of the antenna is accomplished by turning the Ford chassis rear end drive shaft with a reversable, 30 rpm, 1/4 horsepower, 110 volt ac, gearmotor (purchased from W.W. Grainger). The gearmotor speed, working through the chassis existing rear end gearing reduction, results in a moving mast travel speed of 11 inches (about 0.9 degrees) per second. Full 360 degree rotation of the antenna takes about 6-1/2 minutes.

SLIDE 19 (brake lever and solenoid)

The moving platform is equipped with a brake system which engages whenever power is removed from the drive gearmotor. This braking arrangement allows the array to be held on target during wind conditions. Rapid, positive braking also helps when attempting to precisely positioning the antenna. This is especially important since the antenna beamwidth pattern is rather narrow.

SLIDE 20 (hinge plate assembly)

The antenna support boom is attached to the two masts with hinge plate assemblies. These allow the main boom to be rotated axially for elevation steering.

SLIDE 21 (winch mounting and cable routing)

The antenna elevation position is controlled by a winch elevation system. The elevating winch is mounted at the top of the rotating mast. An aircraft cable is run from the winch through a pully connected to the pull arm on the main boom.

SLIDE 22 (winch liftarm and cable routing)

This cable continues the length of the boom, through a second pully afixed to the pull arm at the moving mast and terminates at the top of the moving mast, above the boom hinge. When the winch applies tension to the cable, this tension is applied equally at both hinges. This causes the main boom to rotates evenly and smoothly on both sets of hinges. Boom twisting has not been detectable using this arrangement. Because of the way the winching cable system is designed, it provides additional boom support while the array is being elevated, in effect preventing boom sag at elevation positions other than horizontal.

SLIDE 23 (elevation limit switches)

Elevation rotation stop limit switches are mounted on the boom near the rotating mast hinge. A free swinging arm made from aliminum bar stock trips the appropriate limit switch whenever the array elevation attempts to travel past 0 degrees when coming down or 90 degrees when going up. This feature is required in order to prevent array damage in case of malfunction, especially during computerized control of the array.

SLIDE 24 (azimuth indication potentiometer installation)

Azimuth and elevation indication are provided by high linearity potentiometers. For azimuth, a 10 turn 5000 ohm pot with 0.05%

linearity is used. It will permit readout accuracy within 0.3 degrees. The pot is driven by a chain and sprocket arrangement geared to give 5 pot revolutions for one revolution of the pivot mast. This allows for some over-rotation at each end.

SLIDE 25 (elevation indication potentiometer installation)

The 5000 ohm, single turn, elevation pot has a linearity of 0.25%, permitting readout accuracy within 0.3 degrees. It is mounted at the center of the main boom, adjacent to the relay control and preamp box. A pendulum arm, kept purposely short to minimize free swinging oscillations, is affixed to the pot shaft.

SLIDE 26 (junction box containing coax relays and preamp)

A weather-proof box containing all the transmit/receive coax relays and the preamp protective relays is mounted on the main boom at the center of the array.

SLIDE 27 (control cable termination junction box)

A weather-proof termination box containing the azimuth gearmotor reversing relays and the winch dc motor speed control is mounted on the pivoting mast radius arm, near the mast. All control and power cables connecting from the shack to the antenna system are routed through this box.

SLIDE 28 (antenna/power divider grouping)

All 32 antennas are symmetrecally phased in groups of four using electrically equal lengths of 1/2 inch 75 ohm aluminum jacketed CATV hardline coax. Four port 75 ohm power dividers equipped with CATV LRC coaxial connectors perform the power splitting and impedence matching.

SLIDE 29 (coax termination to antenna feed point)

Termination to each Yagi's feed point is made directly, without connectors. After termination, the area was flooded with non-corrosive RTV sealing compound.

SLIDE 30 (power divider with LRC fittings)

Groups of 4 antennas are interconnected using electrically equal lengths of 3/4 inch, 75 ohm, aluminum jacketed, CATV hardline coax cable. here, LRC connectors are used at each end of the coax lines.

SLIDE 31 (center, 2-way power divider attaching to coax jct. box)

Finally, The two groups of 16 antennas are electrically connected together through a two-way power divider which also converts the array feedpoint impedence to 50 ohm. This divider connects directly to the relay box. A piece of 50 ohm flexible coax connects the relay box output to a length of 7/8 inch 50 ohm hardline which runs to the base of the rotating mast.

SLIDE 32 (cable routing at the base of the pivoting mast)

The far end of the 7/8 inch hardline coming from the antenna relay box is connected through a short length of flexible RG-17 coax to a 190 feet run of 1-3/4 inch heliax going to the shack. The RG-17 is needed to permit flexing during mast rotation.

SLIDE 33 (AZ-EL readout in the shack)

Readout for azimuth and elevation is performed using adjustable bridge circuits and two 3-1/2 digit Intersil A/D converters mounted in a case atop the operating position. Center return toggle switches on the left side of the case provide a means for adjusting the antenna direction by hand.

SLIDE 34 (HP-41 interface to AZ-EL control and readout)

The case containing the readouts and positioning switches also contains home brew interfacing circuitry for connecting the array readout and positioning controls to an HP 41 programmable calculator. The calculator is programmed to compute moon position, read existing position, and activate proper controls to move the array to the computed position, all automatically and continuously, without operator interaction. This arrangement has proven especially helpful at W5UN during contest operation since frequent antenna adjustment is one less thing to be concerned with.

SLIDE 35 (relay switching panel)

The antenna mounted preamp can be switched in or out of the receive circuit, or the preamp output can be routed into the shack through a seperate coax using switches on this box. The center toggle switch also permits switching the preamp input from the antenna to a 50 ohm terminator. This is used whenever sun noise or star noise measurement comparisons are made, or when a backgeround sky noise comparison is desired.

SLIDE 36 (IC 251 transceiver with Autek audio filter on top)

An IC 251 is the primary receiver/transmitter used for EME at W5UN. The output power adjustment control on this rig has been modified to permit adjustment of power on cw. The RA-TB and RB-TA vfo's can also be unlocked to provide more operating flexibility. Return echos are routinely heard at W5UN using only the receiver front end, without additional preamplification. This is surprising since, as VE7BQH so aptly stated, "you need to hit it with a hammer to wake it up" when discussing IC251 front end performance. The Autek audio filter is used for assistance in weak signal reception.

SLIDE 37 (HP-400 ac voltmeter)

An old surplus HP-400 ac voltmeter, with its scale calibrated in db, is used for system performance measurement. By pointing the array at the Sun or other noise sources, and then switching the preamp front end between antenna and 50 ohm terminator, the db difference in signal level (db) is determined. This measurement is run often at W5UN to verify system performance. Typical Sun noise measured under current quiet Sun conditions has been running about 14 db above 50 ohm reference

SLIDE 38 (Mirage 1016 amplifier)

A Mirage 1016 amplifier provides additional drive power needed to drive the final amplifier. Its internal preamp is occasionally used to boost the signal from the antenna mounted preamp. When the Mirage preamp is used alone it causes several birdies to appear at the low end of the band which are not normally there.

SLIDE 39 (two meter final amplifier and power supply)

The final amplifier used at W5UN is the familiar W6PO design with a single 8877 tube. The final loafs easily at 1500 watts. The power supply directly below the amplifier supplies 2.8KV or 4KV (switchable) and can deliver up to 2 amps; much more than is used at this station.

SLIDE 40 (modified Byrd wattmeter)

A Byrd wattmeter, capable of reading 5kw forward power is always in the outgoing coax line and is used for tune-up, swr, and power checking.

SLIDE 41 (Full array on the track)

SLIDE 42 (Full array at dawn)

APPENDIX A

MODIFIED QUAGI
BY W5UN
OPTIMIZED FOR 144.050 MHZ

The average gain measured on the antenna range indicates that this modified design yields a gain approximately 0.4 db more than the standard 4.2 wavelength NBS Yagi. 16 of these Quagis were used at the old QTH of W5UN with good success.

ELEMENT	LENGTH (INCHES)	SPACING (INCHES)
REFLECTOR	86 3/4 (LOOP)	
		21
DRIVEN ELEMENT	82 (LOOP)	
		15.5
DIR. 1	35 15/16	
		33
DIR. 2	35 3/4	
		31
DIR. 3	35 3/8	
		33
DIR. 4	35 1/4	
		31.625
DIR. 5	35	
		36
DIR. 6	34 13/16	
		36
DIR. 7	34 5/8	
		34
DIR. 8	34 5/8	
		34.5
DIR. 9	34 1/2	

OVERALL LENGTH = 305.625 INCHES

ALL DIRECTORS ARE 1/8 INCH SOLID ALUMINUM ROD (LENGTH CUT TO +/- 1/16")

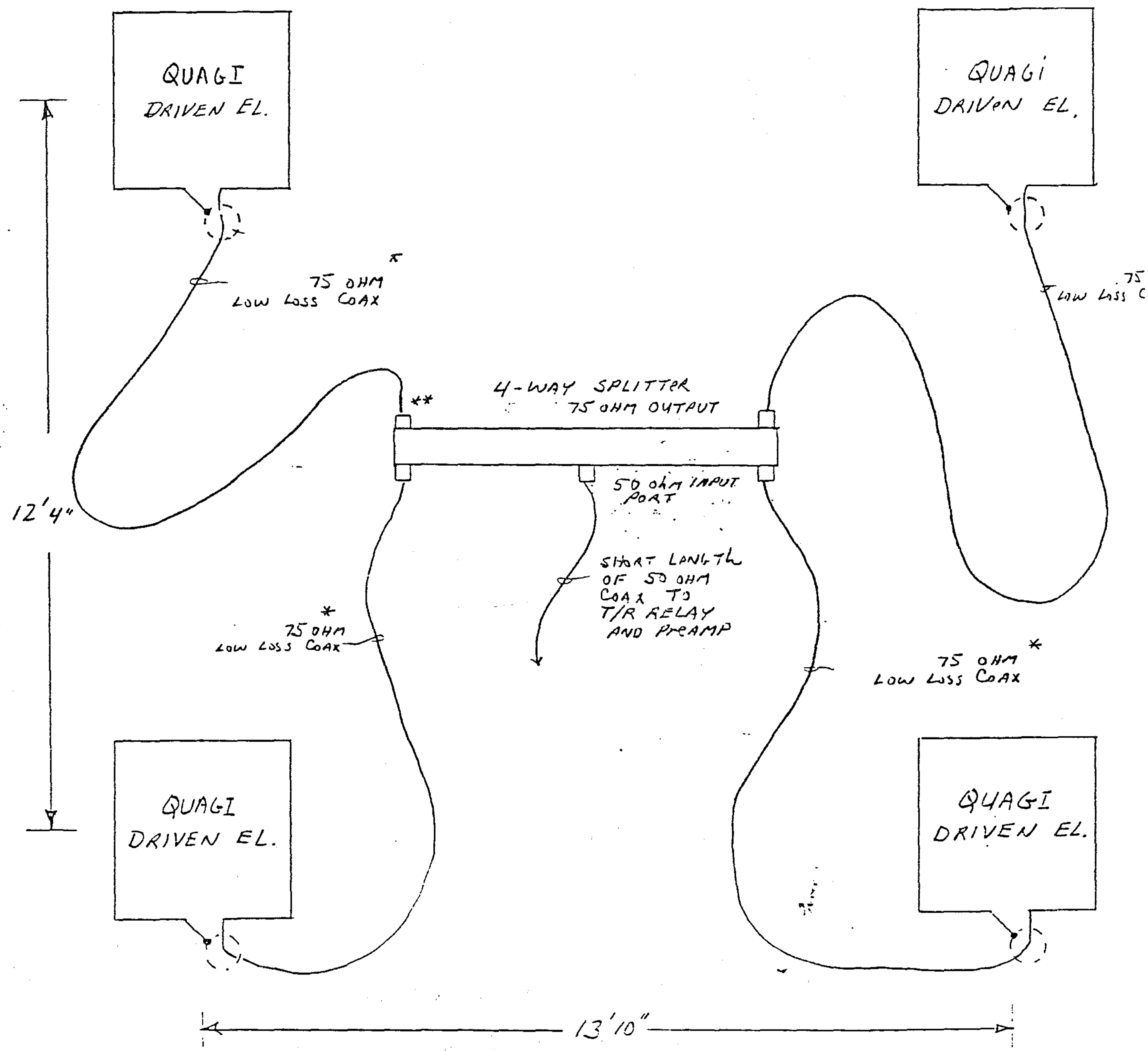
REFLECTOR AND DRIVEN ELEMENT ARE SHAPED INTO SQUARE LOOPS. THEY ARE MADE FROM #12 SOLID COPPER WIRE WITH TYPE TW (THERMOPLASTIC) INSULATION. IT IS IMPORTANT THAT THE INSULATION BE LEFT ON THE WIRE.

THE BOOM IS MADE FROM SEALED WOOD OR FIBERGLASS (NON-CONDUCTING).

APPENDIX

SPACING AND PHASING
FOR 4 Modified QUAGI'S

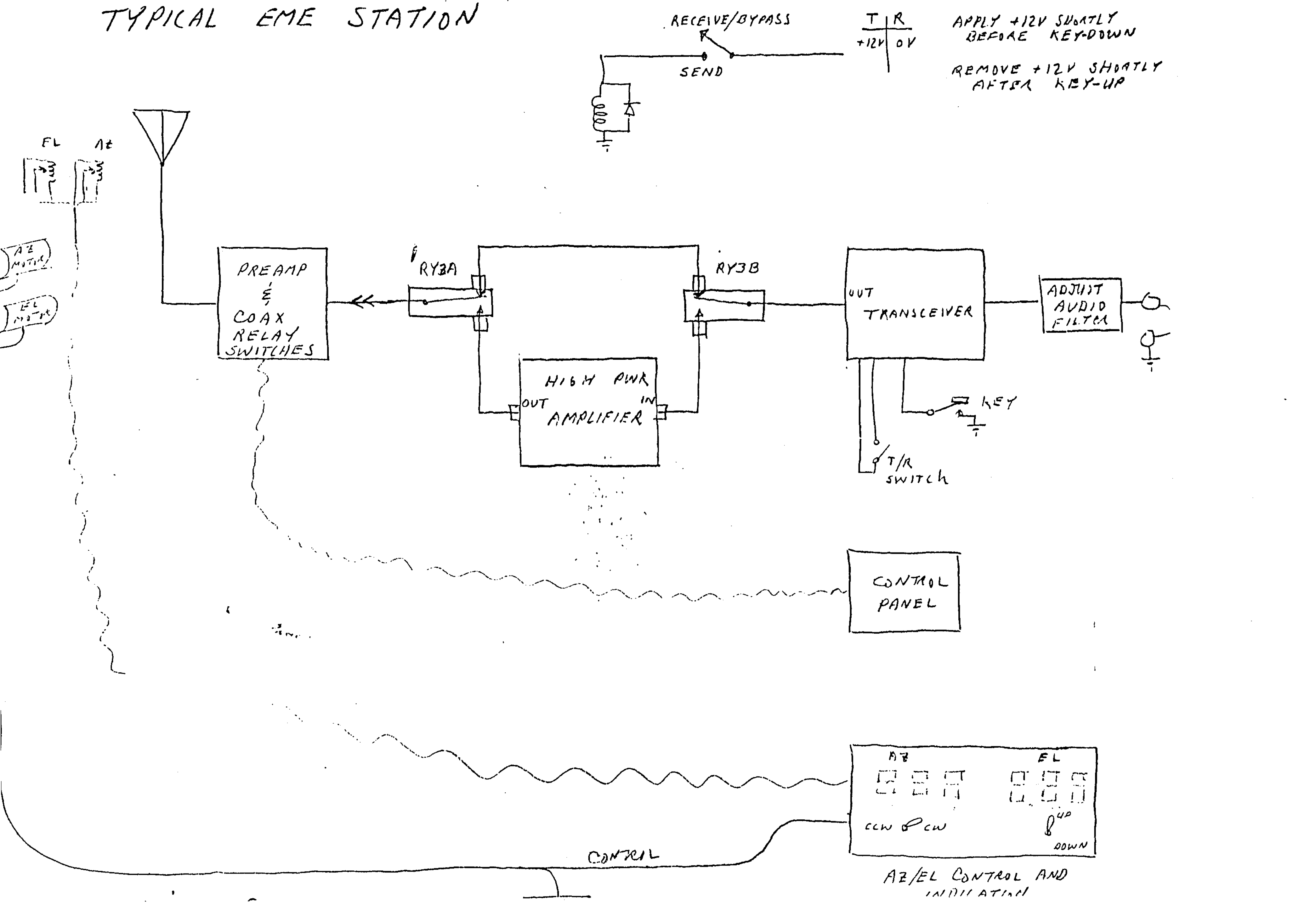
REAR VIEW;
ALL ELEMENTS NOT SHOWN



* ALL 4 COAX PHASING LINES
CONNECTING ANTENNAS TO POWER DIVIDER
MUST BE IDENTICALLY EQUAL LENGTH.
AND LOW LOSS.
75 OHM 1/2" OR 3/4" CATV HARDLINE
WORKS WELL.

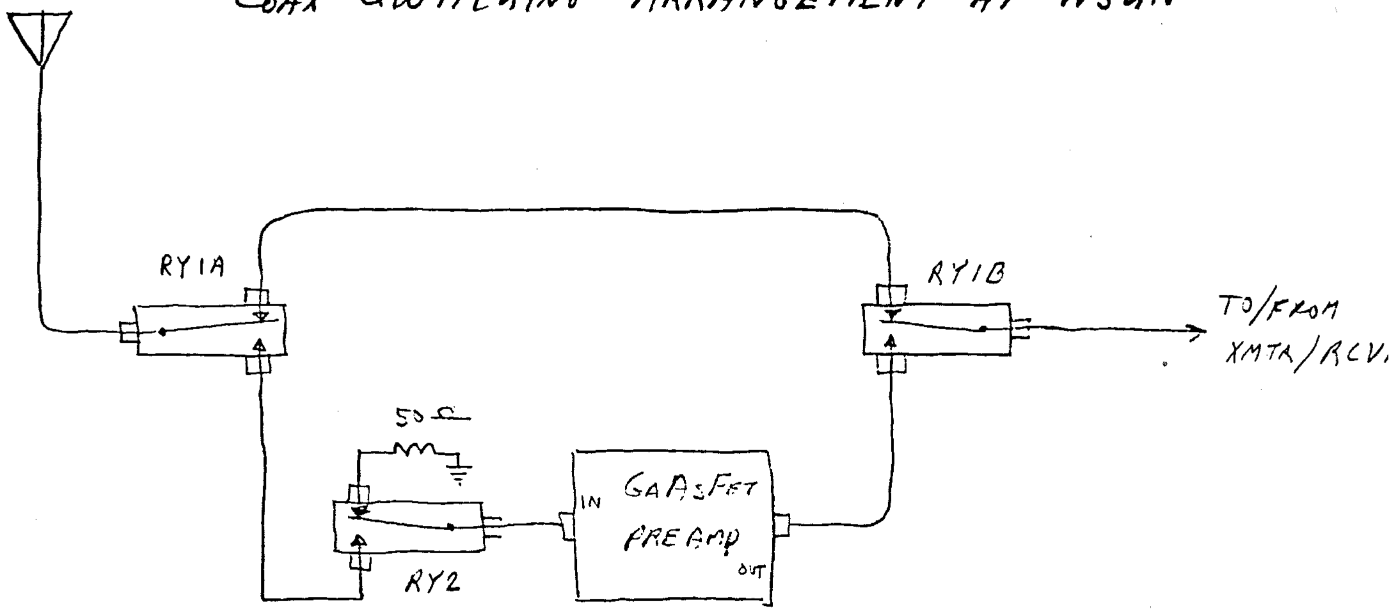
** USE N CONNECTORS
50 OHM COAX. US
LRC CONNECTORS F
CATV HARDLINE.

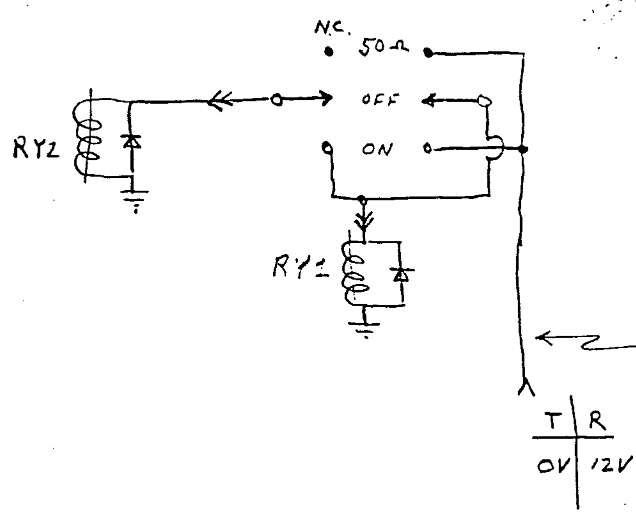
TYPICAL EME STATION



APPENDIX D

COAX SWITCHING ARRANGEMENT AT W5UN





DPDT SWITCH IN SHACK
CENTER-OFF
SPRING RETURN TO OFF FROM 50 Ω POS
MAINTAINED ON POSITION

REMOVE +12V SHORTLY BEFORE KEY-DO.
ADD +12V SHORTLY AFTER KEY-UP

APPENDIX E

Date: Station: Freq: MHz

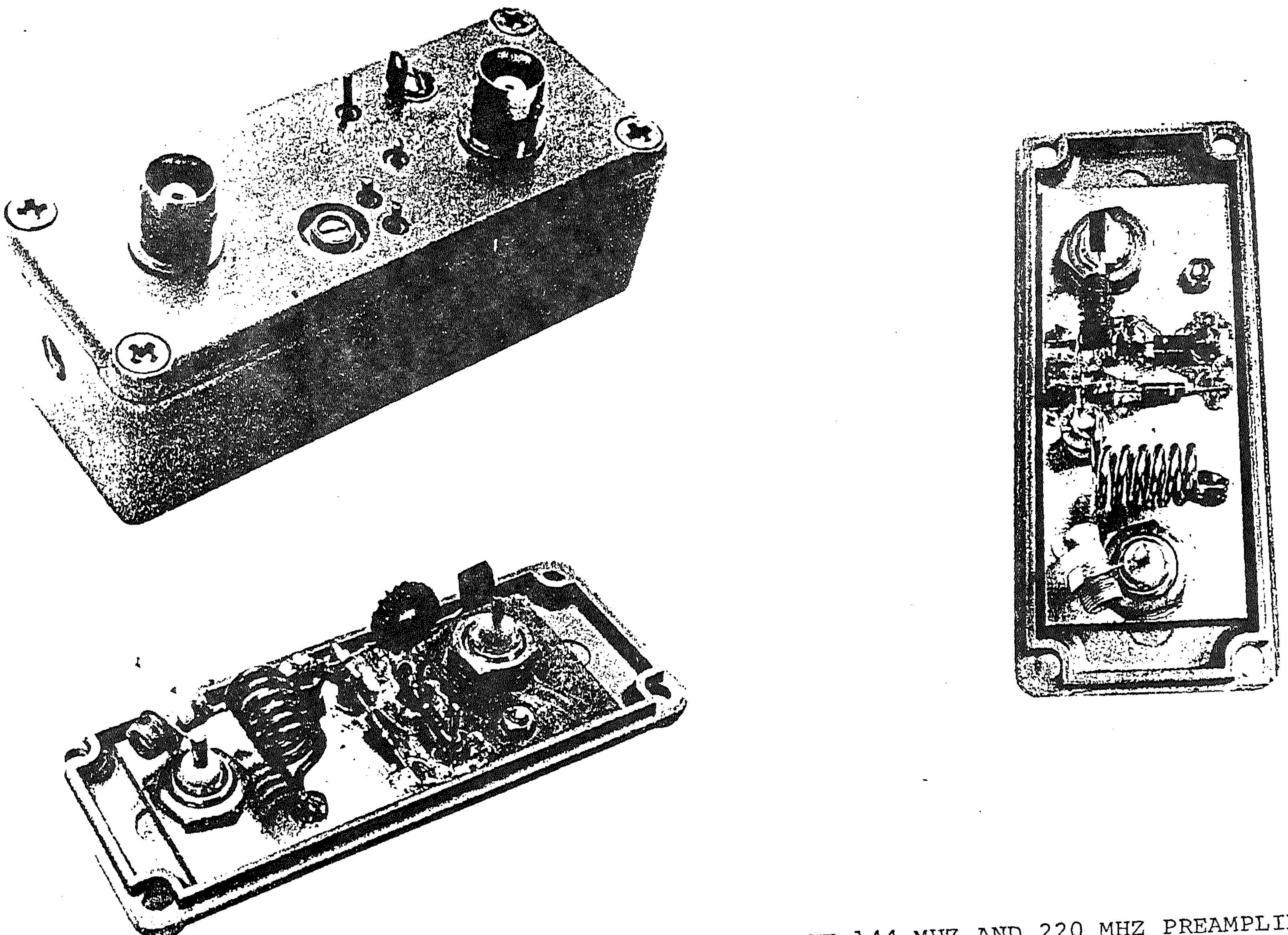
Time: to GMT Remarks:

EASTERN transmitting sequence	WESTERN transmitting sequence
0 - 2	2 - 4
4 - 6	6 - 8
8 - 10	10 - 12
12 - 14	14 - 16
16 - 18	18 - 20
20 - 22	22 - 24
24 - 26	26 - 28
28 - 30	30 - 32
32 - 34	34 - 36
36 - 38	38 - 40
40 - 42	42 - 44
44 - 46	46 - 48
48 - 50	50 - 52
52 - 54	54 - 56
56 - 58	58 - 60

APPENDIX F

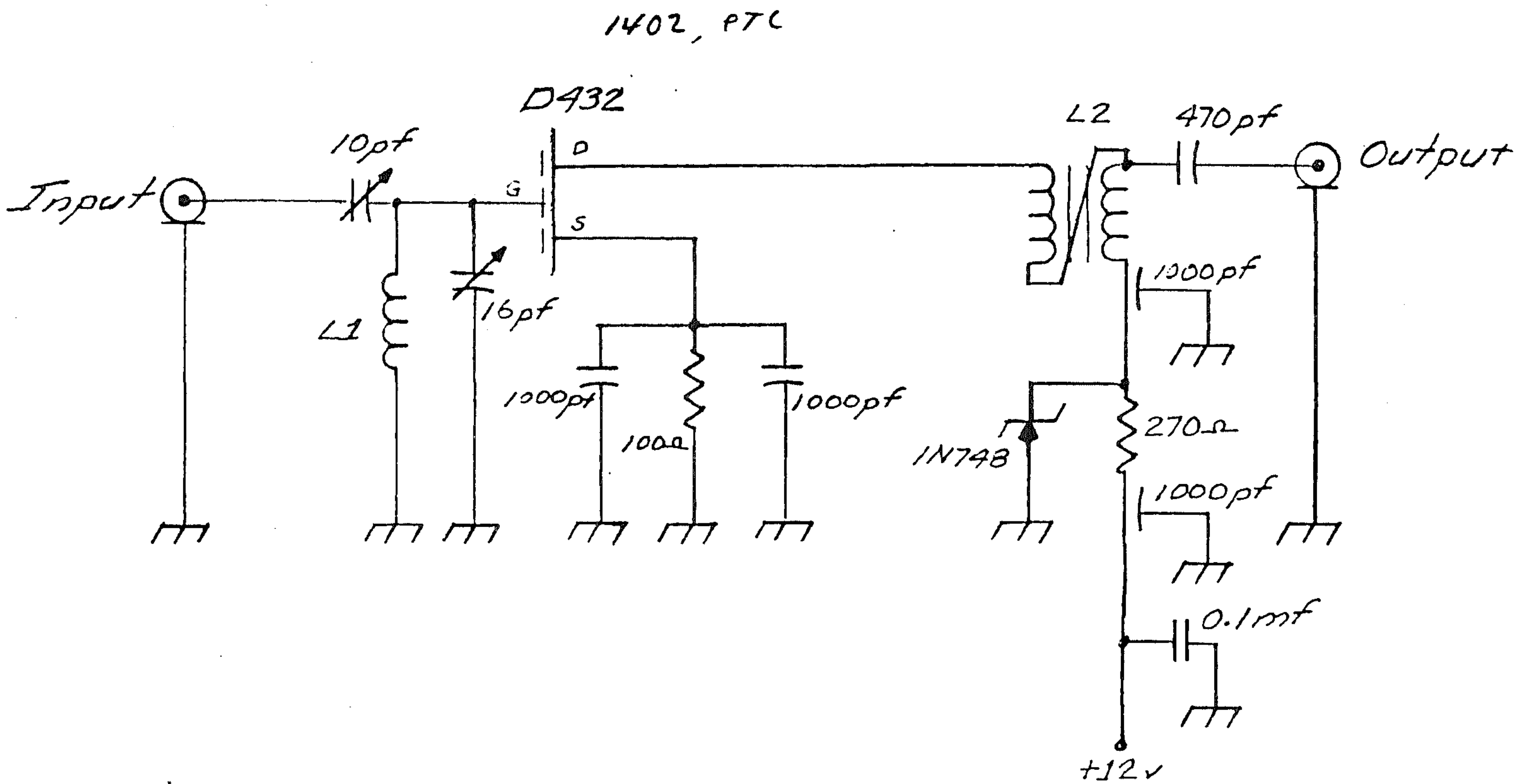
The three GaAsFET preamplifiers described in this EME note were built by W6PO and all are electrically the same. The schematic included in this note can be used for 144, 220 and 432 MHz. The die cast enclosure used on all thee preamplifiers was a BUD CU123. A COMPAC DC 4001 enclosure can also be used. The most important thing to remember is to use absolutely the best components available for the gate circuit. The unloaded "Q" of the gate circuit should be very high to insure a low noise figure. (As an example, with a coil and capacitor circuit in the gate circuit of the 432 MHz preamplifier, the noise figure would not go below 0.7 dB. With the higher "Q" stripline, the noise figure went down to 0.47 dB. Perhaps stripline techniques on 144 and 220 MHz would improve these amplifiers as well.) The noise figure will be 0.5 dB, or lower, with all three preamplifiers. The GaAsFET wants to look into a 100 to 200 ohm load. The 4:1 transformer does the job very well by making a 50 ohm second stage look like 200 ohms. A tuned circuit could be used with more complexity, but the gain of the stage with the transformer will be 18-20 dB on 432 MHz and 20-24 dB on 144 and 220 MHz. No input to output circuit shielding was necessary when using the 4:1 transformer circuit. This transformer idea was suggested by K6OJM and W6YFK. All three preamplifiers were stable in or out of the box. Stabilitiy was checked with a spectrum analyzer, noise figure meter and on the air checks.

APPENDIX F



LAYOUT OF THE 144 MHZ AND 220 MHZ PREAMPLIFIER

APPENDIX F



	144 MHz	220 MHz	432 MHz
L1	6 turns #14 wire 1/4" (0.64 cm) I.D. 1/2" (1.27 cm) long	4 turns #14 wire 1/4" (0.64 cm) I.D. 1/2" (1.27 cm) long	Copper strap 2 1/4" (5.72 cm) long by o.6" (1.52 cm) wide spaced 0.171" (0.43 cm) above ground plane
L2	12 turns of twisted pair of #24 enameled wire on Micrometals T37-0 toroid connected as 4:1 transformer	14 turns of twisted pair of #24 enameled wire on Micrometals T30-0 toroid connected as 4:1 transformer	5 turns of twisted pair #30 enameled wire on 1/4" (0.64 cm) diameter Q1 ferrite toroid connected as 4:1 transformer

APPENDIX H

Antenna Position Indicator
by Larry Molitor, W7IUV

Everyone will agree, I'm sure, that the use of high gain antenna arrays requires accurate positioning. As an example, let us assume we have an antenna with a horizontal beam width of seven degrees. A one percent error in azimuth (3.6 degrees) would result in a signal reduction of more than 3 dB! Obviously we must have extreme accuracy; the question is, how do we get it.

I'll try to show several ways to do this and then show what I consider the best solution. In the first three figures, analog meters or digital meters could be used and the circuits are useable for either azimuth or elevation. All use precision multi-turn pots mechanically coupled to the antenna. We will ignore any mechanical tolerance problems.

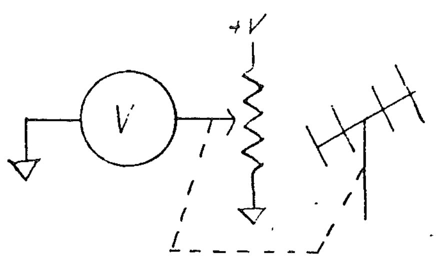


FIG. 1

Figure 1 shows a deceptively simple approach. In practice, a three tune pot might be used and 1.080 volts applied to it. A digital voltmeter would then read 0.0 to 0.360 volts for 360 degrees of rotation. There are a number of problems with this. To get to 0 degrees readout, the pot must go to electrical zero, some pots don't do this. Also, if your pot has mechanical stops and your rotation system does not, you've got big trouble! The overall accuracy of this system is equal to the absolute accuracy of the meter plus or minus the accuracy of the voltage applied to the pot. We will ignore the linearity of the pot, it is assumed you will use one with a linearity of plus or minus 0.25 percent or better. Calibration and drift compensation can be acomplished but this may be beyond the capability of most builders.

The circuit shown in figure 2 resolves the pot zero problem nicely. Using the bridge configuration, the pot will be at the center of rotation of 0 degrees and the supply voltage can be adjusted to make the meter read correctly for 360 degrees.

The thing I don't like about these two circuits, is that you must mechanically adjust the pot for zero AT THE ANTENNA. I find this inconvenient if not impossible to do.

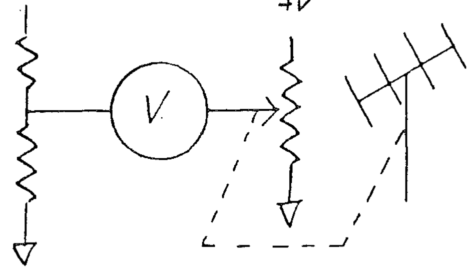


FIG. 2

If we add a couple of multi-turn trim pots as shown in figure 3, we can do all our calibration in the shack or at least from the ground. Here's how: the transducer pot is permanently installed with the approximate center of rotation at 0 degrees antenna heading. This is not critical. Make sure the antenna is pointed North (North Star or whatever). Adjust R-zero for 0 degrees on display. Rotate antenna thru East around to North again and set R-fullscale for 360 degrees on display. Supply voltage can be any thing large enough to insure a 360 degree reading.

This circuit still suffers from power supply drift problems. An additional disadvantage is that you must use an analog meter or a digital meter with differential input (not typical). One big advantage is that if use a belt drive system to couple the pot to the mast, you need not know what the drive ratio actually is. If, for instance, you have a ten-turn pot that actually turns 4.37 times for a single turn of the antenna, who care's. It's all calibrated out with the fullscale pot.

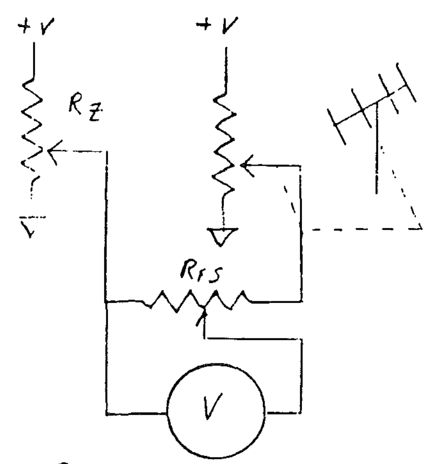


FIG. 3

Figure 3 works very nicely as is for most elevation systems. With only 90 degrees of movement required, you can get 1 degree resolution with an inexpensive analog meter. Power supply requirements are met by a simple three-terminal regulator. This is what I use, and it has prove to be reliable and accurate.

We still have the problem of overall accuracy for azimuth. The circuit shown in figure 4 is my answer to this problem. It easily meets all of the accuracy requirements as well as being simple to build and easy to adjust.

The heart of the circuit is the INTERSIL ICL7107. This is a single-ship 3½ digit voltmeter which has true differential inputs for both reference and unknown voltage. This chip, as well as the common anode LED displays, is available from **CIRCUIT SPECIALISTS, INC., P.O. Box 3047, Scottsdale, AZ, 85257. (order phone 800-528-1417).**

The ICL7107 is a ratiometric device in that it compares the input to the reference and displays the ratio of the two. For example, a typical DVM application would have a percision 1.000 volt reference applied between pins 35 and 36. If 0.0 volts were applied between points G and H in figure 4, the display would read 000, 1.000 volts in would read 1000, 1.525 volts in would read 1525, etc. Suppose the reference were 2.00 volts, then 1.00 volts at the input would read 500.

JUN 15,1986 29x25'55" N MOON POSITION FOR W5UN RANGE: 381,847 KM
SUNDAY 95x21'22" W (PRINTED BY WA1JXN) A+ 1 DAYS 15.65'SD
JD: 2446596.5 (QTH:EL29HK)

GMT	NOTES	W	AZIMUTH	ELEV	GHA	DEC	RT ASCN	144 MHZ xK	144 MHZ DB	432 MHZ xK	432 MHZ DB
0000		Nz	174.0	68.1	93.2	8.0	11H 19M	207	1.5	15	1.0
0015		N	183.9	68.2	96.8	8.0	11H 19M	207	1.5	15	1.0
0030		N	193.7	67.7	100.4	8.0	11H 20M	207	1.5	15	1.0
0045		N	202.9	66.7	104.0	8.0	11H 20M	207	1.5	15	1.0
0100		N	211.3	65.3	107.6	8.0	11H 21M	207	1.5	15	1.0
0115		Nz	218.5	63.2	111.4	7.7	11H 21M	207	1.5	15	1.0
0130		N	224.9	61.1	115.0	7.7	11H 22M	207	1.5	15	1.0
0145		N	230.5	58.7	118.6	7.7	11H 22M	207	1.5	15	1.0
0200		N	235.3	56.2	122.2	7.7	11H 23M	207	1.5	15	1.0
0215		N	239.6	53.5	125.8	7.7	11H 23M	207	1.5	15	1.0
0230		Nz	243.1	50.4	129.6	7.4	11H 24M	207	1.5	15	1.0
0245		N	246.5	47.6	133.2	7.4	11H 24M	208	1.5	15	1.0
0300		A	249.5	44.6	136.8	7.4	11H 25M	208	1.5	15	1.0
0315		A	252.3	41.6	140.4	7.4	11H 25M	208	1.5	15	1.0
0330		A	254.9	38.6	144.0	7.4	11H 26M	208	1.5	15	1.0
0345		Az	257.0	35.2	147.8	7.1	11H 26M	208	1.5	15	1.0
0400		A	259.2	32.1	151.4	7.1	11H 27M	208	1.5	15	1.0
0415		A	261.3	29.0	155.0	7.1	11H 27M	208	1.5	15	1.0
0430		A	263.4	25.9	158.6	7.1	11H 28M	208	1.5	15	1.0
0445		A	265.3	22.7	162.2	7.1	11H 28M	208	1.5	15	1.0
0500		z	266.9	19.3	165.9	6.8	11H 29M	208	1.5	15	1.0
0515			268.7	16.2	169.6	6.8	11H 29M	208	1.5	15	1.0
0530			270.5	12.9	173.2	6.8	11H 30M	213	1.6	15	1.0
0545			272.3	9.7	176.8	6.8	11H 30M	213	1.6	15	1.0
0600			274.0	6.6	180.4	6.8	11H 31M	214	1.6	15	1.0
0615		z	275.6	3.0	184.2	6.5	11H 31M	214	1.6	15	1.0
1845		z	86.9	0.8	6.0	3.3	11H 56M	233	1.9	17	1.1
1900			88.7	4.2	9.6	3.3	11H 56M	234	1.9	17	1.1
1915			90.5	7.4	13.2	3.3	11H 57M	234	1.9	17	1.1
1930			92.3	10.6	16.8	3.3	11H 57M	235	1.9	17	1.1
1945			94.1	13.7	20.4	3.3	11H 58M	235	1.9	17	1.1
2000		z	96.3	16.9	24.1	2.9	11H 58M	235	1.9	17	1.1
2015			98.2	20.0	27.8	2.9	11H 59M	236	1.9	17	1.1
2030			100.2	23.1	31.4	2.9	11H 59M	236	1.9	17	1.1
2045			102.3	26.2	35.0	2.9	12H 0M	261	2.3	18	1.1
2100			104.5	29.3	38.6	2.9	12H 0M	261	2.3	18	1.1
2115		z	107.2	32.3	42.4	2.6	12H 1M	261	2.3	18	1.1
2130			109.7	35.3	46.0	2.6	12H 1M	262	2.3	18	1.1
2145			112.3	38.2	49.6	2.6	12H 2M	262	2.3	18	1.1
2200			115.2	41.1	53.2	2.6	12H 2M	263	2.3	18	1.1
2215		E	118.3	44.0	56.8	2.6	12H 3M	263	2.3	18	1.1
2230		Ez	122.2	46.6	60.5	2.3	12H 3M	264	2.3	18	1.1
2245		E	126.0	49.2	64.1	2.3	12H 4M	264	2.3	18	1.1
2300		E	130.2	51.7	67.8	2.3	12H 4M	265	2.3	18	1.1
2315		E	134.9	54.0	71.4	2.3	12H 5M	265	2.3	19	1.2
2330		E	140.2	56.1	75.0	2.3	12H 5M	266	2.3	19	1.2
2345		Ez	146.5	57.8	78.7	2.0	12H 5M	266	2.3	19	1.2
2400		E	152.9	59.4	82.3	2.0	12H 6M	266	2.3	19	1.2

APPENDIX G

APPENDIX H

In our application we don't care what voltage we really have, we only care about **DEGREES**. If we derive a reference from the same source as the bridge is supplied from we can TOTALLY eliminate the need for a regulated supply. True, with an unregulated supply we know what the actual voltage is at the input to the chip. Would ,elieve that I don't care? I, for one, am only interested in a ration indication from the bridge, in other words, **ANTENNA POSITION!!**

This method has been tested and proved. With the power supply varied from 6 volts (ICL7107 maximum) down to where I could just see the display, there was NO change in reading at 360 degrees (worst case).

The resistor values for the reference and the bridge should cover most applications. R1 can be a ten-turn or a three-turn pot. If you have trouble calibrating for a full 360 degree indication, try increasing the value of the 3.9k on pin 36.

Calibration is easy, the elevation indicator is set up just like figure 3 was. R5 adjusts 0 degrees and R6 adjusts 90 degrees (90 microamps on meter).

For the azimuth, R1 is installed with center of rotation at 0 degrees (North). This is not at all critical, plus or minus one-half turn is better than need be. Adjust R2 for 000 readout. Rotate antenna thru East around to North again. If your minus sign is hooked up and the reading goes negative, reverse the leads from R1 at points A and B. Now adjust R3 for a 360 reading, recheck zero and 360, and your done!

A word of caution!! Not shown in the schematic are bypass components. This device must be shielded in a metal box and all leads into and out of the box must be completely filtered for RF, chokes and caps at least. MOS devices, regardless of internal protection, can and will self-destruct in the presence of high RF voltages.

This circuit is presented with the intent of providing a cheap, extremely accurate antenna position indicator using readily obtainable parts. Hopefully some of the hokus-pokus associated with these circuits has been explained away.

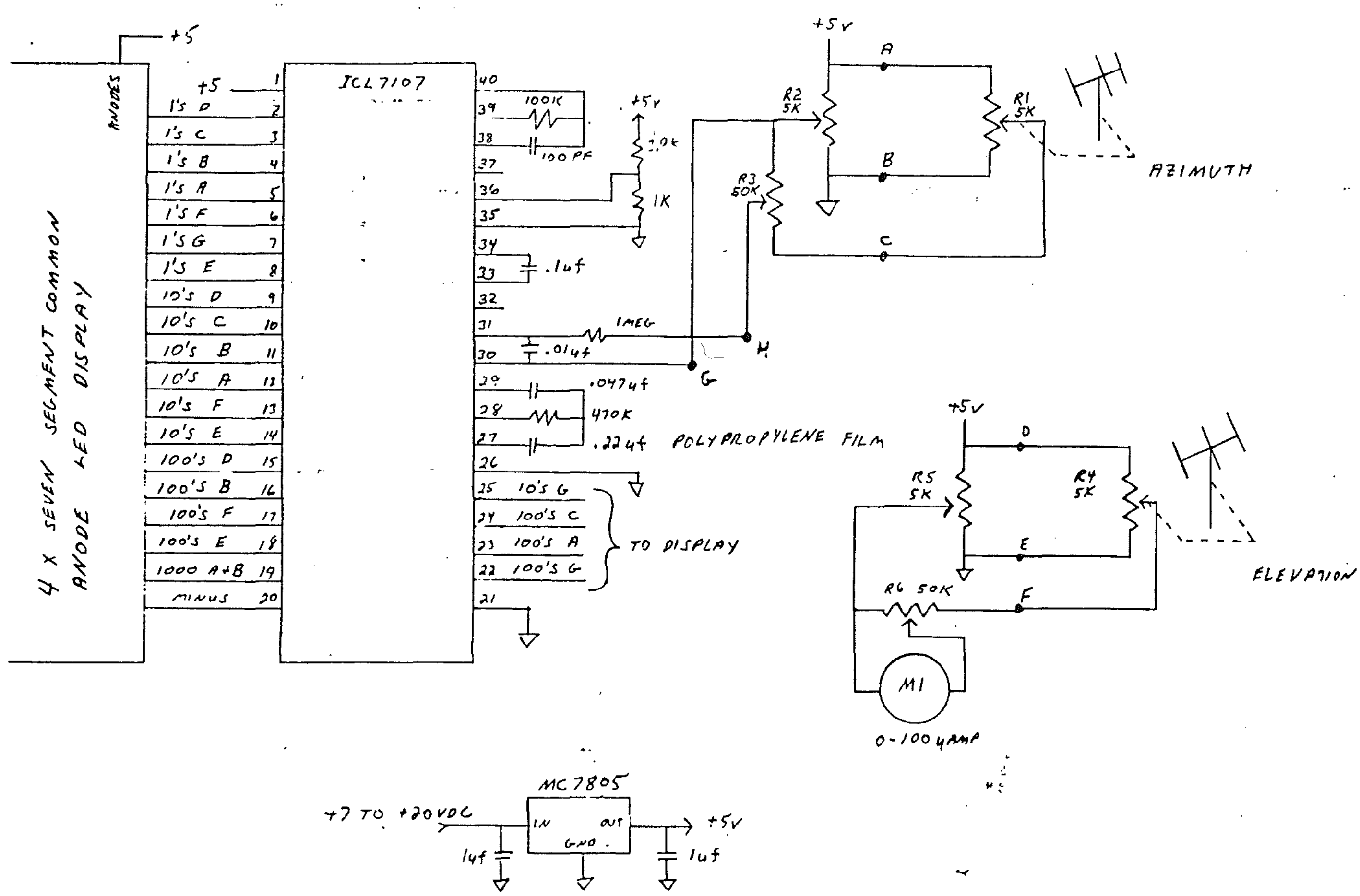


FIGURE 4

5760 AS WE KNOW IT

K5PJR / W5UGO
Tony Bickel / Larry Nichols

WHAT CAN BE DONE?

- DISTANCES - LOS/SCATTER
- MODULATION - CW/SSB/FM
- PROPAGATION - SCATTER, RAIN, & TROPO

WHERE IS EQUIPMENT?

- COM'L AMATEUR FROM EUROPE
- SURPLUS (GOOD VS. BAD)
- SURPLUS SOURCES

WHAT ABOUT ANTENNAS?

- HORNS/OMNI
- DISHES & FEEDS
- MOUNTS & INDICATORS

TEST EQUIPMENT

- WEAK SIGNALS / PROBES
- COUNTERS & POWER METERS
- HARMONICS OF 144 or 1152, etc.
- PROBES FOR TUNING FILTERS

LIASON ON SKEDS

- ANOTHER BAND
- TIME/SEQUENCE
- ABBREVIATIONS

BEACONS, ETC.

- WEATHER RADAR
- HEADING/FREQ. INDICATORS
- ANTENNAS FOR BEACONS

WHAT IS DIFFICULT?

- GETTING EQUIPMENT PORTABLE
- POWER OVER 2 MW (THEN 10 W.)
- POINTING ANTENNAS CORRECTLY
- KNOWING YOUR FREQUENCY

GEOGRAPHY AND ITS IMPORTANCE

- TOPO MAPS (LIBRARY COPIES)
- PROTRACTOR & COMPASS
- LANDMARKS
- HAND CALCULATOR

OBSERVATIONS (PLAY TAPES)

HIGH PERFORMANCE YAGIS FOR 432 MHz

By Steve Powlishen K1FO

Yagi design is no longer a black art

We now know what configurations work best.

Today's high performance yagi must have both varing spacings and lengths

Spacings should get progressively wider
Lengths should get progressively shorter

It's time to trash those fixed spacing or element length yagis (i.e. NBS, W2NLY etc.)

Greenblum knew this in the early 1950's
What took the rest of this so long to catch on?

2 June 1986

We also know what to expect
from a modern long yagi

A clean pattern:

First sidelobes down 16 to 18 dB

Front to back 20 TO 25 dB

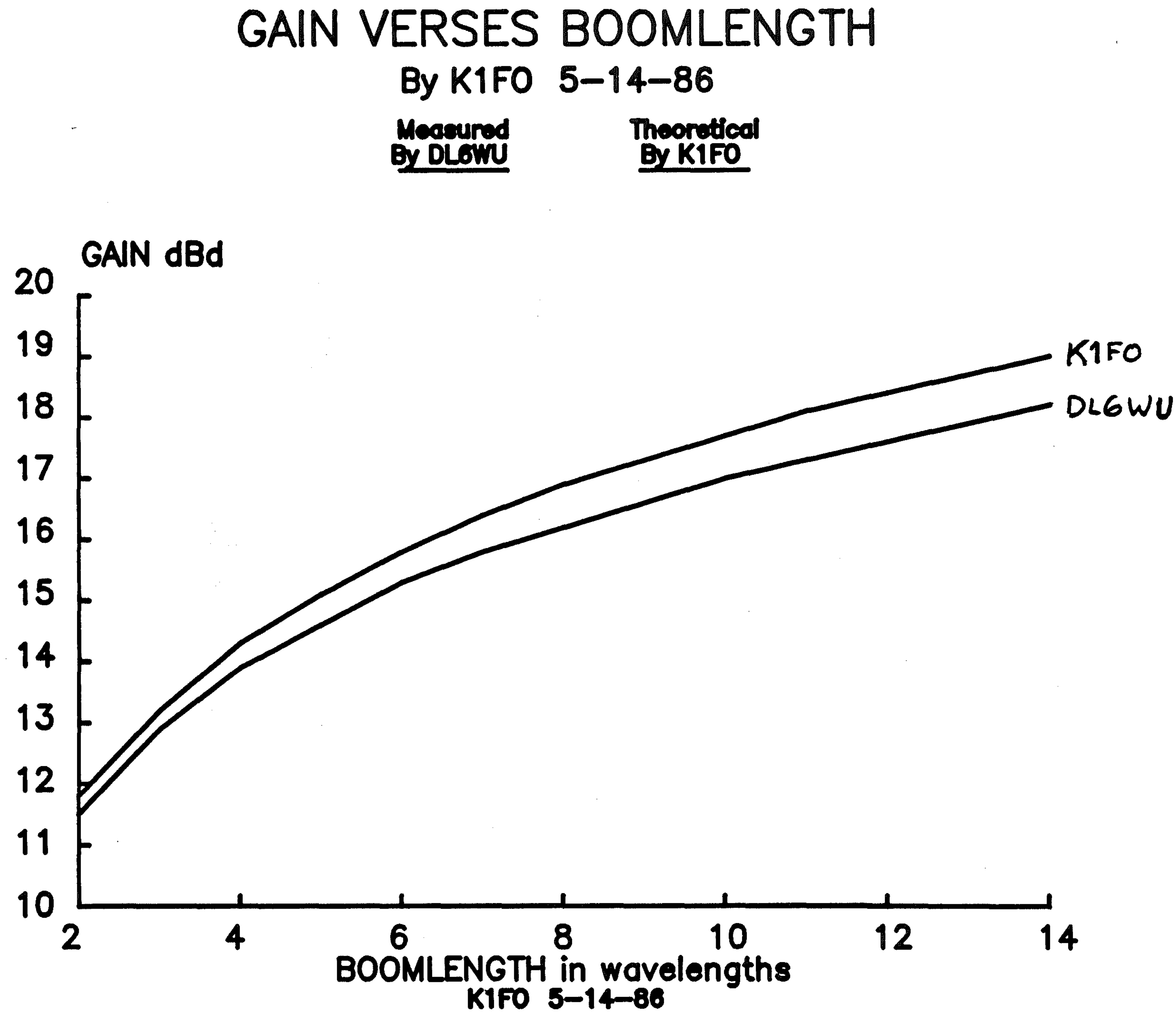
All other lobes down greater than 25 dB

We even know how much gain
to expect given the boomlength

(At least within a few tenths of a dB)

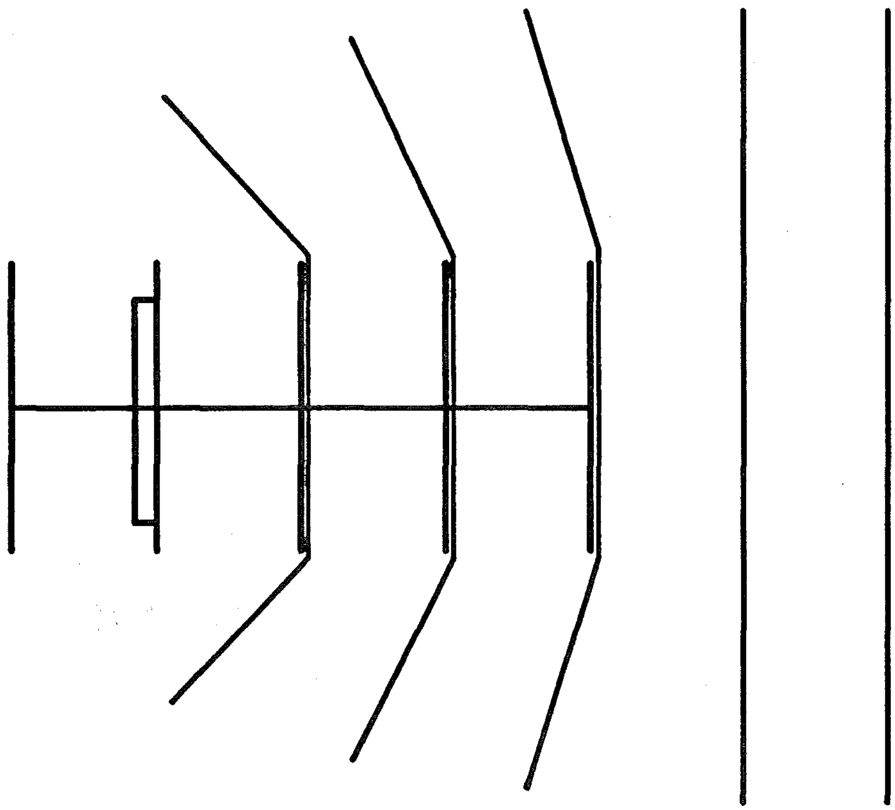
It will also have good gain bandwidth

(Greater than 2% of center frequency)


GAIN VERSES BOOMLENGTH
By K1FO 5-14-86
Measured
By DL6WU
Theoretical
By K1FO
GAIN dBd
20
19
18
17
16
15
14
13
12
11
10
2
4
6
8
10
12
14
K1FO
DL6WU
BOOMLENGTH in wavelengths
K1FO 5-14-86

4

HOW DOES A YAGI WORK?



By creating a discontinuity in the propagation medium it distorts the traveling wave

A good yagi will focus these "bent" waves into the driven element

WHAT TO DO FOR A NEW 432 ARRAY?

Commercial yagis very limited in selection

DL6WU performs good, but
track down all the parts
and drill all those holes

Besides lets not get in another
NBS rut, try something different!
Maby it's possible to make something
better than the DL6WU design

Could a commercial yagi be modified
to perform without peer?

It sure would simplifiy construction

424B PROBLEMS

1. Poor pattern
   −11 dB first sidelobes
   overly narrow main lobe (19°)
2. Terrible wet weather VSWR
3. Tuned too close to 432 MHz

424B FEATURES

1. Good mechanical construction
2. Reasonable cost considering
   all stainless hardware including U bolts
3. Insulated through the boom elements
4. Tunable T match

WHERE TO START?

Analyze yagi designs that work well, and also those that don't

424B suffers from too many identical spacings and director lengths

Both conditions cause poor patterns and bandwidth

Why do you think that NBS quit at 4.2 wv?

Tri—reflector not worth the extra 0.2 dB

The gain addition of any mulitiple reflector arrangement is inversely proportional to to how well the directors are tuned

In other words a Band—Aid

Why didn't Cushcraft develop them?

$100K	Computer, programs training
$ 40K	Engineer Salary
$ 60K	Overhead
$ 50K	Model maker, antenna range etc.
$250K	Total

U.S. Market for long 432 Yagis

500 a year? probably high

Payback over 5 years (probably too long)

Must also figure time value of money

R & D cost per yagi	$150.00
Materials & Labor	$100.00
Dealer Markup	$107.00
Total List Price	$357.00

They can't afford to!!

IMPROVED 424B CHRONOLOGY

April 1984: Try first new director arrangement, based on gut feel 7 new holes, seemed to work

May 1984: W1EJ computer analyzes it I'm on the right track

June—July 1984: Cut and try not much improvement.

August 1984: Get my hands on the WB3BGU yagi program

Sept 1984: Get it running, translate to HP BASIC, fix bugs add graphics

Oct — Dec 1984: Analyze every available yagi design to find qwirks in program

January 1985: Analyze 10 different spacing arrangements, choose one that requires only 3 new holes

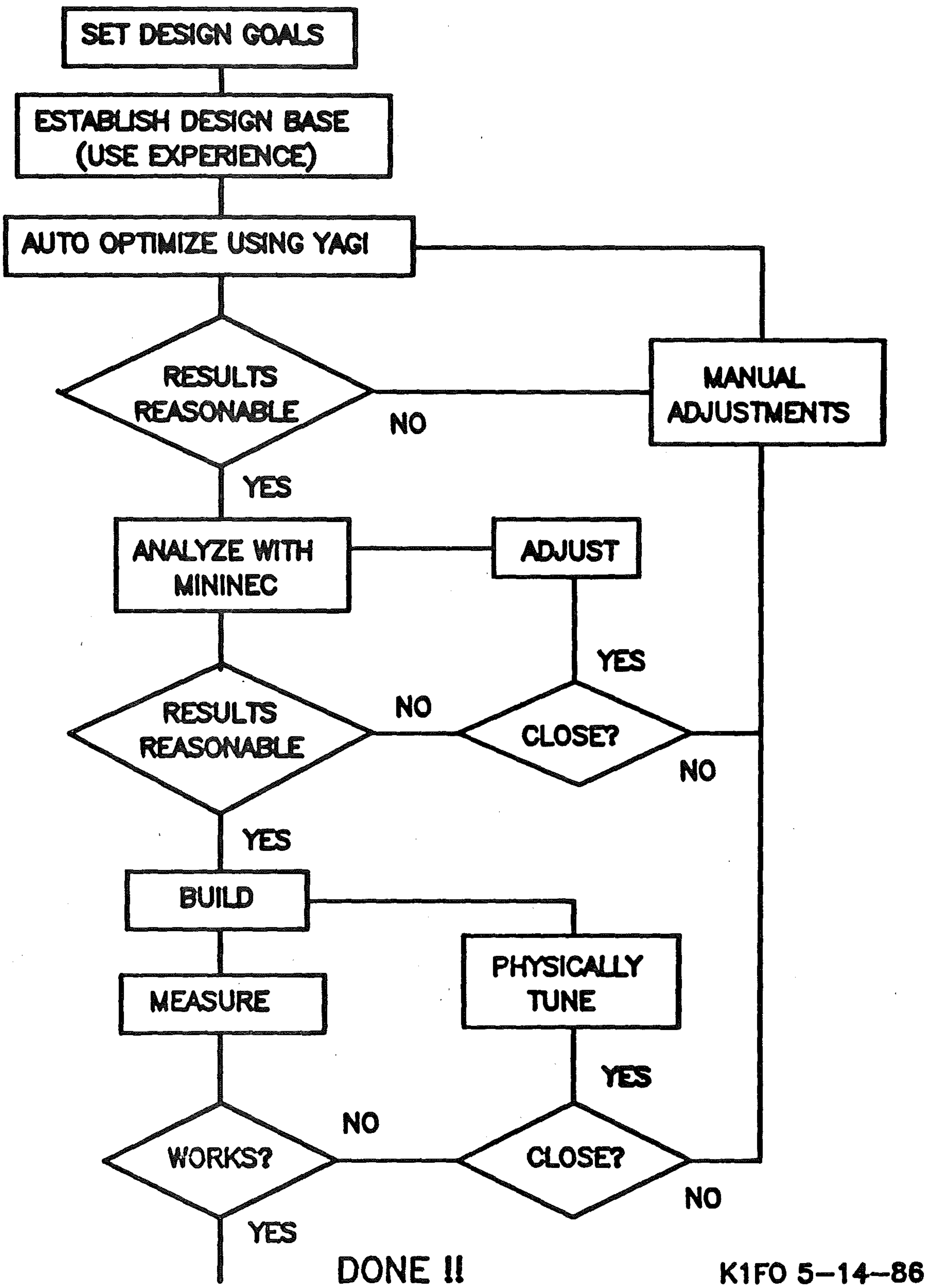
February 1985: Start playing again with element lengths. I'm living by the computer. Start in ernest on 24' long 32 element version.

March 1985: Write automatic length optimization routine.

April 1985: Computer running 24 hours optimizing.

May 1985: Start building 24' antennas 5 builds, but its not right yet. Version #1 brought to Eastern VHF Conference. Beats 22' KLM by 0.2 dB and 24' W1JR by 0.3 dB

COMPUTER AIDED YAGI DESIGN CYCLE



RESULTS

Two very high performance yagis

Which are easy to build

17' (7.5 wv) 24 element yagi

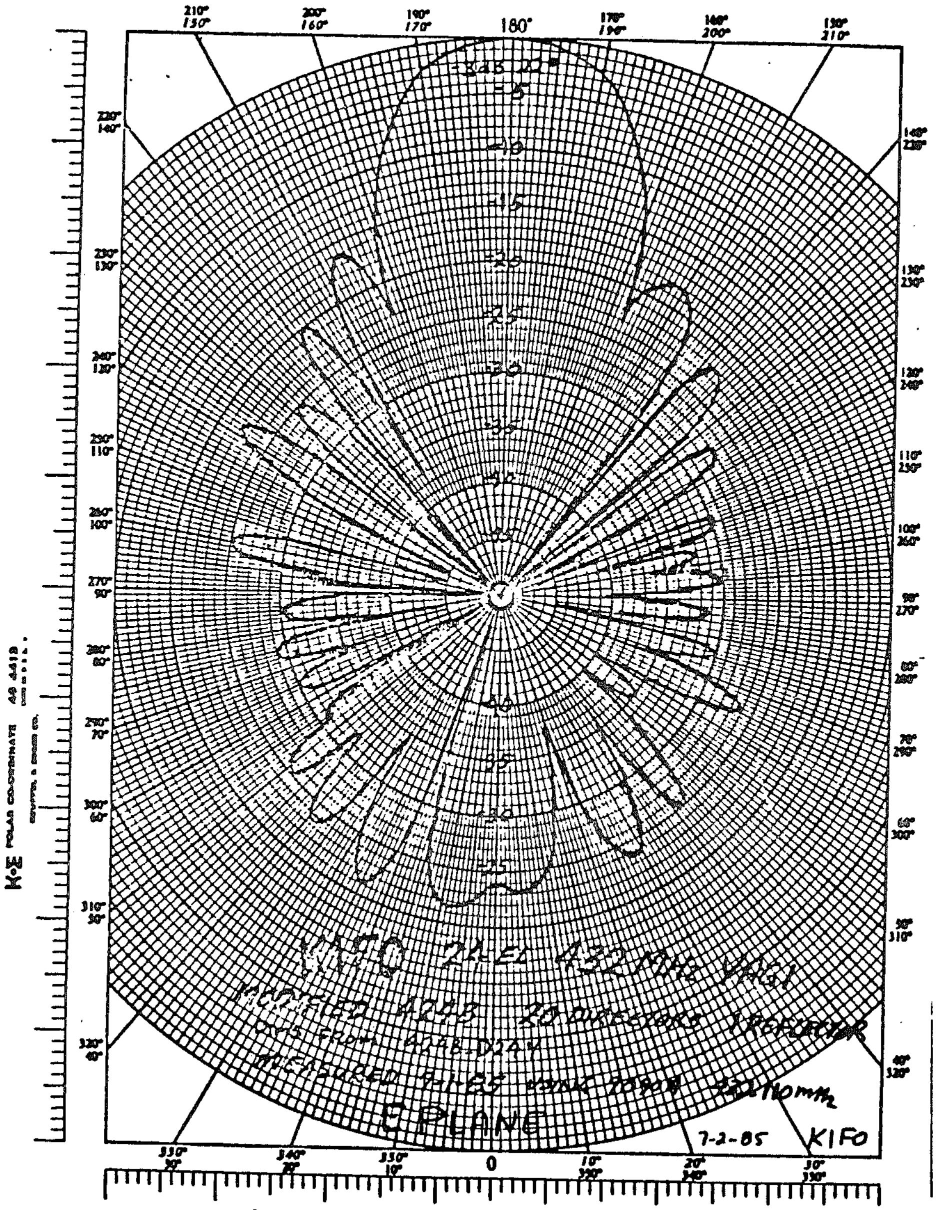
Made from a 424B
Only needs 3 new holes drilled
and one 14" piece of 3/16" rod

16.2 dBd gain, 25 dB fb
−17 dB first sidelobes

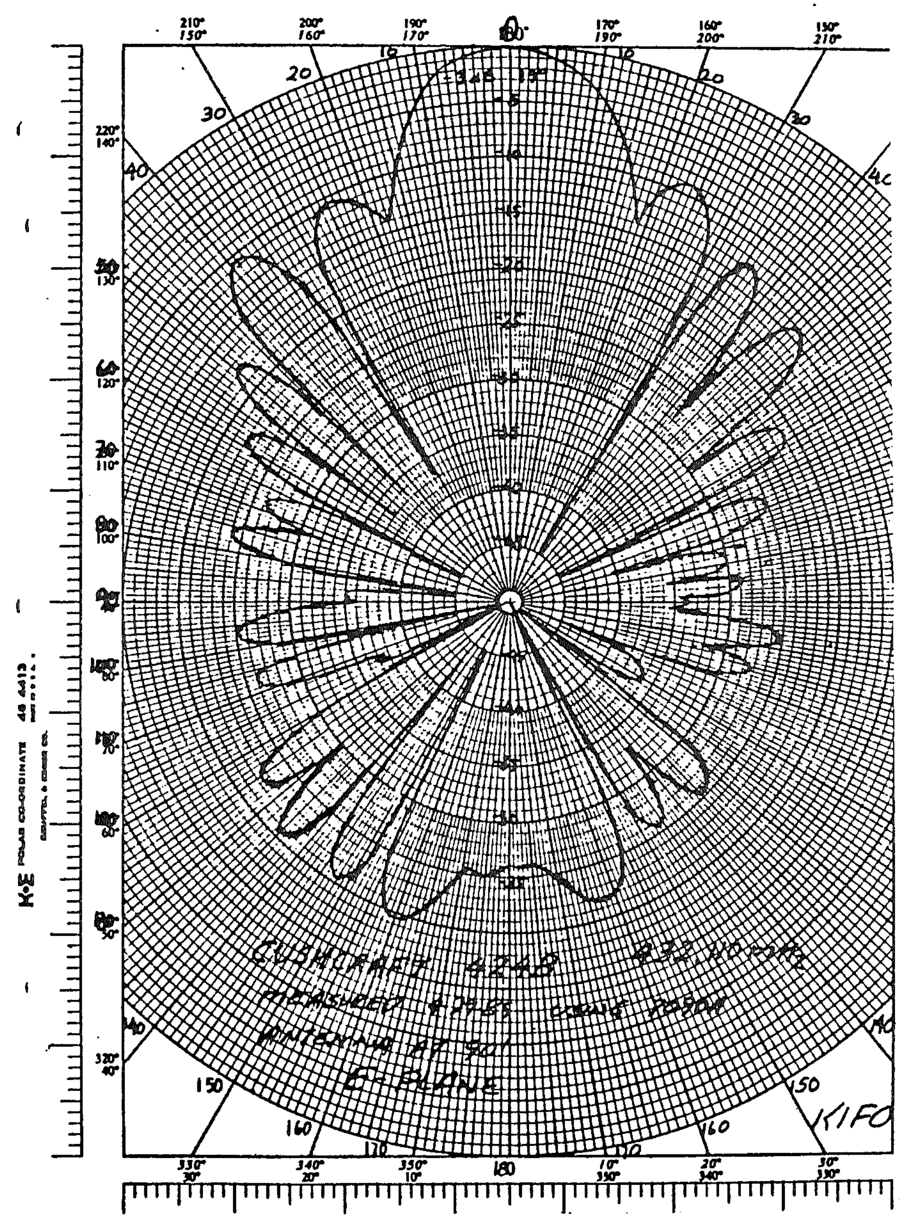
24' (10.5 wv) 32 element yagi

Made from a 424B, some Cushcraft parts
Only 3 home made parts besides elements

17.7 dBd gain, 25 dB front to back
−17 dB first sidelobes



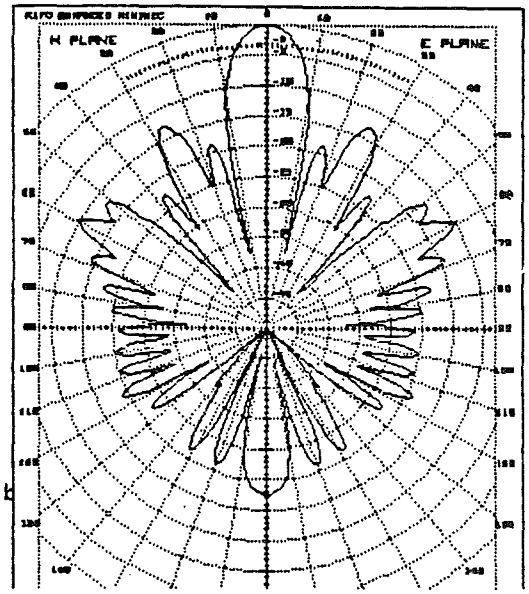
K1FO 24 el MODIFIED 424B
1 REFLECTOR, SAME BOOMLENGTH
E PLANE



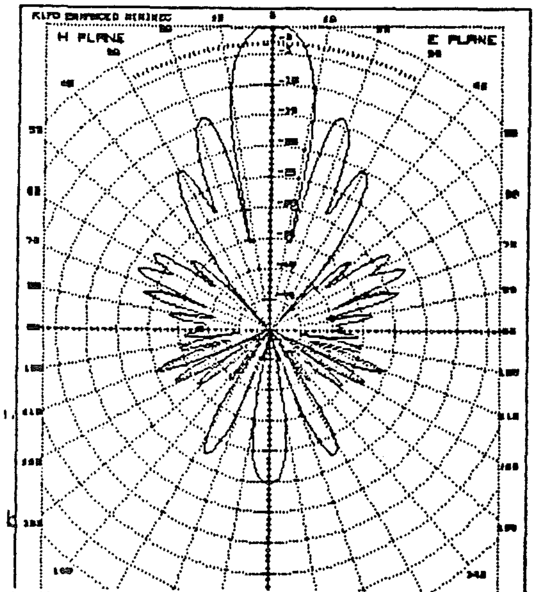
STOCK 424 B
E PLANE

WHY IS A CLEAN PATTERN IMPORTANT ?

Compare these patterns!!



2 x Stock 424B
H Plane spaced 52''



2 x K1FO Modifed 424B
H Plane spaced 60''

Not only is the pattern of the array with the modified 424Bs significantly cleaner, but the wider spacing gives 0.5 dB more stacking gain.

On receive an EME array of the K1FO modified 424Bs will be close to 3 dB better!!!
This added performance comes from:
+0.5 dB individual yagi gain advantage
+1.0 dB higer array gain from wider spacing
+1.5 dB S/N due to lower array temperature from cleaner pattern.

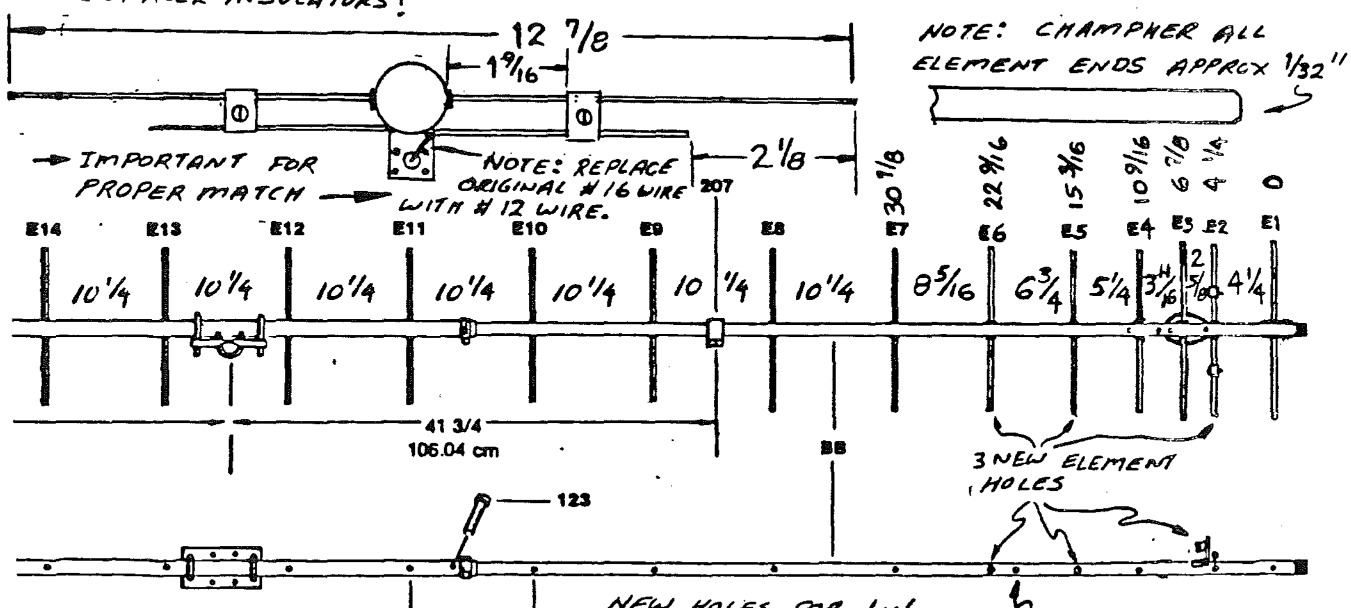
On transmit an EME array of the K1FO modified 424Bs will be close to 1.5dB better than stock 424Bs.

24 ELEMENT K1FO MODIFIED 424B
SAME BOOMLENGTH, SINGLE REFLECTOR
22 DIRECTORS

DECIMAL		FRACTION	1/2 el OUT OF BOOM
Elength(1)=13.875	!	13 7/8 "	6 7/16
Elength(2)=12.875	!	12 7/8 "	5 15/16
Elength(3)=12.875	!	12 7/8 "	5 15/16
Elength(4)=12.375	!	12 3/8 "	5 11/16
Elength(5)=12.375	!	12 3/8 "	5 11/16
Elength(6)=12.25	!	12 1/4 "	5 5/8
Elength(7)=12.0625	!	12 1/16"	5 17/32
Elength(8)=11.875	!	11 7/8 "	5 7/16
Elength(9)=11.75	!	11 3/4 "	5 3/8
Elength(10)=11.5625	!	11 9/16"	5 9/32
Elength(11)=11.375	!!!	11 3/8 "	5 1/8
Elength(12)=11.375	!!!	11 3/8 "	5 1/8
Elength(13)=11.375	!!!	11 3/8 "	5 1/8
Elength(14)=11.28125	!!!	11 9/32"	5 5/64
Elength(15)=11.03125	!!!	11 1/32"	4 61/64
Elength(16)=11.03125	!!!	11 1/32"	4 61/64
Elength(17)=11.09375	!!!	11 3/32"	4 63/64
Elength(18)=11.0625	!	11 1/16"	5 1/32
Elength(19)=10.875	!	10 7/8 "	4 15/16
Elength(20)=10.875	!	10 7/8 "	4 15/16
Elength(21)=10.875	!	10 7/8 "	4 15/16
Elength(22)=10.9375	!	10 15/16"	4 31/32
Elength(23)=10.9375	!	10 15/16"	4 31/32
Elength(24)=10.875	!	10 7/8 "	4 15/16
!			

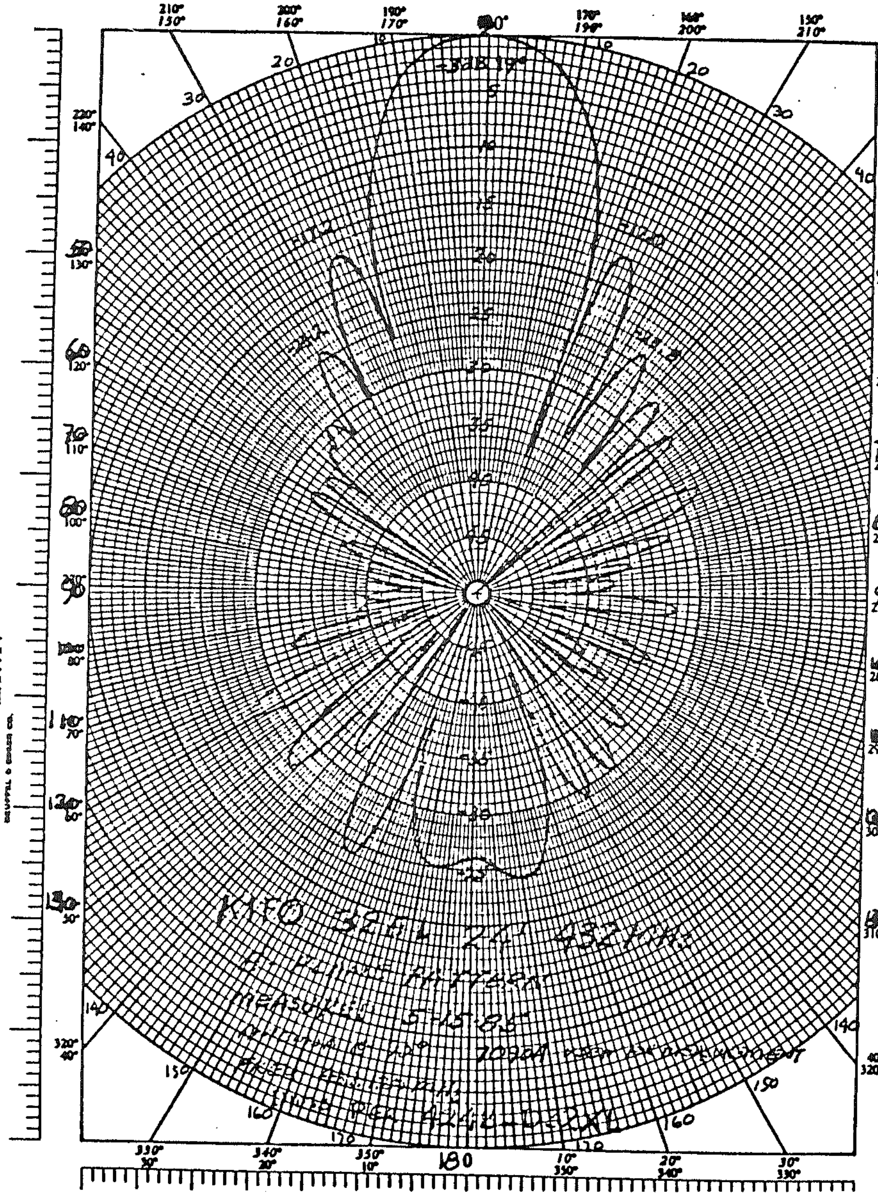
NOTE: DO NOT USE BLACK RECTANGULAR SPACER INSULATORS!

VERSION 'D' 424B_Dxxy
2 ADDITIONAL DIRECTORS



424B

NEW HOLES FOR 'N' CONNECTOR BRACKET & BALUN CLAMP MUST BE DRILLED 2 5/8" TO REAR OF THE ORIGINAL HOLES.



424B_D32Y 10 August 1985

Element Lengths for 32 element extended 424B 17.1 dBd GAIN

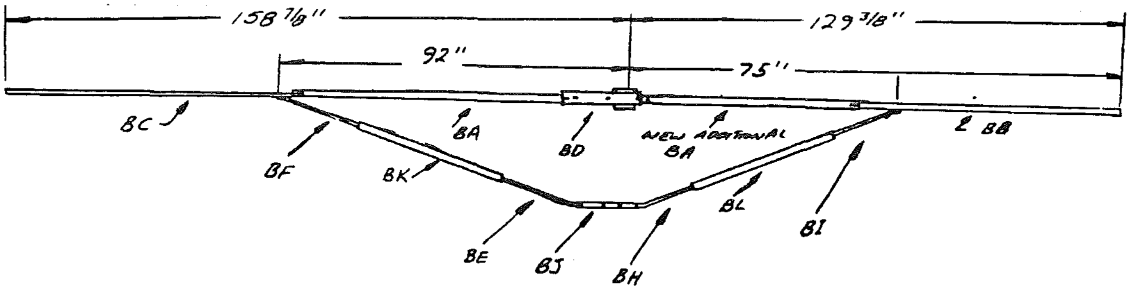
		DECIMAL		FRACTION	1/2 el OUT OF BOOM
260	!				
270		Elength(1)=13.9375	!	13 15/16"	6 15/32
280	!	Elength(2)=13.375	!	13 3/8 "	6 3/16
290		Elength(3)=12.9375	!	12 15/16"	5 31/32
300		Elength(4)=12.375	!	12 3/8 "	5 11/16
310		Elength(5)=12.375	!	12 3/8 "	5 11/16
320		Elength(6)=12.25	!	12 1/4 "	5 5/8
330		Elength(7)=12.0625	!	12 1/16"	5 17/32
340		Elength(8)=11.875	!	11 7/8 "	5 7/16
350		Elength(9)=11.75	!	11 3/4 "	5 3/8
360		Elength(10)=11.5625	!	11 9/16"	5 9/32
370		Elength(11)=11.375	!!!	11 3/8 "	5 1/8
380		Elength(12)=11.375	!!!	11 3/8 "	5 1/8
390		Elength(13)=11.375	!!!	11 3/8 "	5 1/8
400		Elength(14)=11.3125	!!!	11 5/16"	5 3/32
410		Elength(15)=11.0625	!!!	11 1/16"	4 31/32
420		Elength(16)=11.0625	!!!	11 1/16"	4 31/32
430		Elength(17)=11.125	!!!!!	11 1/8 "	4 15/16
440		Elength(18)=11.125	!!!!!	11 1/8 "	4 15/16
450		Elength(19)=10.9375	!!!	10 15/16"	4 29/32
460		Elength(20)=10.9375	!!!	10 15/16"	4 29/32
470		Elength(21)=10.9375	!!!	10 15/16"	4 29/32
480		Elength(22)=11.0000	!!!	11 "	4 15/16
490		Elength(23)=10.9375	!!!	10 15/16"	4 29/32
500		Elength(24)=10.9375	!!!	10 15/16"	4 29/32
511		Elength(25)=10.8125	!!!	10 13/16"	? 4 27/32
512		Elength(26)=10.8125	!	10 13/16"	4 29/32
513		Elength(27)=10.8125	!	10 13/16"	4 29/32
514		Elength(28)=10.8125	!	10 13/16"	4 29/32
515		Elength(29)=10.8125	!	10 13/16"	4 29/32
516		Elength(30)=10.875	!	10 15/16"	4 15/16
517		Elength(31)=10.875	!	10 15/16"	4 15/16
518		Elength(32)=10.8125	!	10 13/16"	4 29/32

SPACINGS:

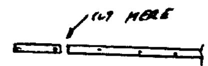
USE MODIFIED REAR BOOM SECTION AS DESCRIBED FOR 24 ELEMENT VERSION.

REF-DE 4 1/4"
DE-D1 2 5/8" ← NEW HOLE (FOR DE)
D1-D2 8 11/16"
D2-D3 5 1/4" ← NEW HOLE (FOR D2)
D3-D4 6 3/4" ← NEW HOLE (FOR D3)
D4-D5 8 5/16"
ALL OTHER SPACINGS 10 1/4"

32 element 24' EXTENDED 424B

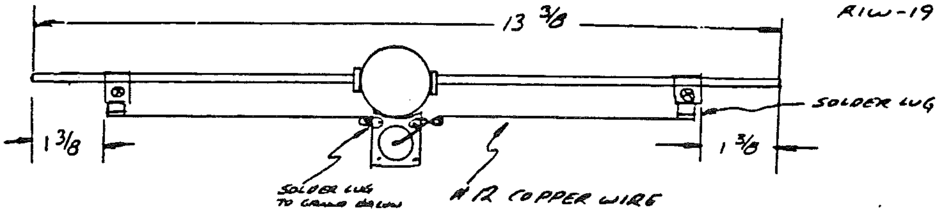


NOTE: PARTS BE, BF, BH, BI & BJ ARE FROM CUSHCRAFT 220B
PARTS BD, BK & BL ARE NEW, SEE DRAWING FOR DETAILS
CUT ADDITIONAL BA BOOM SECTION JUST BEHIND FRONT DIRECTOR
USE 8-32 SCREWS & STAINLESS HOSE CLAMPS AT ALL BOOM JOINTS

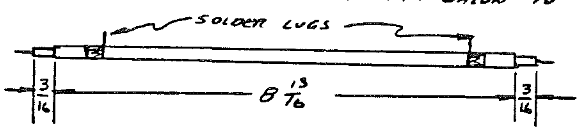


DRIVEN ELEMENT

CONSTRUCTION SIMILAR TO RIW-19

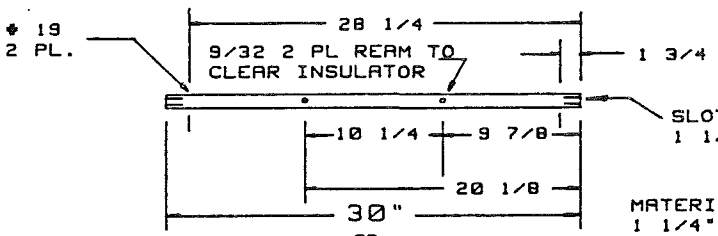


BALUN: USE UT-141 OR SHORTEN CUSHCRAFT BALUN TO FOLLOWING DIMS:



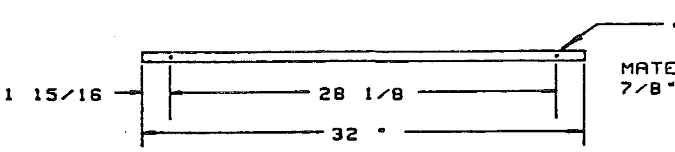
K1FO 32 ELEMENT 24' LONG 432 MHz YAGI

K1FO
5-12-86



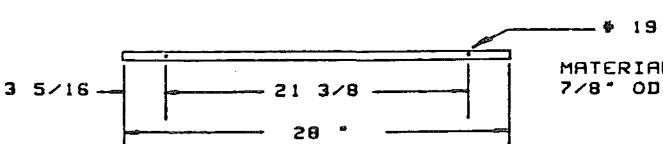
MATERIAL: 6061-T6 ALUM.
1 1/4" OD, .058" WALL

BD
CENTER BOOM SECTION



MATERIAL: 6061-T6 ALUM.
7/8" OD, .058" WALL

BK
REAR BOOM SUPPORT CENTER SECTION



MATERIAL: 6061-T6 ALUM.
7/8" OD, .058" WALL

BL
FRONT BOOM SUPPORT CENTER SECTION

PARTS FOR 24' EXTENDED MODIFIED 424B

K1FO
28 May 1985

32 ELEMENT EXTENDED 424B

FOR THE EXPERIMENTALLY INCLINED

24 element version only:

The stock Cushcraft 424B balun is 1.0'' too long. Shortening the balun will improve the pattern balance and should further improve the wet weather VSWR. If you use a correct lingth balun the dimensions of the T-match and / or driven element length will most likely be somewhat different for an acceptable match.

24 & 32 element versions:

Shortening the reflector to 13.6875'' and shortening director # 1 to 12.8125'' will further improve the wet weather VSWR and also improve the rear half of the pattern without causing a perceptable gain loss. These dimensions were not given as I have not yet worked out driven element dimensions that give an acceptable match.

More sophisticated director dimensions have been worked out for both the 24 and 32 element yagis. The new director dimensions shoud give 0.2 dB more gain in the 24 element yagi (16.4 dBd) and 0.1 dB more gain on the 32 element version. The patterns are better especially in the rear half of the pattern (Important for g/t on EME). These latest dimensions were not used in this information as the revised designs have not been tested. I will provide the revised dimensions to anyone sending me a SASE. At this time you will be on your own for the driven element and proving that they work correctly. I do not expect to find the time to finalize these revised designs within the next 6 months.

THE W1EJ YAGI DESIGNS

Computer designed

All spacings and lengths are different!

Progressively wider spacing

Progressively shorter lengths

Gain near theoretical maximum

Patterns not quite as good as desired

First E sidelobes −16.5 dB (−15 H)

Front to back in low 20's

THE K1FO YAGIS

Based upon the W1EJ spacings and director taper

Director lengths adjusted to tune to 432 MHz

Dimensions converted from theoretical tenths of millimeters to buildable English dimesions (mostly 1/16")

Two tested and easily duplicatable designs with real world dimensions

22 ELEMENT VERSION

The RIW yagi of the 1980's

6.1 wv (14 feet) long

15.8 dBd gain (~0.8 dB over RIW)

Better pattern than RIW

First sidelobes −17 E AND −15 H
(same as RIW)

Front to back > 20 dB (5 dB over RIW)

Minor lobes in H plane 5 to 8 dB
lower than RIW
(Important in EME arrays)

Low windload (0.8 sq ft)

Light weight (< 4 lbs)

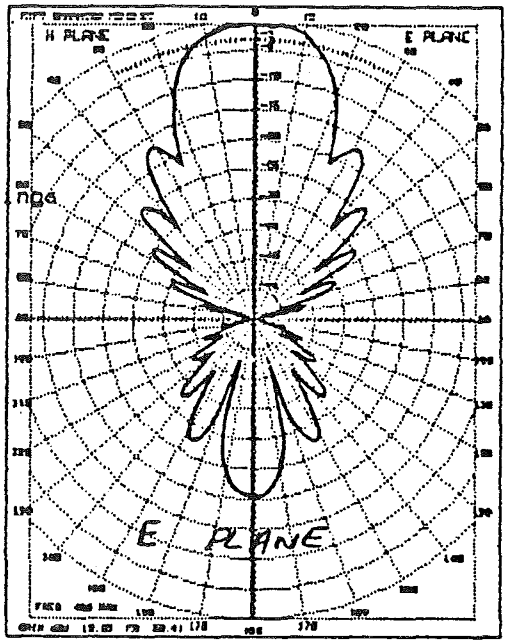
K1FO 22 ELEMENT 17 LONG 432 MHz YAGI

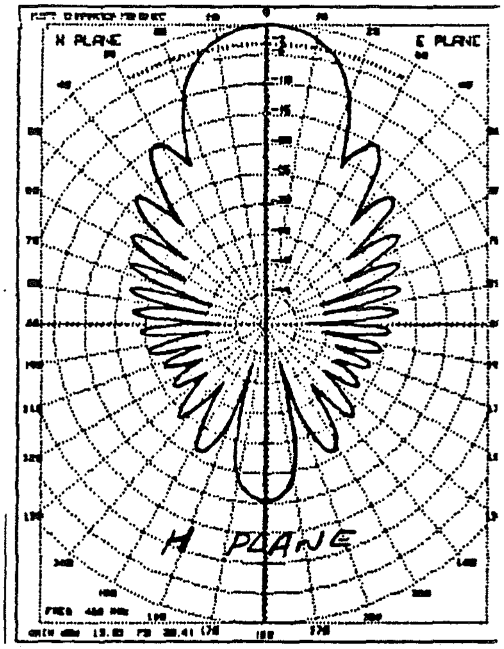
ELEMENT SPACINGS ARE FROM 33 ELEMENT YAGI COMPUTER DESIGNED BY W1EJ
GAIN AT 432 MHz 15.8 dBd OR ≈ 0.8 dB OVER K2RIW 19el YAGI

E PLANE -3dB BW 23°
H PLANE -3dB BW 24°
ow WINDLOAD ≈ 0.8 FT²
1SWR: (MEASURED AT FEED)
DRY 1.12:1
WET 1.48:1
@ 432.120 MHz

NOTE: ABSOLUTE GAIN PEAK IS AT 434 MHz. PATTERN DETERERATES RAPIDLY ABOVE 434 MHz.

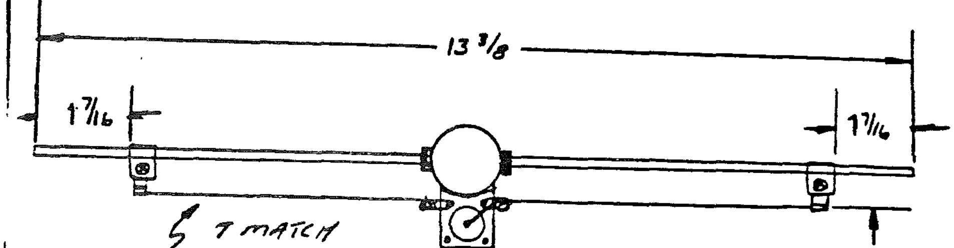
YOU MAY WANT TO SHORTEN ALL ELEMENTS 1/16". GAIN AT 432 WILL DROP ONLY 0.05 dB



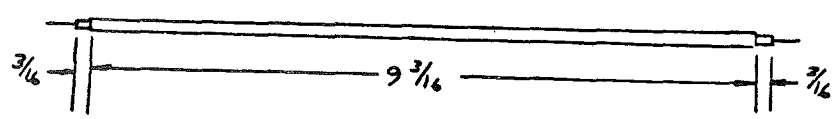


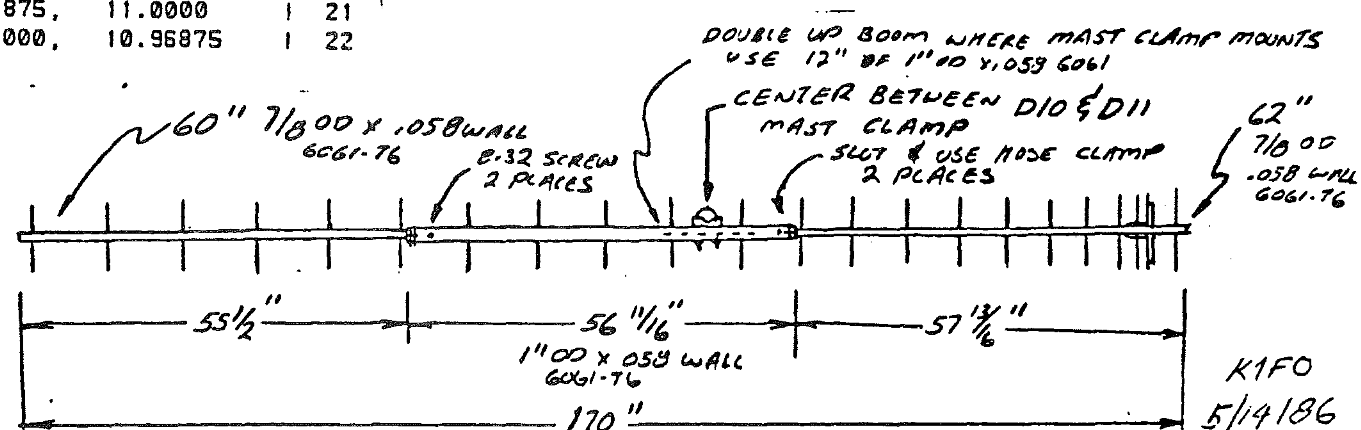
SPACING	LENGTH		E
0.	13.6250	!	1
4.09375,	13.3750	!	2
5.7500,	12.6875	!	3
8.8125,	12.2500	!	4
13.0625,	12.0625	!	5
18.3750,	11.8750	!	6
24.5000,	11.7500	!	7
31.4375,	11.6250	!	8
38.9375,	11.5625	!	9
47.0625,	11.5000	!	10
55.6875,	11.4375	!	11
64.6250,	11.3750	!!!	12
73.9375,	11.3125	!!!	13
83.53125,	11.2500	!!!	14
93.4375,	11.21875	!!!	15
103.5000,	11.1875	!!!	16
113.7500,	11.1250	!	17
124.1875,	11.09375	!	18
134.7500,	11.0625	!	19
145.3750,	11.03125	!	20
156.1875,	11.0000	!	21
167.0000,	10.96875	!	22

DRIVEN ELEMENT



BALUN:
MATERIAL UT-141





ELEMENTS 3/16" INSULATED THROUGH THE BOOM ALA K2RIW

BOOM LAYOUT

K1FO
5/14/86

33 ELEMENT VERSION

The ultimate 24' long yagi

18.0 dBd gain (~0.5 dB over DL6WU)

Comprable E plane pattern to DL6WU
- −16.5 dB first sidelobes
- 23 dB front to back

Better H plane pattern than DL6WU
- first sidelobes similar (−15 dB)
- minor lobes 5 to 10 dB lower

Not for the faint of heart
- Close to 3 sq ft windload
- over 9 lbs weight
- 18 degrees − 3 dB beamwidths

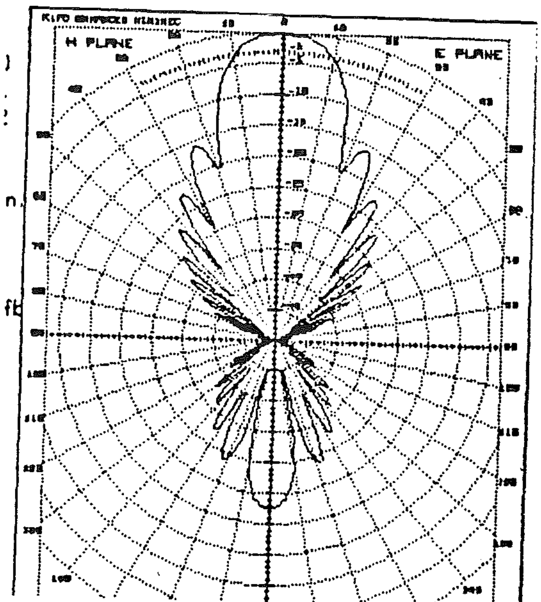
W1EJ/K1FO 33 el 24' 432 mHz YAGI

		X1	Y1		Boom
190	!	X1	Y1		
200	DATA	0,	13.6975	!	
210	DATA	4.09375,	13.3750	!	
211	DATA	5.7500,	12.7500	!	
220	DATA	8.8125,	12.3125	!	
230	DATA	13.0625,	12.1250	!	1"
240	DATA	18.3750,	11.9375	!	
250	DATA	24.5000,	11.8125	!	
260	DATA	31.4375,	11.6875	!	
270	DATA	38.9375,	11.6250	!	
280	DATA	47.0625,	11.5625	!	
290	DATA	55.6875,	11.5000	!	
300	DATA	64.6250,	11.46875	!!!	
310	DATA	73.9375,	11.40625	!!!	
320	DATA	83.53125,	11.34375	!!!	1 1/8"
330	DATA	93.4375,	11.3125	!!!	
340	DATA	103.5000,	11.28125	!!!	
350	DATA	113.7500,	11.21875	!!!	
360	DATA	124.1875,	11.21875	!!!!!	
370	DATA	134.7500,	11.1875	!!!!!	
380	DATA	145.3750,	11.1875	!!!!!	1 1/4"
390	DATA	156.1875,	11.1250	!!!!!	
400	DATA	167.0000,	11.09375	!!!!!	
410	DATA	177.9375,	11.0625	!!!	
420	DATA	188.90625,	11.03125	!!!	
430	DATA	199.9375,	11.0000	!!!	1 1/8"
440	DATA	211.03125,	10.96875	!!!	
450	DATA	222.1250,	10.96875	!!!	
460	DATA	233.2500,	10.9375	!	
470	DATA	244.4375,	10.90625	!	
480	DATA	255.6250,	10.8750	!	
490	DATA	266.8750,	10.84375	!	1"
500	DATA	278.1250,	10.84375	!	
510	DATA	289.3750,	10.8125	!	

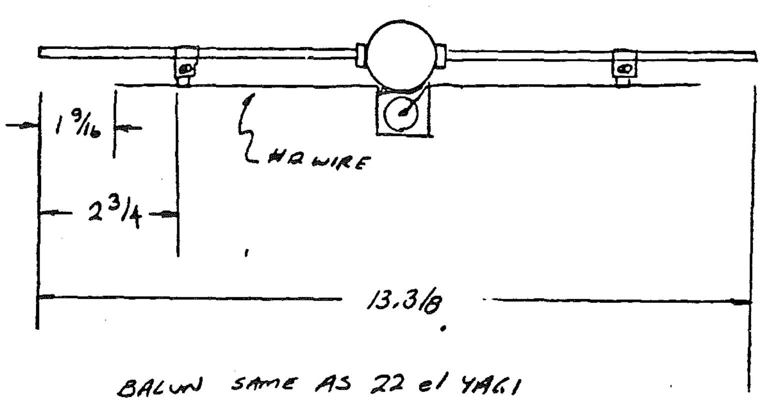
GAIN 18.00 dBd @ 432
GAIN PEAK @ 434 MHz

VSWR @ 432.120 mHz
1.18:1

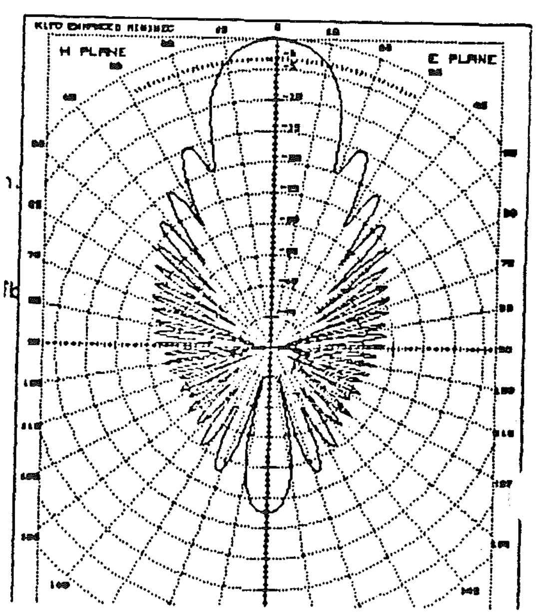
USE BOOM SUPPORT
AS PER K1FO 32 el YAGI



E PLANE 18° -3dB BW



BALUN SAME AS 22 el YAGI
ELEMENTS 3/16" INSULATED MOUNTED THROUG
A ROUND BOOM



K1FO 5/14/86

H-PLANE 18.5° -3dB B

A WORD ABOUT THE DL6WU YAGIS

Is an excellent design using progressive Spacings and director lengths

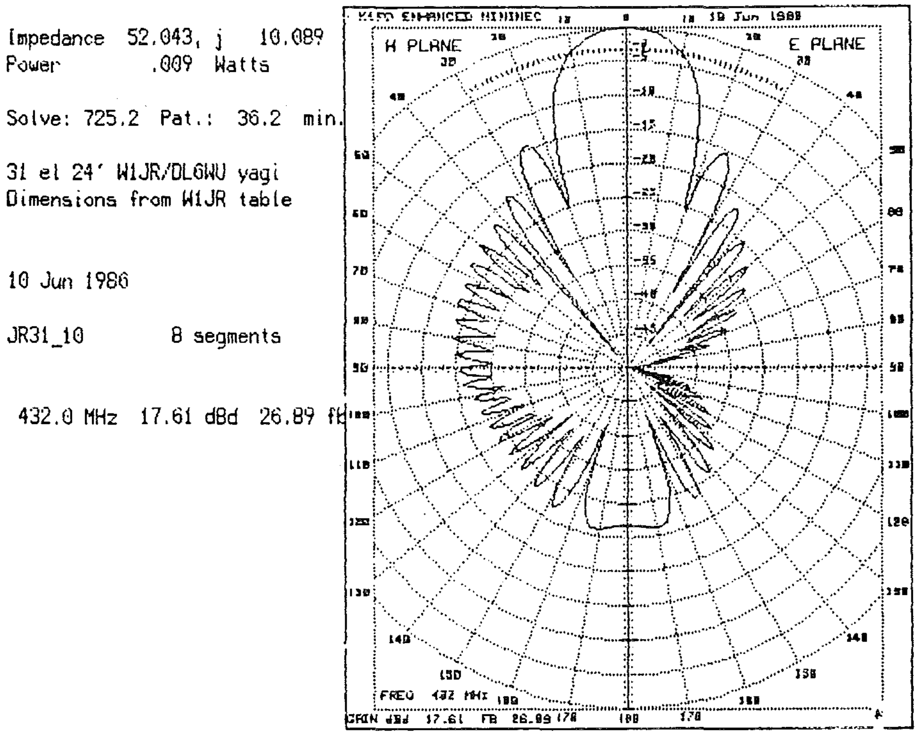
Very good patterns (deteriorates somewhat for longer versions)

Can change length (# of elements) without retuning directors

To accomodate variable length the directors are tuned slightly high and not fully optimized for any single boomlength

The gain that any given DL6WU yagi has is not the maximum obtainable for that boom length (probably >90% however)

Have done some work optimizing 24' W1JR/ DL6WU yagi. So for +0.2 dB gain and a significantly cleaner pattern



Calculated E and H plane patterns for the 31 element 24′ long W1JR/DL6WU yagi

Dimensions used are per those published by W1JR in October 1984 and re-printed in February 1986 VHF/UHF and above.

The calculated gain and pattern is slightly optimistic over real life This is due to the absence of mechanical tolerence errors in the model and also the non accounting for unwanted radiation of the feed, balun losses and ohmatic losses.

Real world gain of this yagi is about 17.5 dBd.

Real world sidelobes are -15.0 dB E plane and -13.8 dB H plane.

Impedance 25.359, j -9.572
Power .017 Watts

Solve: 725.2 Pat.: 36.2 min.

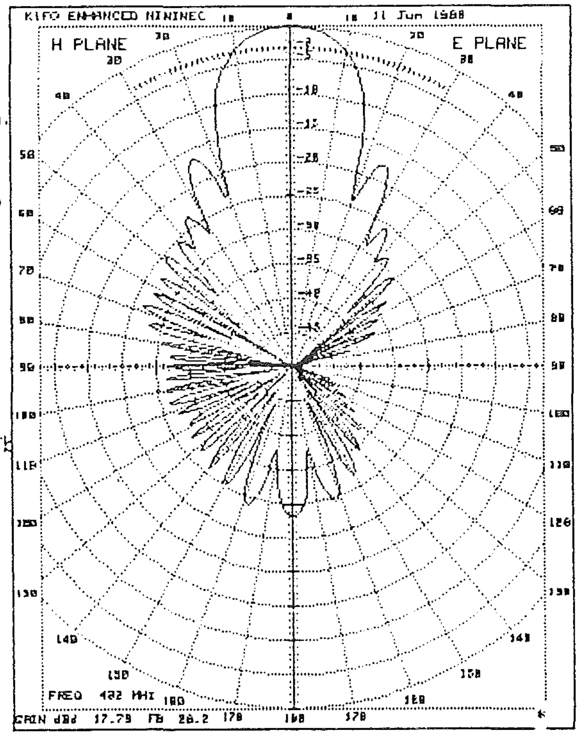
W1JR/DL6WU 31 element yagi
with optimized element lengths
by K1FO

11 Jun 1986

JR31_31 8 segments

432.0 MHz 17.79 dBd 28.20 fb

Sidelobes: -17.5 E, -16.4 H




```
193      ! W1JR/DL6WU 31 element 24' long yagi with element lengths
194      !              optimized by K1FO
195      !
196      !     SPACING  LENGTH
200     DATA    -5.00,   351     !    Element lengths are for 3/16" diameter
210     DATA    0.000,   340     !    elements mounted insulated through a
211     DATA    1.913,   325     !    1" square aluminum boom.
220     DATA    6.830,   314     !
230     DATA   12.732,   308     !    Element lengths are in millimeters
240     DATA   19.617,   305     !
250     DATA   27.294,   302     !    Spacings are the same as published
260     DATA   35.573,   296     !    for the 31 element 24' W1JR version
270     DATA   44.234,   293     !    published in February 1986 VHF/UHF &
280     DATA   53.277,   292     !    Above page 33 and given in inches.
290     DATA   62.731,   289     !
300     DATA   72.567,   286     !    These lengths were computer generated
310     DATA   82.812,   285     !    and designed to improve both the gain
320     DATA   93.249,   285     !    and pattern of the 24' W1JR/DL6WU Yagi.
330     DATA  103.877,   284     !
340     DATA  114.697,   282     !    The gain of this yagi is about 17.7 dBd
350     DATA  125.707,   281     !    or 0.2 dB higher than the gain of the
360     DATA  136.718,   280     !    version published by W1JR.
370     DATA  147.729,   279     !
380     DATA  158.739,   278     !    Both E and H plane sidelobes are about
390     DATA  169.750,   277     !    2 dB farther down than the W1JR version,
400     DATA  180.761,   276     !    Front to back is about 3 dB higher and
410     DATA  191.771,   275     !    most other minor lobes are over 5 dB
420     DATA  202.782,   274     !    farther down.
430     DATA  213.793,   274     !
440     DATA  224.803,   273     !    A preliminary version of this yagi was
450     DATA  235.814,   273     !    brought to the 1986 Northeast VHF conf. by
460     DATA  246.825,   272     ! W1JR, where the antenna range confirmed both
470     DATA  257.835,   272     !    its gain potential and exceptionally
480     DATA  268.846,   271     !    clean pattern.
490     DATA  279.857,   271     !
```

CONCLUSION

Thanks to amateur experimentors (both emprical and computer analyzed) we are now 90% of the way to the ultimate long yagi (2 to 12 wv)

The computer programs available to amateurs today still require a skilled operator to interpret the results

In the not too distant future more sophisticated programs will allow anyone to select frequency, desired length or gain and construction method
The program will then simply output the dimensions of a perfect yagi

USING MMIC's IN A 902 MHz TRANSVERTER

Donald L. Hilliard, WØPW

The amateur use of the Monolithic Microwave Integrated Circuit (MMIC) is a rather recent occurrence. These are small devices that look rather like a microwave transistor. They are, in fact, gain blocks that are internally matched to 50 ohms over a wide bandwidth. An external blocking capacitor on both input and output plus a decoupling choke and/or resistor are all that are required for operation. The bandwidth is typically a few MHz. to several GHz., and usually the associated noise figure is quite low. They require no tuning or adjustments of any kind.

Very often in the design of microwave transverters, a signal may need to be amplified up to a few 10's of db's. The MMIC is sometimes ideally suited to do this. (See Figure 1) This transverter design uses four of these devices. They are all made by Avantek and are available from Avantek distributors. One such distributor is Spirit Electronics, 7819 E. Greenway, Suite 9, Scottsdale, AZ, 85260; phone: (602) 998-1533. The approximate price of these devices are: MSA-0104, $2.75; MSA-0404, $3.25; MSA-0835, $11.25. With this background information, let's proceed to the transverter circuit description.

Circuit Description

One of the more important sections of any transverter is the local oscillator. In Figure 1, it is shown as a block. Figure 3 shows the schematic. Approximately 10 mw of power is required at 758 MHz. This level is divided equally in a Wilkinson type power divider to feed two mixers each of which requires 5 mw or +7 dbm at the l.o. port. This divider is described in detail in Figure 5. Each output of this divider feeds a double balanced mixer type TFM-2, made by Mini-Circuits Labs. The output of the mixer at 902 MHz. is approximately -12 dbm. The transmit mixer output is then delivered through a 3 db attenuator to an interdigital filter. The output of this filter is amplified by two MMIC's, an MSA-0104 and an MSA-0404. The output of the MSA-0404 is connected through another 3 db attenuator to the input of a Toshiba S-AU15 amplifier module. The level at the output of the 3 db. attenuator is approximately +2 dbm. This module is a 20 db. gain linear amplifier. The output of this gain block is approximately 200 mw. The 144 IF signal is fed through a 20 db. attenuator and a 6 db. attenuator. This assumes a 3 watt drive signal. The signal level after being attenuated by 26 db. is approximately 7.5 mw. The receive signal path from the antenna relay uses an MSA-0835 MMIC as a preamplifier. This device has a noise figure of approximately 2.9 db. and a gain of 25 db. at 900 MHz. The output of this amplifier is fed into an interdigital filter which is identical to the one used in the transmitter circuit. This filter is described in detail in Figure 4. The IF port feeds an MSA-0104 MMIC as an IF preamplifier.

Local Oscillator

The local oscillator circuit uses four 2N5179 transistors, one as an oscillator and three as frequency doublers. The oscillator uses a standard overtone circuit. It uses a 5th overtone crystal at 94.75 MHz. The output of the oscillator is capacitively coupled to Q2 which doubles to 189.5 MHz. A lightly coupled double tuned circuit is used in the collector of Q2 to minimize the 94 MHz. component. The output of this stage is similarly coupled to Q3 which doubles to 379 MHz. Again, a double tuned circuit is used at the collector of Q3.

Q4 is the final doubler circuit. At the collector of Q4, a triple tuned circuit is used to further minimize all spurious signals present at the output. An output level of +10 dbm. is available at this point.

A Wilkinson power divider is used at this point to divide the 758 MHz. signal so as to provide two equal amplitude +7 dbm. signals to the l.o. ports of mixers M1 and M2. The two quarter wave line sections should have an impedance of 70 ohms. Since I did not have any miniature 70 ohm coax, I decided to make my own. By replacing the center conductor of RG174 coax with a No. 30 wire, the impedance is raised from 50 ohms to approximately 75-80 ohms. While this is not exactly what is wanted, it is close enough and an equal division is achieved. Figure 5 details the dimensions of this device and Figure 2 shows its physical location on the circuit board.

Mixers

The Mini Circuits Lab model TFM-2 mixer was chosen for two reasons. It is reasonably priced at $11.95 and it is readily available. It performs well at 900 MHz. Other similar type mixers can also be used. The connections are detailed in Figure 7.

Transmit Circuit

The output of the transmit mixer is connected through a 3 db. attenuator to a 3 resonator interdigital filter. This filter is described in detail in Figure 4. It was described in a paper presented by Rick Campbell, KK7B, at the 1985 Estes Park 1296/2304 MHz. Conference. The output from this filter is amplified in two reasonably priced ($3.00) Avantek plastic package MMIC's. As shown in Figure 1, these devices build the 902 MHz. signal level up to a +4 dbm. level. This level needs to be reduced to approximately +1.5 to +2 dbm. to drive the Toshiba S-AU15 amplifier module.

This Toshiba module is a two stage device whose bases are biased up slightly so the device has fairly good linearity. It requires only 8 volts so a 7808 3 terminal regulator is used to drop and regulate the supply. The module draws approximately 50 milliamps quiescent current and about 150 milliamps peak. The power output is in excess of 200 milliwatts. A drawing showing the S-AU15 connections is shown in Figure 8C.

Receive Circuit

The receive mixer IF output port is fed into an MSA-0104 MMIC. This device has a noise figure of approximately 5 db. This added to the mixer loss of about 7 db. means the noise figure of the mixer will be about 12 db. The gain of the MSA-0104 is about 19 db. at 144 MHz. At this point, let us look at the input preamplifier. This amplifier is another MMIC; an MSA-0835. Its relatively good N.F. and high gain make it a good choice for a receiving preamp at 902 MHz. The output of this device is fed into another interdigital filter which is identical to the one used in the transmit circuit. This filter then feeds the R.F. port of the receive mixer. Connectors for the MSA amplifiers are shown in Figures 8A and 8B.

R.F. Switching

The R.F. input and output switching is done with two small S.P.D.T. TO-5 relays. These relays are relatively expensive and if you don't have some of them or know where you can obtain a couple, you may wish to use BNC or SMA connectors for both converter inputs and outputs and do your R.F. switching external to the transverter unit. A schematic of these relays is shown in Figure 6.

General Layout

Figure 2 shows the component layout I used. While it is not necessary to duplicate the layout exactly, it would be well to follow the general idea unless you have had R.F. layout experience. If the transverter board were made a couple of inches longer, another power amplifier stage could be added. If c.w. only is to be used, one of the 10 to 20 watt output power blocks could be added in the additional space also. These power blocks are available from Amperex, Motorola, NEC, Toshiba and others.

Spurious Responses

The local oscillator signal is reasonably clean. The 379 MHz. component is down approximately 30 db. or more. All other significant components are down better than 50 db.

A replica of the transmitter section output is shown in Figure 9. If the -41 db. level of the second harmonic is troublesome, another bandpass filter could be used at the output, or a quarter wavelength open stub made of .141 coax could be connected at the output of the Toshiba S-AU15. This stub should be approximately 1.14" long and connected to the S-AU15 output pin with the shortest possible connection. This should reduce the 1804 MHz. level by another 10-20 db.

Power

Power requirements are 13.5 v.d.c. at approximately 200 ma. when in the receive mode. This increases to 400 ma. peak in the transmit mode, approximately 100 ma. of this being drawn by the relays.

Components

Some sources are listed for some of the "harder to obtain" parts:

- Mixers, TFM-2

  Mini Circuits Lab
  P.O. Box 166
  Brooklyn, NY 11235

- Amplifier, S-AU15

  Matcom, Inc.
  450 San Antonio Road
  Palo Alto, CA 94306

- Relays, TO-5

  Any Teledyne distributor

- .141 Coax

  Microwave Components of Michigan
  11216 Cape Cod
  Taylor, MI 48180

902 MHz. TRANSVERTER / 144 MHz. IF

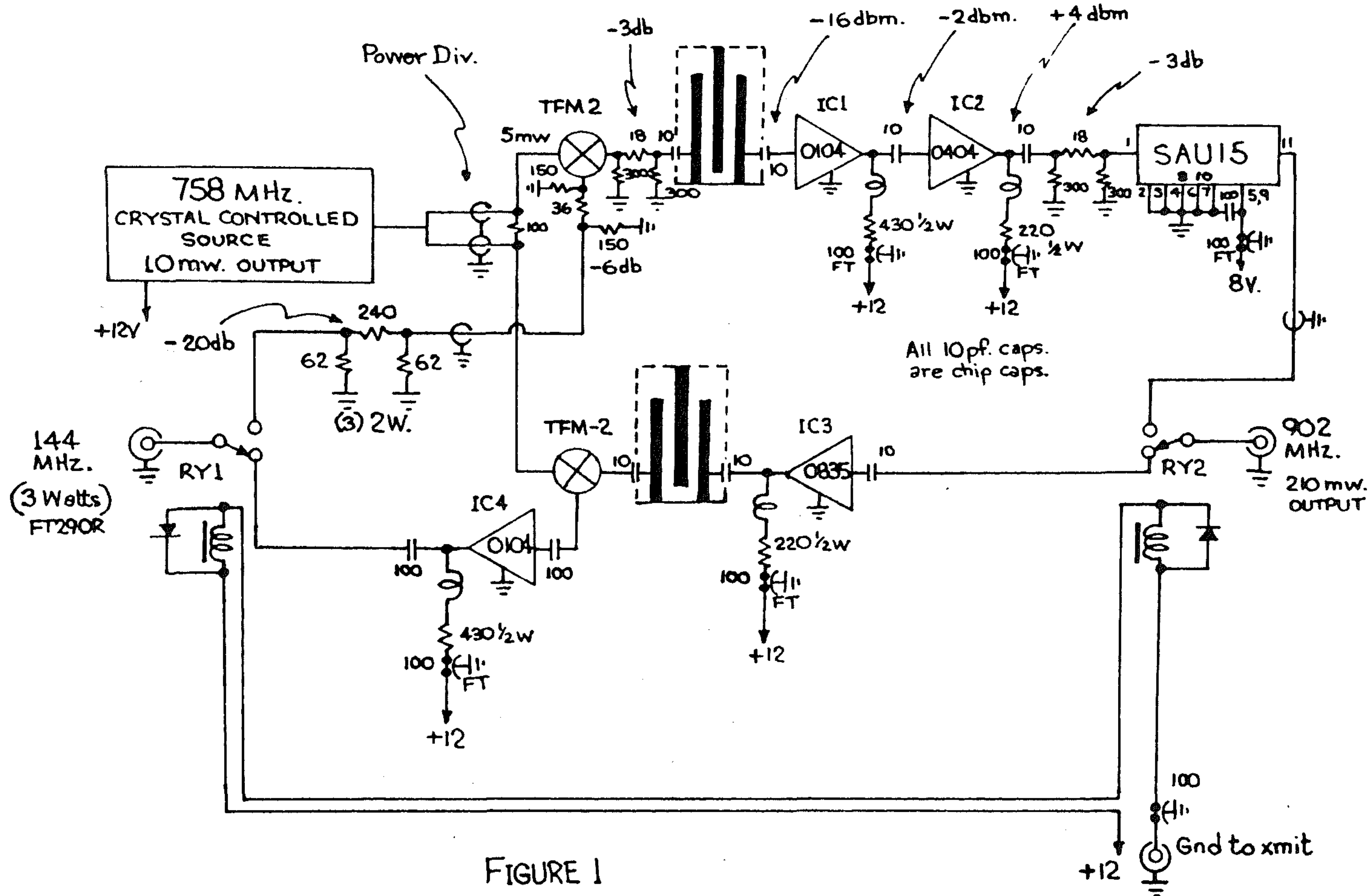
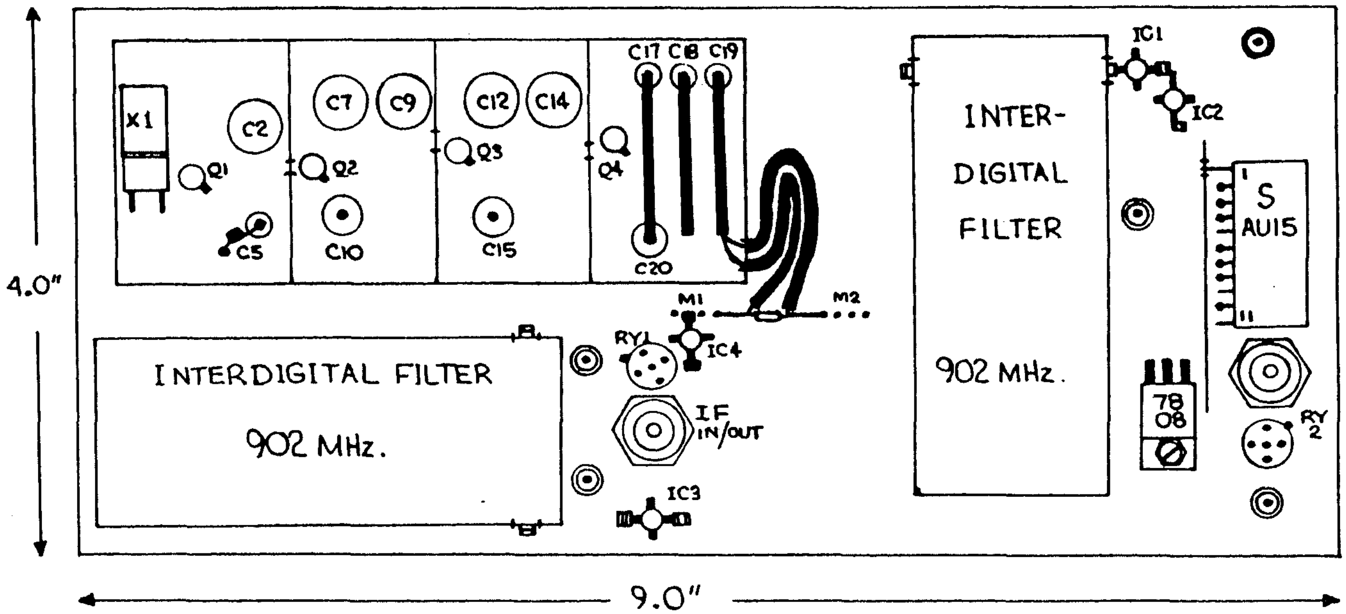


FIGURE 1



GENERAL COMPONENT LAYOUT
902 MHz. TRANSVERTER
FIGURE 2

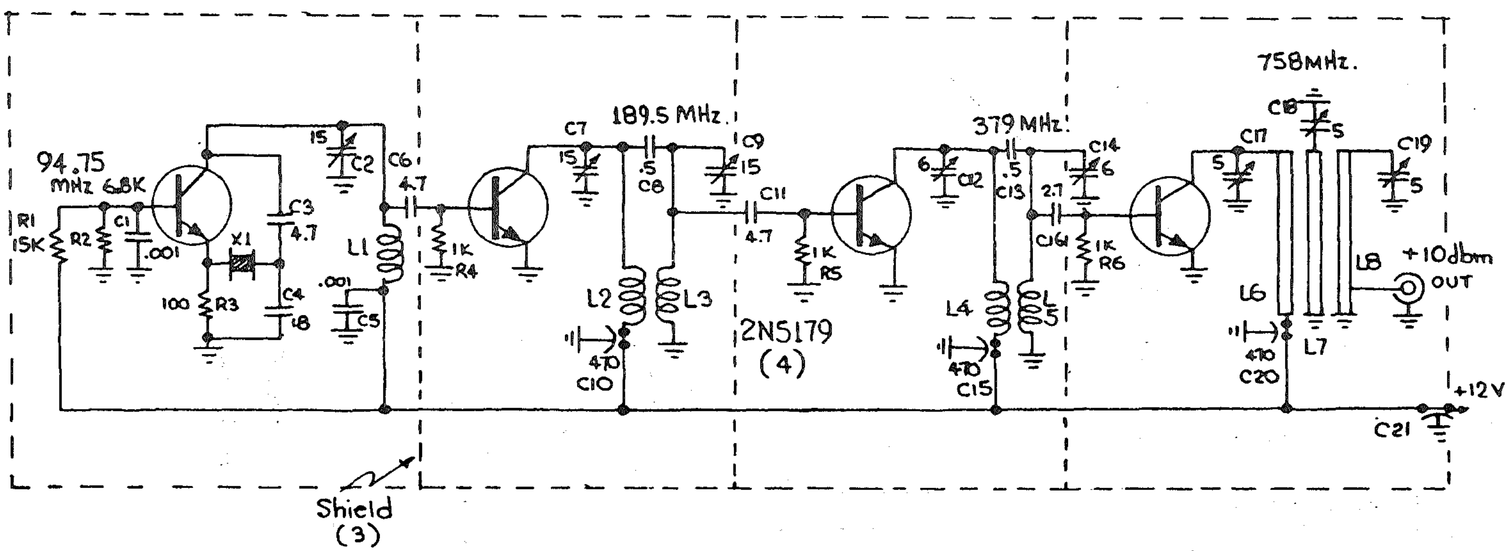


FIGURE 3

758MHz. LOCAL OSCILLATOR

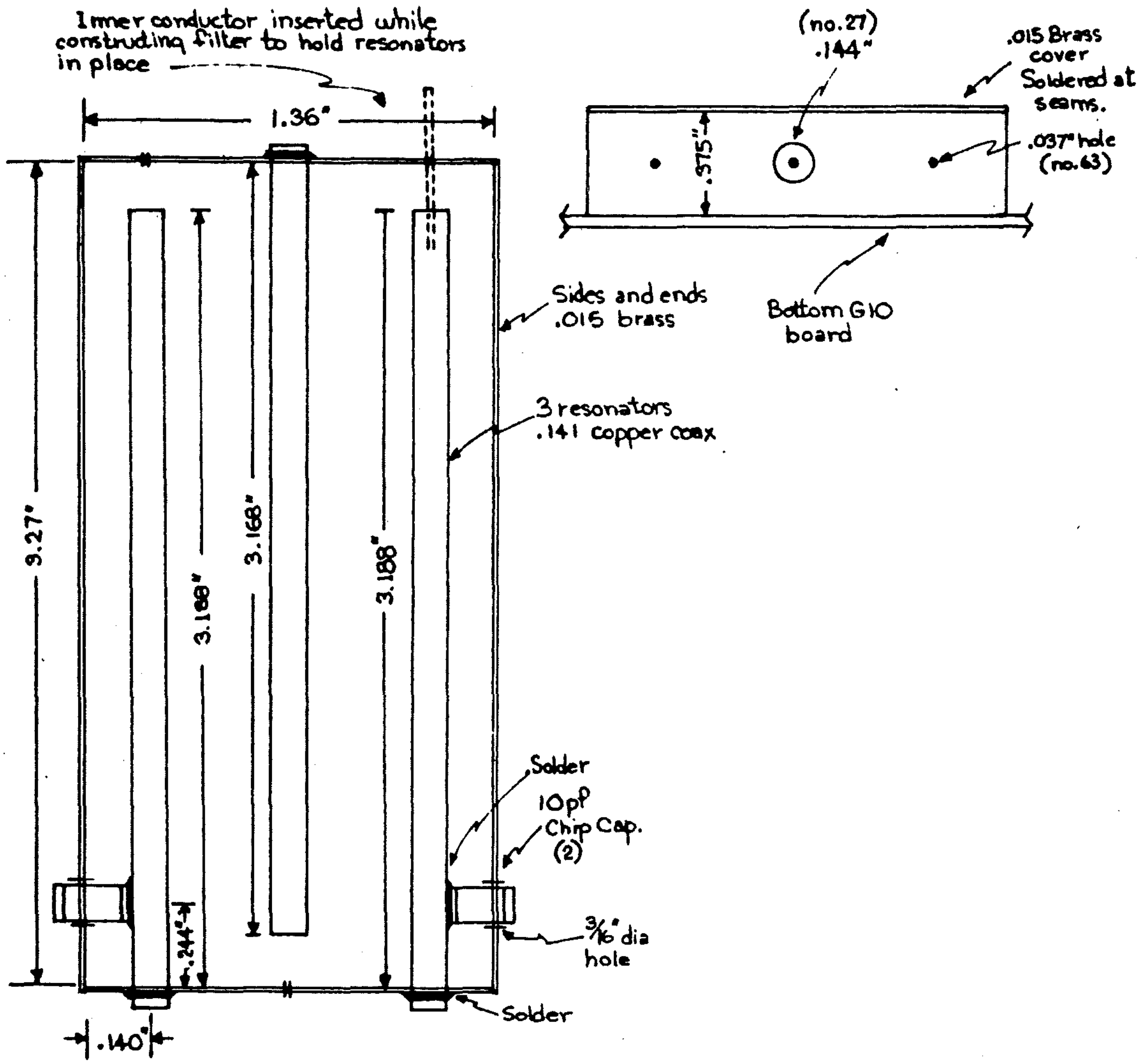
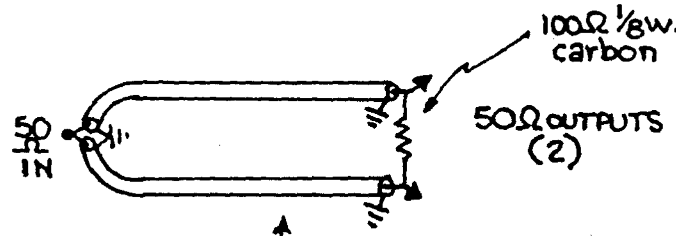


FIGURE 4
INTERDIGITAL FILTER

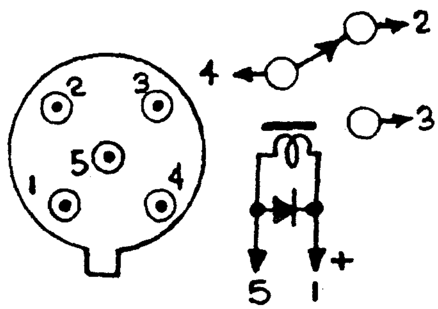


RG174/center conductor
removed and replaced
with #30 enan. wire

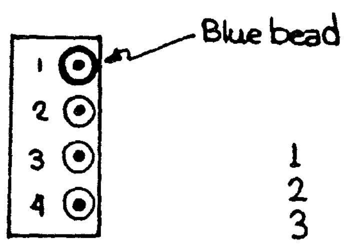
2 identical lengths 2.57" long
end of shield to end of shield
All lead lengths minimum.

FIGURE 5

2 PORT POWER DIVIDER
758 MHz.

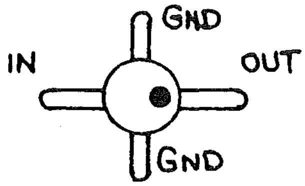


TELEDYNE RELAY
411D
FIGURE 6

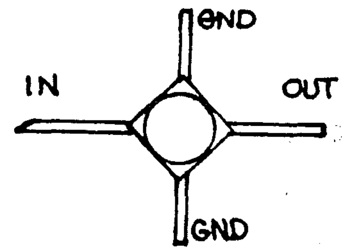


1	RF
2	IF
3	Gnd
4	LO

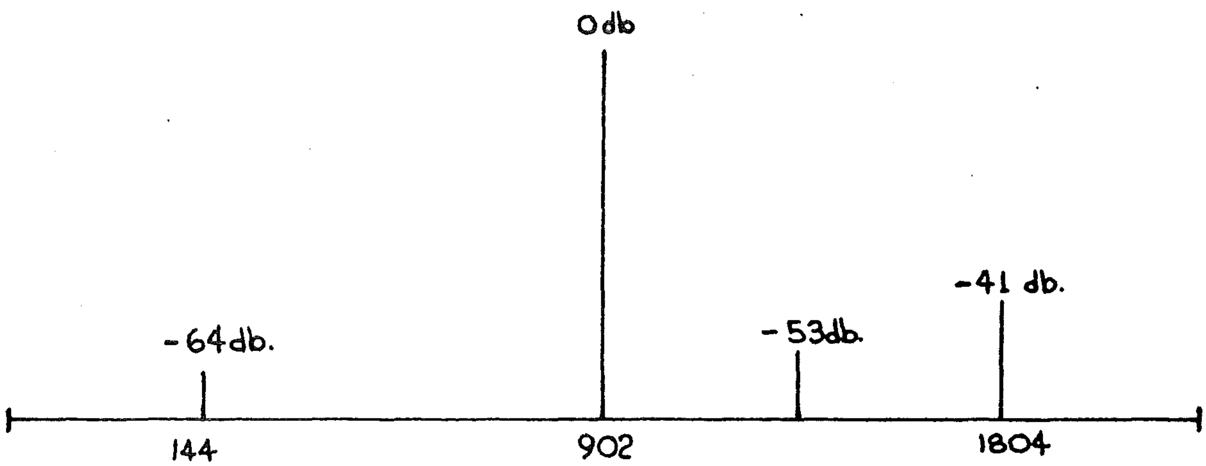
BOTTOM VIEW
TFM-2
MIXER
FIGURE 7



MSA 0104
MSA 0404
TOP VIEW
FIGURE 8A



MSA 0835
TOP VIEW
FIGURE 8B

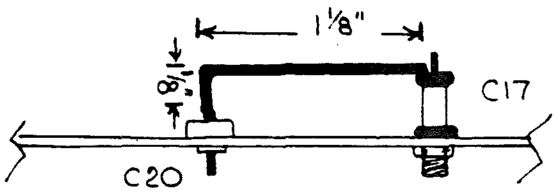


SPURIOUS SIGNAL OUTPUT LEVELS
FIGURE 9

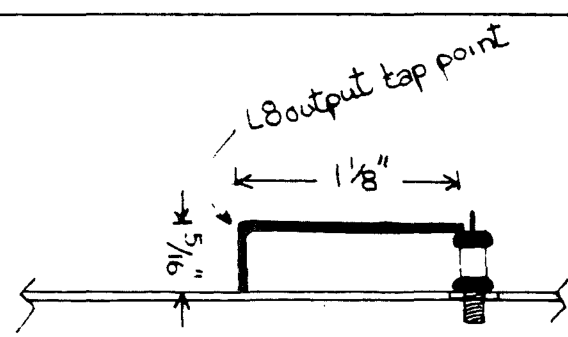
COMPONENT LIST

C1,5	Capacitor, ceramic disc, miniature, 1000 pf.
C2,7,9	Capacitor, air variable, 15 pf. Trim-Tronics 10-1120-2015-000
C3,6,11	Capacitor, ceramic disc, miniature, 4.7 or 5 pf.
C4	Capacitor, ceramic disc, miniature 18 or 20 pf.
C8,13	Capacitor, "gimmick" small, insulated hookup wire twisted 3/8", approximately .5 pf.
C10,15,20,21	Capacitor, ceramic button feedthrough, 470 pf.
C12,14	Capacitor, air variable, 6 pf., Trim-Tronics 10-112-25006-000
C16	Capacitor, ceramic disc, miniature, 2.7 or 3 pf.
C17,18,19	Capacitor, ceramic tubular trimmer, Trim-Tronics 60-0405-10003-000
L1	7T. #22 enam., 1/4" dia., CW
L2,3	5T. #18 copper, 1/4" dia., spaced wire dia.
L4,5	3T. #18 copper, 1/4" dia., spaced 3 wire dia.
L6,7,8	#14 wire [see drawings below]
R1	Resistor, carbon, 1/4 W., 15K
R2	Resistor, carbon, 1/4 W., 6.8K
R3	Resistor, carbon, 1/4 W., 100 ohm
R4,5,6	Resistor, carbon, 1/4 W., 1000 ohm
X1	Crystal, 5th overtone, 94.750 MHz., HC-25U

Attenuator resistors (3 in the transmitter chain) are 1/8 W. carbon. Use as close to zero lead length as possible.



L6



L7,8

Computer Analysis Of Yagi Antennas With Some Useful Results

By J. Edward Pearson, KF4JU

June 17, 1986

INTRODUCTION

For many years, amateur radio operators have wanted to fully understand the principles of yagi operation so that they could design and build antennas having superior performance and lower cost than commercial versions. Understanding antennas, although quite complicated, is within the comprehensive capability of many amateurs. One could just build and test antennas hoping to stumble on a good one, but this is a monumental task and only a few notable people have suceeded using this method. Without some form of analytical capability, range testing alone is usually an aggravating task and produces misleading results. One could say that there are as many places to make mistakes in a range test as they are in a numerical analysis. However, once the correct analysis procedure is established it is far more productive to analyze many antenna configurations then build only the best. A reliable range test can then provide the final proof. There is probably one important fact to keep in mind when contemplating the virtues of each method. That is, a reliable computer program can analyze in a short period of time what a person could build and test in a lifetime.

PRINCIPLES OF ANALYSIS

To gain an understanding of the analytical procedure involved in antenna analysis lets start with the basic equation shown in 1.

$$E = I \times R \qquad (1)$$

If we can determine the current in an element then we can calculate the field strength in the magnetic and electric plane. This will eventually lead us to the pattern shape and array directivity (forward gain). However, there are a few complicating factors yet to be presented. First, the terms in equation 1 will be of the complex form. That is, the terms consist of both a real and imaginary part. For example, the resistance of an element is the real part of impedance while reactance is the imaginary part. This term is usually referred to as an elements self-impedance. An element operating at resonant has only radiation resistance, assuming no ohmic losses. The reactive part by definition is zero. And finally, we are seldom concerned with single element antennas so a method is needed which solves for the currents in all elements of a multi-element array. Let us expand equation 1 so that other elements can be taken into account as shown in equation 2.

$$I(1)Z(11)+I(2)Z(12) \;---\; +I(n)Z(1n)=E(1) \qquad (2)$$

This equation shows that the voltage seen at the center of an element is the current in that element times its self-impedance plus the current in each of the other elements times its mutual-impedance. Here the mutual-impedance is a numerical value describing the degree of coupling between the two elements of interest and is generally associated with just the distance between them. This is a simplified case but is sufficient for yagis having element lengths near one half wave and diameters not atrociously large. These impedance values are also of the complex form. If we examine equation 2 we see that all element currents available for numerical solution. However, a very basic rule of mathematics states simply that 'n' unknown values requires 'n' equations if we are to arrive at a unique solution for each unknown. This is easily constructed by writing the remaining equations for each element voltage taking into account the self-impedance and the interactions between that element and all others in the array. Equation 3 shows these relationships in the form of a matrix.

$$\begin{array}{l} I(1)Z(11)+I(2)Z(12) \;---\; +I(n)Z(1n)=0 \\ I(1)Z(21)+I(2)Z(22) \;---\; +I(n)Z(2n)=E(2) \\ - - - - - - - - - - \qquad - - - - - - - \\ I(1)Z(n1)+I(2)Z(n2) \;---\; +I(n)Z(nn)=0 \end{array} \qquad (3)$$

To explain briefly, if the subscripts of 'Z' are the same then that term is the self-impedance of the element. If they are different then it is the mutual-impedance between those two elements. Look carefully at the right hand column and note that all terms are zero except for one. The zero terms are parasitic elements since they are always uncut at their centers and can therefore have no voltage while the second equation is the driven element supplied with an arbitrary and complex drive voltage. One might ask "How can all of those element voltages add up to zero". Keep in mind that all currents and impedances are of the complex form. The associated phase angles allow these zero voltage conditions to exist. As mentioned earlier, 'n' unknowns require 'n' equations for a unique solution and now we have all of them. Using a method called "Gaussian elimination with maximal column pivoting" we can determine each element current in its complex form. As mentioned earlier, the current in each element is needed in complex form so that we can determine the field strength at all angles in the magnetic plane. Since we are normally concerned with horizontally polarized antennas this will be the vertical plane. At each angle in this plane, the complex current in each element is combined with its actual position in the array to determine its contribution to the total field strength in the magnetic plane. The horizontal or the electric plane is derived from the magnetic plane using the form factor. The form factor for the elements in a yagi array is that of a dipole. The omni-directional pattern in the magnetic plane transforms into the double lobes seen in the electric plane as a result of this form factor. From these data, other important values can be derived such as forward gain, front-to-back ratio, side-lobe intensities, beamwidth, and feed-impedance. This has been a brief description of the analysis procedure commonly used to determine the important parameters that describe the performance of a yagi array. This model is commonly used to analyze yagi arrays[1] and was employed by Lawson[2] in his excellent series of articles published in Ham Radio Magazine in 1980.

The equations described above do not provide a direct means of designing or optimizing antennas. However, they are the essential tools needed to proceed toward that objective. Design of yagi arrays is possible by starting with an arbitrary set of dimensions, analyzing, and noting the results. Some and probably all of the dimensions are changed during repeated analysis. Eventually, the best set of dimensions is kept and all others discarded. Of course, experienced designers usually start with a reasonably good set of values and proceed towards an optimized set of dimensions. It should be pointed out that optimization can have many different meanings. The intended use of the antenna usually dictates just what performance features are important. Many computer programs provide some means of automatically stepping through a series of dimensional variations with these important parameters in mind. Perhaps you can now see the potential of the computer as a design aid when compared to construction and test methods.

THE COMPUTER PROGRAM

Before describing the computer program and its features, a brief history is in order so that the proper people might be cited for their help and inspiration. The initial impetus for this project started in May of 1984 with the re-reading of an article by Schulz[3] in the March 1984 issue of HAM RADIO. In this article, Schulz described the procedures for determining the element currents and feed-impedance of a three element yagi. He also made comments regarding the other parameters that could be obtained by continuing the analysis. Also included were references to Lawson[2]. This was the first inspiration and from there the project expanded rapidly. During that same period of time, Jaffin was publishing his excellent series of articles on the analysis of antennas for various VHF/UHF bands. During that period of time, several problems were encountered in locating the necessary equations to complete the first version of the computer program. Fortunately, Jaffin was near the end of his series and made a copy of his Fortran program available through the magazine publisher[4]. This solved the remaining problems as various subroutines were quickly translated to Basic to run on a Sanyo 555-2. It soon became obvious that large antennas (greater than 25 elements) would require more memory so an additional 512KB was installed. After expansion of the program to include many new features, the slow execution speed of interpreted Basic became painfully obvious. For example, a 60 element array took four hours for a single analysis. From this point on, the hardware and software tools accumulated quickly. A quick survey of the shack reveals an IBM PC/XT[5] clone with 8MHZ clock, 8087 math coprocessor, V20 cpu, 4 color plotter, mouse, Logitech Modula-2/86[6] compiler, word processors, and other assorted tools. Now, the same 60 element array takes about seven minutes instead of four hours to analyze. As you can see, some rather sophisticated equipment is needed for results to be obtained in a reasonable length of time. Of course, main frame machines are considerably faster than the present configuration. However, their cost is certainly beyond the reach of even the most enterprising amateur. This has been a brief history of the development of this program so that the reader will have an appreciation for the work expended in the last two years.

PROGRAM FEATURES

The salient features of the program are shown in Table 1 with more detailed examples discussed later.

Table 1

PROGRAM FEATURES

1. Antenna library maintained on disk with resident editor for adding, deleting, copying, or modifying any antenna.

2. Analysis of any arbitrary set of element dimensions including a y-axis offset.

3. Combination linear and taper analysis of any group of elements.

4. Neighborhood analysis of each element in a group. Neighborhood meaning that an elements dimensions can vary near its nominal values.

5. Bandwidth analysis with nominal, low, high, and step frequency independently selectable.

6. Optimizer of the simple form. Dimensions are varied in a systematic fashion with better values kept. Definition of better is determined by user.

7. Construction charts with element diameter compensation, matching data for a hairpin feed, and stacking data for four antennas in a square array.

8. Plotting capability in both cartesian and polar form with pauses for pen change (4 colors).

OBSERVATIONS WORTH NOTING

Before describing some of the results obtained with this program, a brief explanation of the data result format is in order. Figure 1 shows a typical data printout. The first column is the array directivity or forward gain in decibels relative to a dipole (DBd). Column two gives the front-to-back ratio in DB. This shows the response at the back of the antenna relative to the front. The next two columns are the magnetic and electric plane responses respectively of the first side lobes starting at and relative to the front of the antenna. The values are the response below that seen at the front. The following two columns give the resistive and reactive components respectively of the feed impedance. The last two columns, if present, are dimensions in wave-lengths of an element of interest and depend on just what type of an analysis is being performed.

OBSERVATION 1

The gain of an antenna is determined primarily by the antenna length, not by the number of elements. However, there is a limiting factor in that the maximum element spacing for optimum gain seems to be just over 0.4 waves for uniformly spaced directors. Ehrenspeck and Poehler[7] have treated this subject quite well with their experiments on 10 GHz. Figure 1 shows the analysis of a 7 element antenna in which the forward director was extended in increments until the maximum gain was found. The peak occurred at a spacing of 0.452 waves. This is similar to Ehrenspeck and Poehlers results even though this spacing applies only to the forward two directors. Also note that the front-to-back and feed resistance take on less acceptable values. This is generally the case when lengthening the antenna using only the forward director space.

OBSERVATION 2

In contrast to the previous observation, there seems to be little effect in gain in regards to the spacing of the reflector behind the driven element. To illustrate this point, the reflector was analyzed using the neighborhood feature. The reflector spacing was allowed to assume values between 0.0855 and 0.3299 waves while its length varied between 0.4817 and 0.5305 waves. Five spacings and lengths in these ranges were analyzed and the results shown in figure 2. Note that the nominal gain is 10.6 DBd (third group, third row, in italics) and the best that can be obtained is only 10.64DBd. Also note that a serious loss is seen when the spacing is quite close and the length short, almost near resonance. In essence, the element is beginning to take on some aspects of a director as evidenced by the abrupt change in front-to-back ratio. The nominal reflector dimensions for this antenna are typical of many VHF/UHF antennas.

OBSERVATION 3

Element lengths must be near resonance if they are to influence antenna performance. Many people wonder what effect a metal piece will have if it is in the vacinity of an antenna. If that piece of metal is perpendicular to the elements then it will have no coupling and hence no effect. However, any degree of non-perpendicularity will have some degree of coupling and possibly an effect. To demonstrate this situation, the same 7 element antenna has been altered in that an eighth element has been added between the first two directors and its length allowed to vary from 0.0207 to 0.5704 waves. Figure 3 shows the results of this experiment with the italicized line representing element resonance. Note that only lengths near resonance have any appreciable effect on performance. To further examine this effect, the region near resonance was expanded so that more details could be seen. The results are shown in figure 4. It is interesting to note that the gain and front-to-back both approach zero. Also, the magnetic plane sidelobe intensity is nearly zero. This indicates that the antenna has become a very poor broadside with a good portion of the radiation going up and down. In essence, the new director has become an additional reflector redirecting the power that contributed to the end-fire gain.

OBSERVATION 4

Antennas designed by NBS seem to perform better approximately 1-2% higher in frequency. Figure 5 shows a bandwidth analysis of an NBS 12 element (2.2 wavelength) antenna. Notice that the frequency associated with highest gain is between 146.5 and 147.0 MHz while the design frequency is 144.5 MHz. This seems to be true of all NBS antennas but the 12 element was selected for analysis because it is often used by commercial manufacturers as one of their intermediate size offerings. The gain difference is probably important only in special cases. In these cases, the operator has probably selected an optimized antenna and is not concerned with this problem.

OBSERVATION 5

Many amateurs have attempted to take an antenna for one band and scale the dimensions so as to use that design on another band. This is entirely proper but many people fail to realize that "all" dimensions should be scaled not just element length and spacing. To be perfectly strict, nuts, bolts, clamps, and especially element diameter should be scaled. If the scaling is done properly there is no substantial reason why a good design cannot be used on any amateur band. This assumes that materials and skin depth considerations have been given due consideration for the microwave bands. Perhaps the most common error in scaling occurs in element diameter compensation. It is often convenient to use the same diameter rod for elements on 2 M., 1.3 M., and 70 cM.. This is typically 3/16" aluminum rod. Element diameter changes, in terms of wavelengths, require a correction in length so that the reactive component of the elements self-impedance remains the same. The procedure for calculating these changes was covered quite well by Lawson[8] in his series of articles. Also, there have been correction tables published[9] which provide the necessary data without the need for any calculations. Also, the subject of boom correction procedures should be studied by those intending to use construction techniques different from the original design. Boom correction requirements are another subject entirely and will not be dealt with any further in this article.

OBSERVATION 6

In the previous analytical results you might have noticed the range of values encountered for the feed impedance. The reactive part can be eliminated, or for that fact created, by altering the length of the driven element. The resistive portion is essentially fixed unless one resorts to folded dipole and its variations. Resistance usually falls in the 20 ohm region but is not restricted to those values. On a few occasions, you will find values approaching 50 ohms or even higher. On many occasions, you will find values on the order of 10-15 ohms. This is typical for long high gain antennas in which the side-lobes have purposely been suppressed. Antenna analysis does not consider the feed-point matching mechanism as it has essentially no bearing on the problem. Therefore, matching is usually left to the discression of the builder. If the originator has included some actual matching data, consider yourself lucky and use it. Be careful of calculated but unproven data. On many occasions, very low calculated feed resistances are not correct and can lead to many hours of fruitless construction. The calculations are based on the assumption that current distribution is sinusoidal. This is not always the case so be weary of unsubstantiated matching data.

OBSERVATION 7
A careful perusal of the available antenna literature would reveal many different geometric shapes. That is, both constant and progressive element spacing would be found. Also, element lengths may be constant or tapered or even hour glass shaped as is the case of many NBS antennas. One might ask which combination is best and of course there is no single conclusion since performance is in the ear of the communicator. Each combination has features that may be important in a particular application. It has been the experience of this author that antennas of the Tilton type seem to have the best combination without exaggerating one feature at the expense of another. Tilton antennas take on the form of linear or slightly concave tapered element lengths while the spacing takes on progressively larger values while approaching the front of the structure. These antennas are also efficient in terms of gain versus material quantity thereby providing light weight, low wind resistance, and reduced cost. These are always three good items of consideration.

NEW ANTENNA DESIGNS
Five antenna designs are offered to the reader for their unrestricted use and are shown in figures 6 through 15. Pattern and construction data are given. Both They are the result of many months of work in looking for good general purpose antennas while exhibiting high gain, reasonable front-to-back, low side-lobe intensity, and an acceptable feed-impedance. You will notice in the fabrication charts that they seem to "fit just right" on a convenient length of boom material. This is by intent since they were created for a given frequency, boomlength, and element diameter. As mentioned previously, they can be scaled to any frequency provided that all dimensions have been properly considered. Also mentioned was the fact that calculated feed-impedances are not always correct. That is certainly the case with the 16, 21, and 32 element antennas. The two smaller antennas have been built using the calculated hairpin data with no problems encountered. Keep in mind that it is always wise to cut the matching components longer and trim to the required length. The 16 element antenna was built using a tee match without series capacitors with the driven element extended by a sizable value. This is most likely due to a non-sinusoidal current distribution as previously mentioned. The data for this

match is shown in figure 16. An additional comment should be made indicating that all dimensions are considered valid for insulated elements. This author is not totally convinced of the need for or the magnitude of a boom correction factor for through the boom insulated elements. There are many notable people on both sides of the issue with no direct evidence offered by any. This would make an excellent subject of investigation for next years conference.

CONCLUSIONS

Computer analysis does not provide an exact answer to an antennas performance due to many simplifying assumptions made during the development of the mathematical model. However, a similar degree of difficulty is found in obtaining accurate range measurements. The model used here and by many other people has been shown to be reasonably accurate and somewhat conservative when used to analyze existing antennas and develop new ones. The proof of any model lies in verification by accurate measurement. This model has passed that test at least within the requirements of the serious amateur designer. Keep in mind an earlier statement regarding the productivity of the compute and build method versus that of the build only method. The contrast should stimulate new thoughts.

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[3] Walter J. Schulz, Jr., K3OQF, "key to 3-element Yagi design", HAM RADIO, March, 1984, pages 48-51.

[4] Stanley Jaffin, WB3BGU, "applied Yagi antenna design part 6: the model and a special teaching tool", HAM RADIO, October, 1984, pages 89-96.

[5] IBM PC/XT is a registered trademark of International Business Machines.

[6] Modula-2/86 is the name of a copyrighted software product from Logitech, Inc..

[7] H. W. Ehrenspeck and H. Poehler, "A New Method for Obtaining Maximum Gain from Yagi Antennas", IRE TRANS. ANTENNAS PROPAGATION., vol. AP-7, October, 1959, pages 379-386.

[8] James L. Lawson, W2PV, "Yagi antenna design: practical designs", HAM RADIO, December, 1980, pages 30-41.

[9] J. Edward Pearson, KF4JU, "Resistance And Reactance Values For Various Element Lengths And Diameters", VHF-PLUS UPDATE, January, March, May, September, 1985.

Figure 1

Neighborhood analysis of a 7 El. KF4JU Ver 3

Element number 7

Fgain	F:B	Hside	Eside	Feed-R	Feed-X	Length	Space-X
10.60	*21.03*	*-12.99*	*-20.14*	*23.0*	*-10.8*	*0.4397*	*1.2337*
10.65	20.57	-13.26	-20.41	20.7	-10.3	0.4397	1.2459
10.70	19.64	-13.54	-20.41	18.7	-9.6	0.4397	1.2581
10.75	18.52	-13.83	-20.70	17.1	-8.7	0.4397	1.2703
10.79	17.40	-14.13	-20.73	15.7	-7.7	0.4397	1.2826
10.82	16.37	-14.43	-21.04	14.6	-6.7	0.4397	1.2948
10.85	15.43	-14.75	-21.10	13.7	-5.6	0.4397	1.3070
10.87	14.61	-15.08	-21.42	13.0	-4.6	0.4397	1.3192
10.88	13.88	-15.41	-21.76	12.4	-3.6	0.4397	1.3314
10.88	13.25	-15.75	-21.85	12.0	-2.6	0.4397	1.3436
10.88	12.70	-16.10	-22.20	11.6	-1.7	0.4397	1.3559
10.87	12.22	-16.46	-22.56	11.4	-0.7	0.4397	1.3681
10.85	11.80	-16.83	-22.68	11.3	0.2	0.4397	1.3803
10.83	11.44	-17.20	-23.05	11.2	1.0	0.4397	1.3925
10.80	11.14	-17.58	-23.43	11.2	1.8	0.4397	1.4047
10.77	10.88	-17.97	-23.82	11.3	2.6	0.4397	1.4169

Figure 2

Neighborhood analysis of a 7 El. KF4JU Ver 3

Element number 1

Fgain	F:B	Hside	Eside	Feed-R	Feed-X	Length	Space-X
10.61	18.95	-12.46	-19.06	25.8	-10.9	0.4817	-0.3299
10.63	22.07	-11.98	-18.85	26.8	-10.9	0.4939	-0.3299
10.56	26.30	-11.67	-18.54	27.6	-11.3	0.5061	-0.3299
10.45	32.40	-11.47	-18.62	28.1	-11.8	0.5183	-0.3299
10.35	43.21	-11.36	-18.79	28.3	-12.3	0.5305	-0.3299
10.55	16.58	-13.37	-19.71	23.3	-11.0	0.4817	-0.2688
10.64	19.59	-12.78	-19.65	24.6	-10.6	0.4939	-0.2688
10.60	23.22	-12.39	-19.26	25.6	-10.7	0.5061	-0.2688
10.52	27.67	-12.13	-19.28	26.3	-11.1	0.5183	-0.2688
10.43	33.88	-11.97	-19.40	26.8	-11.4	0.5305	-0.2688
10.39	14.05	-14.39	-21.26	20.0	-12.2	0.4817	-0.2077
10.60	17.39	-13.53	-20.40	21.6	-11.1	0.4939	-0.2077
10.60	*21.03*	*-12.99*	*-20.14*	*23.0*	*-10.8*	*0.5061*	*-0.2077*
10.54	25.06	-12.66	-20.09	24.1	-10.9	0.5183	-0.2077
10.46	29.94	-12.43	-19.87	24.8	-11.2	0.5305	-0.2077
9.99	10.87	-15.24	-24.61	15.3	-15.6	0.4817	-0.1466
10.52	15.25	-14.17	-21.90	17.5	-12.8	0.4939	-0.1466
10.58	19.52	-13.40	-21.13	19.6	-11.8	0.5061	-0.1466
10.52	23.91	-12.95	-20.68	21.1	-11.5	0.5183	-0.1466
10.44	28.89	-12.67	-20.40	22.3	-11.5	0.5305	-0.1466
7.54	4.45	-11.50	-24.91	8.6	-26.1	0.4817	-0.0855
10.33	12.55	-14.67	-23.35	10.7	-18.0	0.4939	-0.0855
10.54	18.87	-13.47	-21.50	14.2	-14.7	0.5061	-0.0855
10.46	24.94	-12.89	-20.93	16.9	-13.5	0.5183	-0.0855
10.36	31.83	-12.57	-20.61	18.7	-13.1	0.5305	-0.0855

Figure 3

Neighborhood analysis of a 7 El. KF4JU Ver 3

Element number 4

Fgain	F:B	Hside	Eside	Feed-R	Feed-X	Length	Space-X
10.60	21.06	-13.00	-20.15	23.1	-10.6	0.0207	0.2321
10.59	21.11	-13.02	-20.16	23.1	-10.4	0.0512	0.2321
10.59	21.15	-13.03	-20.18	23.2	-10.2	0.0818	0.2321
10.59	21.20	-13.04	-20.19	23.3	-09.9	0.1123	0.2321
10.58	21.25	-13.06	-20.20	23.3	-9.7	0.1429	0.2321
10.58	21.30	-13.07	-20.22	23.4	-9.4	0.1734	0.2321
10.57	21.36	-13.08	-19.96	23.5	-9.0	0.2039	0.2321
10.57	21.42	-13.09	-19.97	23.6	-8.6	0.2345	0.2321
10.56	21.49	-13.11	-19.98	23.8	-8.1	0.2650	0.2321
10.54	21.56	-13.12	-19.72	23.9	-7.5	0.2956	0.2321
10.53	21.63	-13.12	-19.72	24.2	-6.7	0.3261	0.2321
10.50	21.69	-13.10	-19.44	24.5	-5.5	0.3566	0.2321
10.45	21.67	-16.29	-42.67	25.1	-3.7	0.3872	0.2321
10.35	21.35	-15.56	-44.86	26.3	-0.6	0.4177	0.2321
10.07	19.73	-13.83	-47.57	29.5	6.4	0.4483	0.2321
8.38	*12.68*	*-8.44*	*-51.72*	*52.3*	*32.9*	*0.4788*	*0.2321*
6.87	6.67	-4.76	-14.13	31.6	-68.1	0.5093	0.2321
10.30	14.95	-10.31	-18.98	20.9	-31.3	0.5399	0.2321
10.56	17.34	-11.53	-19.88	21.1	-23.4	0.5704	0.2321

Figure 4

Neighborhood analysis of a 7 El. KF4JU Ver 3

Element number 4

Fgain	F:B	Hside	Eside	Feed-R	Feed-X	Length	Space-X
8.38	*12.68*	*-8.44*	*-51.72*	*52.3*	*32.9*	*0.4788*	*0.2321*
7.82	11.22	-7.30	-50.58	62.2	39.0	0.4819	0.2321
7.02	9.48	-5.91	-49.18	78.2	45.2	0.4849	0.2321
5.87	7.38	-5.46	-9.99	105.4	47.3	0.4880	0.2321
4.21	4.80	-3.76	-8.93	146.6	30.0	0.4910	0.2321
1.93	1.74	-1.41	-7.26	174.3	-31.3	0.4941	0.2321
-0.16	-0.91	0.97	-6.17	137.6	-94.4	0.4971	0.2321
0.50	-0.53	0.94	-7.73	85.1	-104.7	0.5002	0.2321
3.07	2.09	-1.14	-10.50	54.6	-92.5	0.5032	0.2321
5.31	4.63	-3.18	-12.55	39.4	-79.0	0.5063	0.2321
6.87	6.67	-4.76	-14.13	31.6	-68.1	0.5093	0.2321
7.92	8.29	-5.98	-15.34	27.3	-59.8	0.5124	0.2321

Figure 5

Bandwidth analysis of a 12 El. NBS

Design frequency = 144.50

Freq(MHz)	Fgain	F:B	Hside	Eside	Feed-R	Feed-X
144.00	11.76	25.64	-11.36	-16.75	26.8	6.6
144.50	11.85	29.95	-11.34	-16.73	26.2	10.7
145.00	11.94	28.81	-11.32	-16.48	25.7	15.0
145.50	12.00	24.43	-11.26	-16.42	25.5	19.5
146.00	12.05	21.08	-11.20	-16.14	25.5	24.1
146.50	12.08	18.62	-11.09	-16.03	25.9	28.7
147.00	12.08	16.74	-10.98	-15.71	26.6	33.4
147.50	12.06	15.26	-10.82	-15.56	27.8	38.0
148.00	12.02	14.07	-10.68	-15.41	29.4	42.5

Figure 16
Tee Match

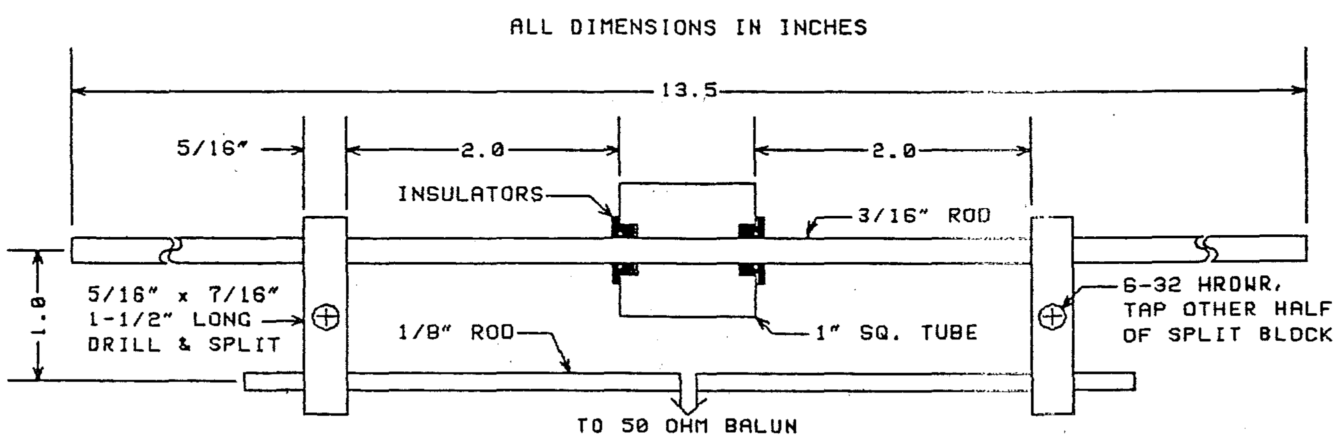


Figure 6

Fabrication data for a 7 El. KF4JU Ver 3

Prepared by KF4JU

Gain(dBd)	Freq(MHz)	Feed-Impedance
10.60	144.20	23.0 -j 10.8 ohms

F:B	No. of El.	El. Dia.	Array-Length
21.03	7	0.187	118-0

First side lobe intensities(dB)

Magnetic plane	Electric plane
-12.99	-20.00

El	No	Length (in)	Space-X (in)	Space-Y (in)	Length (wl)	Space-X (wl)	Space-Y (wl)
Ref	1	41-7/16	0-0	0-0	0.5061	-0.2077	0.0000
Drv	2	39-3/16	17-0	0-0	0.4788	0.0000	0.0000
D1	3	38-7/16	28-0	0-0	0.4695	0.1344	0.0000
D2	4	37-11/16	44-0	0-0	0.4604	0.3298	0.0000
D3	5	37-7/16	65-0	0-0	0.4573	0.5863	0.0000
D4	6	36-11/16	90-0	0-0	0.4482	0.8917	0.0000
D5	7	36-0	118-0	0-0	0.4397	1.2337	0.0000

Construction data for a hairpin-match
New driven element length = 38-5/8 inches
Stub-length for 12 ga. wire on 1/2 inch centers = 2-0 inches

Driven element length for zero feed reactance = 39-21/32 inches

Stacking data for four antennas in a square array
H-plane stacking distance = 88-1/4 inches
E-plane stacking distance =116-1/4 inches
H-plane beamwidth = 47.7 degrees
E-plane beamwidth = 41.6 degrees

Figure 7

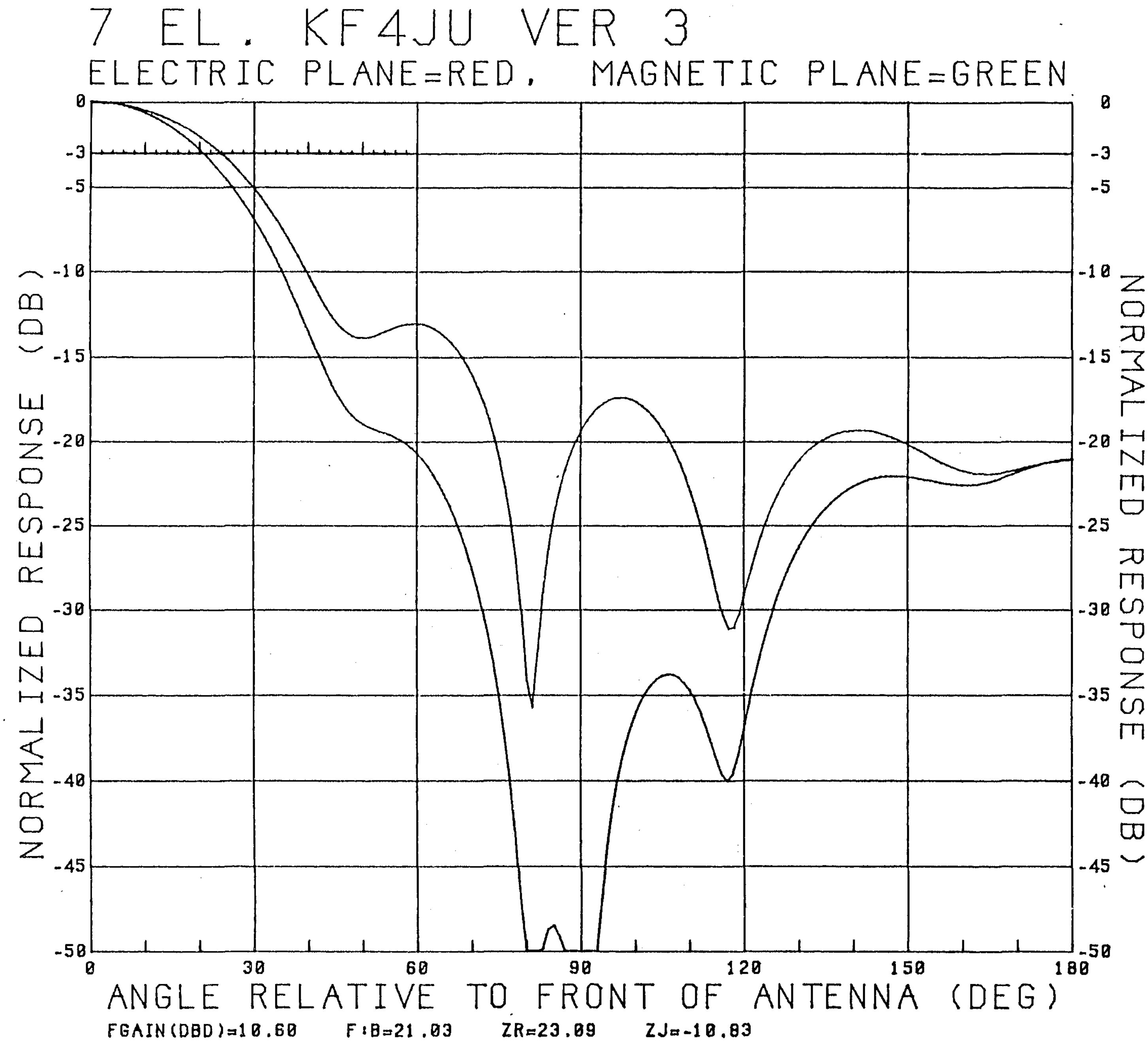

7 EL. KF4JU VER 3
ELECTRIC PLANE=RED, MAGNETIC PLANE=GREEN
NORMALIZED RESPONSE (DB)
0
-3
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
0
30
60
90
120
150
180
ANGLE RELATIVE TO FRONT OF ANTENNA (DEG)
FGAIN(DBD)=10.60 F:B=21.03 ZR=23.09 ZJ=-10.83

Figure 8

Fabrication data for a 12 El. KF4JU Ver 3

Prepared by KF4JU

Gain(dBd)	Freq(MHz)	Feed-Impedance
13.10	144.20	17.6 +j 3.4 ohms

F:B	No. of El.	El. Dia.	Array-Length
26.59	12	0.187	238-0

First side lobe intensities(dB)

Magnetic plane	Electric plane
-15.06	-18.64

El	No	Length (in)	Space-X (in)	Space-Y (in)	Length (wl)	Space-X (wl)	Space-Y (wl)
Ref	1	41-3/16	0-0	0-0	0.5030	-0.1466	0.0000
Drv	2	39-3/16	12-0	0-0	0.4787	0.0000	0.0000
D1	3	37-9/16	24-0	0-0	0.4590	0.1466	0.0000
D2	4	37-1/4	37-0	0-0	0.4550	0.3054	0.0000
D3	5	37-0	56-0	0-0	0.4520	0.5374	0.0000
D4	6	36-11/16	78-0	0-0	0.4480	0.8062	0.0000
D5	7	36-7/16	100-0	0-0	0.4450	1.0749	0.0000
D6	8	35-9/16	128-0	0-0	0.4344	1.4169	0.0000
D7	9	34-1/8	155-0	0-0	0.4170	1.7468	0.0000
D8	10	35-1/2	183-0	0-0	0.4336	2.0888	0.0000
D9	11	35-1/4	210-0	0-0	0.4306	2.4186	0.0000
D10	12	34-15/16	238-0	0-0	0.4268	2.7606	0.0000

Construction data for a hairpin-match
New driven element length = 38-1/16 inches
Stub-length for 12 ga. wire on 1/2 inch centers = 1-19/32inches

Driven element length for zero feed reactance = 39-1/16 inches

Stacking data for four antennas in a square array
H-plane stacking distance =123-1/2 inches
E-plane stacking distance =143-0 inches
H-plane beamwidth = 35.6 degrees
E-plane beamwidth = 33.0 degrees

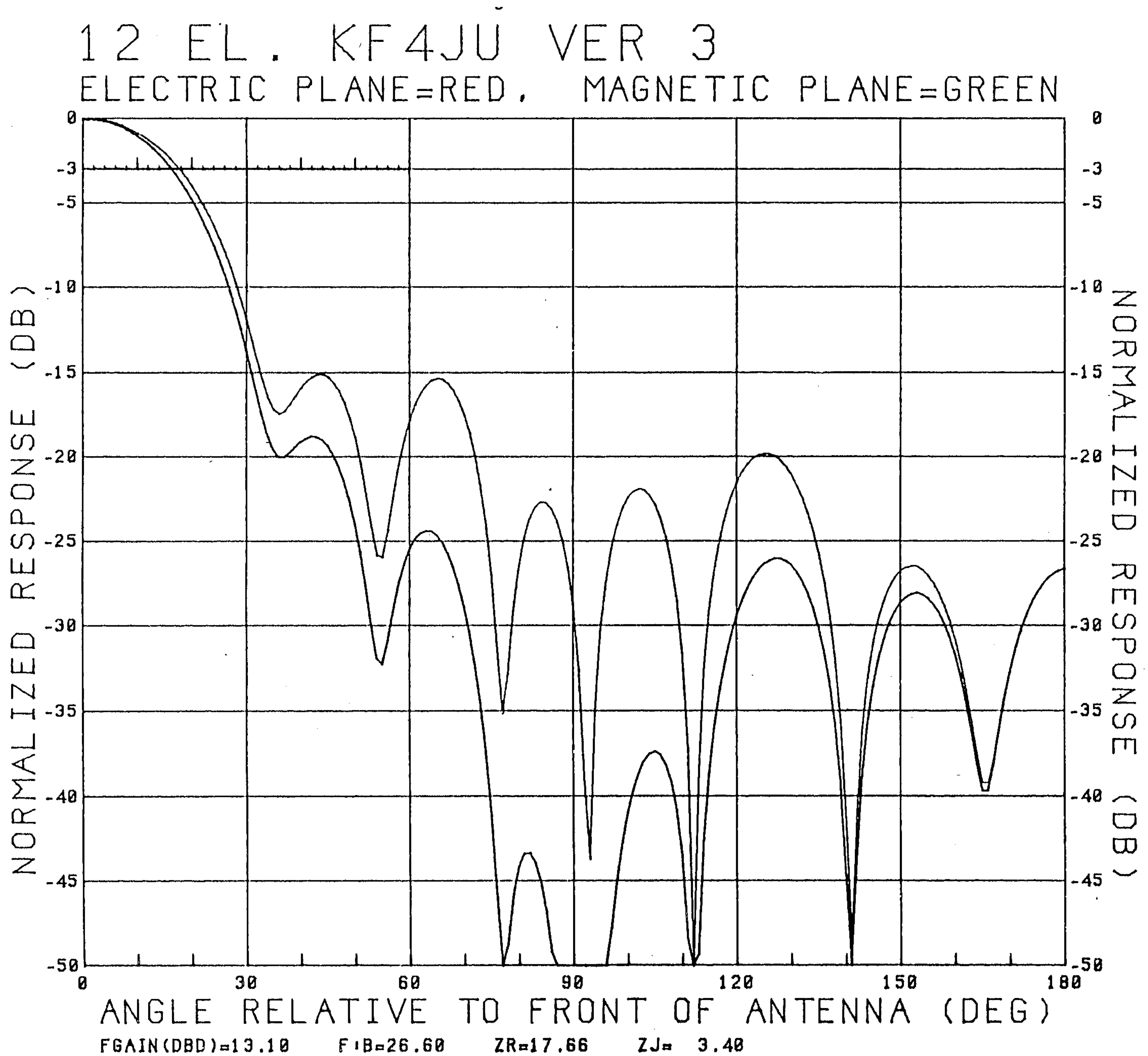

12 EL. KF4JU VER 3
ELECTRIC PLANE=RED, MAGNETIC PLANE=GREEN
0
-3
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
NORMALIZED RESPONSE (DB)
0
30
60
90
120
150
180
ANGLE RELATIVE TO FRONT OF ANTENNA (DEG)
FGAIN(DBD)=13.10 F/B=26.60 ZR=17.66 ZJ= 3.40

Figure 10

Fabrication data for a 16 El. KF4JU Ver 3

Prepared by KF4JU

Gain(dBd)	Freq(MHz)	Feed-Impedance
14.40	432.10	12.8 +j 0.5 ohms

F:B	No. of El.	El. Dia.	Array-Length
22.21	16	0.188	118-0

First side lobe intensities(dB)

Magnetic plane	Electric plane
-16.15	-18.49

El	No	Length (in)	Space-X (in)	Space-Y (in)	Length (wl)	Space-X (wl)	Space-Y (wl)
Ref	1	14-0	0-0	0-0	0.5124	-0.1990	0.0000
Drv	2	12-15/16	5-7/16	0-0	0.4736	0.0000	0.0000
D1	3	12-1/2	9-9/16	0-0	0.4575	0.1510	0.0000
D2	4	12-1/16	13-9/16	0-0	0.4415	0.2974	0.0000
D3	5	12-3/16	19-7/16	0-0	0.4461	0.5124	0.0000
D4	6	11-13/16	27-3/8	0-0	0.4324	0.8030	0.0000
D5	7	11-3/4	34-3/4	0-0	0.4301	1.0729	0.0000
D6	8	11-5/8	43-11/16	0-0	0.4255	1.4001	0.0000
D7	9	11-1/2	53-1/8	0-0	0.4209	1.7455	0.0000
D8	10	11-3/16	62-5/16	0-0	0.4095	2.0818	0.0000
D9	11	11-1/16	70-11/16	0-0	0.4049	2.3884	0.0000
D10	12	10-15/16	80-11/16	0-0	0.4004	2.7544	0.0000
D11	13	10-13/16	89-7/8	0-0	0.3958	3.0907	0.0000
D12	14	10-3/4	98-1/4	0-0	0.3935	3.3972	0.0000
D13	15	10-13/16	107-7/16	0-0	0.3958	3.7335	0.0000
D14	16	10-3/4	118-0	0-0	0.3935	4.1202	0.0000

Stacking data for four antennas in a square array
H-plane stacking distance = 49-1/4 inches
E-plane stacking distance = 54-1/2 inches
H-plane beamwidth = 30.4 degrees
E-plane beamwidth = 28.7 degrees

Figure 11

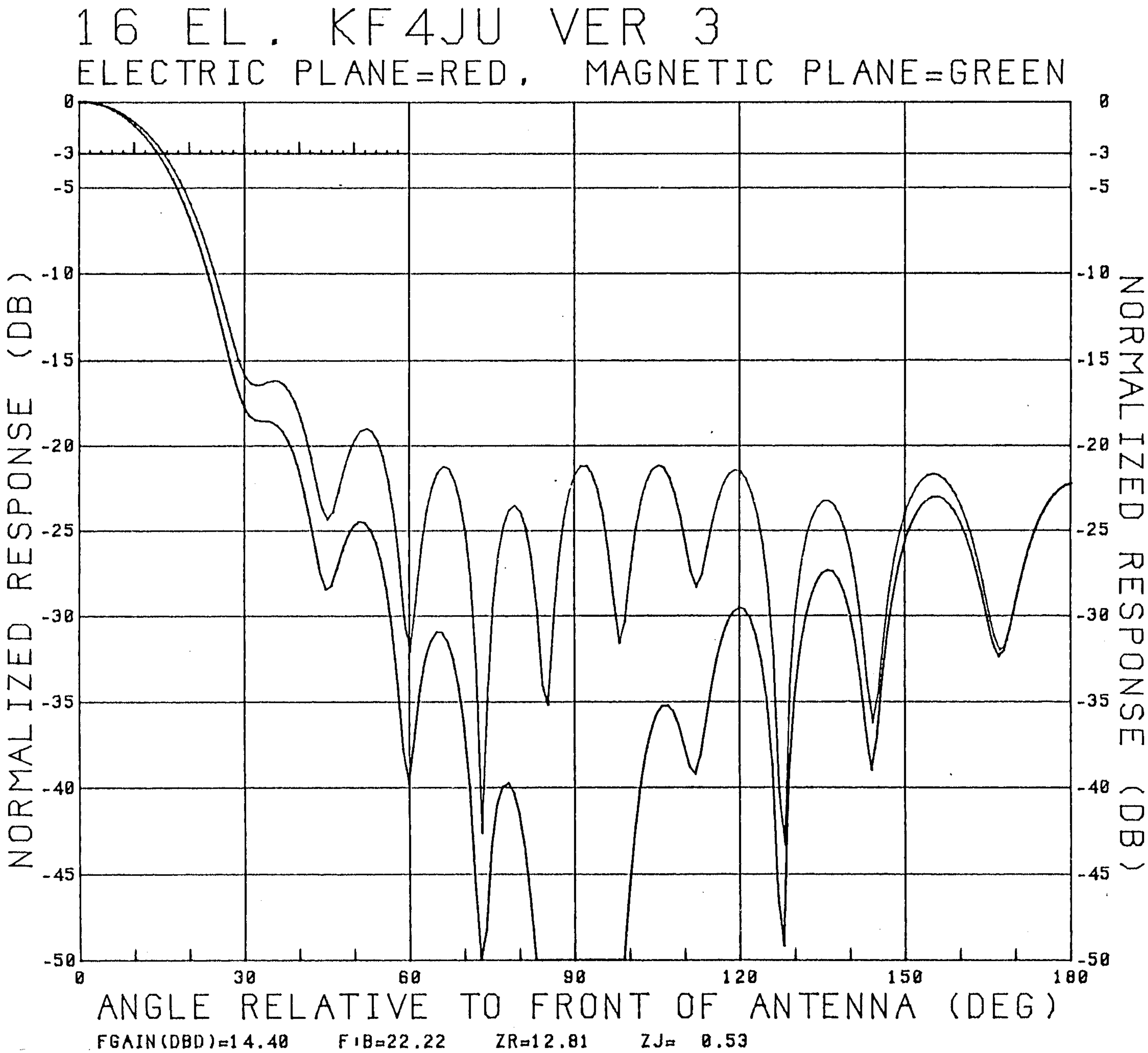

16 EL. KF4JU VER 3
ELECTRIC PLANE=RED, MAGNETIC PLANE=GREEN
NORMALIZED RESPONSE (DB)
0
-3
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
0
30
60
90
120
150
180
ANGLE RELATIVE TO FRONT OF ANTENNA (DEG)
FGAIN(DBD)=14.40 F/B=22.22 ZR=12.81 ZJ= 0.53

Figure 12
Fabrication data for a 21 El. KF4JU Ver 1

Prepared by KF4JU

Gain(dBd)	Freq(MHz)	Feed-Impedance
16.00	1296.10	14.7 +j 26.9 ohms

F:B	No. of El.	El. Dia.	Array-Length
21.04	21	0.125	59-0

First side lobe intensities(dB)

Magnetic plane	Electric plane
-14.45	-16.15

El	No	Length (in)	Space-X (in)	Space-Y (in)	Length (wl)	Space-X (wl)	Space-Y (wl)
Ref	1	4.445	0.000	0.000	0.4880	-0.2100	0.0000
Drv	2	4.308	1.913	0.000	0.4730	0.0000	0.0000
D1	3	4.117	3.261	0.000	0.4520	0.1480	0.0000
D2	4	3.871	4.818	0.000	0.4250	0.3190	0.0000
D3	5	3.707	6.913	0.000	0.4070	0.5490	0.0000
D4	6	3.725	8.835	0.000	0.4090	0.7600	0.0000
D5	7	3.725	11.831	0.000	0.4090	1.0890	0.0000
D6	8	3.598	14.709	0.000	0.3950	1.4050	0.0000
D7	9	3.525	17.077	0.000	0.3870	1.6650	0.0000
D8	10	3.598	20.374	0.000	0.3950	2.0270	0.0000
D9	11	3.598	23.498	0.000	0.3950	2.3700	0.0000
D10	12	3.488	26.085	0.000	0.3830	2.6540	0.0000
D11	13	3.488	28.954	0.000	0.3830	2.9690	0.0000
D12	14	3.488	32.251	0.000	0.3830	3.3310	0.0000
D13	15	3.488	35.712	0.000	0.3830	3.7110	0.0000
D14	16	3.488	39.583	0.000	0.3830	4.1360	0.0000
D15	17	3.525	43.409	0.000	0.3870	4.5560	0.0000
D16	18	3.397	46.833	0.000	0.3730	4.9320	0.0000
D17	19	3.397	50.349	0.000	0.3730	5.3180	0.0000
D18	20	3.397	55.504	0.000	0.3730	5.8840	0.0000
D19	21	3.397	59.002	0.000	0.3730	6.2680	0.0000

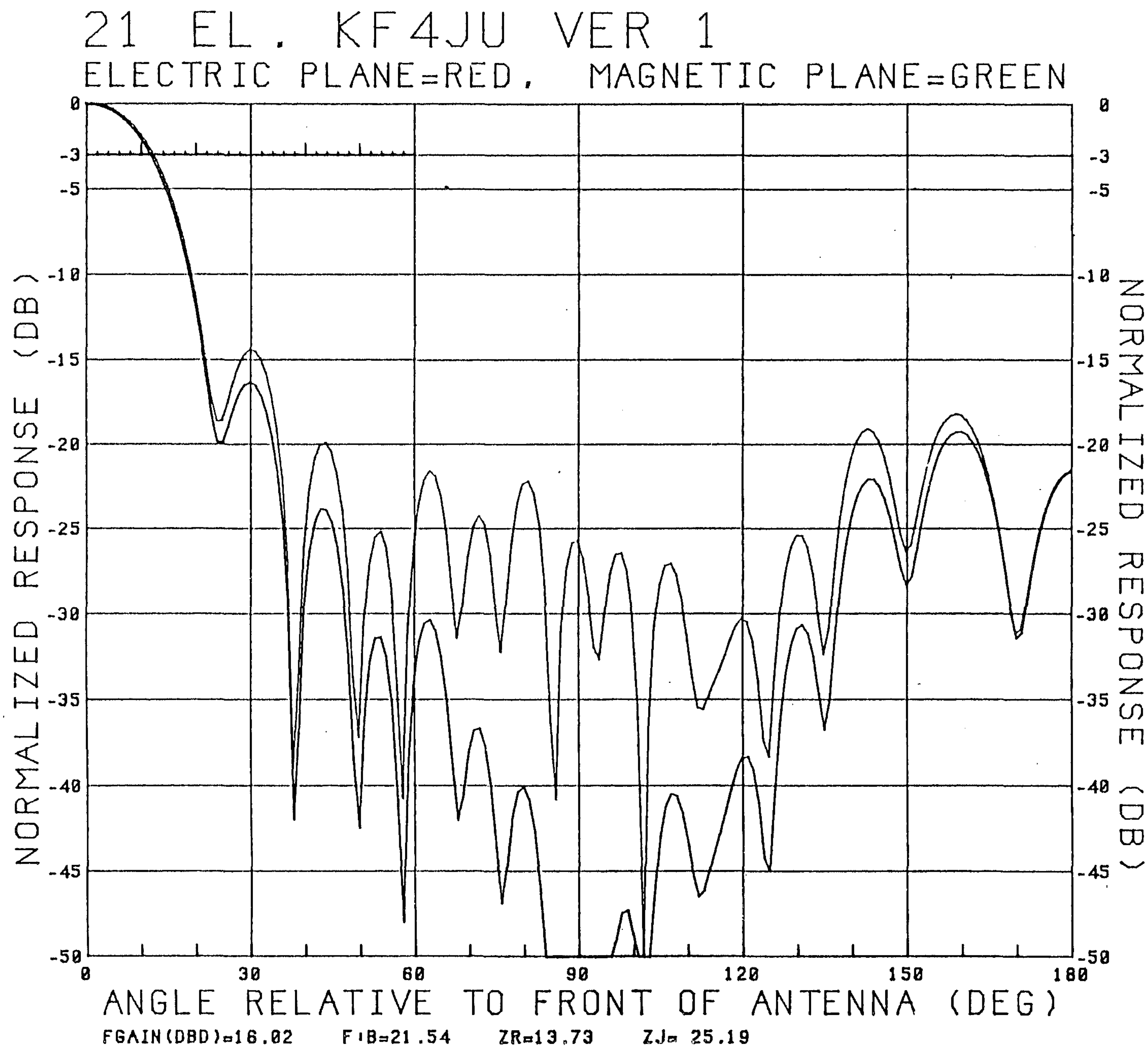
Construction data for a hairpin-match
New driven element length = 3.971inches
Stub-length for 12 ga. wire on 1/2 inch centers = 0-5/32 inches

Driven element length for zero feed reactance = 4.122inches

UNCONFIRMED

Stacking data for four antennas in a square array
H-plane stacking distance = 19-1/2 inches
E-plane stacking distance = 21-0 inches
H-plane beamwidth = 24.8 degrees
E-plane beamwidth = 23.9 degrees

Figure 13



21 EL. KF4JU VER 1
ELECTRIC PLANE=RED, MAGNETIC PLANE=GREEN
NORMALIZED RESPONSE (DB)
0
-3
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
0
30
60
90
120
150
180
ANGLE RELATIVE TO FRONT OF ANTENNA (DEG)
FGAIN(DBD)=16.02 F/B=21.54 ZR=13.73 ZJ= 25.19

Figure 14

Fabrication data for a 32 El. KF4JU Ver. 8

Prepared by KF4JU

Gain(dBd)	Freq(MHz)	Feed-Impedance
17.80	1296.10	12.6 +j 22.0 ohms

F:B	No. of El.	El. Dia.	Array-Length
26.53	32	0.125	95-0

First side lobe intensities(dB)

Magnetic plane	Electric plane
-14.35	-15.43

El	No	Length (in)	Space-X (in)	Space-Y (in)	Length (wl)	Space-X (wl)	Space-Y (wl)
Ref	1	4.442	0.000	0.000	0.4877	-0.2000	0.0000
Drv	2	4.311	1.822	0.000	0.4733	0.0000	0.0000
D1	3	4.115	3.170	0.000	0.4518	0.1480	0.0000
D2	4	3.866	4.727	0.000	0.4245	0.3190	0.0000
D3	5	3.707	6.822	0.000	0.4070	0.5490	0.0000
D4	6	3.728	8.744	0.000	0.4093	0.7600	0.0000
D5	7	3.728	11.740	0.000	0.4093	1.0890	0.0000
D6	8	3.601	14.618	0.000	0.3954	1.4050	0.0000
D7	9	3.528	16.986	0.000	0.3873	1.6650	0.0000
D8	10	3.622	20.283	0.000	0.3977	2.0270	0.0000
D9	11	3.601	23.407	0.000	0.3954	2.3700	0.0000
D10	12	3.486	25.994	0.000	0.3827	2.6540	0.0000
D11	13	3.538	28.499	0.000	0.3884	2.9290	0.0000
D12	14	3.486	32.160	0.000	0.3827	3.3310	0.0000
D13	15	3.486	35.621	0.000	0.3827	3.7110	0.0000
D14	16	3.486	39.492	0.000	0.3827	4.1360	0.0000
D15	17	3.528	43.318	0.000	0.3873	4.5560	0.0000
D16	18	3.374	46.853	0.000	0.3704	4.9442	0.0000
D17	19	3.402	50.258	0.000	0.3735	5.3180	0.0000
D18	20	3.402	55.413	0.000	0.3735	5.8840	0.0000
D19	21	3.402	58.546	0.000	0.3735	6.2280	0.0000
D20	22	3.402	62.181	0.000	0.3735	6.6270	0.0000
D21	23	3.371	65.450	0.000	0.3701	6.9860	0.0000
D22	24	3.288	68.356	0.000	0.3610	7.3050	0.0000
D23	25	3.319	71.990	0.000	0.3644	7.7040	0.0000
D24	26	3.236	75.415	0.000	0.3553	8.0800	0.0000
D25	27	3.257	78.320	0.000	0.3576	8.3990	0.0000
D26	28	3.236	81.590	0.000	0.3553	8.7580	0.0000
D27	29	3.205	84.860	0.000	0.3519	9.1170	0.0000
D28	30	3.175	88.129	0.000	0.3486	9.4760	0.0000
D29	31	3.154	91.399	0.000	0.3463	9.8350	0.0000
D30	32	3.124	94.997	0.000	0.3430	10.2300	0.0000

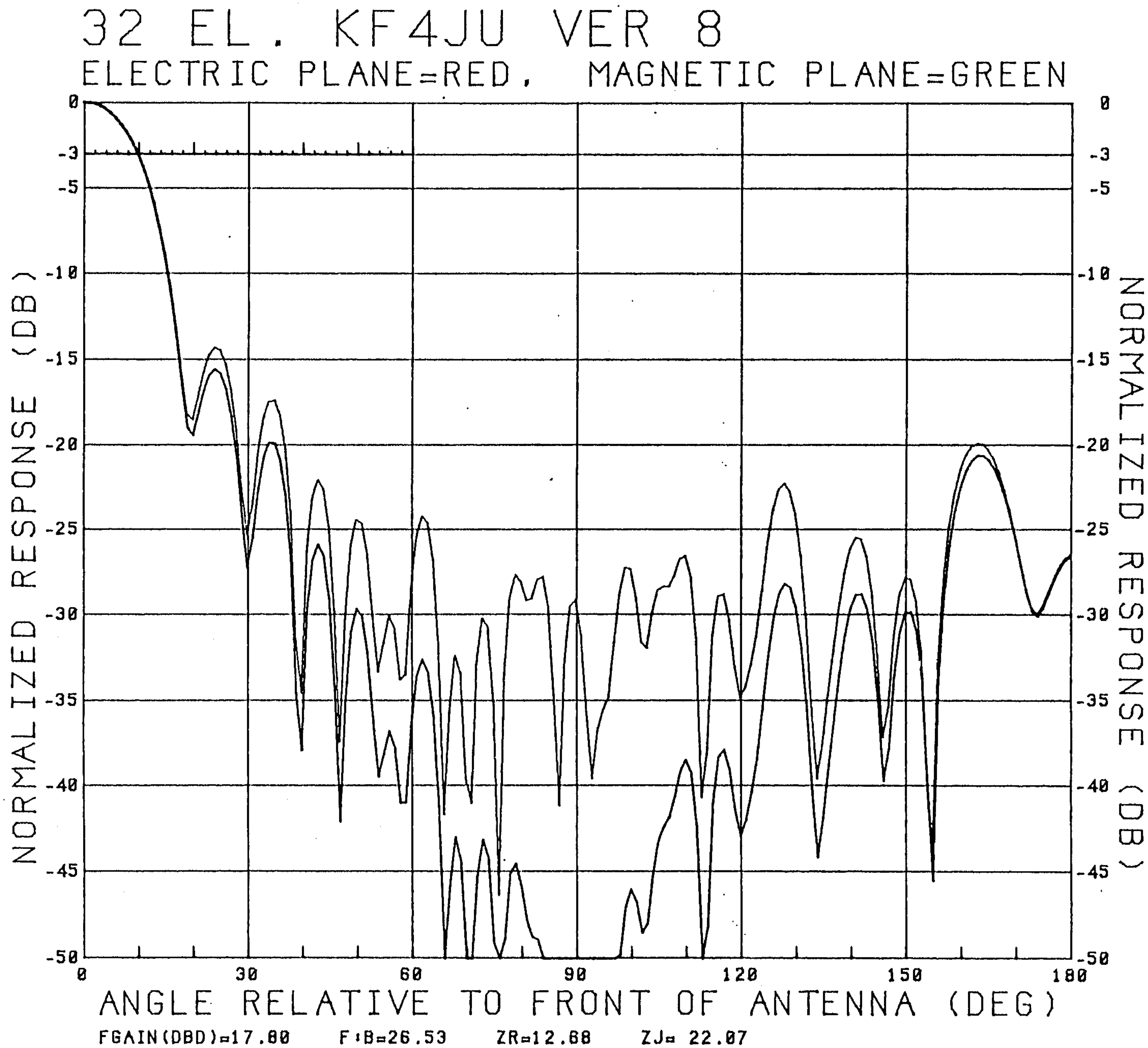
Construction data for a hairpin-match
New driven element length = 4.013inches
Stub-length for 12 ga. wire on 1/2 inch centers = 0-1/8 inches

Driven element length for zero feed reactance = 4.158inches

UNCONFIRMED

Stacking data for four antennas in a square array
H-plane stacking distance = 24-0 inches
E-plane stacking distance = 25-0 inches
H-plane beamwidth = 20.2 degrees
E-plane beamwidth = 19.7 degrees

Figure 15



32 EL. KF4JU VER 8
ELECTRIC PLANE=RED, MAGNETIC PLANE=GREEN
NORMALIZED RESPONSE (DB)
0
-3
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
0
30
60
90
120
150
180
ANGLE RELATIVE TO FRONT OF ANTENNA (DEG)
FGAIN(DBD)=17.80 F:B=26.53 ZR=12.68 ZJ= 22.07

Joe Reisert, W1JR
Rev. 30 June 1986

"Radio Propagation on 50 MHz and Above", Central States VHF Conference, July 86

Radio propagation is a fascinating subject especially on the frequencies above 50 MHz. Compared with HF propagation, this is almost an untouched territory just yearning to be studied. Propagation such as FAI was only recently discovered. Aurora has been confined to 450 MHz and below when we know it is possible up through 2450 MHz. Likewise, as I write this paper, the first sporadic E QSO above 148 MHz has yet to be completed.

Two things seem to motivate the exploration of the frequencies above 50 MHz: the building and testing of new and improved "state-of-the-art" equipment and the setting of DX records. The gear has been driven by solid state devices which make communications more reliable and portable (gear that can be carried by one man!). This in turn has made record challenges much more popular.

Low-noise bipolar and FET devices with their successors (GaAs FETs, HEMTs, etc.) are making receivers theoretically almost noise-free, especially if a small amount of coolant is applied to the active device. Remember that just over a decade ago parametric amplifiers and klystron pumps were the order of the day in low-noise receivers. Nowadays, we can better a paramps performance with a preamplifier that is only 1 to 2 cubic inches in volume!

New solid state devices are making RF power and gain very inexpensive. Amateur 2XSSB QSO's have recently been reported as high as 24 GHZ! And the later was accomplished with homebrew gear in contrast to many prior attempts that used borrowed or commercial gear.

Finally, the state-of-the-art in antenna design has improved tremendously especially between 50 and 2450 MHz. Low sidelobe high gain antennas are now commonplace. Long (in terms of wavelength) boom Yagi and loop Yagi gains are approaching theoretical limits. Parabolic dishes are yielding near theoretical maximum gain and with low side lobes. We still have some room for improvement but we are almost there.

Table 1 gives an overview of the frequency spectrum that is now available to the USA Amateurs. Note that between 81 and 300 GHz there are two Amateur frequency allocations where no communications have been reported. Even between 10.5 and 81 GHz reported Amateur QSO's are rare.

To give you an idea of the latest possibilities to get into the record books, I have prepared tables 2, 3, and 4. They were first published in my VHF/UHF World monthly column in Ham Radio Magazine in July 1985 (ref. 2). Since then they have been updated and republished (ref. 7).

Table 2 shows the world-wide terrestrial and table 3 shows the world-wide EME DX records. I decided to introduce a new twist since the propagation and geography of North America is different than that of the rest of the world. Table 4 shows the DX record data for North America only (ref. 2). This is a more practical way to measure North Americans against their peers. Table 4 has been updated several times and undoubtedly it will have some changes between the time I send this paper in for publishing and the conference. Especially look for changes on our newest band, 902-928 MHz.

Joe Reisert, W1JR
Rev. 30 June 1986

"Radio Propagation on 50 MHz and Above", Central States VHF Conference, July 86

Also enclosed with this paper is a copy of the record authentication sheet that I developed. It is send out to persons who feel they can challenge a DX record. It requests extensive information but this is necessary to make sure that the claims are valid. Also remember that Amateur DX records are often broken by as little as 1 or 2 miles so every bit of information especially on exact location is necessary!

My talk today will quickly display these tables of frequency allocations and records. However, since they are a permanent part of this paper, I will not dwell on them. Instead I will concentrate on explaining the various known propagation modes shown in brief form on table 5. Time permitting, tape recordings of some propagation modes will be played.

The references shown below will fill in the rest of the material since time will not permit an in-depth treatment of all modes of propagation. At the end of this presentation, you should be well aware of the possibilities that are right around the corner just waiting for someone to challenge.

Good luck and keep me updated on any new happenings, discoveries and especially any challenges to the records shown on the enclosed tables.

References (These references and the references at the end of each article referenced should contain most of the information needed to study radio propagation).

1. Joe Reisert, W1JR, "VHF/UHF World-The VHF/UHF Primer:An Introduction to Propagation", Ham Radio, July 1984, Pg. 14.
2. Joe Reisert, W1JR, "VHF/UHF World-Propagation Update", Ham Radio, July 1985, Pg. 86.
3. Joe Reisert, W1JR, "VHF/UHF World-Improving Meteor Scatter Communications", Ham Radio, June 1984, Pg. 82.
4. Joe Reisert, W1JR, "VHF/UHF World-220-MHz EME Requirements", Ham Radio, Sept. 1984, Pg. 45.
5. Joe Reisert, W1JR, "Requirements and Recommendations for 70-cm EME", Ham Radio, June 1982, Pg. 12.
6. Joe Reisert, W1JR, "VHF/UHF World-Meteor Scatter Communications", Ham Radio, June 1986, Pg. 68.
7 Joe Reisert, W1JR, "VHF/UHF World-Microwave and Millimeter-Wave Propagation, Part 1", Ham Radio, July 1986, page 82.
8 Joe Reisert, W1JR, "VHF/UHF World-Microwave and Millimeter-Wave Propagation, Part 2", Ham Radio, Aug. 1986, page 69.

Table 1

Joe Reisert, W1JR
Rev. 29 June 1986

Updated FCC VHF, UHF and Above Frequency Allocations:

Band	Frequencies	Notes
6 meters	50-54 MHz	cw only 50-50.1 MHz.
2 meters	144-148 MHz	cw only 144.0-144.1 MHz.
135 cm	220-225 MHz	
70 cm	420-450 MHz	OSCAR only 435-438 MHz. Some Canadian border restrictions from 420-430 MHz.
33 cm	902-928 MHz	Restrictions apply in CO, WY, Reg. 3 & White Sands area. Band available since 28 Sept. 1985.
23 cm	1240-1300 MHz	1215-1240 MHz was reallocated on 1 March 1986.
13 cm	2300-2310, 2390-2450 MHz	2310-2390 MHz removed November 6, 1984.
9 cm	3300-3500 MHz	
6 cm	5650-5925 MHz	
3 cm	10-10.5 GHz	
12 mm	24-24.25 GHz.	
6 mm	47-47.2 GHz	48-50 GHz was reallocated on 1 March 1986.
4 mm	76-81 GHz	71-75.5 GHz was reallocated on 1 March 1986.
3 mm	119.98-120.02 GHz	New assignment effective 1 March 1986.
2 mm	142-149 GHz	165-170 GHz and 240-250 GHz was reallocated on 1 March 1986.
1 mm and up	300 GHz & up!	

Table 2

Joe Reisert, W1JR
Updated 23 June 1986

World Wide Claimed VHF/UHF/SHF Terrestrial DX Records

Frequency	Record Holder	Date of QSO	Prop. Mode	DX miles (km)
50 MHz	Note 1.			
70 MHz	GW4ASR/P-5B4CY	81-06-07	Es	2153 (3465)
144 MHz	I4EAT-ZS3B	79-03-30	TE	4884 (7860)
220 MHz	KP4EOR-LU7DJZ	83-03-09	TE	3670 (5906)
432 MHz	KD6R-KH6IAA/P	80-07-28	Tropo duct	2550 (4103)
903 MHz	AF1T-WB1FKF	86-01-13	Tropo	53 (85)
1296 MHz	KH6HME-N6CA	84-06-24	Tropo duct	2472 (3977)
2.3 GHz	VK5QR-VK6WG/P	78-02-17	Tropo duct	1170 (1883)
3.4 GHz	VK5QR-VK6WG	86-01-25	ducting	1171 (1885)
5.7 GHz	G3ZEZ-SM6HYG	83-07-12	ducting	610 (981)
10 GHz	I0SNY/EA9-I0YLI/IE9	83-07-08	ducting	1032 (1660)
24 GHz	I3SOY/3, IW3EHQ/3-I4BER/6, I4CHY/6	84-04-25	LOS	180 (289)
47 GHz	HB9AMH/P-HB9MIN/P	85-01-13	LOS	31.7 (51)
75 GHz	HB9AGE/P-HB9MIN/P	85-12-30	LOS	0.3 (0.5)
474 THz	K6MEP-WA6EJO	79-06-09	LOS	15 (24)

Notes:
1. 6 meters has been left blank on this listing because long-path QSO's (those exceeding 12440 miles or 20016 km) have been reported ducting solar cycles 19 and 21.

Table 3

Joe Reisert, W1JR
Updated 14 May 1986

World Wide Claimed VHF/UHF/SHF EME DX Records

Band	Record Holder	Date of QSO	Prop. Mode	DX miles (km)
50 MHz	K6MYC-K8MMM	84-07-24	EME	2127 (3422)
144 MHz	K6MYC-ZS6ALE	83-02-18	EME	12088 (19450)
220 MHz	K1WHS-KH6BFZ	83-11-17	EME	5058 (8139)
432 MHz	F9FT-ZL3AAD	80-04-18	EME	11679 (18793)
903 MHz	none reported			
1296 MHz	PA0SSB-ZL3AAD	83-06-13	EME	11595 (18657)
2304 MHz	PA0SSB-W6YFK	81-04-05	EME	5491 (8836)

3300 MHz and above: None reported.

Table 4 Joe Reisert, W1JR

N. American VHF and Above Claimed DX Records (note 1) Updated 23 June 1986

Frequency	Record	Date	Prop. Mode	DX Miles (km)
50 MHz	Note 2			
144 MHz	KA1ZE-WB0DRL	86-02-08	Aurora	1348 (2169)
	KH6GRU-WA6JRA	73-07-29	Ducting	2591 (4169)
	VE1UT-VK5MC	84-04-07	EME	10,985 (17676)
	W4EQR-W7HAH	81-07-09	Es	1881 (3027)
	W5HUQ/4-W5UN	83-07-25	FAI	1229 (1977)
	K5UR-KP4EKG	85-12-13	MS	1960 (3153)
	KP4EOR-LU5DJZ	78-02-12	TE	3933 (6328)
	K1RJH-K5WXZ	68-10-08	Tropo	1465 (2358)
220 MHz	W3IY/4-WB5LUA	82-07-14	Aurora	1145 (1842)
	KH6UK-W6NLZ	59-06-22	Ducting	2540 (4087)
	K1WHS-KH6BFZ	83-11-17	EME	5058 (8139)
	K1WHS-K0ALL	85-08-12	MS	1274 (2049)
	KP4EOR-LU7DJZ	83-03-09	TE	3670 (5906)
	VE3EMS-WB5LUA	82-09-28	Tropo	1181 (1901)
432 MHz	W3IP-WB5LUA	86-02-08	Aurora	1182 (1901)
	KD6R-KH6IAA/P	80-07-28	Ducting	2550 (4103)
	K2UYH-VK6ZT	83-01-29	EME	11,567 (18612)
	W2AZL-W0LER	72-08-12	MS	1020 (1641)
	WA2LTM-WB5LUA	79-09-10	Tropo	1310 (2108)
903 MHz	W1JR-K3YTL	86-06-15	Tropo	267 (430)
1296 MHz	KH6HME-N6CA	84-06-24	Ducting	2472 (3977)
	K2UYH-VK5MC	81-12-06	EME	10,562 (16995)
	W4WSR-WA5TKU	85-06-03	Tropo	1112 (1790)
2.3 GHz	PA0SSB-W6YFK	81-04-05	EME	5491 (8836)
	W4ODW-WB5LUA	86-02-20	Tropo	628 (1003)
3.3 GHz	K6HIJ/6-W6IFE/6	70-06-18	LOS	214 (344)
5.6 GHz	K5FUD-K5PJR	77-09-20	Tropo	267 (430)
10 GHz	WA4GHK/4-WD4NGG	84-08-07	Ducting	297 (478)
	W7JIP/7-W7LHL/7	60-07-31	LOS	265 (426)
24 GHz	KX0O/0,W0MXY/0-NK0P/0,WA0VSL/0	85-08-24	LOS	74 (119)
48 GHz	W2SZ/1-WA2AAU/1	84-09-08	LOS	.3 (.5)
76-149 GHz	None reported			
474 THz	K6MEP-WA6EJQ	79-06-09	LOS	15 (24)

Note 1. The records are listed alphabetically by mode. Ducting is suspected where the path is mostly over water. No efforts are made to separate out ducting on overland paths so they're grouped under tropo.

Note 2. 6-meters records were left off since the primary mode is often hard to distinguish. Also long-path QSO's have been reported during solar cycles 19 and 21 which exceed 12433 miles (20004 km).

Table 5

Joe Reisert, W1JR
Rev. 30 June 1986

"Radio Propagation on 50 MHz and Above", Central States VHF Conference, July 86

Typical Propagation (Based on North American stations):

Propagation Mode	Frequencies	Remarks
Line of sight	50 MHz and up	Unobstructed path plus some extention.
F2	50 MHz	Requires high sunspot activity. Fall and winter seasons are best.
Backscatter	50 MHz	Present during high sunspot activity as in F2 or during intense sporadic E ionization.
Sporadic E	50-225 MHz	Typically mid-May thru early August and again but weaker between, mid-November and mid-January. No 220 MHz completed QSO's yet but a few close calls!
TE (trans-equatorial)	50 MHz	At equinox +/-2 weeks especially when F2 propagation is typical.
Equatorial FAI	50-450 MHz	Same as TE requirements
Ionospheric Scatter	50-144 MHz	Best around noon times especially when solar ionization is high.
Aurora	50->450 MHz	Optimum 24-48 hours after a solar disturbance. 900-2450 MHz is possible but no reported Amateur QSO's.
Artifical Aurora	50->450 MHz	Man made by heating ionosphere with high power between 4 and 15 MHz. Similar to normal Aurora except for location near heater.
Auroral Es	50 MHz	Occurs several hours after Aurora dies down.
Meteor scatter	50-450 MHz	Best during meteor showers but possible using sporadic meteors between 4 and 8 AM local time. >225 MHz is very difficult.
FAI (field aligned irregulatities)	50-450 MHz	Best during years when solar activity is very high. Sounds and acts similar to Aurora.
EME (Earth-Moon-Earth)	50 MHz and up	High path loss, 250-275 dB typical, but is possible with >500 watts, 1 dB noise figure and 20-30 dB gain antenna system.
Tropospheric scatter	50 MHz-20 GHz	Good out to 800 miles especially with high ERP. Setup is best if similar to EME.

Table 5 (cont'd)

Joe Reisert, W1JR
Rev. 30 June 1986

"Radio Propagation on 50 MHz and Above", Central States VHF Conference, July 86

Typical Propagation (Based on North American stations):

Propagation Mode	Frequencies	Remarks
Tropo. bending and super-refraction.	144 MHz and up	Good from spring thru fall with high (>30" typical) barometer.
Tropo. ducting	50 MHz and up.	Same as tropospheric bending. You must be in or able to couple into the duct.
Lightning scatter	144 MHz and up	Sporadic. Both stations should aim at lightning center. Similar to meteor scatter.
Aircraft scatter	144 MHz and up	Best with aircraft at midpoint. 500 miles is about the maximum DX.
Knife edge diffraction	1 GHz and up	Best with sharp edge such as a mountain peak near one end of the path.
Obstacle gain	500 MHz and up	Both stations should aim at buildings, hills, structures etc. Best when obstacle is near one end of the path.
Rain Scatter	5 to 20 GHz	Aim antenna into storm center even if it is elevated.

DL6WU ANTENNA DESIGN

Program written by Jerry Haigwood, KY4Z, and Bob Stein, W6NBI - Based on article 'Extremely Long Yagi Antennas' by Gunter Hoch, DL6WU: VHF Communications, 3/82

DESIGNED BY : KOKE

CENTER FREQUENCY = 2304 MHz   28 el yagi

GAIN = 16.7 dBd

DRIVE IMPEDANCE = 200 OHMS (APPROX), WITH FOLDED DIPOLE D.E.

BOOM LENGTH: 4 ft
REFLECTOR TO
LAST DIRECTOR = 3.95 FT = 47.4 IN. = 120.5 CM

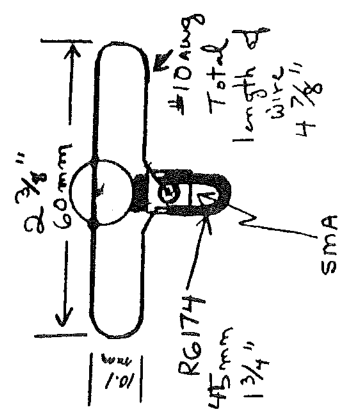
BOOM DIAMETER = 0.375 IN. = 0.95 CM   3/8" OD (1/4 copper tube)

ELEMENT DIAMETERS:
DRIVEN = 0.102 IN. = 0.26 CM
PARASITIC = 0.102 IN. = 0.26 CM   #10 wire

Elements pass through and are NOT insulated from a metal boom

CUMULATIVE SPACING CM	CUMULATIVE SPACING IN.		ELEMENT LENGTH CM	ELEMENT LENGTH IN.
Ref	Ref	REFL	6.78	2.668
2.81	1.107	D.E.	5.96	2.347
3.87	1.524	D 1	5.91	2.326
6.03	2.374	D 2	5.82	2.290
8.83	3.477	D 3	5.73	2.255
12.09	4.759	D 4	5.65	2.223
15.70	6.180	D 5	5.58	2.196
19.60	7.715	D 6	5.52	2.172
23.74	9.346	D 7	5.47	2.152
28.09	11.061	D 8	5.42	2.134
32.64	12.849	D 9	5.38	2.118
37.34	14.702	D 10	5.34	2.104
42.20	16.616	D 11	5.31	2.091
47.20	18.583	D 12	5.28	2.080
52.32	20.600	D 13	5.25	2.069
57.57	22.664	D 14	5.23	2.059
62.81	24.728	D 15	5.21	2.050
68.05	26.791	D 16	5.18	2.041
73.29	28.855	D 17	5.16	2.033
78.53	30.918	D 18	5.14	2.025
83.77	32.982	D 19	5.13	2.018
89.02	35.046	D 20	5.11	2.011
94.26	37.109	D 21	5.09	2.005
99.50	39.173	D 22	5.08	1.998
104.74	41.236	D 23	5.06	1.993
109.98	43.300	D 24	5.05	1.987
115.22	45.364	D 25	5.03	1.981
120.46	47.427	D 26	5.02	1.976

DRIVEN Element
2304mhz



Joe Reisert, W1JR
26 February 1985

VHF/UHF/SHF Propagation Record:

Band:________________ Propagation Mode:______________________ Date:______________

DX (miles)_____________ (km)_______________

Station 1	Station 2
Call:___________________	Call:___________________
Name:___________________	Name___________________
QTH:___________________	QTH:___________________
Lat:__________ Long:__________	Lat:__________ Long:__________
Grid locator:__________	Grid Locator:__________
Elevation:__________	Elevation:__________
Location description:__________	Location description:__________
Antenna type__________	Antenna Type:__________
Estimated Gain (dBi)__________	Estimated Gain (dBi)__________
TX Freq:__________	TX Freq:__________
TX Power:______ Feed line loss:______	TX Power:______ Feed line loss:______
Modulation:__________	Modulation:__________
RX Freq:__________	RX Freq:__________
RX type:__________	RX Type:__________
Noise Figure:____ Feed line loss:____	Noise Figure:____ Feed line loss:____
RX Bandwidth:__________	RX Bandwidth:__________
Rcvd. Signal to Noise Ratio:__________	Rcvd. Signal to Noise Ratio:__________
Other Equipment Description:	Other Equipment Description:

Comments:_______________________________________

The information submitted above is correct to the best of my knowledge.

Submitted by:____________________ Call:__________ QTH:______________

____________________ Phone Number (AC______) ______________

Received by:____________________ Date:____________________

A NEW DIMENSION IN METEOR COMMUNICATION

Presented to the Central States VHF Society, July 1986

by
Tim Pettis
KL7WE

What comes to mind when you think of meteor communications? Are you reminded of 60 second contacts during meteor showers, or do you think of reliable year around communications? Well, if your vision is not one of "24 hour a day, 365 day per year", you are missing a "new dimension in meteor communications"!

Advances in data transmission technology and rule changes by the FCC which permit ASCII transmissions at rates of up to 19.2 KBPS on the amateur bands make this possible. Anything that can be digitized, voice, video or data, can be transmitted.

Although interactive communications by meteor scatter is possible, the highest and most productive use of the mode is remote telemetry, or computer to computer file transfer of data. This data can take any form, from Mother's Day messages to disaster communications or from digitized voice to video frames.

The best part of the deal is that your message will get through and, depending on the parameters under which your station is operating, the time in which the message will be delivered is predictable within any required statistical probability. There is no other form of propogation which will support communications over distances of up to 2,000 KM any time of day or night with predictable accuracy and without periods of total blackout such as those experienced on the High Frequency bands.

Of particular interest to this group is the gathering of grid squares and new states. Visualize turning the computer on one evening and waking up the following morning with 6 new states and 10 new grid squares in the log.

Let us examine the mechanism that makes this possible and see how one predicts the performance of meteor burst communications systems.

PHYSICAL PROPERTIES

Meteors are defined as extraterrestrial objects that travel in elliptical orbits around the sun. They are, for the most part, cometary debris and other forms of space dust of unspecified origin. There are two classes of meteors, shower meteors and sporadic meteors.

Shower meteors are groups of particles of similar velocity in fairly well defined orbits around the sun. They are generally associated with the passing of a comet. Visually they are the most spectacular. Although they amount to a very small percentage of all meteors, they account for most of the amateur communications done by meteor propogation.

Sporadic meteors move in random orbits around the sun. They are not uniformly distributed throughout the sky, though they are confined to within 20 degrees of the ecliptic. Intersection with meteor orbits is not uniform throughout the year. The peak occurs in July with the minimum occuring in February. This seasonal variation is about 4:1. See table 1. The relative rotation of the earth on its axis produces a diurnal variatio which peaks at 6 AM local time and is minimum at 6 PM local time. This diurnal variation is also about 4:1.

Table 2 lists the physical properties of meteors. It is important to note the distinction between overdense and underdense meteors. It is the underdense meteors in which we are interested. Although overdense meteors produce a higher degree of ionization, hence longer bursts and stronger signals, they also produce multipath distortion which tends to degrade data transmissions. In any event, there are far too few overdense meteors to be of real value to consistent communications.

PATH GEOMETRY

As meteors encounter the resistance of the atmosphere they produce an ionized trail. These trails occur at an altitude of from 80 to 120 KM above the surface of the earth. Underdense trails are about 4 meters in diameter and 20 to 40 KM in length. Unlike overdense trails, they serve tc reradiate radio signals rather than reflect them, hence the term "underdense".

Owing to the relative mass distribution of meteors and the height at which they produce ionization, there is a high probability of paths between 800 and 1200 KM. The probability of paths over 1200 KM drop to zero as the distance approaches 2,000 KM. At distances below 800 KM, the probability of paths exceeding a usable duration decrease by a factor of two to about 300 KM, the point below which ground wave communications take over. Propagation distances can be seen as analogous to Sporadic "E" in terms of distance, since the ionization occurs at nearly the same height above the earth. Unfortunately there is no "double hop" in meteor scatter.

SYSTEM ANALYSIS

To assess the performance of a meteor burst system, one must consider the following parameters:

1. Operating Frequency
2. Transmitter Power
3. Receive Threshold
4. Modulation
5. Data Rate
6. Burst Time Constant
7. Number of Meteors
8. Range

It is helpful to relate this exercise to more familiar modes. With CW transmission it is possible, due to its extremely low information rate, to copy signals whose SNR (signal to noise ratio) is less than 0 DB. Its bandwidth can be as little as a few Hertz. Voice transmission which can viewed as carrying a higher information rate requires a 3,000 Hz bandwidth and at least a 10 DB SNR for minimum intelligibility. Data transmission follows similar rules. The higher the data rate, the larger the required bandwidth and the higher the required signal power.

The easiest place to start the analysis is with the "total receivec power", Pr. This is the power, in DBW, required to be recieved at the antenna to produce acceptable reception. It is defined as:

Pr = 10 Log KTo[104/Lr(20/f)E2.3 + F] + 10 Log (En/Ne) + 10 Log (Data Rate)

where Lr = Line loss ahead of receiver
K = Boltzmans Constant
To = 300 deg K
F = Reciever Noise Factor
En = Signal Energy per bit
Ne = Total Reciever Noise Density
f = Frequency in MHz
Pr = Total Recieved Power

The first term of the equation computes the noise power generated by the receiver in DB/Hz. It factors the galactic noise, frequency, antenna line loss and noise factor of the receiver. This calculation is not exact but represents a reasonable approximation at frequencies below 150 MHz.

The second term computes the "signal power per bit" to "noise density" ratio required to achieve a specific bit error rate, "BER". See table 3.

The last term factors the bandwidth as a function of the data rate.

To compare two systems, we will define the term PF, power factor, expressed in DB as:

PF = Pt + Gt + Gr - Pr

where Pt = Transmit power in DBW
Gt = Transmit antenna gain in DBI
Gr = Receive antenna gain in DBI
Pr = Total received power in DBW as calculated above.

If the number of meteors observed per unit time is known for a given system, the meteor rate for another system operating on a different frequency and with a differnt power factor can be calculated as follows:

Mc/Mt = [10 E 0.05(PFc - PFt)] [10 E 1.5 Log(fT/fC)]

where Mc = Meteor rate of new system
Mt = Meteor rate of known system
PFc = Power factor of new system
PFt = Power factor of known system
fC = Operating frequency of new system
fT = Operating frequency of known system

The power factors being equal, to double the frequency will reduce the number of meteors per hour to 0.35 of the original value. Or, a system at 144 Mhz will observe only 20% of the meteors that one operating on 50 MHz will observe.

Increasing the power factor of the system by 10 DB will increase the number of meteors per hour by a factor of 3.16. Decreasing power by 3 DB will reduce the number of meteors to 71% of the original value.

The final factor is "burst time constant". Burst time is proportional to operating frequency, the diffusion constant, and the forward scattering angle, which is a function of range. In an effort to facilitate understanding, table 4 has been prepared showing the average burst time constant in milliseconds for 28, 50, 144 and 432 MHz at ranges from 500 KM to 2,000 KM.

For a given number of meteors which exceed a specific signal threshold, one can determine the probability that a certain number of them will exceed a specified duration by:

M/Mc = e E -(t/Td)

where M = Number of bursts/Hr exceeding a specified threshold for T sec
Mc = Number of bursts/Hr exceeding a specified signal threshold
Td = Burst time constant
t = Time in seconds

In other words, refering to table 5, 36% of the meteors will exceed the time constant in duration and 64% will not. 80% of the meteors will have a duration of .2 times the time constant.

It would follow that from this information we could predict, using standard distribution, the average waiting time for a suitable burst, and hence how long it would take to transmit a message of a certain length.

One can predict the waiting time for a suitable occurance by using:

P = 1 - e E -(Mt/60)

P = Probability of meteor occurance in time t
M = Meteor rate/hour
t = time in hours

Table 6 computes the waiting time in minutes for various rates of meteors per hour.

SYSTEM REQUIREMENTS

Consider the requirements of packet radio as it exists today. Most packet radio TNCs, terminal node controllers, are based on transmission at 1,200 BPS using FSK. Current protocol contains from 20 to 75 control characters, and up to 256 characters of text. At 1,200 BPS a full data frame would require 2.2 seconds. Transmitting minimum overhead and a 40 character text would require 400 ms. This "overhead to text ratio" produces about the lowest throughput one could consider useful. (The overhead alone requires 133 ms.)

COLLECTING DATA

Chart recordings were made to determine the actual meteor rate. The transmit station was located in Fairbanks and operated on 28.100 MHz with 30 Watts into a 7 DBI gain antenna. I received with a dipole of 2.1 DBI. The path length was 485 Km.

The number of meteors exceeding the threshold required to support 1200 BPS coherent PSK were counted from the recordings. Excerpts from the recordings are shown in Appendix A. The number was normalized for the time of year and produced a peak number of 37 meteors per hour.

Although this number is representative of the optimum time of day, 6 AM local time, and nearly the peak of sporadic meteor activity, June, it represents the poorest choice of distance (less than 500 kM). Considering the power factor, PF, of this system, the number of meteors is somewhat less than that predicted in other reports. The most likely reason for this lower rate is the extremely short path. The choice of this path as an example is defensible, however, in that the results will not likely allow us to overestimate the performance of any proposed system.

PREDICTING PERFORMANCE

Table 7 extrapolates the data for three bands given the conditions listed thereon. Every effort was made to choose realistic operating parameters such as antenna size and power levels, as well as transmission rates and modulation schemes which are both legal and available to amateurs.

Table 8 completes the picture. Using the number of meteors per hour for medium power level, 1200 BPS FSK transmission and the constraint that the minimum packet duration is on the order of 400 ms, we can compute the number of meteors per hour on which a packet of information can successfully transmitted. Remember, although the values are for 6 AM local time, they are conservative due to the choice of path tested.

CURRENT APPLICATIONS

It is obvious that current packet hardware is usable for meteor communications on 10 and 6 meters. The frame length can be much longer on 10 than on 6 meters, however, due to the burst duration and can be adapted to the individual path. (Shorter packets on higher frequencies and shorter paths.)

At 2 meters we are faced with quite an enigma in that the burst time constant is quite short and the number of trails whose duration is suitable is in even shorter supply. Using current hardware, refering to table 8, and medium power, paths under 1000 kM are statistically improbable. Over 1,000 kM, there is a measurable probability of transmitting at least the overhead and a signal report (one or two characters of text). Not much more is really possible.

CONCLUSIONS

The use of current packet technology on the amateur bands for meteor burst communications is possible on both 10 and 6 meters, using moderate power levels and modest antennas. At 2 meters communications is possible, but with the existing byte oriented protocol and available modems, the throughput is severely limited.

The choice between 10 and 6 meters is just that. At 10 meters, the galactic noise is much higher than at 6 meters, however the burst time constant is much greater so that success at shorter paths is more probable. On 10 meters, on all paths, the probability that the burst will exceed the duration of the packet is much greater, making it a better choice for current packet hardware.

On the other hand, the potential for 2 meter meteor scatter is not all lost. Though the FCC specifies the baud rate, it does not specify the bit rate. We currently think of the two as synonomous, but they are not. Using dibit coding, 2400 BPS can be transmitted at a rate of 1200 baud. The technique would certainly still be marginal, as it would still require bursts which are longer than the time constant.

Most TNCs are equiped with external outputs capable of working with other modems up to 9,600 BPS, some as high as 19.2 KBPS. It is certainly the use of this technology that will move meteor scatter into greater application in the amateur community.

In the mean time, is there anyone in the Pacific Northwest that is interested in testing the limits of propogation by meteor scatter on 10 or 6 meters. It is only 2,400 KM from Anchorage to Seattle!

Table 1

Average Number of Meteors Per Hour, Normalized by Month

Month	Average
January	29
February	26
March	28
April	29
May	53
June	84
July	100
August	84
September	68
October	61
November	52
December	39

Note: Percent of peak activity which occurs in July, not including shower meteors.

Table 2

PHYSICAL PROPERTIES OF METEORS

TYPE	MASS (grams)	RADIUS (cm)	NUMBER PER DAY	DENSITY (elec./meter)
Enter	10 E 3	4	10 E 2	---
Overd/V	10 E 2	2	10 E 3	---
Overd/V	10	0.8	10 E 4	10 E 18
Overd/V	1	0.4	10 E 5	10 E 17
Overd/V	10 E -1	0.2	10 E 6	10 E 16
Overd/V	10 E -2	0.08	10 E 7	10 E 15
Underd	10 E -3	0.04	10 E 8	10 E 14
Underd	10 E -4	0.02	10 E 9	10 E 13
Underd	10 E -5	0.008	10 E10	10 E 12
Underd	10 E -6	0.004	10 E11	10 E 11
Underd	10 E -7	0.002	10 E12	10 E 10
NonRad	<10 E-8	<0.004	10 E20	Nil

Enter = Survive entry
Overd/V = Overdense/Visual
Underd = Underdense/Nonvisual
NonRad = Can not be detected by radio

Table 3

BER/SNR*

BER	Coherent PSK	Quad PSK	Non-coherent FSK
10 E-1	0	2.0	4.0
10 E-2	3.5	5.0	8.0
10 E-3	6.0	6.8	10.2
10 E-4	7.6	8.4	11.5
10 E-5	8.6	9.4	12.1

* BER = Bit Error Rate
* SNR = 10 Log (En/Ne) in DB

Table 4

Burst Time Constant

Range(kM)	500	1,000	1,500	2,000
28 MHz	320ms	895ms	1,348ms	1,515ms
50 MHz	100ms	280ms	405ms	480ms
144 MHz	12ms	33ms	50ms	57ms
432 MHz	1.4ms	3.7ms	5.7ms	6.4ms

Table 5

Burst Duration Distribution

```
1.0 - +
0.9 -    +
0.8 -        +
0.7 -            +
0.6 -                +
0.5 -                    +
0.4 -                         +
0.3 -                                 +
0.2 -                                            +
0.1 -
0.0     I     I     I     I     I     I     I     I     I
        0    0.2   0.4   0.6   0.8   1.0   1.2   1.4   1.6
```

Table 6

Waiting time in Minutes

M rate =	15	30	60	120	240	450	800
P 99%	18	9	4.7	2.5	1.2	.45	.27
R 90%	9.3	4.6	2.2	1.2	.45	.25	.15
O 50%	2.8	1.2	0.7				

PROBABILITY

Table 7

Meteor Rate Per Hour

PWR	Mod	28 MHz	50 MHz	144 MHz
30	C/PSK	37	61	59
300	C/PSK	117	193	178
1000	C/PSK	213	352	327
30	FSK	23	38	35
300	FSK	72	119	110
1000	FSK	132	218	202

Common parameters:

1200 BPS, 475 kM path,

Individual parameters:

	28 MHz	50 MHz	144 MHz
Combined ant gain in DBI	12	18	24
Rx Noise Fig. in DB	4	2	1
PF at 30 W Coh PSK	177	188	202
PF at 300W Coh PSK	187	198	212
PF at 1000W Coh PSK	192	204	217
PF at 30 W FSK	173	184	198
PF at 300 W FSK	183	194	208
PF at 1000 W FSK	188	189	213

Table 8

Meteor Rate Per Hour
Exceeding a Specified Duration
by Frequency
Using FSK at 1200 BPS
see table 7

at 28 MHz, PF = 183
rate = 72/hr

Range	Td	.4s	.8s	1.2s	1.6s	2.0s
500KM	.320	32	6	2	--	--
1000KM	.895	46	29	19	12	8
1500KM	1.348	54	40	30	22	16
2000KM	1.515	55	42	33	25	19

at 50 MHz PF = 194
rate = 119/hr

500KM	.100	2	--	--	--	--
1000KM	.280	29	7	2	--	--
1500KM	.405	44	17	6	2	--
2000KM	.480	52	22	10	4	2

at 144 MHz PF = 208
rate = 110/hr

	Td	.1s	.15s	.2s	.25s	.3s
500KM	.012	--	--	--	--	--
1000KM	.033	5	1	--	--	--
1500KM	.050	15	5	2	--	--
2000KM	.057	19	8	3	1	--

Tx = Fairbanks Alaska
30 watts 3eL yagi

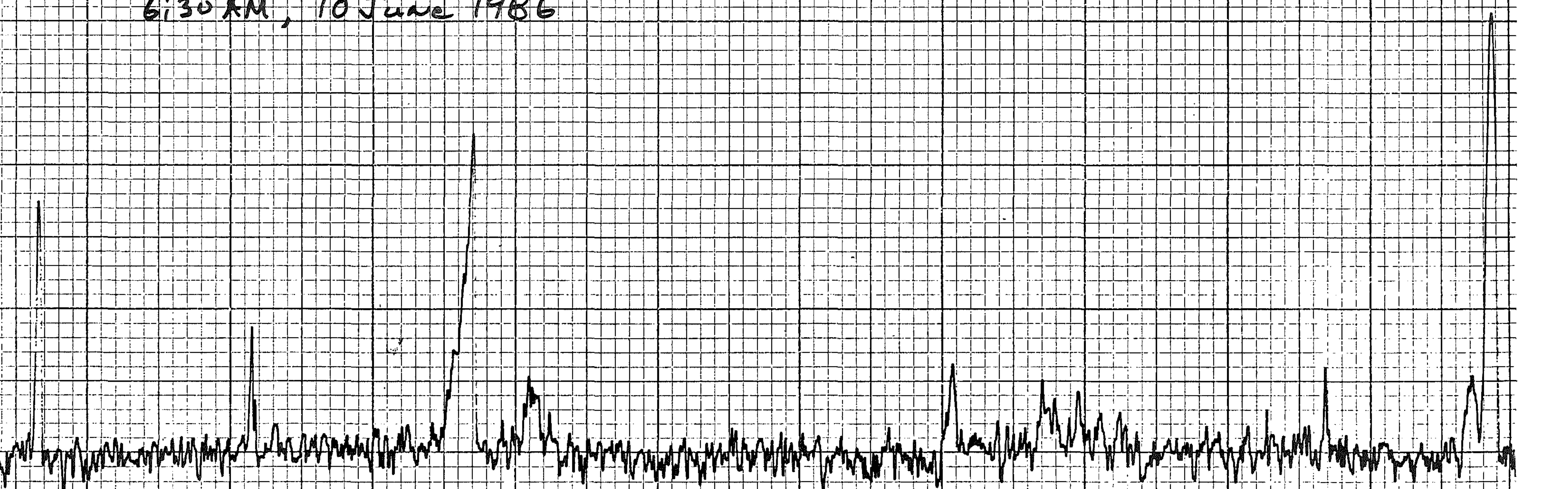
Rx = Anchorage, Alaska
dipole & TS130S

frequency 28.100 MHZ

Vertical Scale = 1/2" per db

Horizontal Scale = 10 seconds/inch

6:30 AM, 10 June 1986



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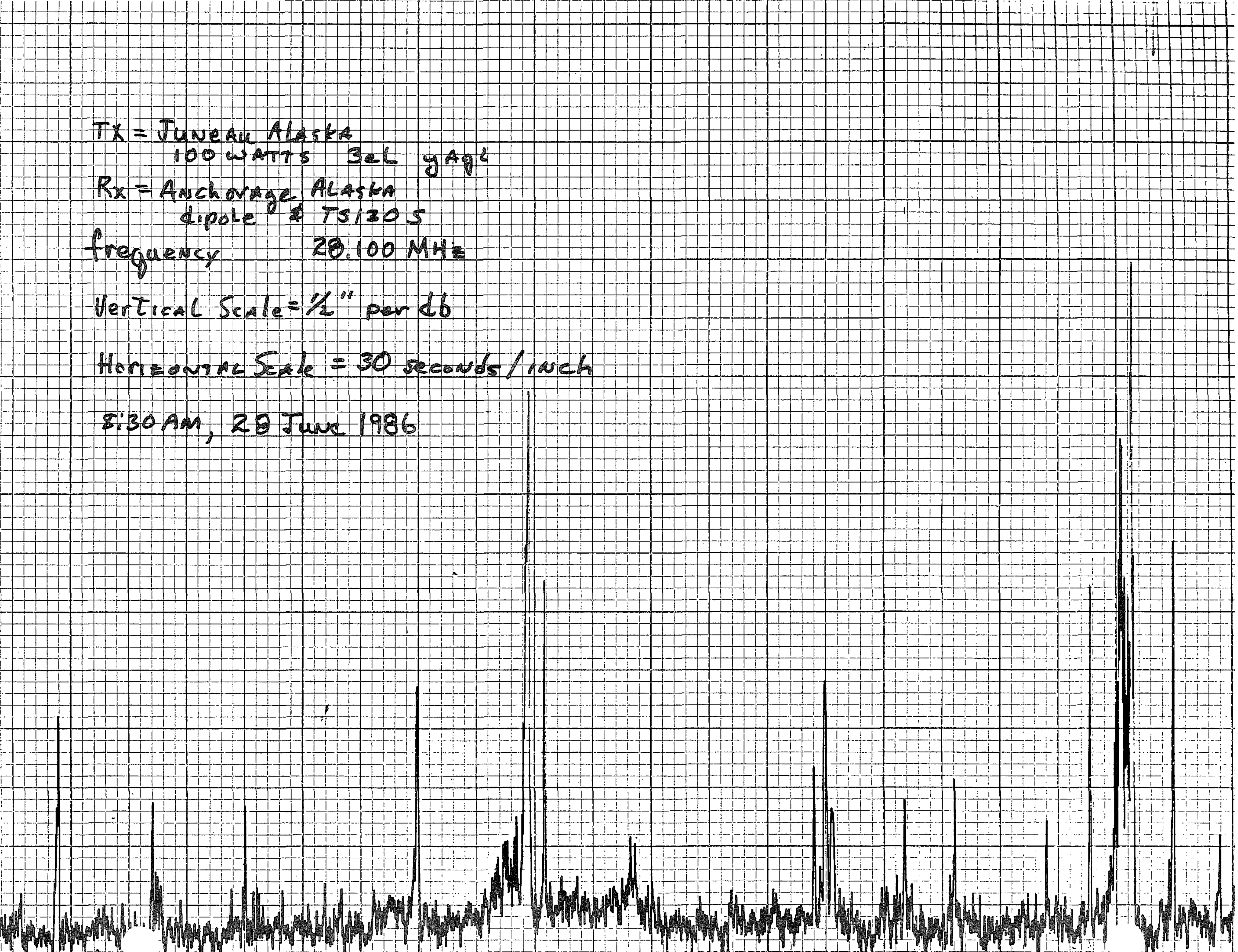

TX = JUNEAU ALASKA
100 WATTS 3eL yAgi
Rx = Anchorage ALASKA
dipole & TS130S
frequency 28.100 MHz
Vertical Scale = ½" per db
Horizontal Scale = 30 seconds/inch
8:30 AM, 28 June 1986
KL7WE

3456 MHz OPERATION

MAY - JUNE 1986

RICK FOGLE WA5TNY

NORTH TEXAS MICROWAVE SOCIETY

In early May of this year during a 432 MHz roundtable, the subject of 3456 MHz operation was brought up. There were already a number of stations in the North Texas area on 1296 and 2304 MHz. Someone mentioned that the 2160 MHz LO from the 2304 converter could be mixed with 1296 to produce a signal at 3456 MHz. Since I already had a 1296 MHz converter and a LO module from SSB Electronics on 2160 MHz, we decided to lash up a prototype transverter and give it a try.

I had a few Vari L double balanced mixers to do the up and down conversion so all that was needed was a low noise front end amplifier and a transmit power amp.

The front end turned out to be very easy to obtain. I had an Avantek 80° LNA from TVRO Setup, so I built an SMA to waveguide transition and bolted it to the LNA. Measured noise figure thru the LNA and DBM was 1.4 dB, which was good enough for the prototype system.

Transmit power was obtained from a surplus Western Electric 660A microwave relay station power amp. It was originally designed for 3.7 - 3.9 GHz operation with 30 dB gain and 2 watts out. I tested it at 3.4 GHz and the gain was rolled off excessively. I removed the covers and by placing small pieces of copper tape on the microstrip while monitoring the power, was able to recover the full 30 dB gain. All that was needed was to amplify the -10 dBm transmit signal from the DBM up to about +3 dBm. This was done with a two stage MMIC amplifier.

The output of the DBM was filtered using a bandpass filter removed from a Collins satellite receiver. The transverter was assembled in the chassis of the scrapped-out Collins receiver.

The system has worked very well, with numerous contacts while operating portable from EM12, 11, 01, 02, 03. KA5JPD, Carl Napper, constructed a telescoping mount on his van for a 6' dish. The dish was fed by a TVRO scaler feed with slightly lengthened probe to improve return loss. On June 15 of this year, while operating portable from these grids, five North Texas Microwave Society 3456 MHz stations qualified for VUCC. Dish alignment was found to be very critical, as the beamwidth was only a few degrees. Manual rotation of the dish was done by Carl and N5MP, Mike Payne. Longest path worked with this set up so far is about 120 miles, but signals were typically 5 x 7 to 5 x 9. All the stations except one were running a watt or less transmit power to dishes that ranged from two feet to seven feet in diameter.

As we have been operating on this band only a few months, it is difficult to say how the propagation compares with the lower frequency microwave bands, but the higher gains available with a fairly small dish and the availability of TVRO components make this an easy band to operate on.

SYSTEM DESCRIPTION

1296 CONVERTER - Based on the SSB Electronics LT23S receive section. Uses MGF1202 RF amp and MGF1202 mixer. NF 1.2 dB, gain 30 dB. Fed with 1152 MHz LO derived from 96 MHz XTAL x3, x2, x2. LO uses a Murata clip on 60°C oven for improved frequency stability.

TX AND RX MIXERS - Vari-L DBM 500 mixers obtained from scrapped-out Collins satellite receiver. Note that on transmit side the IF is fed to the X port and RF taken from the R port. This is due to limited frequency response of the X port (1500 MHz max).

3.4 GHz BPF - Obtained from Collins satellite receiver, but can be built from various interdigital filter construction articles in HAM RADIO magazine. Main use is to remove 2160 MHz LO and other undesired spurs from DBM.

MMIC AMP - Avantek MSA-0385 driving a MSA-0485 two stage MMIC amp. This is a 50 ohm microstrip PC board on FR-4 (G10) material. See Al Ward's info on MMIC's.

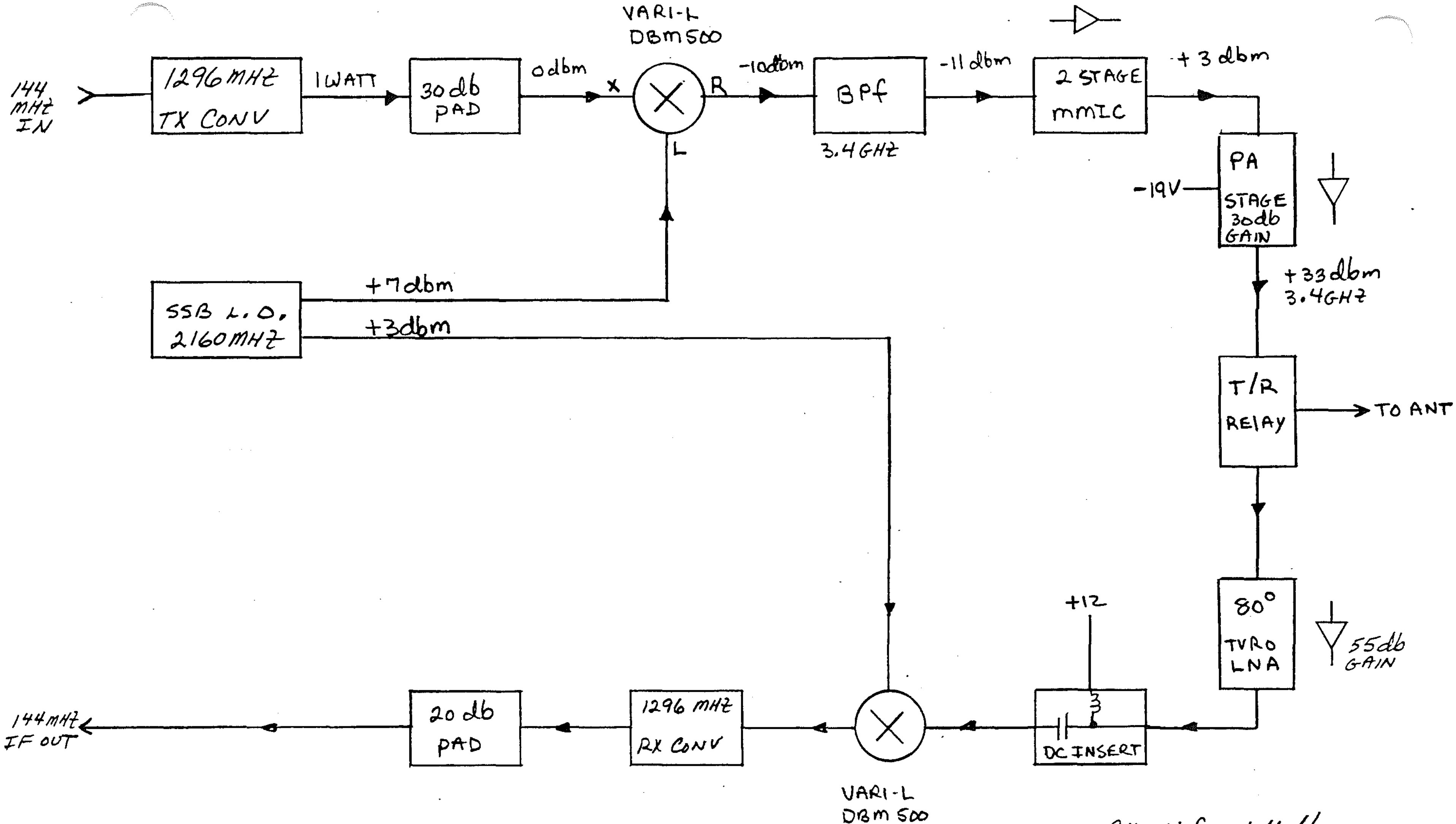
TX PA STAGE - Western Electric model 660A two watt PA stage. This unit is designed for 3.7 to 3.94 GHz and about 30 - 33 dB of linear gain. It has wave-guide flange input and output and runs on -19 volts. Has to be re-tuned by modifying microstrip lines on the alumina substrates. These units are showing up at flea markets.

TVRO FRONT END - Standard TVRO LNA with waveguide to coax adapter. These units run from 40 - 55 dB gain. Usually have to supply +12 to +15 volts on the center conductor of the RF output, so a DC blocking capacitor and RF choke have to be added inside unit or external DC inserter used.

1296 TX CONVERTER - Based on the SSB Electronics LT23S low level TX stages. Uses a pair of MRF 911's as a balanced mixer, pair of MRF 911's as inter-mediate amp and BFQ 34 output transistor. Runs about 1 watt out. Uses common LO with RX converter.

2160 MHz L.O. - LO module from SSB Electronics 2304 MHz transverter. Has two output, one at +7 dBm and the other at about +3 dBm. The +7 dBm side is okay for the TX mixer, but the +3dBm side is slightly low on drive for the RX mixer. A better solution would be to amplify the +3 side with a MMIC amp and use a power divider to drive both mixers. Conversion loss of the DBM 500 mixer goes up rapidly as LO drive falls below +7 dBm.

This by no means is the ultimate 3.4 GHz transverter, but represents a quick method of obtaining a fairly good transceive capability. Future improvements scheduled for this transverter are to improve power output by replacing the Western Electric 660A amplifier with a pair of Avantek IMFET amplifiers. These are internally matched gasfet power amplifier modules which have about 11 dB gain. This should provide about 6 - 8 watts of solid state RF power that can run directly off a +12 v supply. The Western Electric amp now used requires -19 volts supplied by a switching power supply. Al Ward and I are designing the IMFET amplifier now, and should have more info soon. I have included some very preliminary info on the device. As you can see, this is the only good way to develop high power at microwave frequencies without using a TWT.



RX N.F. 1.4 db
TX PWR 2 WATTS

Simple 3.4 GHz TRANSVERTOR
R. Fogle 7/86

IM-2935-3
3 Watt, 2.9-3.5 GHz Internally Matched Power GaAs FET

INTERNALLY MATCHED FETs

FEATURES

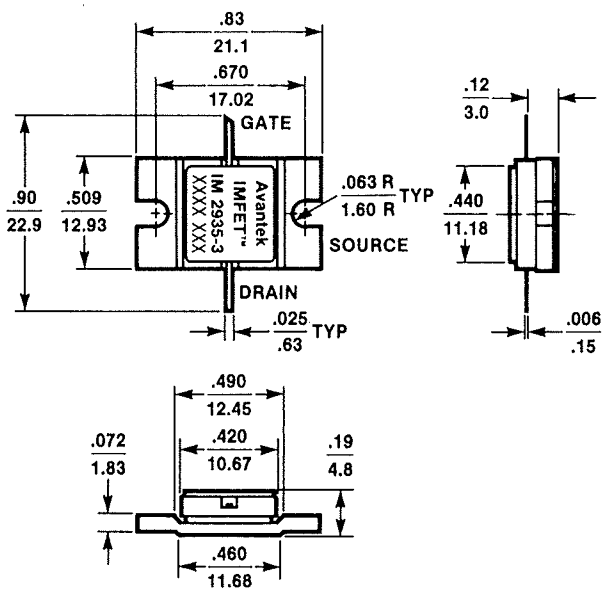
- 2.9-3.5 GHz Bandwidth
- Class A Operation
- Input and Output Internally Matched
- High Gain
- 3 Watt Output Power
- High Power Added Efficiency
- Hermetically Sealed Metal Ceramic Package

DESCRIPTION

Each Avantek IMFET™ internally matched GaAs FET delivers high power output and power added efficiency plus high gain. When used in a 50 ohm system, no external tuning is required to achieve all guaranteed specifications. All matching circuits are fabricated on thin-film substrates and use no lumped devices.

The IM-2935-3 uses Avantek 0.5 μm GaAs FET chips with a gate periphery of 10 mm for the 3 watt device (-3). The internal input and output matching circuits have been designed to optimize performance in the 2.9-3.5 GHz frequency band. High reliability is assured by the use of a gold-based refractory metal system, silicon nitride passivation, and hermetic packaging combined with Avantek's stringent quality assurance and testing program.

Avantek IMFET™ Package



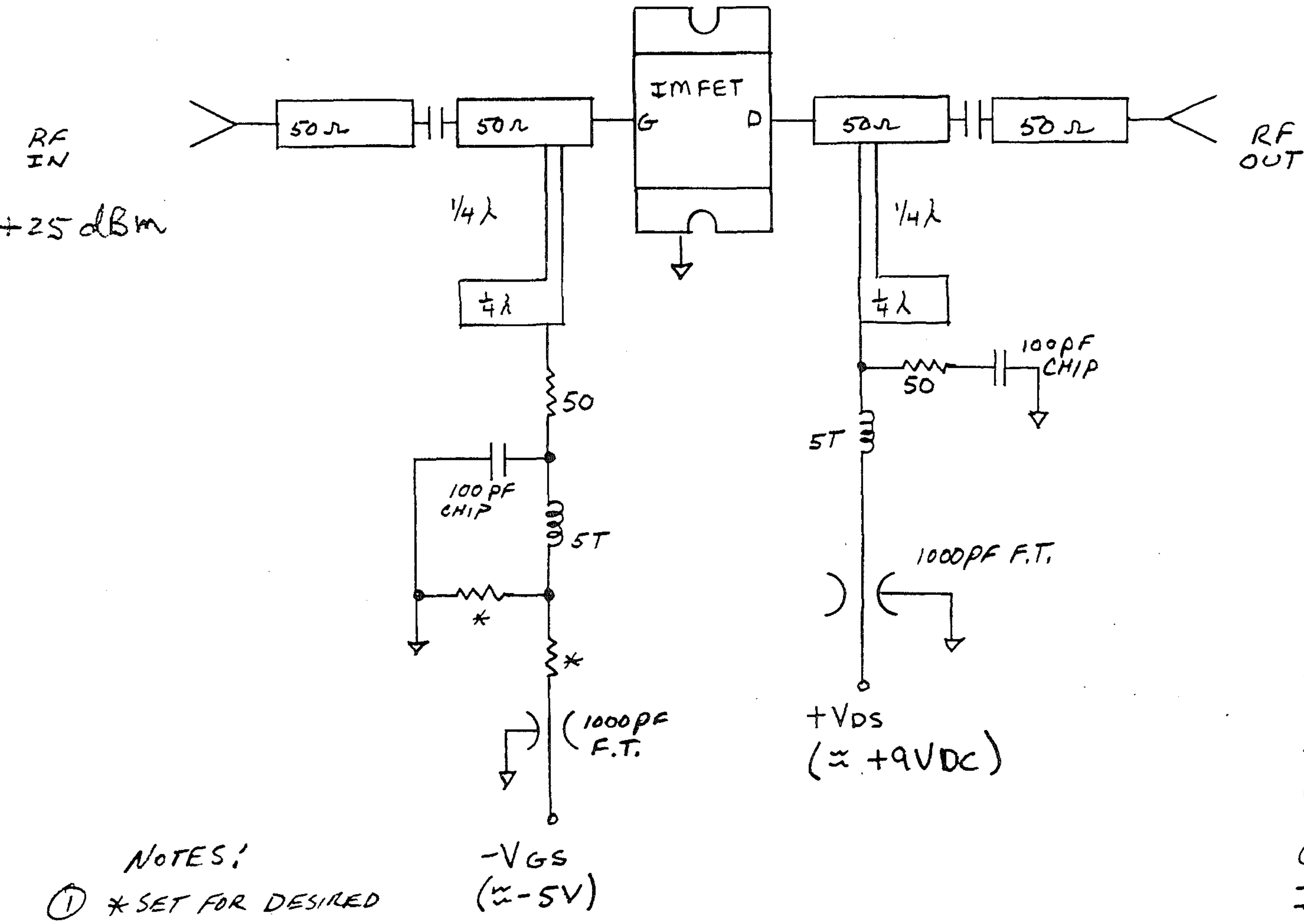
NOTES. (UNLESS OTHERWISE SPECIFIED)

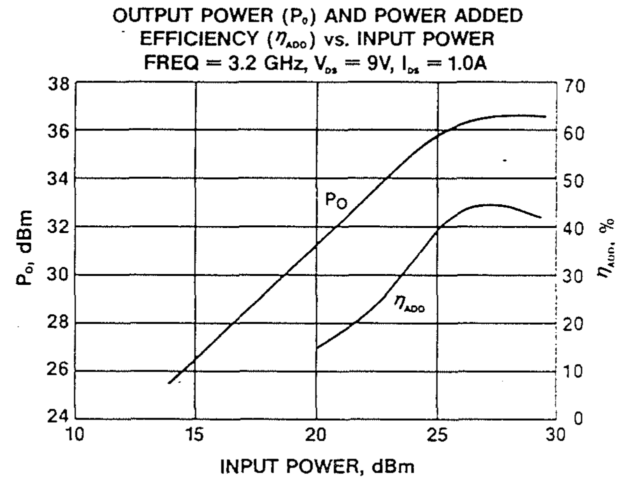
1. DIMENSIONS ARE IN $\frac{\text{IN}}{\text{MM}}$

2. TOLERANCES $\frac{.XX \pm .02 \quad .XXX \pm .010}{.X \pm .05 \quad .XX \pm .25}$

RF PERFORMANCE SPECIFICATIONS, T_A = 25°C

Symbol	Parameters: Test Conditions V_{DS} = 9V, f = 2.9-3.5 GHz (unless otherwise specified)	Units	Min.	Typ.	Max.
P_{1dB}	Output Power at 1 dB $I_D \leq 1.2$ A	dBm	34.8	36.0	
G_{1dB}	Gain at 1dB Compression Point $I_D \leq 1.2$ A	dB	10	11.5	
η_{add}	Power Added Efficiency[1] $I_D \leq 1.2$ A	%	30	35	
VSWR	Small Signal Input VSWR[2]			2.0	





IMFET = AVANTEK
IM-2935-3
2.9-3.5 GHZ

P1dB = +36 dBm
VDS = +9V
IDS = ≤ 1.2A
VGS = -5V
GATE CURRENT 10 mA
INPUT level +25 dBm
GAIN ≈ 11 dB

NOTES:

1. * SET FOR DESIRED VGS AND IDS
2. SEQUENCE PWR SUPPLY TO APPLY BIAS BEFORE DRAIN VOLTAGE
3. DO NOT APPLY RF UNTIL FET IS BIASED ON.
4. USE GOOD L.F AND H.F DECOUPLING TO PREVENT BIAS CKT OSC.

INFORMATION FROM FUJITSU AP NOTE.

TYPICAL IMFET Amplifier
3.4 GHZ 4 WATTS OUT
R Fogle WASTNY 6/1/86

Noise from the Stars

by Gerd Schrick, WB8IFM 4741 HARLOU DRIVE
DAYTON OH 45432

- In the early 30s Karl Jansky was tasked by Bell Telephon to investigate atmospheric noise, which at that time with the growing HF overseas traffic played a big role in system performance.
- He found three types of noises: 1) set noise generated within the receiver, 2) atmospheric noise or static, and 3) a peculiar noise. First, this was believed to be interference, then as coming from the sun. But eventually it became clear by comparing measurements over a period of time that the noise was synchronized with star time, and thus for the first time noise from the stars was identified.
- Jansky performed his experiments at 20 MHz, at which frequency we know now the atmospheric noise subsides and star noise appears. Not much attention was paid to Jansky's findings. However, in 1937 Grote Reber, W9GFZ, built a 30' dish and surveyed the sky at VHF frequencies and published the first " skynoise" maps.
- In WW II the field of electronics developed by leaps and bounds, and after the war the time was ripe for the new field of "Radio Astronomy". No other than our John Kraus, W8JK, played a major role in the ensuing exploration of " radio space". and this radio branch is now considered " Queen of Astronomy".

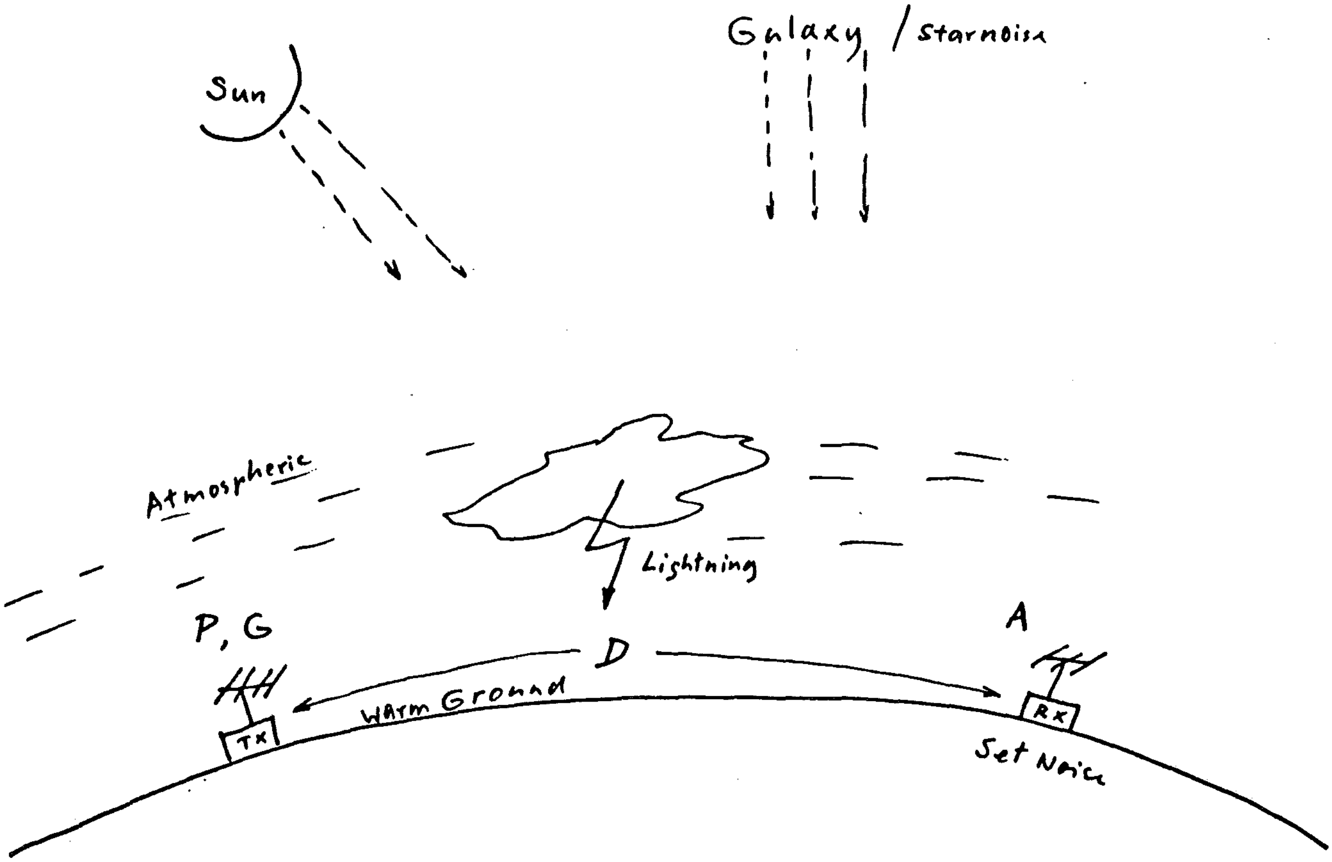
The ideal antenna, switch and preamplifier generates no noise of its own. If it was not for external noise pickup, very little signal strength would be needed for communicating.

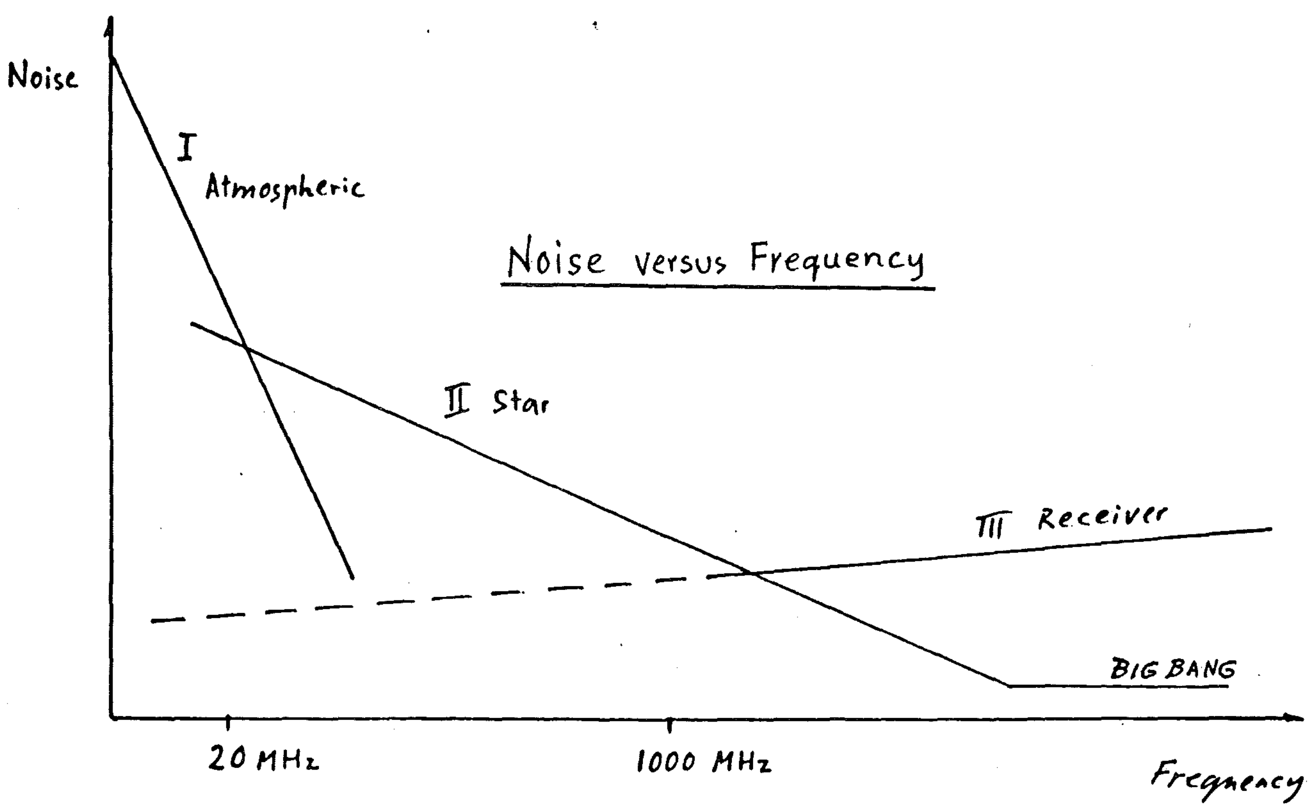
Presently,at VHF,receiver systems are near ideal and sensitive enough to pick up limiting noise from the outside, either from the ground or atmosphere or from the stars. Rotating the beam through 360° will vary this noise usually by 10 dB.
At UHF and microwaves, however, the battle continues as the external noise drops dramatically and is not matched by a drop in the receiver system noise. Additionally the noise generated from the losses in the antenna, cable and relay contact , although low, becomes as important as receiver or LNA noise.

As to the noise from the stars: NASA has compiled "Sky Noise Maps" at two most interesting communication frequencies: 136 and 400 MHz. These maps show the entire sky as seen from the earth with contour lines in °Kelvin, which is the preferred measure for noise at microwave frequencies.
In order to calculate the noise pickup from the sky, you have to integrate the temperatures over the coverage area of your antenna. The resultant temperature in °Kelvin is referred to as antenna temperature (TA). This represents the external noise that the signal, picked up by the same antenna position, has to overcome. However, as mentioned, additional noise is added by antenna losses, cable losses, switch losses, as well as internally generated receiver noise. Compared to the receiver noise (LNA),it becomes exctremely important to minimize these losses. This requires a large low loss cable (hardline), but better yet, the LNA should be mounted directly at the antenna. An antenna relay , if needed, should be of extremely high quality (low loss,low SWR).

A typical calculation assuming an antenna temperature of TA = 35°K, a combined cable and relay loss of 1 dB = 75°K and a LNA of .5 dB = 35°K adds up to a total noise of 145°K. By moving the LNA directly to the antenna 75°K can be subtracted, which improves the signal to noise ratio 2:1 (3 dB).

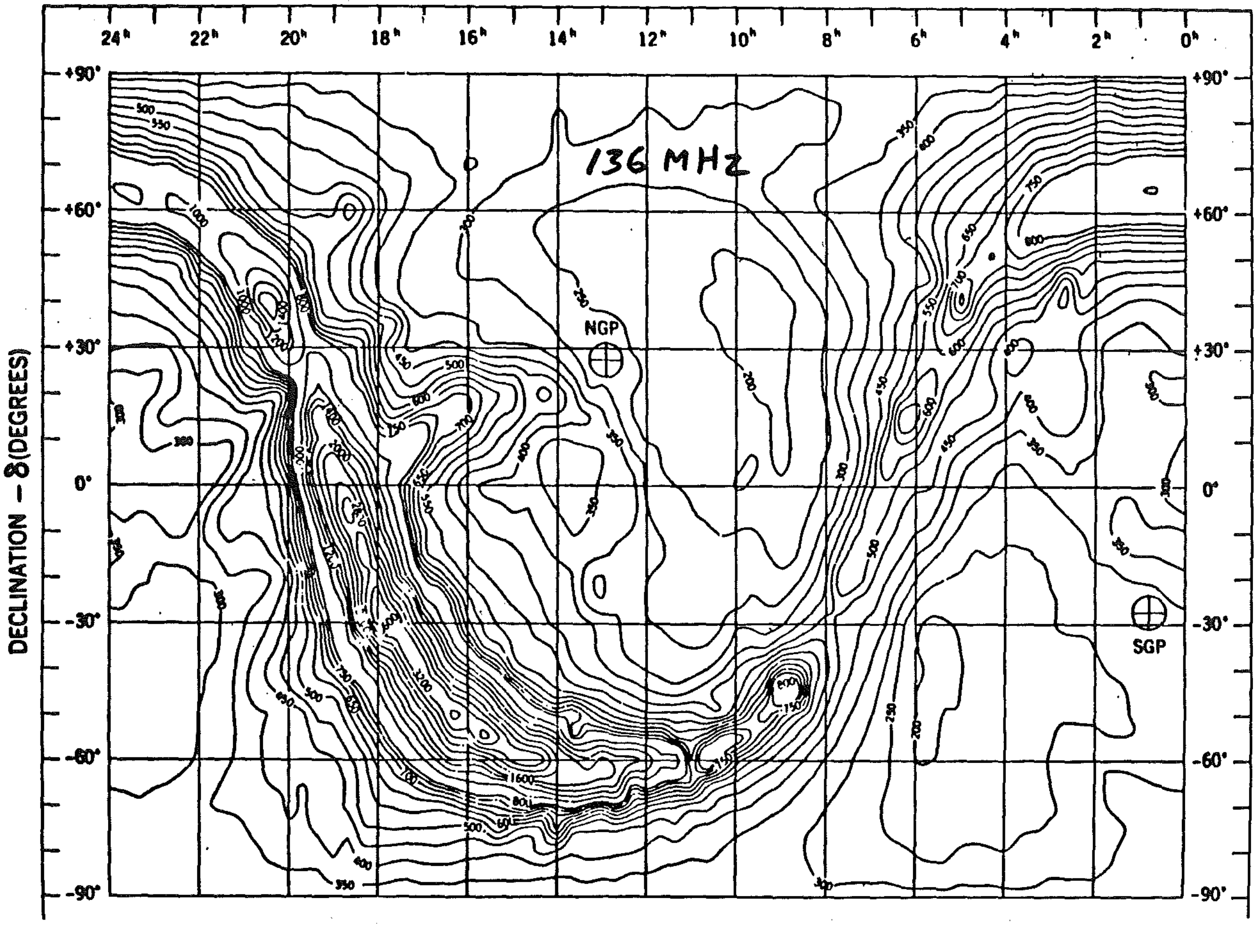
Natural Noises

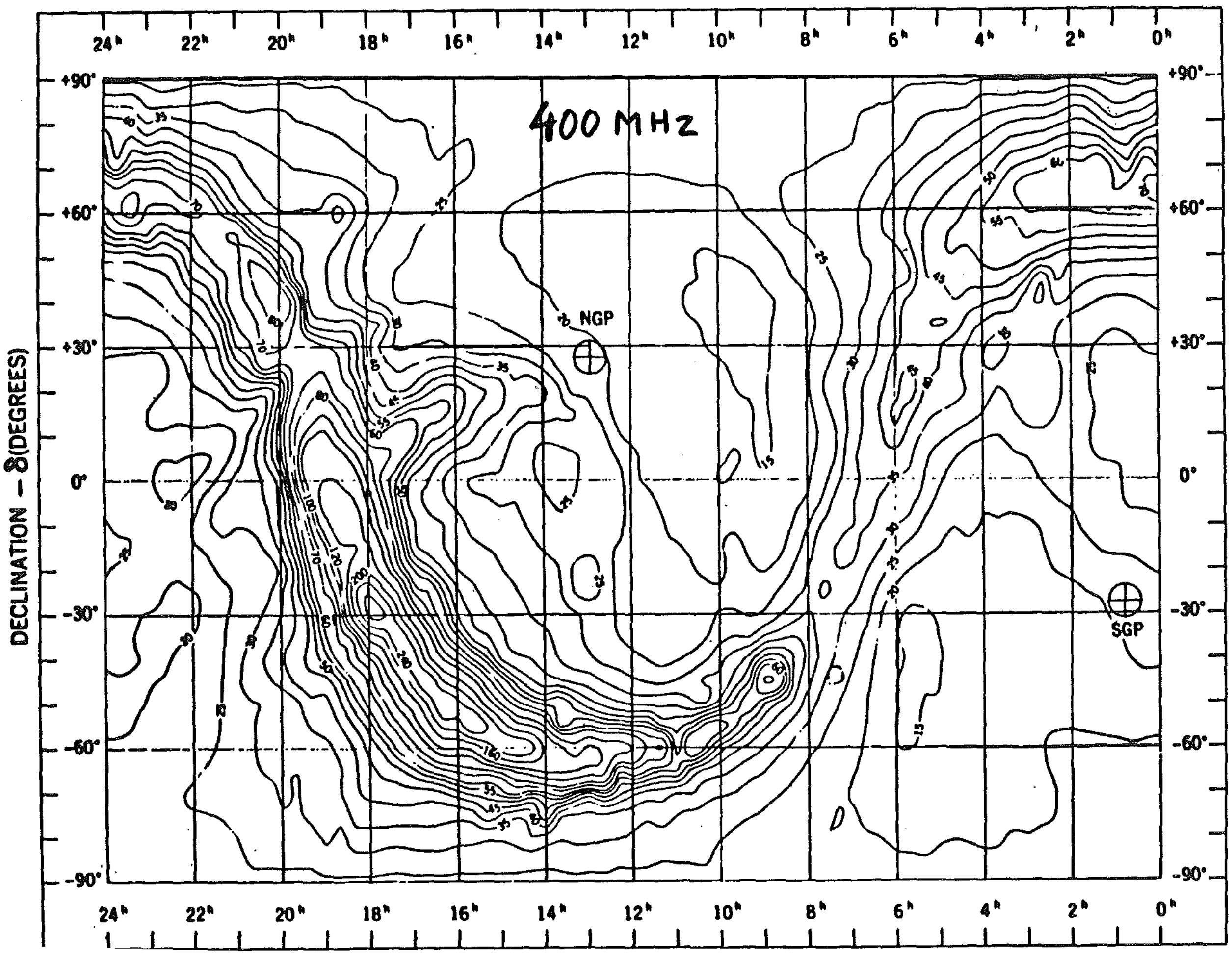


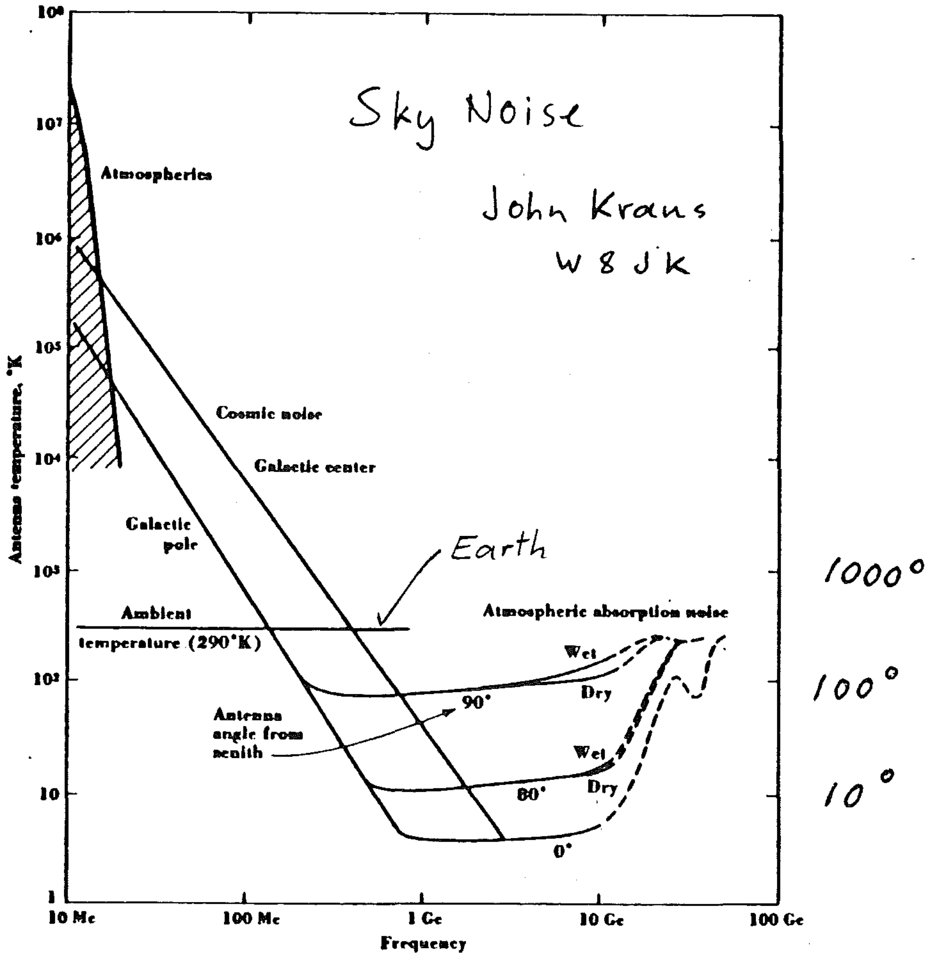


Courtesy NASA

BRIGHTNESS TEMPERATURE (KELVIN)





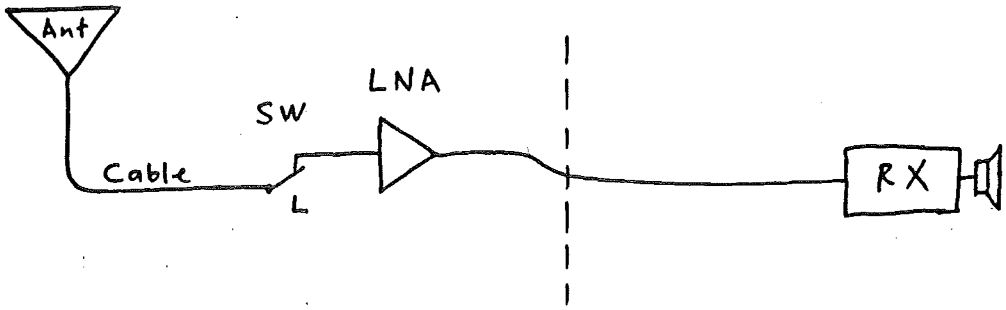


Antenna sky noise temperature as a function of frequency and antenna angle. A beam angle (HPBW) of less than a few degrees and 100 percent beam efficiency are assumed. (After Kraus and Ko, 1957, cosmic noise below 1 Gc; Penzias and Wilson, 1965, and Dicke et al., 1965, cosmic noise above 1 Gc; Croom, 1964, atmospheric noise; and CCIR, 1964, atmospherics).

Conversion Factors

To obtain → / multiply by ↓	Sensitivity µV f. 10dB S/N a. 2.5 kHz BW	Noisefigure NF dB	Noisetemperature T °K
µV	1	$10\lg(166.5\,\mu V^2+1)$	$48310\,\mu V^2$
NF	$.078\sqrt{10^{\frac{NF}{10}}-1}$	1	$290(10^{\frac{NF}{10}}-1)$
T	$.00455\sqrt{T}$	$10\lg(1+\frac{T}{290})$	1

VHF/UHF - System Noise

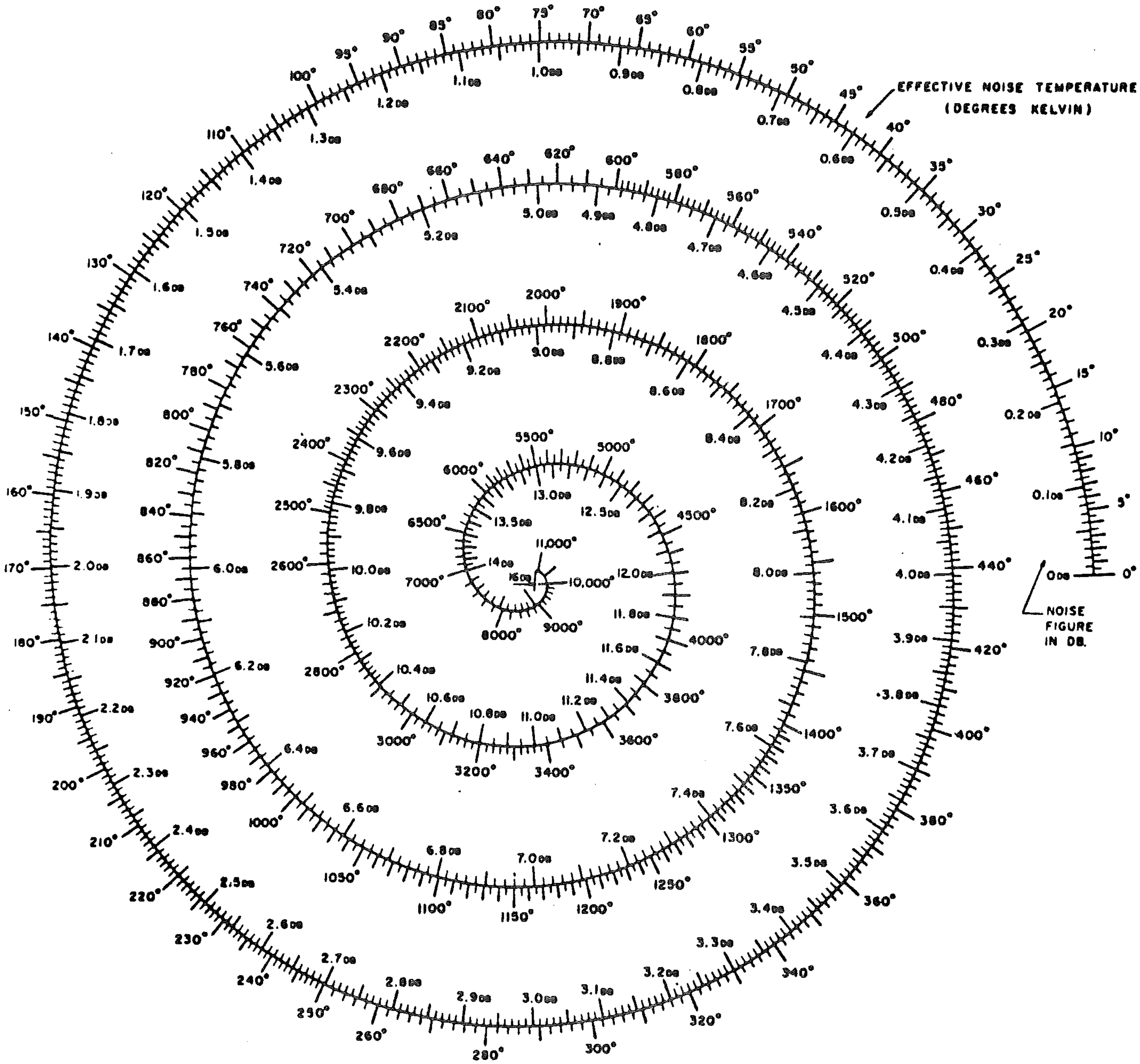


System Noise = Antenna Noise* + Antenna Loss + Cable Loss + Switch Loss + LNA

* unavoidable

NF dB	T °K
3 dB	290°
2 dB	170°
1 dB	75°
.8 dB	59°
.6 dB	43°
.5 dB	35.4°
.4 dB	28°
.3 dB	21°
.2 dB	13.7°
.1 dB	6.8°
.05 dB	3.4°

NOISE FIGURE AND NOISE TEMPERATURE



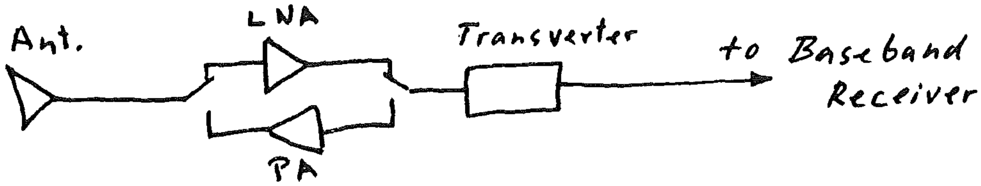
$$NF(dB) = 10 \lg \left(\frac{T}{290} + 1\right)$$

$$T\,(°K) = 290 \left(10^{\frac{NF}{10}} - 1\right)$$

A. C. Hudson, Radio and Electrical Engineering Division, National Research Council, Ottawa, Canada 1965

WB8... 4-86

Microwave Installation



AS YOU GO HIGH UP IN FREQUENCY (435 AND BEYOND) IT BECOMES MORE IMPORTANT TO USE THE BEST LOW LOSS CABLE BETWEEN ANTENNA AND EQUIPMENT, BETTER YET MOVE THE IMPORTANT PARTS OF THE EQUIPMENT: THE LOW NOISE PREAMPLIFIER (LNA) AND THE HIGH POWER TRANSMIT AMPLIFIER (PA) RIGHT NEXT TO THE ANTENNA. ON THE MICROWAVE FREQUENCIES IT PAYS TO MOVE MIXER AND LOCAL OSCILLATOR ALSO CLOSE TO THE ANTENNA (TRANSVERTER). ANY RELAY BETWEEN ANTENNA AND LNA SHOULD HAVE THE LOWEST POSSIBLE LOSS, AS IT DIRECTLY ADDS TO THE NOISE FIGURE AND MIGHT NEGATE THE EFFECTIVENESS OF THE HIGH PRICED LNA.

Transverters available from Microwave Modules (England)
23 and 13 cm and SSB Electronics (Germany)

Baseband Equipment

435 Mc Equipment	Freqn. Mc	PWR W	NF dB	PWR Supply	CW Filter	Price List	Price Disc.	Rem.
IC 471 A	430/50	25	<17	opt.	no	800	720	Base
IC 490 A	430/40	10	<17	ext.	no	650	585	Mobile
IC 1271 A	1240/1300	10	<8	ext.	no	1000	930	Base
TS 811 A	430/50	25	7	incl.	no	900	800	Base
TR 9500	430/40	10	11	ext.	no	650	570	Mobile
FT 226 R	144/48 430/40	10	6	incl.	opt.	1225	1030	Base
FT 790 R	430/40	1		ext.	no	400	360	Portable

LNAs are available from a number of sources, shop for lowest Noise Temperatur (Noise Figure) agreeable with your budget (or home brew)

Microwaves and Satellites.

This year we are experiencing the bottom of the present sunspot cycle with poor dx conditions on the favorite higher HF-bands (10 + 15). What better time then to turn to the LOS (line of sight) waves. Although earthbound connections from hundreds to about a thousand miles are possible under proper conditions, these frequencies (435 and up) are the up and coming domain of the satellites. In a few months the shining star of the Ham satellites, also known as OSCAR 10, is 3 years old and still going strong. As most satellites it operates full duplex using 2 separate bands. OSCAR 10 operates modes B and L (see tbl). As can be seen from this table, the 435 MHz band is heavily used, and it would be a good first step or investment to obtain a 435 MHz all-mode transceiver. *"Baseband"*

OSCAR 10 is in semistationary orbit and has a period of close to 12 hours, thus orbiting the earth twice a day. It progresses about 10° in latitude per day resulting in a 19 day cycle. About half of this cycle is presently available for us. Connections can be made spanning almost half the globe,and over 100 DXCC countries are active. For mode B, in addition to the 435 MHz transceiver recommended above, a 100 W power amplifier is needed to boost the power, a low-noise antenna mounted preamplifier for 145 MHz and a converter to feed into the HF-station receiver. Crossyagi antennas are recommended for 145 and 435 MHz with gains between 10 and 13 dBd. Combinations are offered by Cushcraft, KLM and as of late Hygain.

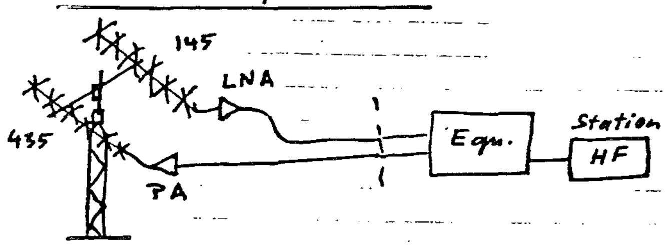
The polarisation switch offered by KLM and Hygain is a feature that is not really required and akin to using LSB on 28 MHz, when everybody is using USB. (The satellite is only using right hand circular polarisation). Lastly, provided a clear shot to the West over South to the East is available, the antennas can be mounted close to the ground (10 to 20'). Two rotators, for azimuth (regular TV-rotator) and elevation (U 100 Alliance TV-rotator) are needed.

The U 100 permits a mast to protrude left and right.

Satellite Operating Modes.

Mode	Frequencies in MHz Uplink	Down Link
A	146	29
B	435	146
J	146	435
L	1269	435
S	2300	435

OSCAR 10 / MODE B



Antennas

Cushcraft A 144-20T $75
416TB $60
Boom + Bracket $30

LNA

Hamtronics LNG $50

PA

Mirage 1010 $290
PWR (20A) $100

Rotators any TV $50
Alliance U 100 $50

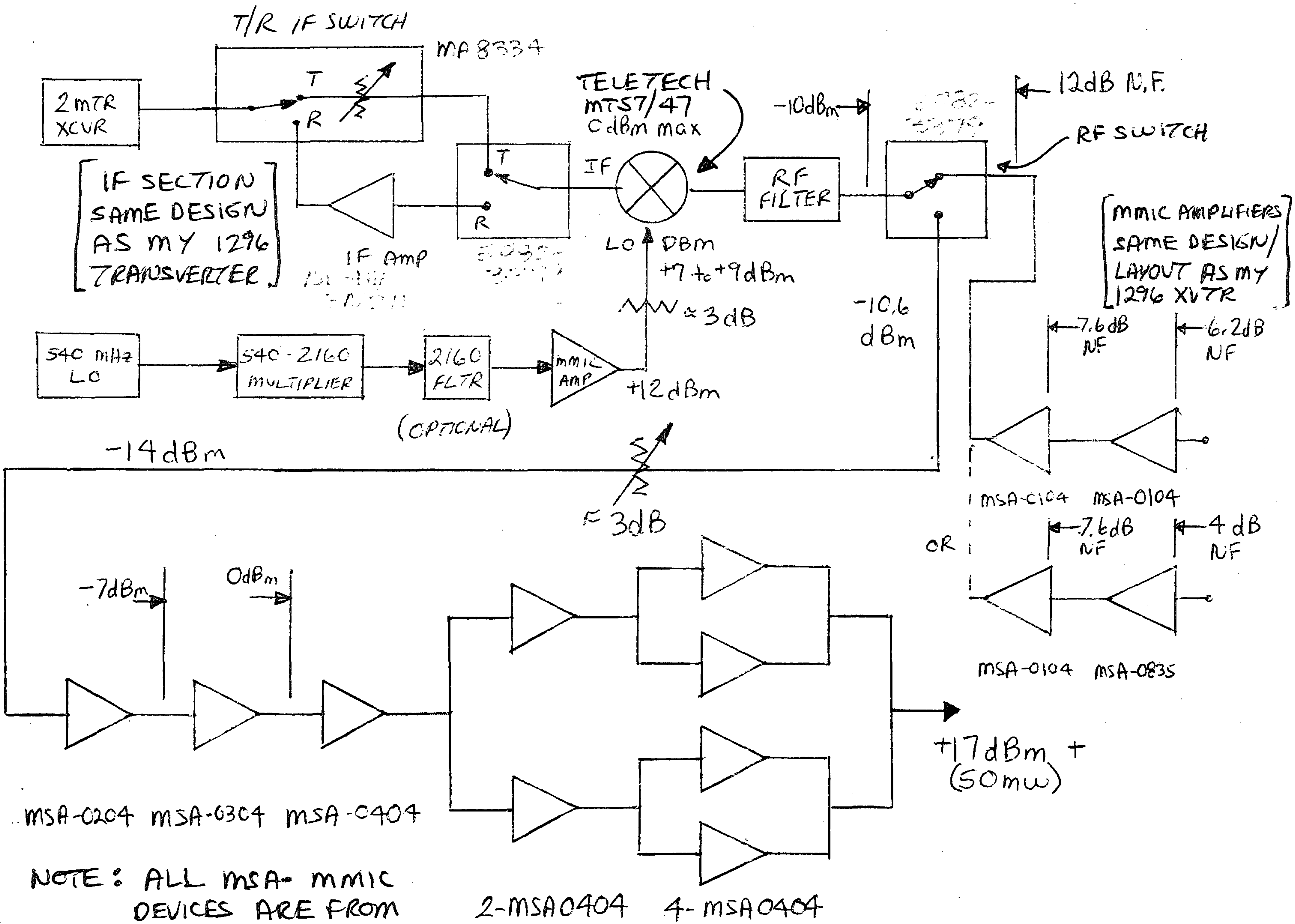
Equipment Choices

A: TENTEC 2510 $490 (350)
PWR (5A) $50

or B: YAESU FT 790R $360
10W PA $120
PWR (5A) $50
Hamtronics 2m Conv $50

or C: ICOM 471 A $720
Hamtronics 2m Conv $50

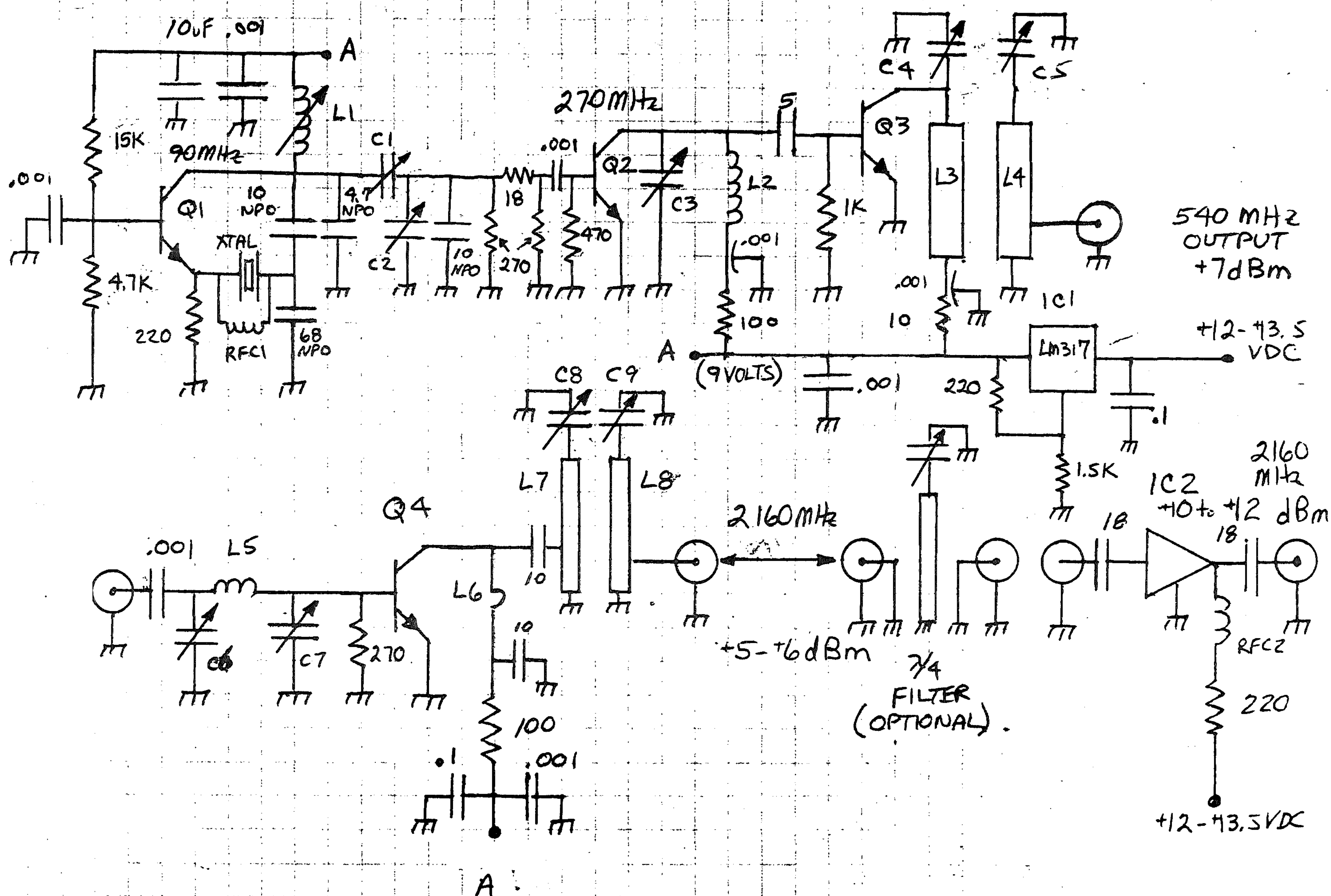
WB8IFM



NOTE: ALL MSA- MMIC DEVICES ARE FROM AVANTEK

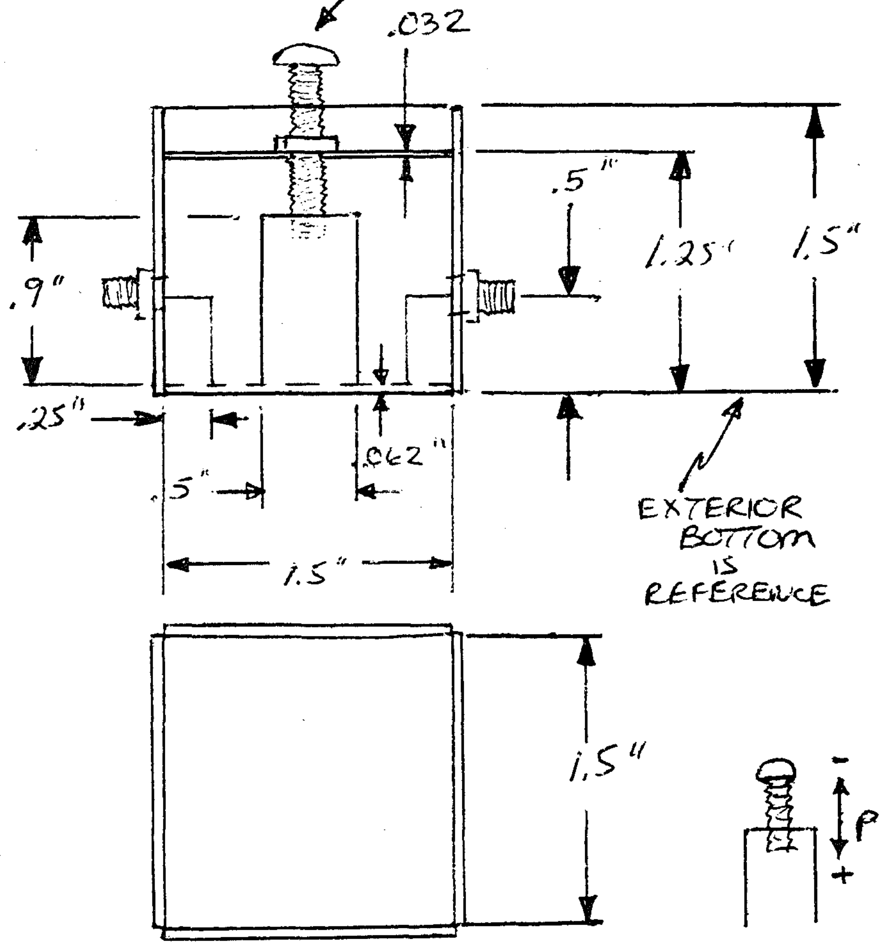
2304 MHz TRANSVERTER

FIGURE 1
WB5LUA

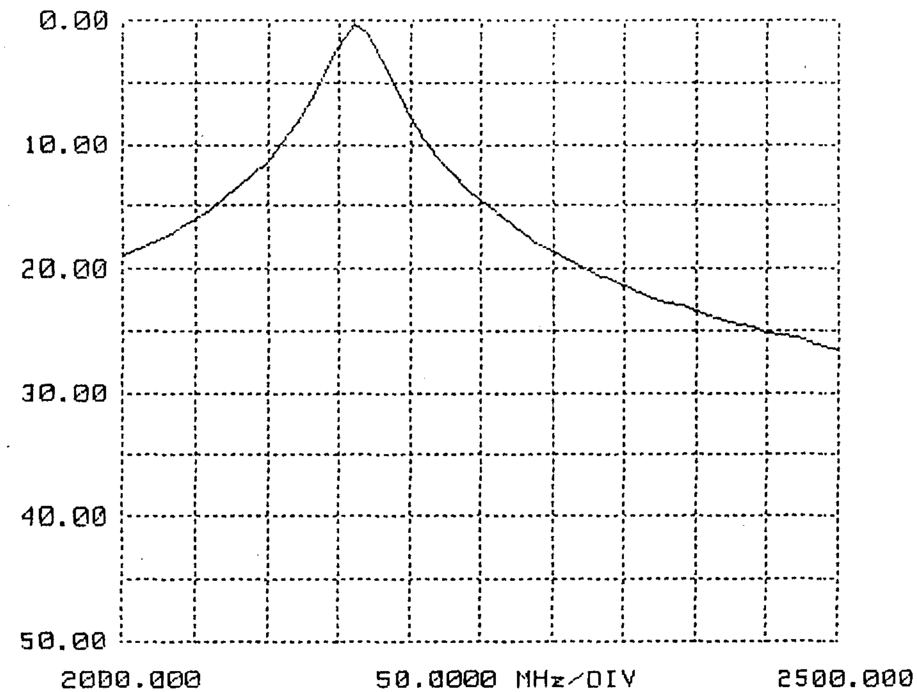


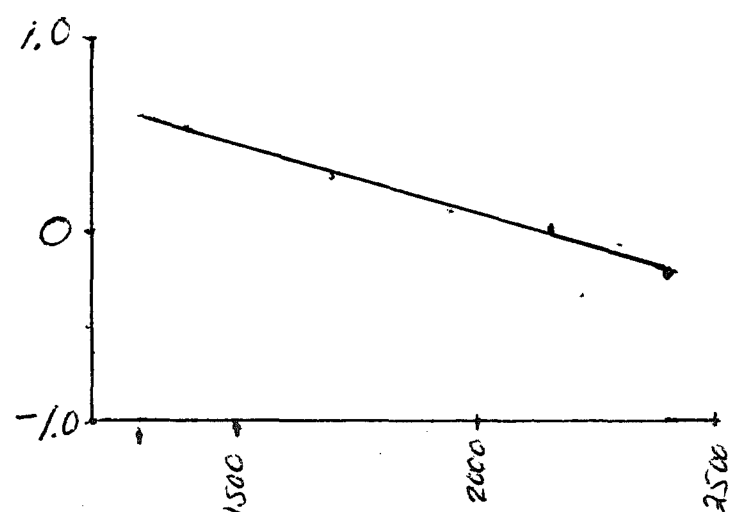
2160 MHz LOCAL OSCILLATOR
FIGURE 2

REVISION B
WB5LUA



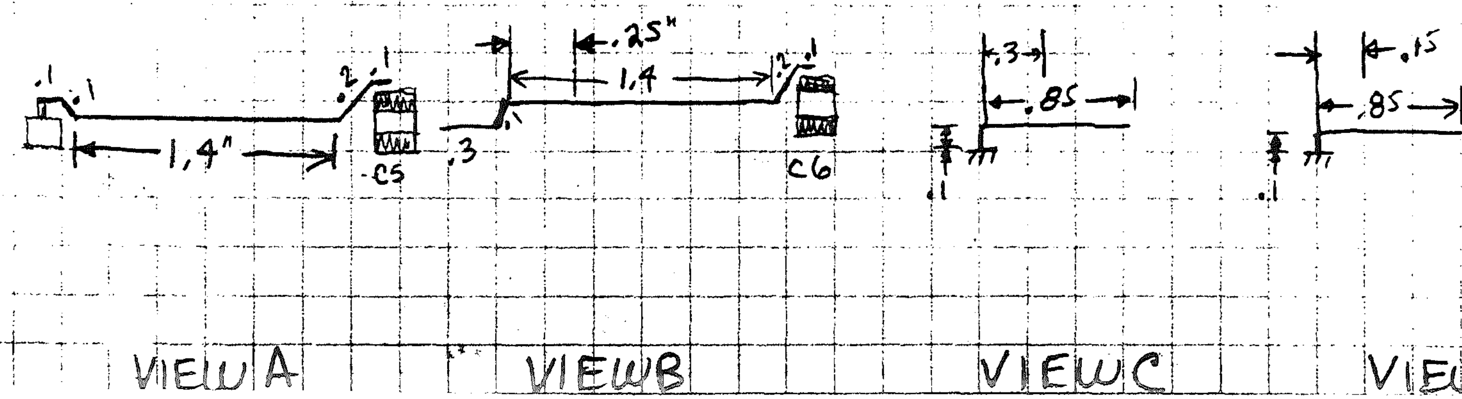
2160 MHz CAVITY FILTER
FIGURE 3





PENETRATION VS FREQ. WB5LUA

L1	4T #24GA .25" ID COILFORM (WH.SLUG)
L2	3T #24GA .125" I.D. S.W.D.
L3	.5 INCH WIDE MICROSTRIPLINE .125 INCH ABOVE GROUNDPLANE - SEE VIEW A
L4	.5 INCH WIDE MICROSTRIPLINE .125 INCH ABOVE GROUND PLANE - SEE VIEW B (SPACE .1" edge to edge; Tap .25" From Ground)
L5	2 TURNS #24GA .125" I.D. SWD
L6	1 TURN .125" I.D. MADE FROM LEAD OF 1/4 WATT 100 OHM RESISTOR
L7	.25 INCH WIDE MICROSTRIPLINE .85 INCH LONG AND .1 INCH ABOVE GROUNDPLANE. TAP CAPACITOR .3 INCH UP FROM GROUND - SEE VIEW C
L8	SAME AS L7, TAP OUTPUT .15 INCH UP FROM GROUND - SEE VIEW D. SPACE L7 AND L8 .1 INCH APART EDGE TO EDGE
IC1	LM317 VOLTAGE REGULATOR
IC2	MSA 0404 AVANTEK MMIC
C1-C5	.8-16pf PISTON TRIMMER
XTAL	90 MHz OVERTONE CRYSTAL
RFC1	.38 uH MINIATURE RF CHOKE
Q1, Q2	2N3563, 2N918
Q3	2N3866
Q4	HXTR 3101 (Hewlett Packard)
C6, C7	1.8-6.0 pf MINIATURE CERAMIC VARIABLE CAPACITOR (MOUSER ELECT. P/N 24AA070
C8, C9	.3-3.0 pf MINIATURE PISTON TRIMMER
RFC2	6 TURNS #28 GA .125 INCH ID SWD



2160 LO
PARTS LIST
REVISION B
WB5LUA

2304 MHz. DOUBLE BALANCE MIXER

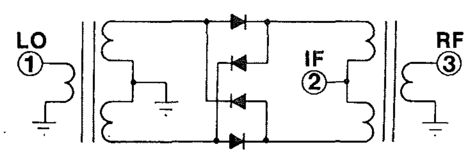
- TELETECH MT-57 $26.00 SINGLE QTY'S (HP QUAD DIODE)

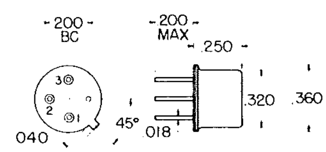
  MT-47 $8.00 SINGLE QTYS (NEC QUAD DIODE)
- SPECIFIED AS A BLOCK DOWNCONVERTER DBM

  RF 900-1400 MHz

  LO HIGH SIDE INJECTION (UP TO 2GHz.)

  +7 dBm
- TO-5 PACKAGE





- MEASURED PERFORMANCE

  RF 2304 MHz

  LO 2160 MHz @ +6 dBm

  IF 144 MHz

  CONVERSION LOSS (SSB) ⇒ 9.5 dB

  LO-IF ISOLATION ⇒ 25 dB

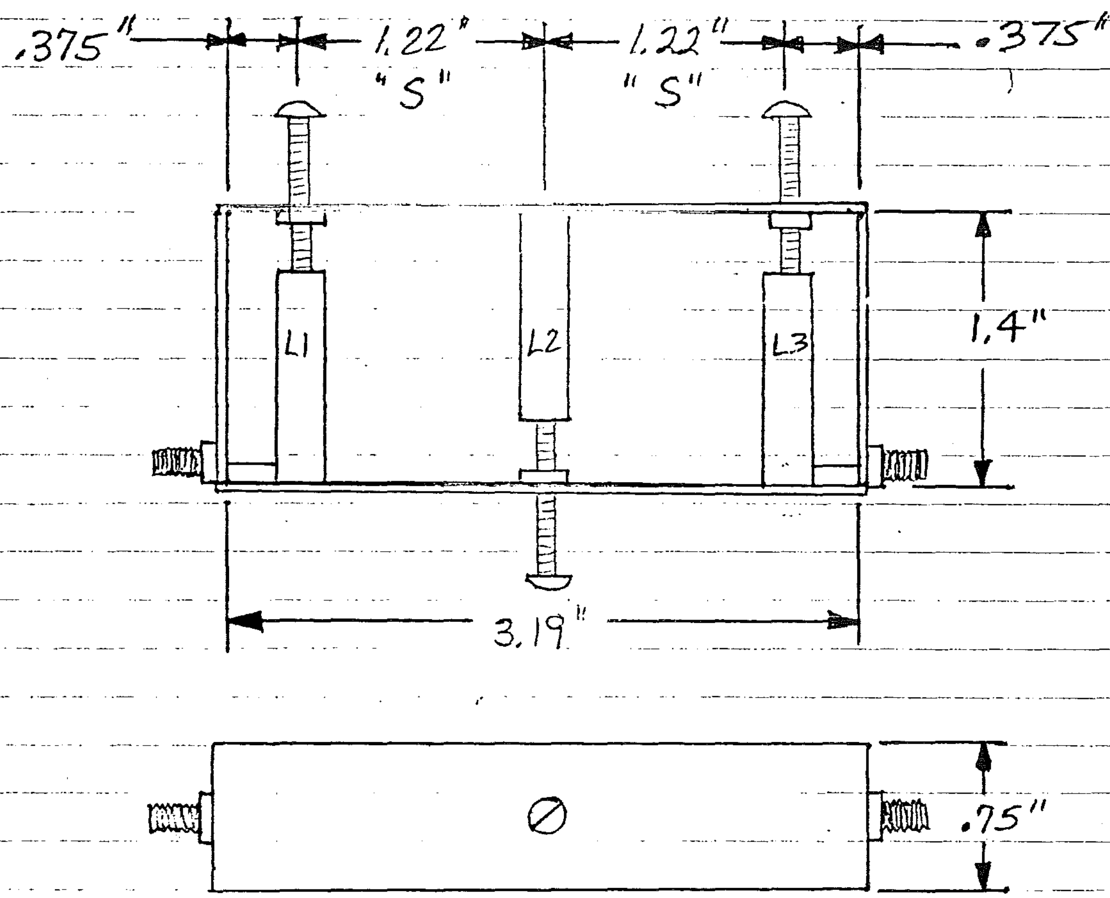
  LO-RF ISOLATION ⇒ 22 dB

- MANUFACTURE

  TELETECH
  2050 FAIRWAY DRIVE
  BOX 1827
  BOZEMAN, MT 59715
  (406) 586-0291

AJ WARD
WB5LUA
9-14-85

2304 MHz. INTERDIGITAL FILTER

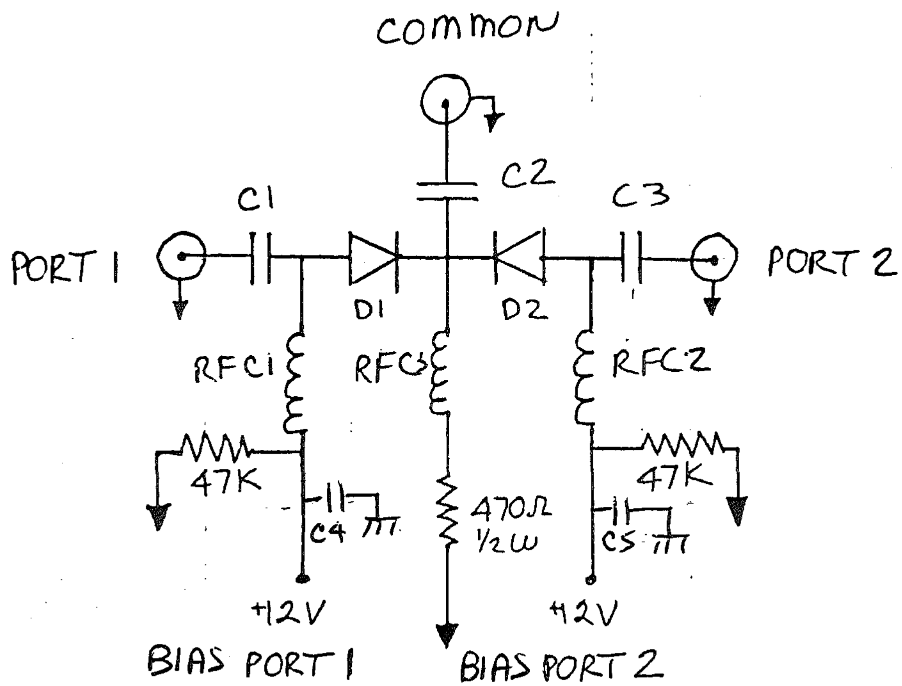


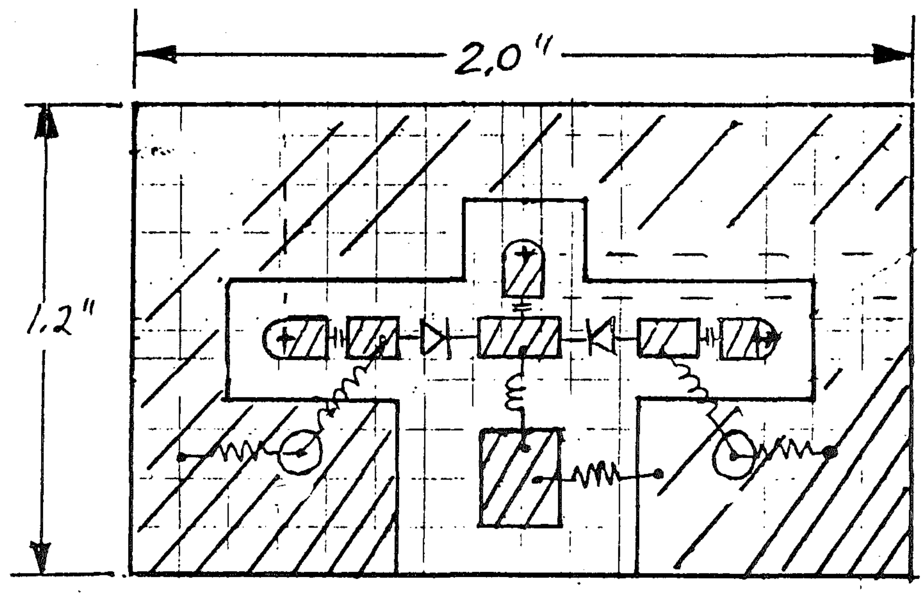
L1, L3 .25" DIA BY 1.1" LONG, TAPPED AT .070" FROM SHORTED END.

L2 .25" DIA BY 1.08" LONG.

- TUNING SCREWS ARE 4-40 BRASS WITH NUTS SOLDERED TO INSIDE WALL.
- BOX MADE FROM .062" G-10 - ALL DIMENSIONS ARE INSIDE BOX MEASUREMENTS.
- DESIGN PARAMETERS OBTAINED FROM COMPUTER PROGRAM WRITTEN BY JERRY HINSHAW, N6JH AND FEATURED IN "HAM RADIO MAGAZINE" JANUARY 1985

A.J. WARD
WB5LUA
9-15-85





COMPONENT LAYOUT

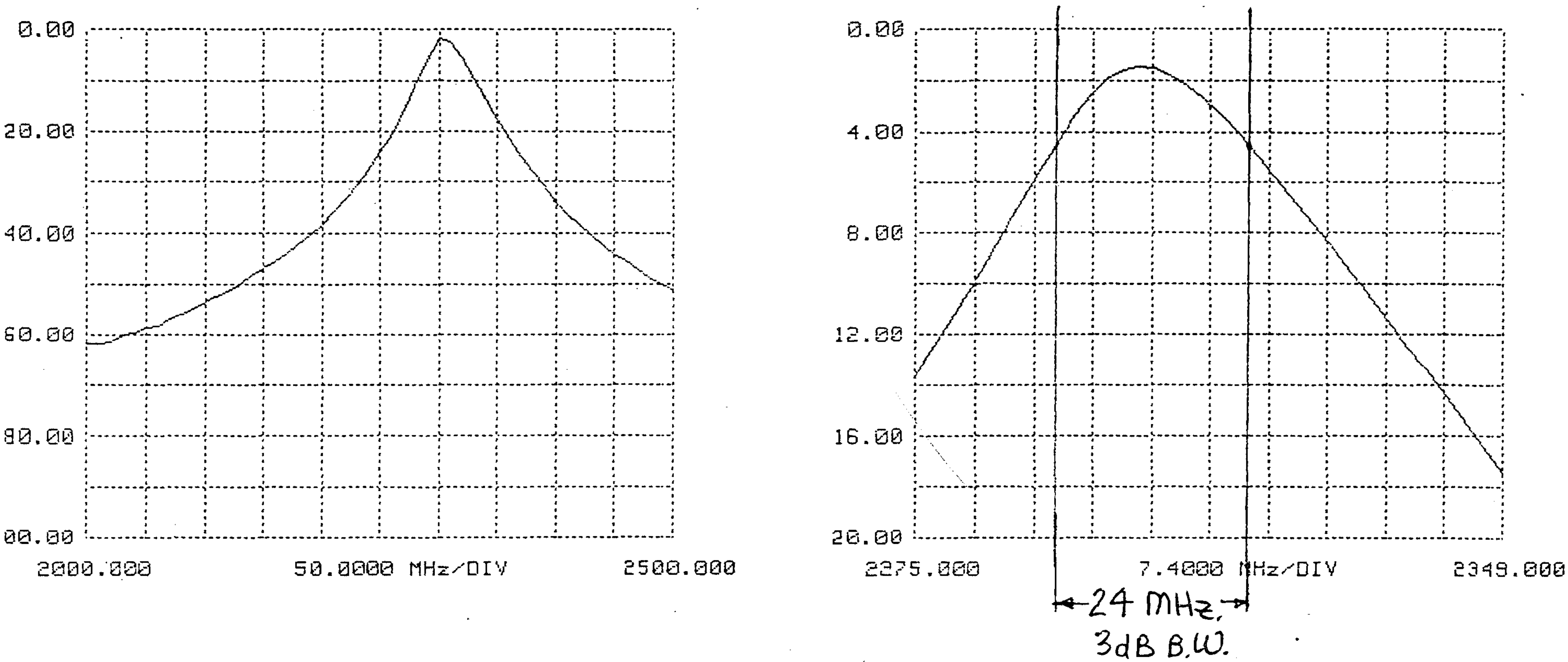
C1, C2, C3	22 pf CHIP CAP.
C4, C5	22-100 pf CHIP CAP. OR F.T.
RFC1, RFC2, RFC3	4 TURNS #28 GA. 1/8" I.D. S.W.D
D1, D2	HP 5082-3379

50 OHM LINEWIDTHS ARE .1 IN. WIDE. DRAWING IS 2X. DIMENSIONS ARE 1X. SLASHED AREA IS COPPER.

2304 MHz RF SWITCH

WB5LUA

FIGURE 8

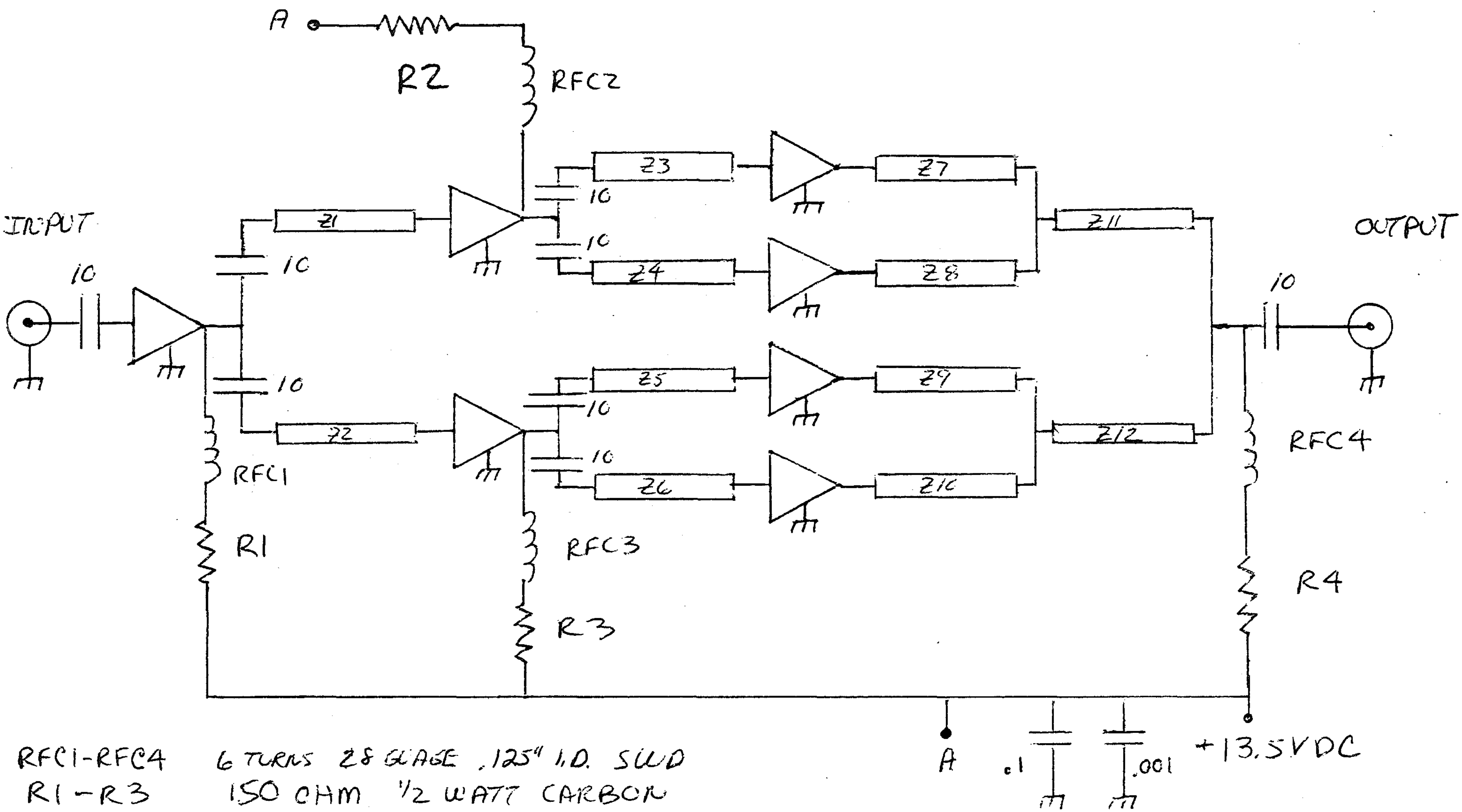


SWEPT RESPONSE OF 2304 MHz BAND PASS FILTER

LOSS	1.5dB	@ F_o for 3dB BW of 24MHz
	61.0dB	@ 2016 MHz (IMAGE WHEN USING ~~144~~MHz IF)
	45.0dB	@ 2160 MHz (LO)
	.5dB	@ F_o when adjusted for min. loss.

FIGURE 7

WB UA

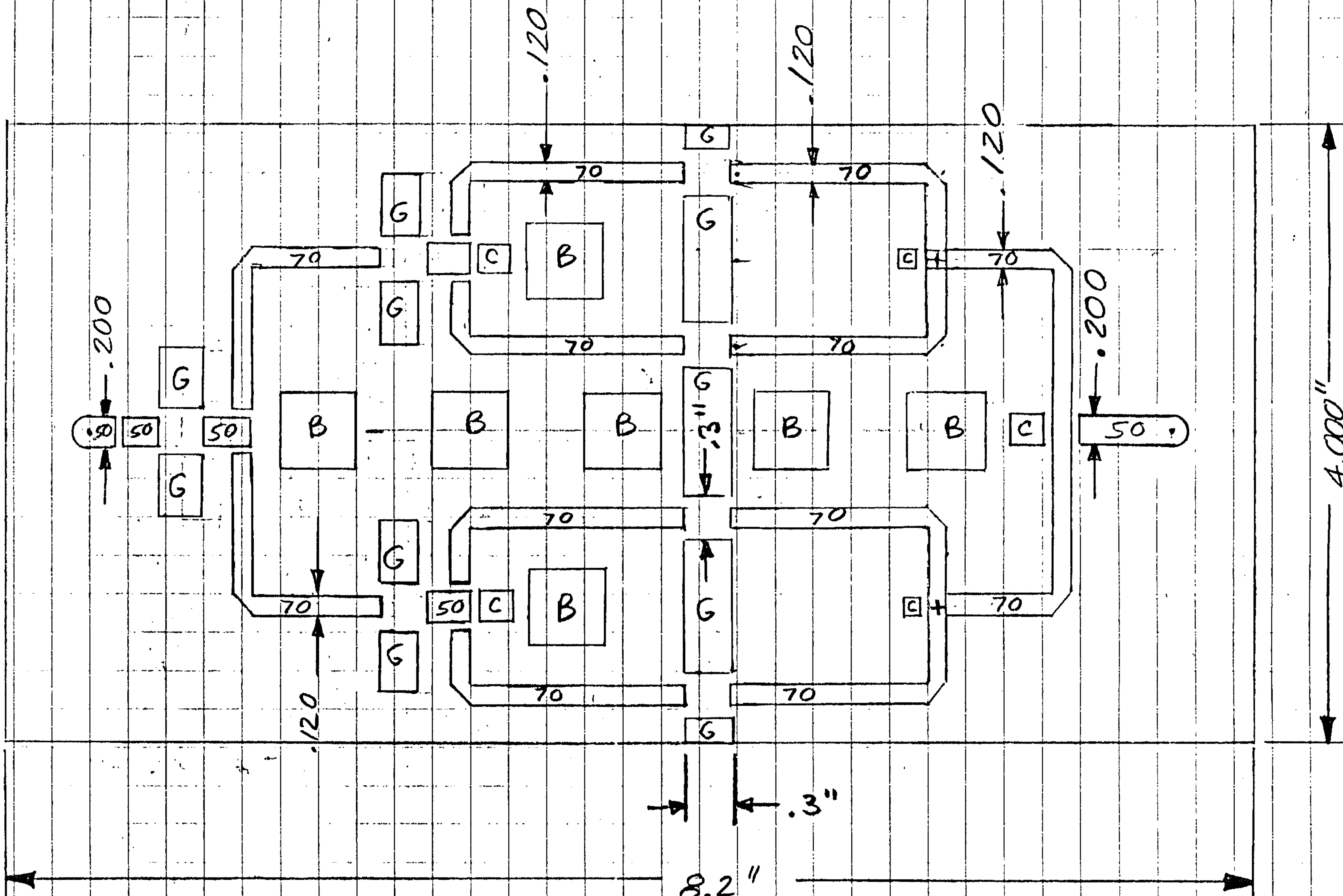


RFC1-RFC4 6 TURNS 28 GUAGE .125" I.D. SWD
R1-R3 150 OHM 1/2 WATT CARBON
R4 30 OHM 2 WATT MIN, CARBON
CONSISTS OF 5-150 OHM 1/2 WATT CARBON RES. IN PARALLEL

SCHEMATIC
2.3 GHz MSA-0404 MMIC AMPLIFIER

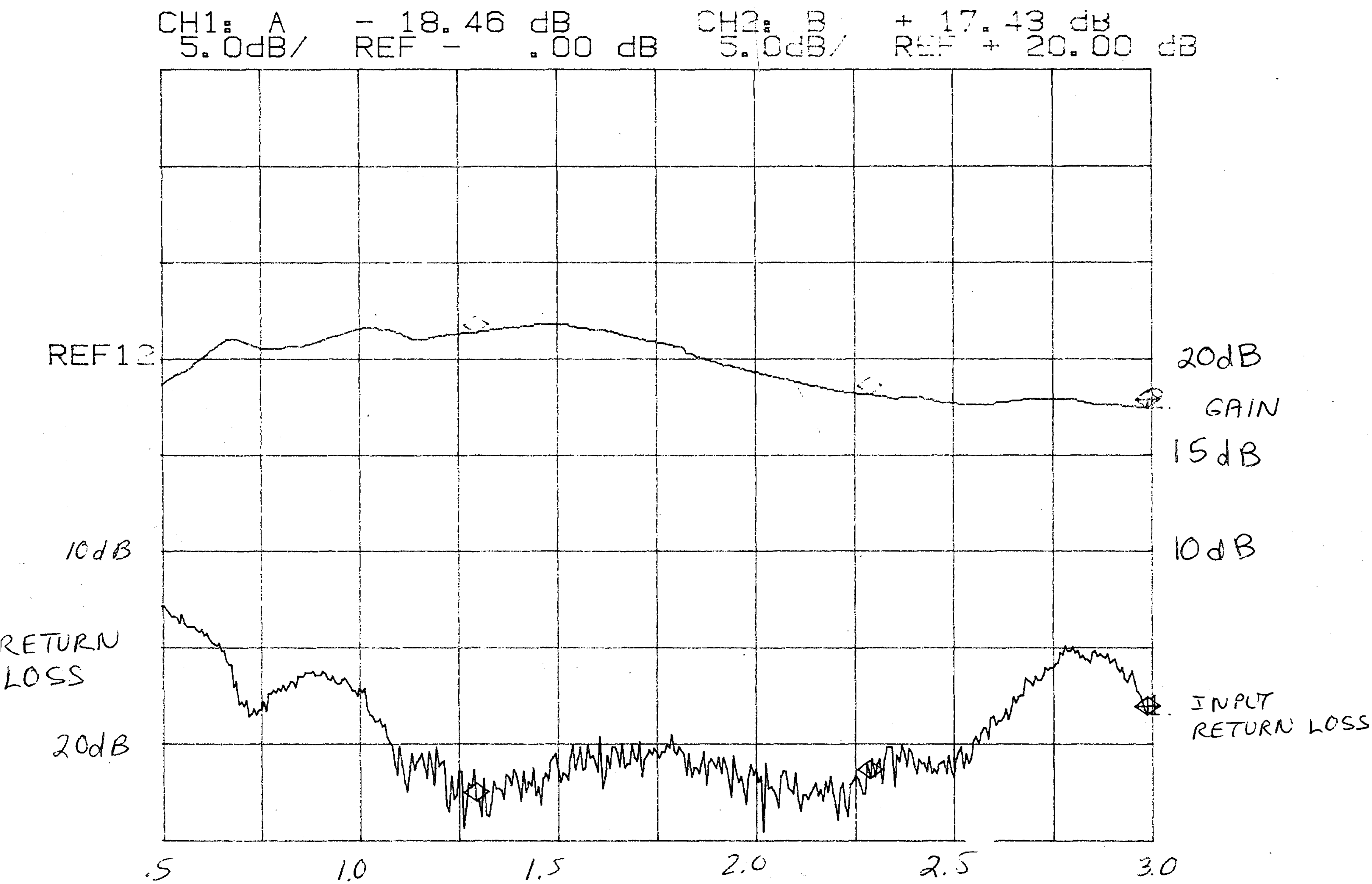
FIGURE9

WB5LUA



PRINTED CIRCUIT BOARD LAYOUT
FIGURE 10

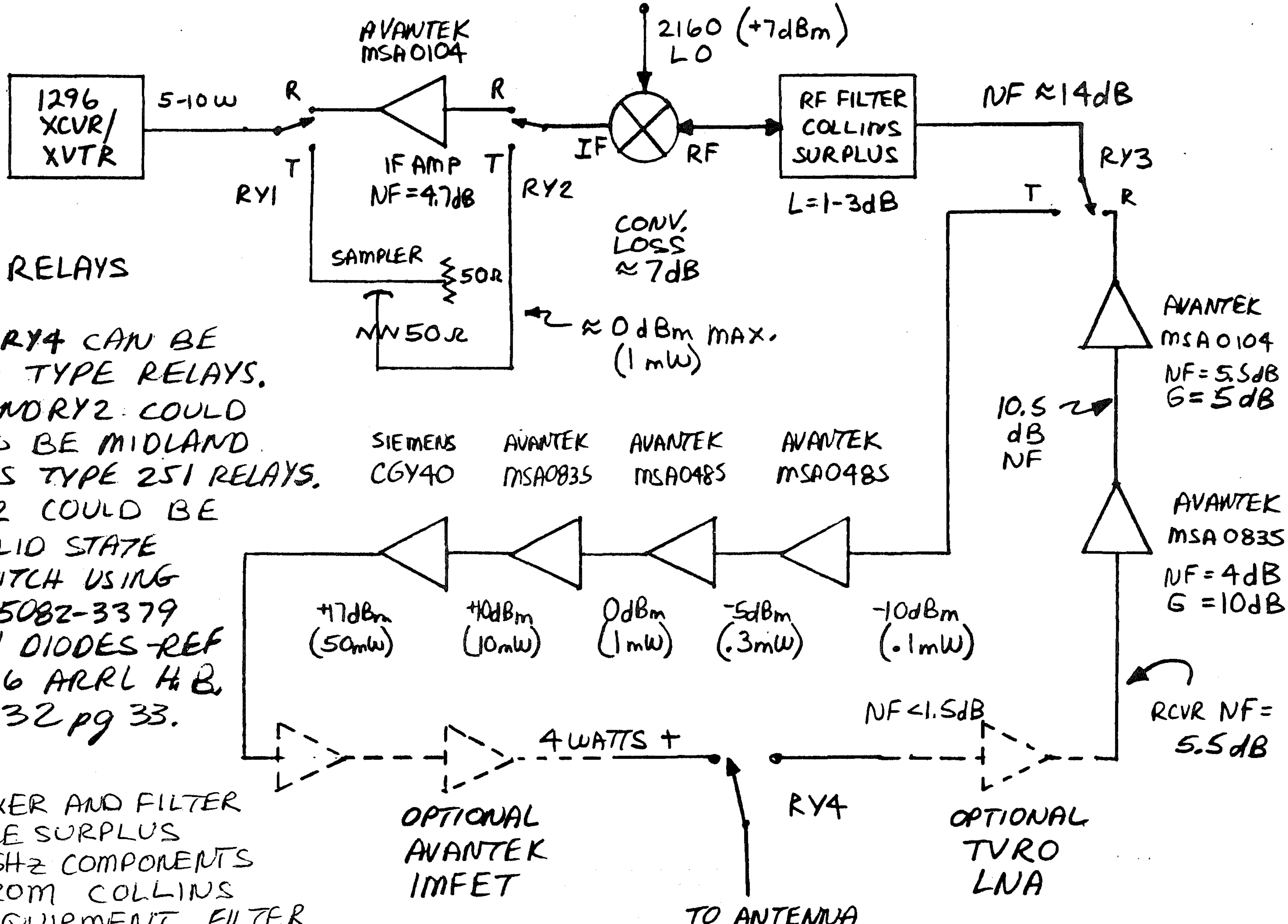
4-MSA0404
2.3 GHz
AMPLIFIER
A.J. WARD
10-- 85



2.3 GHz MSA-0404 MMIC
AMPLIFIER

FIGURE 11
WB5LUA

3456 MHz TRANSVERTER



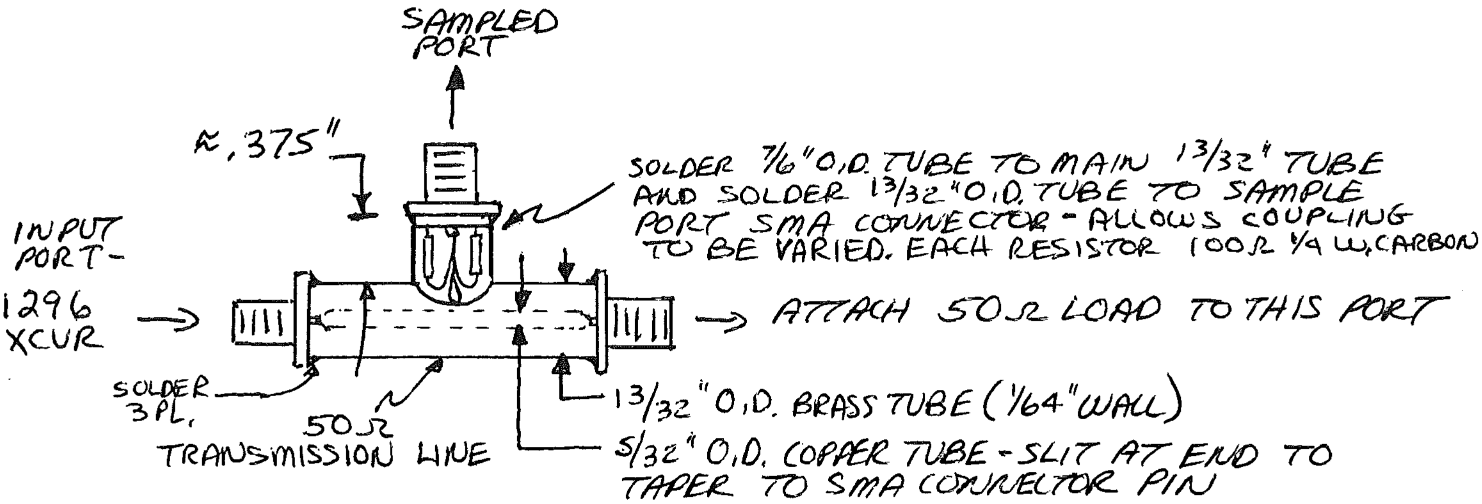
RF RELAYS

RY1-RY4 CAN BE SMA TYPE RELAYS. RY1 AND RY2 COULD ALSO BE MIDLAND ROSS TYPE 251 RELAYS. RY2 COULD BE SOLID STATE SWITCH USING HP5082-3379 PIN DIODES-REF 1986 ARRL H.B. CH 32 pg 33.

MIXER AND FILTER ARE SURPLUS 4 GHz COMPONENTS FROM COLLINS EQUIPMENT - FILTER RETUNED TO 3456 MHz

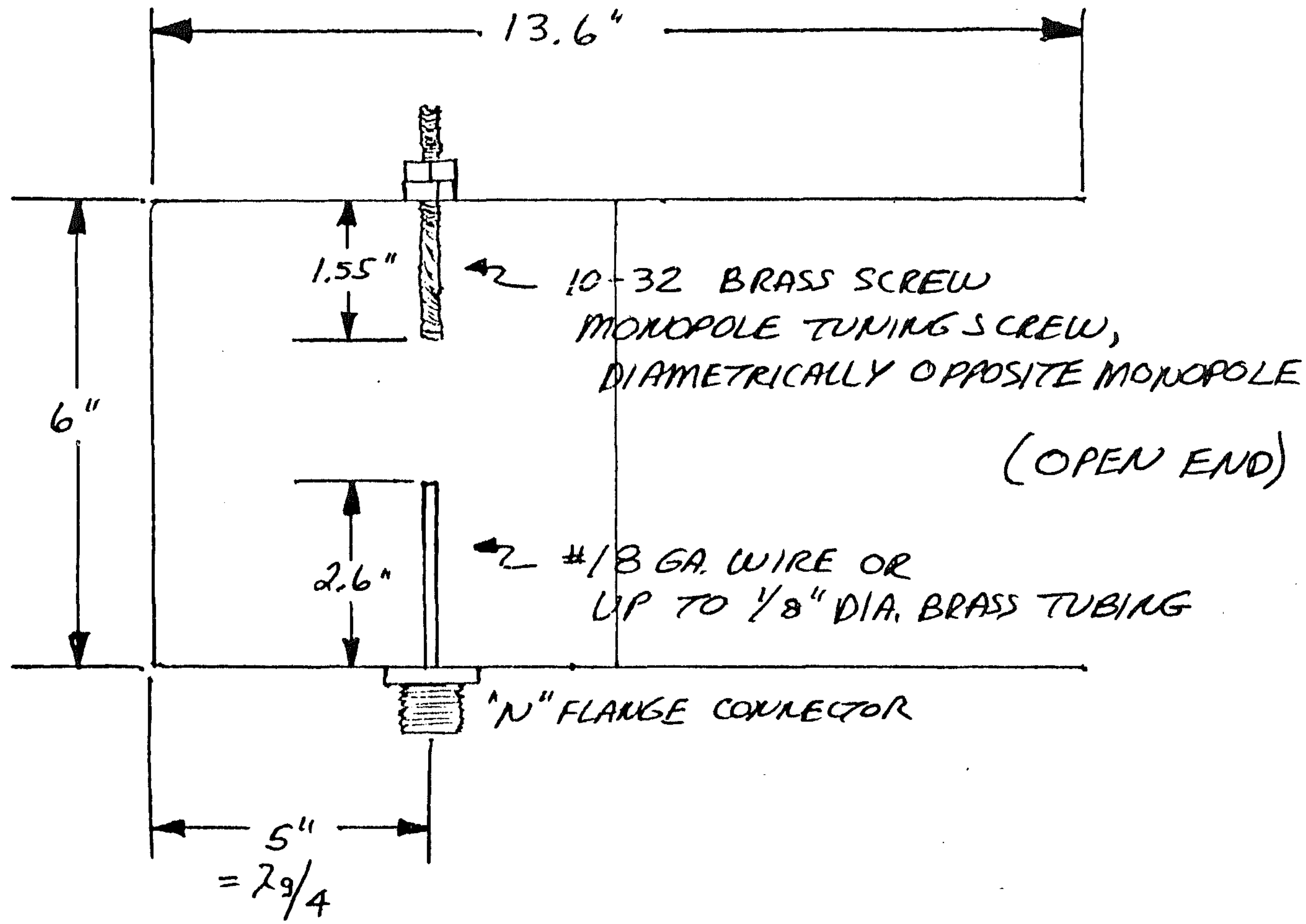
WB5LUA
6-4-86

1296 MHz. SAMPLER



- VSWR OF SAMPLED PORT IS LESS THAN 1.25:1.
- VSWR OF INPUT PORT DETERMINED PRIMARILY BY VSWR OF 50Ω LOAD ATTACHED TO END OF TRANSMISSION LINE - USE LOAD THAT CAN HANDLE POWER OF 1296 EXCITER.
- USE 4 HOLE GOLD-PLATED SMA CONNECTORS AT ALL PORTS
- LENGTH OF MAIN TRANSMISSION LINE NOT CRITICAL
- LENGTH OF TRANSMISSION LINE IN SAMPLED PORT LEG SHOULD BE MADE VARIABLE BY USE OF A 13/32" O.D. TUBE SLIDING INTO A 7/16" O.D. TUBE TO OBTAIN REQUIRED POWER (i.e. 0dBm or 1mW). COUPLING LOOP CAN BE ADDED TO RESISTOR LEADS TO ENHANCE COUPLING TO MAIN TRANSMISSION LINE. 2 100Ω RESISTORS ARE WIRED IN PARALLEL AND ARE CONTAINED INSIDE TUBING.

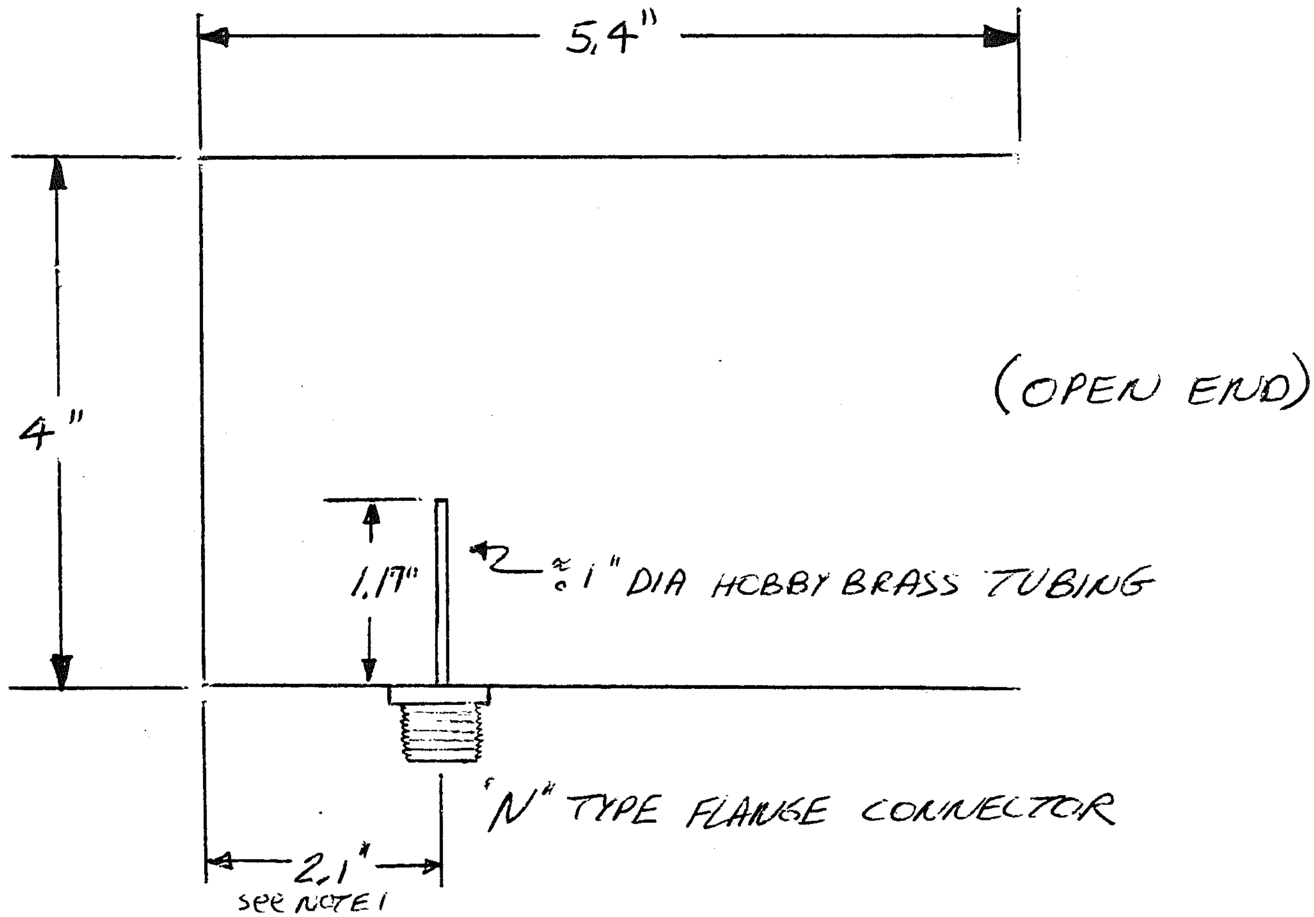
WB5LUA
7-14-86



NOTES
1. HORN CONSTRUCTED FROM 2 - 3lb COFFEE CANS SOLDERED TOGETHER
2. RETURN LOSS ≥ 30dB AT RESONANCE VSWR ≤ 1.06:1 MAXIMUM
3. MEASURED GAIN IS 7.5 dBi

1296 MHz STANDARD GAIN COFFEE CAN HORN

A.J. WARD
9-19-82



NOTES

1. DIMENSION (2.1") IS MEASURED FROM OUTSIDE EDGE OF COFFEE CAN.
2. HORN CONSTRUCTED FROM 1 lb. COFFEE CAN
3. RETURN LOSS ≅ 20dB AT RESONANCE (VSWR = 1.22:1 MAX)
4. MEASURED GAIN IS 8.5 dBi

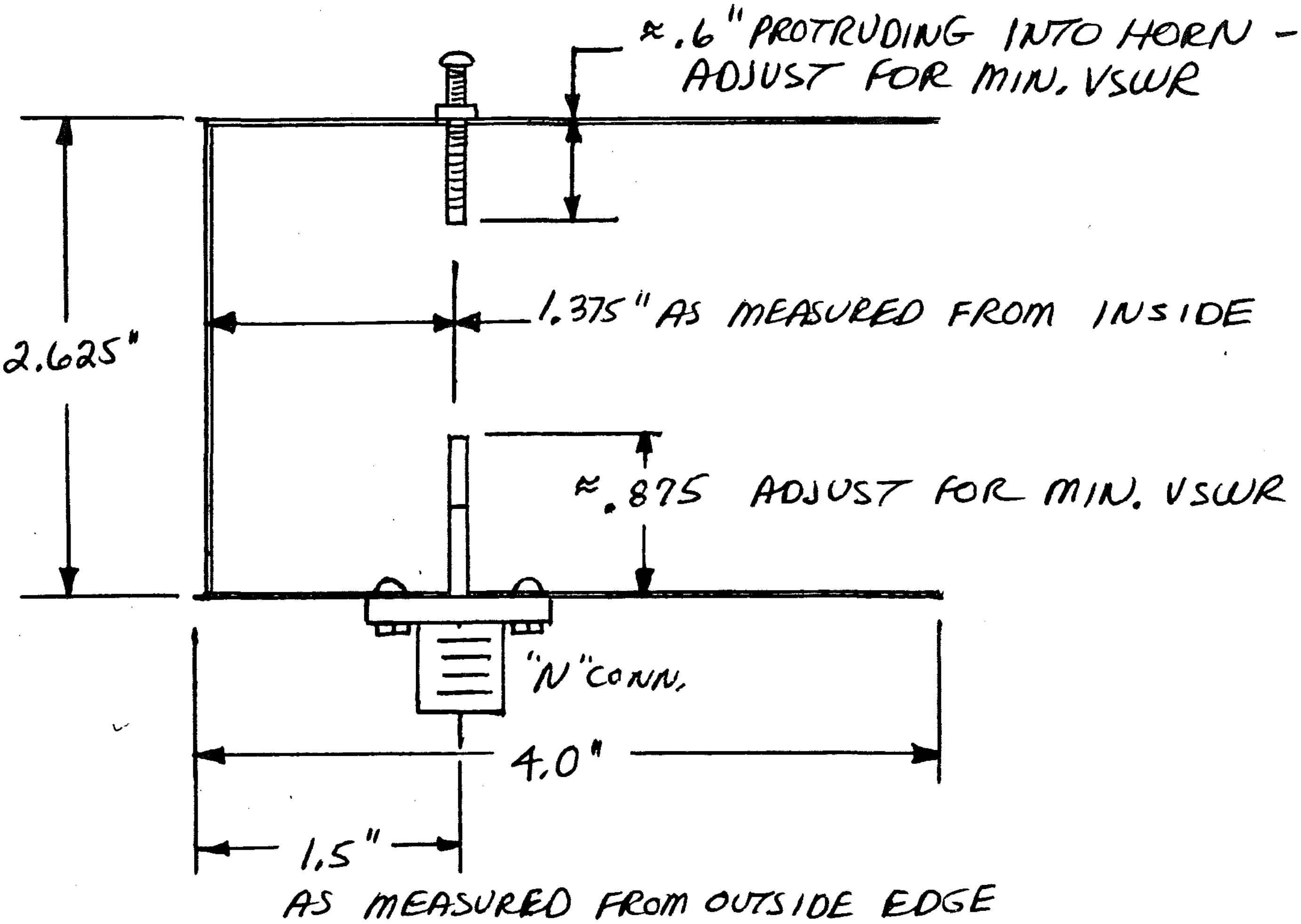
2304 MHz. STANDARD GAIN COFFEE CAN HORN

REV A 7-9-86

AJ WARD 9-8-85

3456 MHz FEED HORN

- FEED HORN HAS BEEN USED SUCCESSFULLY ON DISHES WITH F/D RATIO BETWEEN .375 AND .45
- FEED HORN GAIN ESTIMATED TO BE 8.5dBi SINCE IT WAS SCALED FROM THE 2304 MHz FEEDHORN



MATERIAL:

1. SOUP CAN - RETAIN 1 END OF CAN AS BACK REFLECTOR

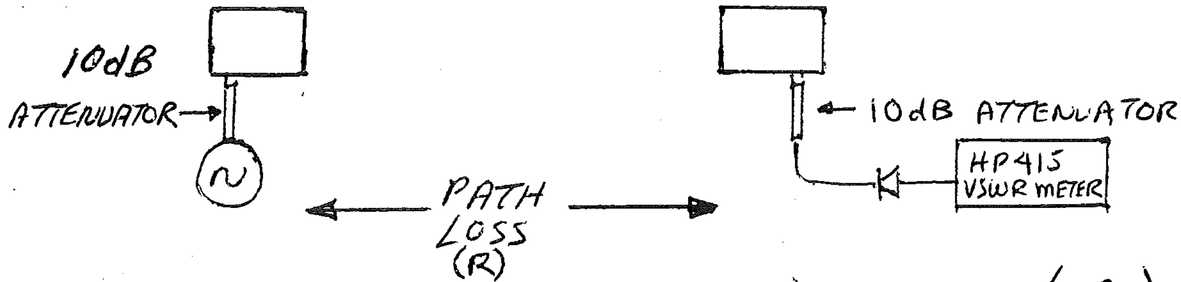
2. MONOPOLE MADE FROM HOBBY BRASS MATERIAL ≈ 1/8" O.D. - USE ADJACENT SIZES SO THEY CAN BE TELESCOPED FOR ADJUSTMENT.

3. TUNING SCREW — 8-32 BRASS WITH BRASS NUT SOLDERED TO CAN

(PRELIMINARY)

WB5LUA
6-4-86

ANTENNA GAIN MEASUREMENT OF 2 IDENTICAL ANTENNAS



$$G(A) + G(B) = 20 \log_{10}\left(\frac{4\pi R}{\lambda}\right) + 10 \log_{10}\left(\frac{P_r}{P_T}\right)$$

- ANTENNAS UNDER TEST MUST BE SEPARATED BY A DISTANCE GREATER THAN $\frac{2D^2}{\lambda}$
- ANTENNAS UNDER TEST MUST BE HIGH ENOUGH ABOVE GROUND SO THAT GROUND REFLECTION IS NOT A FACTOR
- CALIBRATE BY REMOVING FEED HORNS FROM 10dB ATTENUATORS AND MAKE THROUGH CONNECTION WITH ATTENUATORS. DETERMINE $\left(\frac{P_r}{P_T}\right)$
- MEASURE DISTANCE (R) AND CALCULATE PATH LOSS.
- GAIN MEASUREMENT AT 1296 MHz USING TWO IDENTICAL DUAL 3 lb. COFFEE CANS.

RANGE #1 $\quad 2G = 38.52\,dB - 23.6\,dB$

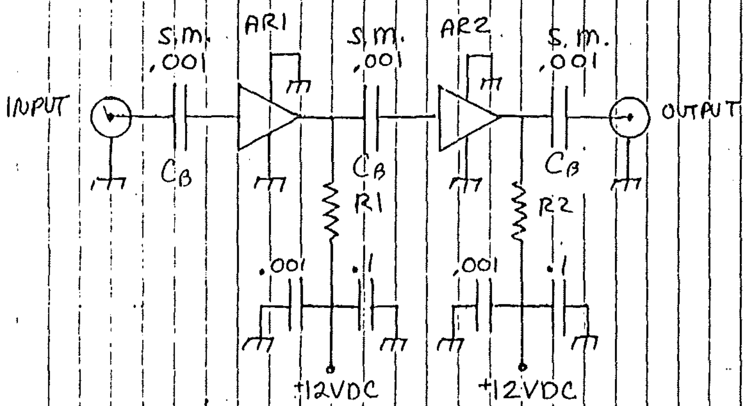
$G = 7.46\,dBi$

RANGE #2 $\quad 2G = 42.36\,dB - 27.3\,dB$

$G = 7.53\,dBi$

AVG = 7.50 dBi GAIN

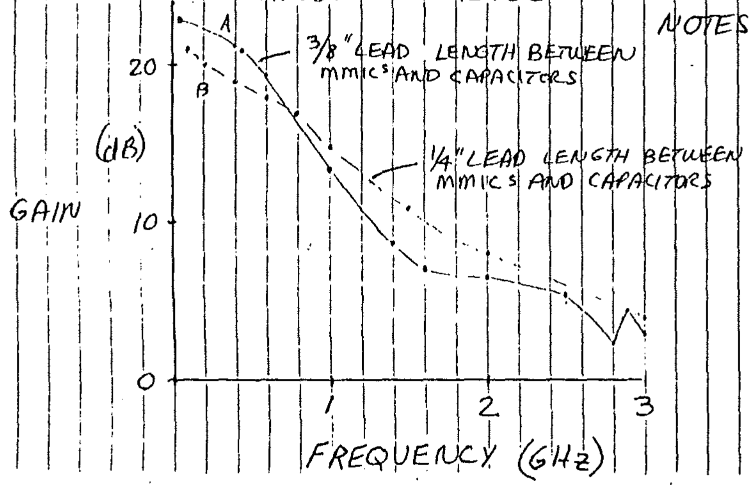
WB5LUA
A.J. WARD
9-16-85



AR1	AVANTEK MSA-0204 MMIC
AR2	AVANTEK MSA-0304 MMIC
R1	270 OHM .5 W RESISTOR
R2	220 OHM .5 W RESISTOR

CAPACITORS IN uF.

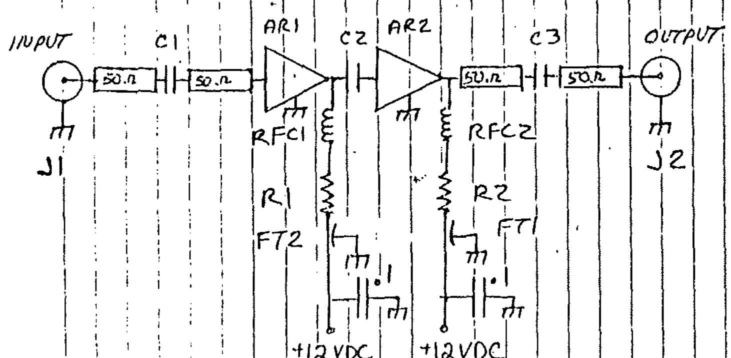
CONNECTORS BNC

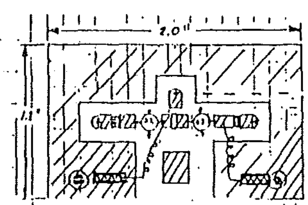


NOTES

1. "DEAD BUG" CONSTRUCTION TECHNIQUES UTILIZED - SEE NOTE
2. .1 uFd BYPASS CAPACITORS ELIMINATE LOW FREQUENCY OSCILLATIONS IN BIAS NETWORK
3. USE OF .1 uFd BLOCKING CAPACITORS ALLOW HF OPERATION DOWN TO 1.2 MHz.

VHF MMIC AMPLIFIER





COMPONENT LAYOUT

- SLASHED AREA IS COPPER
- 50Ω LINE WIDTHS ARE .100"
- DIELECTRIC IS .062" G-10
- EACH MMIC MUST HAVE BOTH COMMON LEADS GROUNDED TO THE GROUND PLANE ON THE CONNECTOR (BOTTOM) SIDE

C1, C2, C3	50-100 pf CHIP CAP
AR1, AR2	AVANTEK MMIC
RFC1, RFC2	4 TURNS #28 GUAGE ENAMEL WIRE .125 INCH I.D. SWD.
R1, R2	BIAS RESISTORS - SEE TABLE I
FT1, FT2	470 pf FEEDTHROUGH CAP.
J1, J2	SMA CONNECTOR

MICROSTRIP MMIC AMPLIFIER

WB5LUA

preliminary data sheet

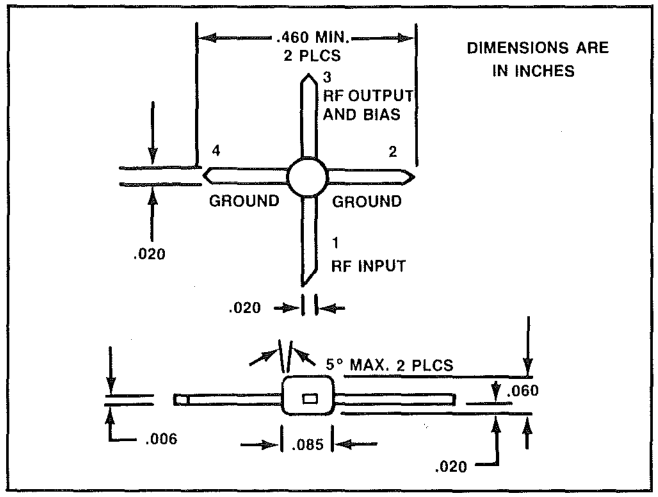
AVANTEK

MODAMP™ MSA-0185, MSA-0285, MSA-0385, MSA-0485 Cascadable Monolithic Silicon Integrated Circuit Amplifiers

Advanced Product Information
January, 1986

FEATURES

- **Low Cost Plastic Packaging**
- **Cascadable (VSWR < 2:1)**
- **Smooth Single-Pole Gain Rolloff**
- **Unconditionally Stable**



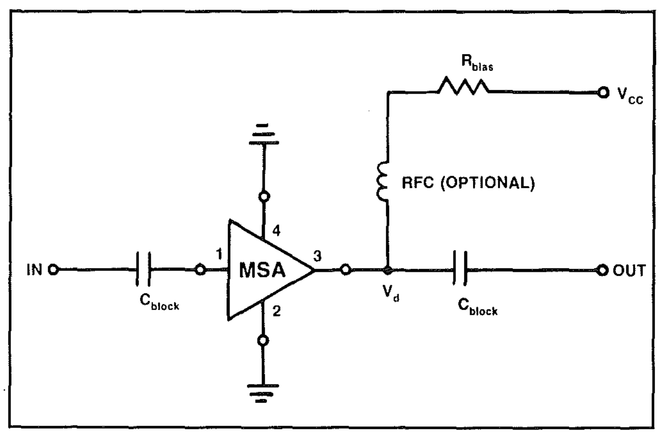
Avantek 85 Plastic Package

DESCRIPTION

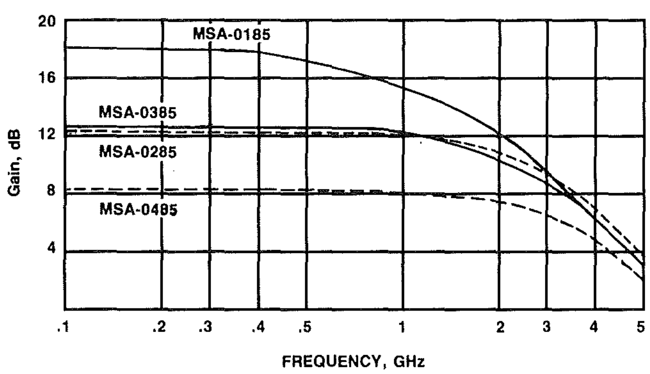
Avantek's MSA-0185, MSA-0285, MSA-0385 and MSA-0485 are a new series of silicon bipolar Monolithic Microwave Integrated Circuits, MODAMPs™, manufactured in a low cost, high performance plastic package. These MODAMPs™ are designed for use as general pupose 50 ohm gain blocks. Typical applications include narrow and broad band IF and RF amplifiers in commercial and industrial applications.

All Avantek MODAMPs™ use nitride self-alignment, ion implantation for precise doping control, and both gold metalization and nitride passivation for high reliability.

Typical Biasing Configuration



Typical S_{21} Gain vs. Frequency



TYPICAL ELECTRICAL SPECIFICATIONS; $T_A = 25°C$

DEVICE	V_{CC} (V)	R_{bias} (Ω)	Typical		Typical @ 500 MHz			Typical $f_{1\,dB}$[1] (MHz)
			I_d (mA)	V_d (V)	$\lvert S_{21}\rvert^2$ (dB)	$P_{1\,dB}$	$NF_{50\Omega}$	
MSA-0185	12	410	17	5	17.4	1.0	5.0	550
MSA-0285	12	280	25	5	12.8	4.0	6.0	1150
MSA-0385	12	200	35	5	12.8	10.0	5.5	1150
MSA-0485	12	140	50	5	8.2	13.0	6.3	2100

NOTE 1: Frequency at which gain is 1 dB less than at 100 MHz.

TYPICAL SCATTERING PARAMETERS, MSA-0185

$V_{CC} = 12V$, $I_d = 17$ mA

Freq. MHz	S_{11} Mag	S_{11} Ang	S_{21} dB	S_{21} Ang	S_{12} Mag	S_{12} Ang	S_{22} Mag	S_{22} Ang
100	.068	163.8	18.46	170.7	.077	4.1	.068	−13.8
500	.062	105.8	17.40	140.6	.084	15.2	.072	−67.7
1000	.065	71.5	15.61	110.7	.102	24.3	.087	−123.8
1500	.036	59.0	13.70	86.6	.127	26.3	.104	−161.2
2000	.059	148.9	12.30	67.1	.157	20.5	.157	−177.2
2500	.096	142.0	10.62	48.8	.180	17.7	.156	154.9
3000	.136	139.3	9.30	33.6	.202	12.0	.145	143.9
3500	.205	129.0	7.89	18.6	.218	5.3	.157	135.3
4000	.279	120.0	6.62	3.1	.246	−4.2	.165	127.3
4500	.335	110.3	5.41	−9.1	.250	−9.9	.159	122.5
5000	.390	99.4	4.26	−20.7	.251	−17.4	.149	124.2
5500	.433	91.1	3.24	−31.0	.256	−22.3	.155	131.0
6000	.479	83.1	2.25	−41.4	.259	−29.6	.174	136.1

TYPICAL SCATTERING PARAMETERS, MSA-0285

$V_{CC} = 12V$, $I_d = 25$ mA

Freq. MHz	S_{11} Mag	S_{11} Ang	S_{21} dB	S_{21} Ang	S_{12} Mag	S_{12} Ang	S_{22} Mag	S_{22} Ang
100	.121	173.5	12.88	174.2	.116	1.4	.126	−7.9
500	.113	154.1	12.75	156.0	.120	4.7	.123	−37.5
1000	.100	130.1	12.47	130.5	.127	6.7	.123	−75.4
1500	.077	120.2	11.75	109.1	.141	9.9	.123	−112.2
2000	.062	126.2	10.99	90.0	.155	8.8	.127	−121.0
2500	.085	147.5	10.35	67.1	.174	5.7	.129	−165.5
3000	.140	146.6	9.35	45.7	.188	−.9	.129	171.2
3500	.207	136.4	8.23	29.6	.199	−5.5	.127	154.8
4000	.273	123.5	7.26	13.6	.207	−10.4	.125	141.7
4500	.344	111.8	6.17	−2.3	.214	−16.9	.123	135.1
5000	.410	101.9	4.90	−16.5	.210	−22.4	.122	135.9
5500	.470	92.4	3.91	−28.9	.222	−27.1	.132	139.7
6000	.516	85.2	2.77	−40.4	.216	−32.5	.165	144.1

TYPICAL SCATTERING PARAMETERS, MSA-0385

$V_{CC} = 12V$, $I_d = 35$ mA

Freq. MHz	S_{11} Mag	S_{11} Ang	S_{21} dB	S_{21} Ang	S_{12} Mag	S_{12} Ang	S_{22} Mag	S_{22} Ang
100	.068	172.1	12.97	174.3	.118	1.2	.154	−10.6
500	.059	156.0	12.78	152.5	.121	5.3	.164	−45.5
1000	.047	145.8	12.40	128.0	.131	9.8	.185	−87.9
1500	.045	172.2	11.75	103.3	.145	11.7	.214	−120.4
2000	.058	173.0	10.80	83.0	.176	10.7	.253	−142.3
2500	.170	174.6	10.25	59.5	.187	5.5	.256	−172.6
3000	.243	157.3	9.10	38.2	.204	−.3	.251	168.0
3500	.319	140.2	7.77	21.4	.214	−6.1	.252	152.4
4000	.386	124.3	6.47	2.9	.219	−13.7	.254	138.4
4500	.456	110.7	5.04	−9.4	.222	−18.4	.237	130.3
5000	.508	99.6	3.90	−23.5	.219	−23.7	.235	125.6
5500	.557	88.7	2.72	−34.0	.225	−26.0	.245	123.7
6000	.596	80.9	1.70	−45.1	.227	−31.2	.265	122.9

TYPICAL SCATTERING PARAMETERS, MSA-0485

$V_{CC} = 12V$, $I_d = 50$ mA

Freq. MHz	S_{11} Mag	S_{11} Ang	S_{21} dB	S_{21} Ang	S_{12} Mag	S_{12} Ang	S_{22} Mag	S_{22} Ang
100	.185	176.9	8.23	175.3	.155	.1	.103	−13.6
500	.180	168.6	8.22	156.5	.156	1.1	.127	−54.4
1000	.173	159.1	8.16	135.1	.161	3.2	.178	−93.9
1500	.174	156.8	8.08	111.7	.170	3.6	.239	−121.4
2000	.190	151.1	7.73	89.6	.186	2.9	.285	−144.8
2500	.240	159.5	7.61	68.7	.204	−.5	.338	−165.2
3000	.313	150.6	6.93	45.9	.221	−5.6	.355	176.2
3500	.391	139.0	5.97	27.3	.226	−10.9	.370	160.5
4000	.465	126.4	4.93	7.8	.250	−22.9	.383	146.9
4500	.524	114.6	3.57	−6.4	.246	−26.1	.385	137.4
5000	.579	105.5	2.39	−21.5	.243	−30.6	.373	129.8
5500	.617	96.6	1.30	−32.3	.242	−32.6	.391	125.1
6000	.643	89.2	.20	−43.7	.242	−38.0	.415	120.8

AVANTEK

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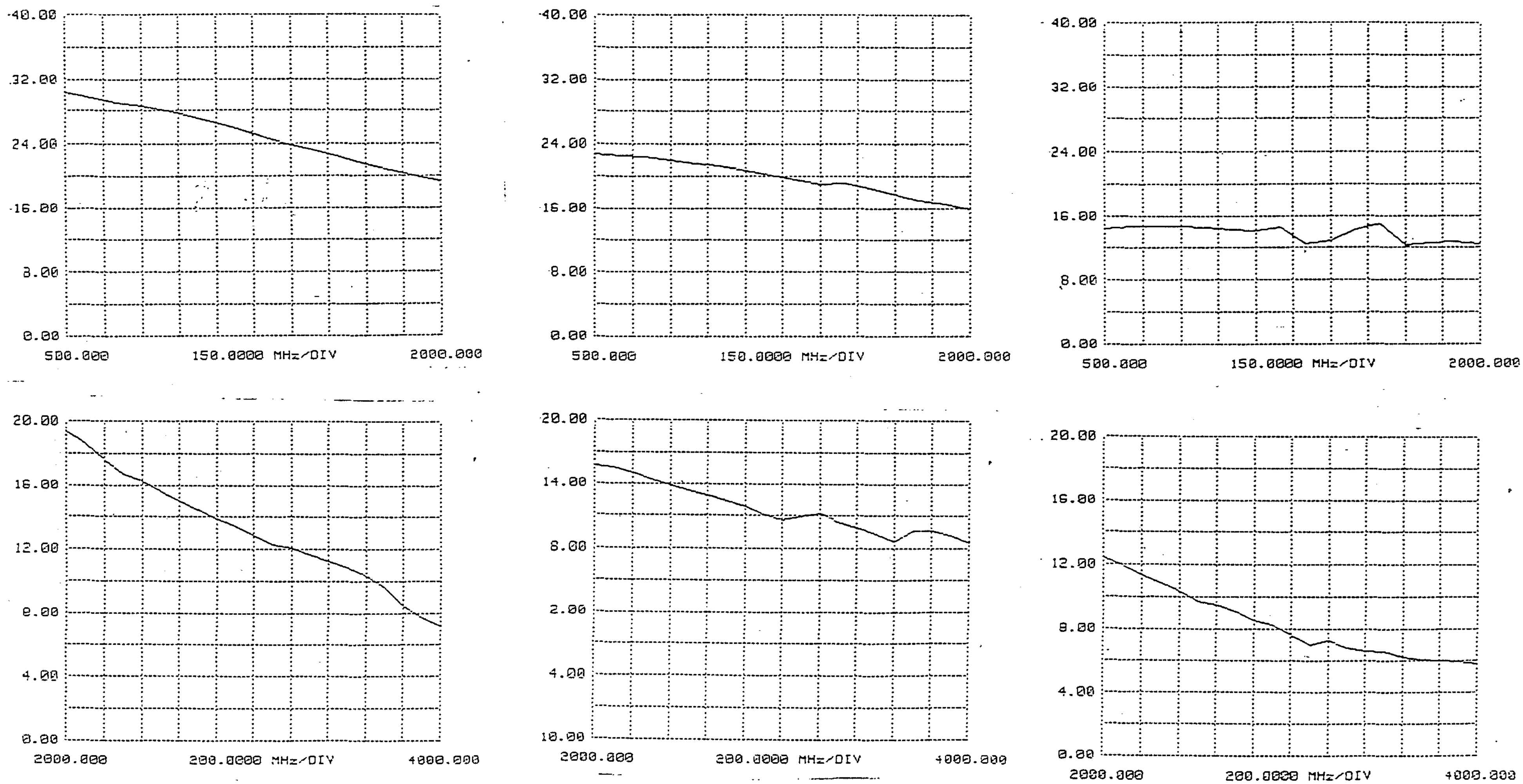
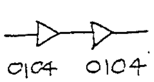
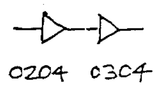
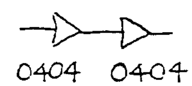




CASCADE MSA 0104
MMIC
AMPLIFIER



CASCADE MSA0204/0304
MMIC
AMPLIFIER

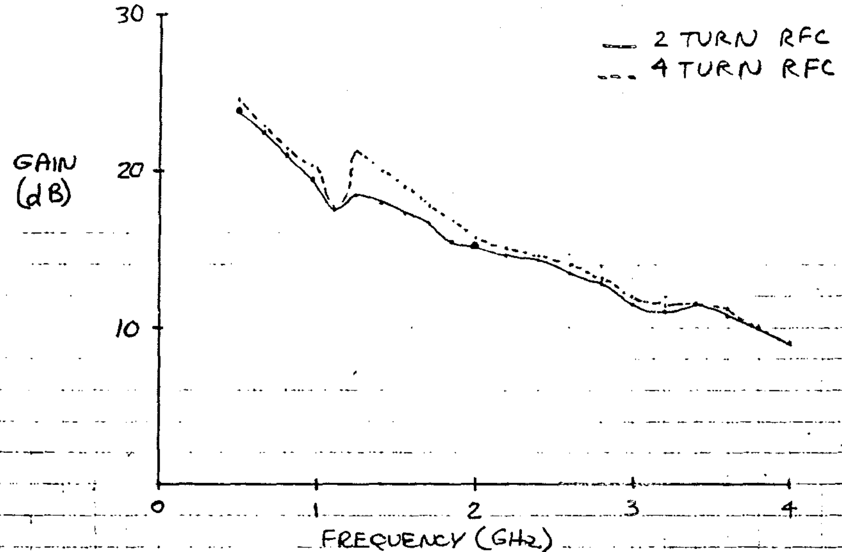


CASCADE MSA 0404
MMIC
AMPLIFIER

MMIC AMPLIFIER GAIN PERFORMANCE
(MICROSTRIP VERSION)

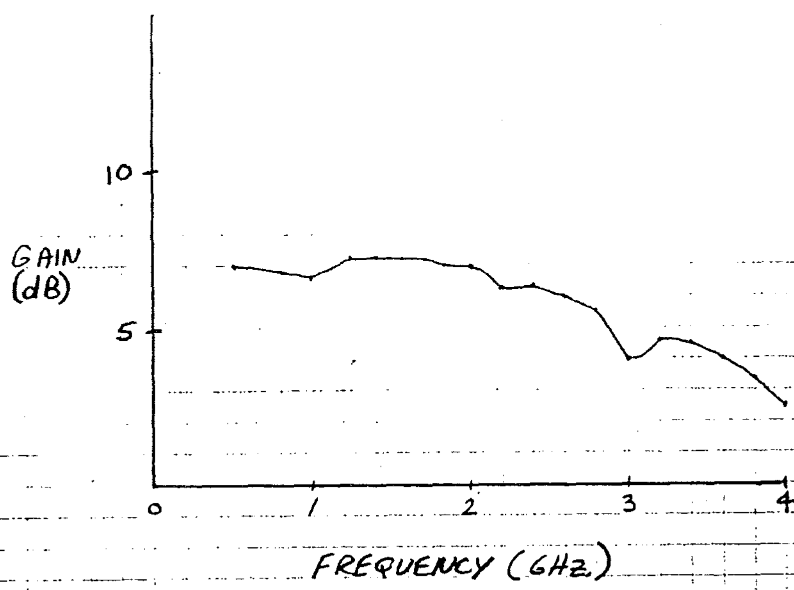
WB5LUA
7-14-86

MSA 0835 MMIC AMPLIFIER



MEASURED PERFORMANCE FOR 2 AND 4 TURN RF CHOKES

MSA 0485 MMIC AMPLIFIER



MEASURED PERFORMANCE FOR MSA0485 MMIC AMPLIFIER

(MICROSTRIP VERSION)

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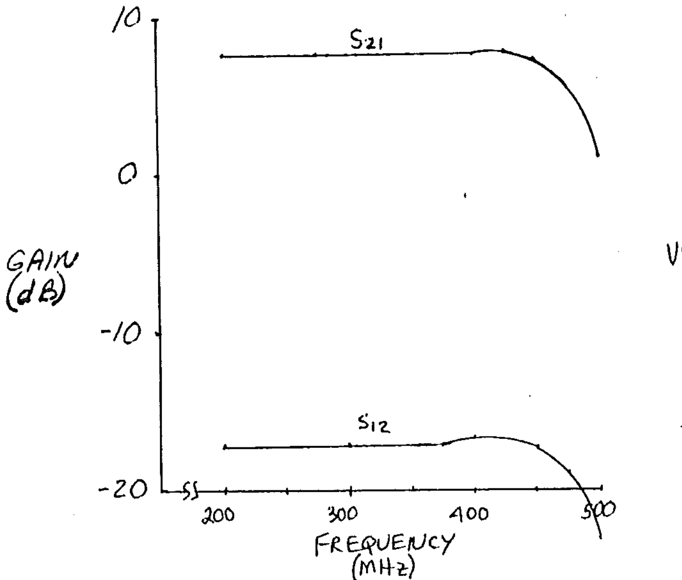
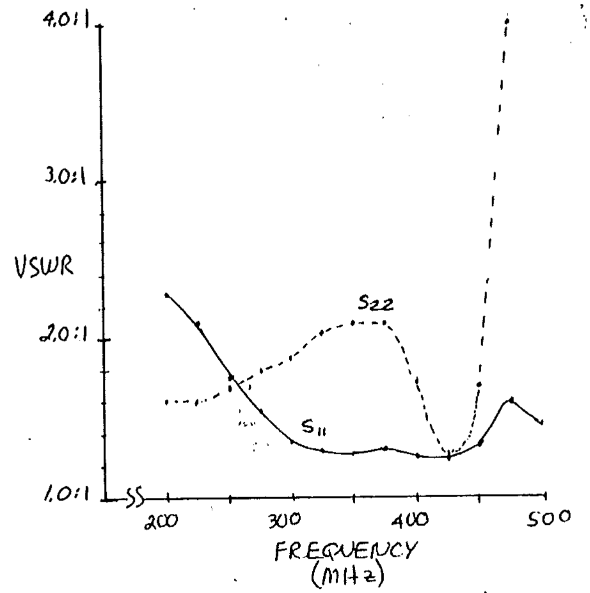
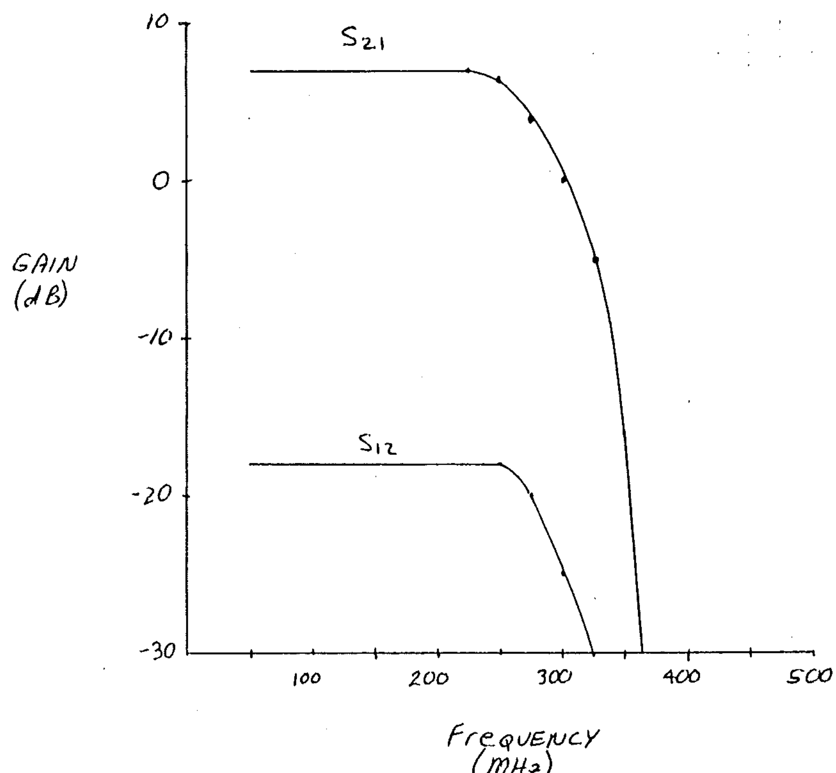
7-14-86



FORWARD (S_{21}) AND REVERSE (S_{12}) GAIN OF 432 MHz PARALLEL MMIC MSA-0404 AMPLIFIER

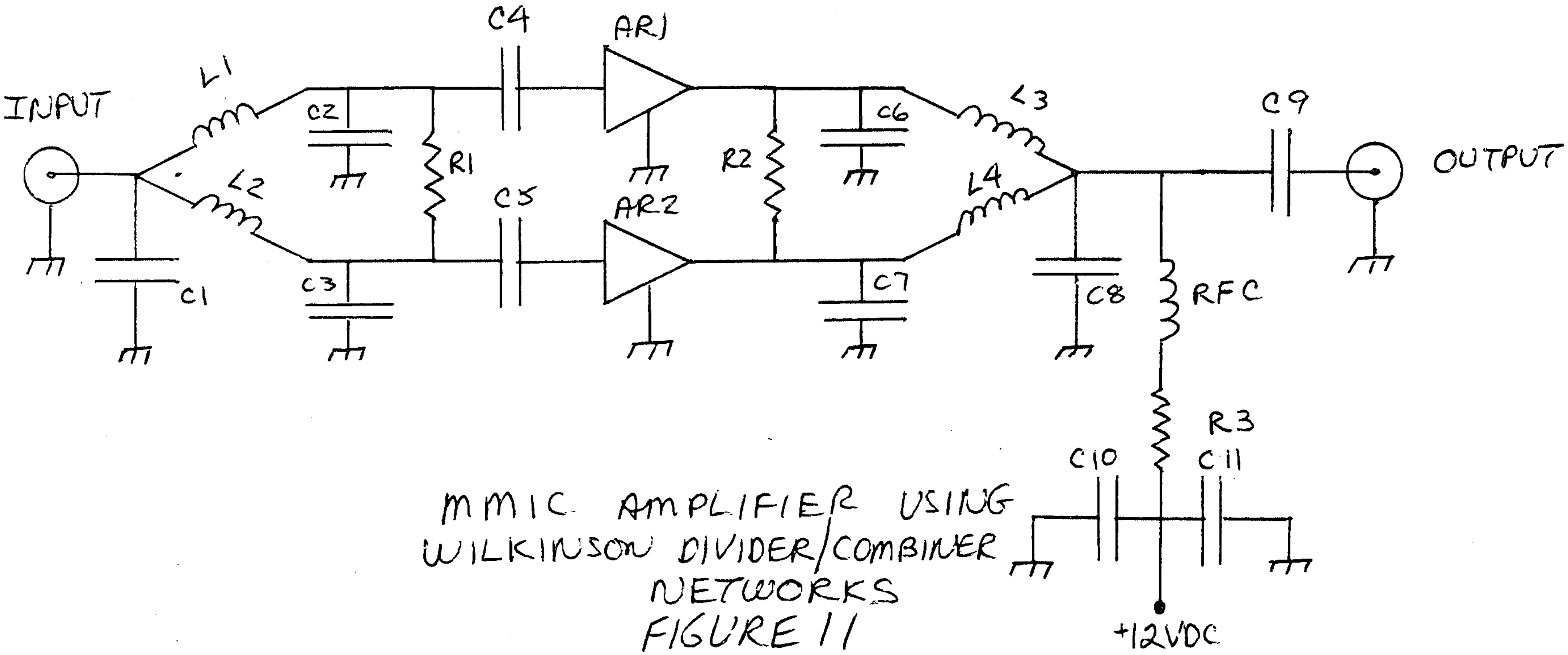


INPUT (S_{11}) AND OUTPUT (S_{22}) VSWR OF 432 MHz PARALLEL MMIC MSA-0404 AMPLIFIER



FORWARD (S_{21}) AND REVERSE (S_{12}) GAIN OF 220 MHz PARALLEL MMIC AMPLIFIER

WB5LUA
7-14-86

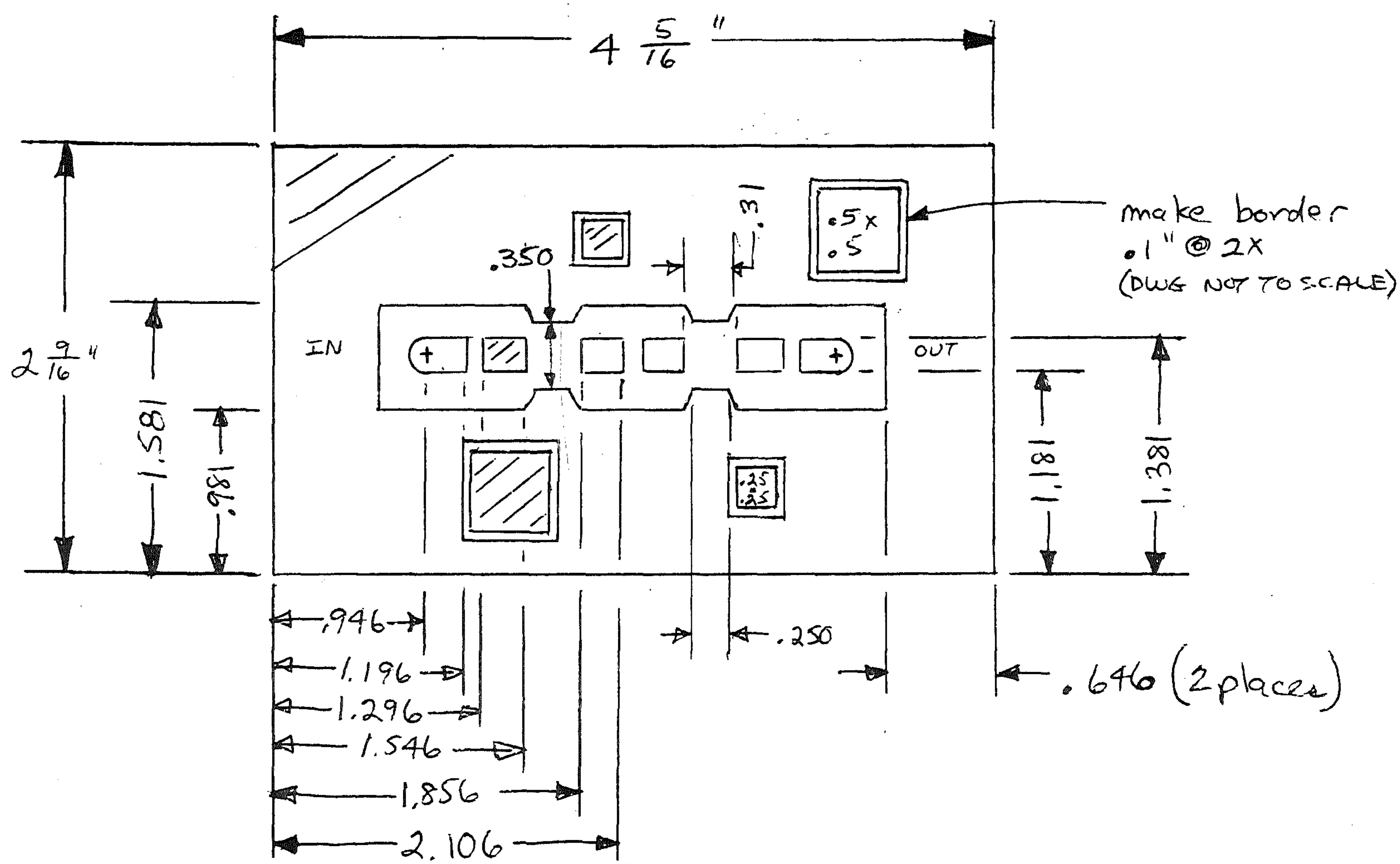


MMIC AMPLIFIER USING WILKINSON DIVIDER/COMBINER NETWORKS
FIGURE 11

Freq.	220 MHz	432 MHz
C1, C8	20pf S.M.	1-10pf VARIABLE CAPACITOR
C2, C3, C6, C7	10pf S.M.	5pf S.M.
C4, C5, C9, C10	470pf S.M.	100pf S.M.
C11	.1 ufd DISC	.1 ufd DISC
L1, L2, L3, L4	50nH (see text)	26nH (see text)
R1, R2	100Ω	100Ω
R3	62Ω 1W	62Ω 1W
RFC	.47uH	.47uH
AR1, AR2	MSA0404	MSA0404

COMPONENT VALUES FOR CIRCUIT DESCRIBED IN FIGURE 10
Table II

WB5LUA



NOTES: 1. DIMENSIONS IN INCHES
2. DIMENSIONS ARE 2X
3. SLASHED AREA IS COPPER
4. $\varepsilon_r = 5.0$, THICKNESS IS .062"

CASCADE MMIC AMPLIFIER
CIRCUIT LAYOUT
A. J. WARD
JAN 6, 1985

AM 6154/AM 6155 On 432 MHz

This simple modification replaces the original pedestal inductor with 3 inches of hobby brass to build a new 432 MHz input circuit. For the power supply and output section changes, I suggest one of the fine articles by N3AHI, WB4MNA or K0TLM.

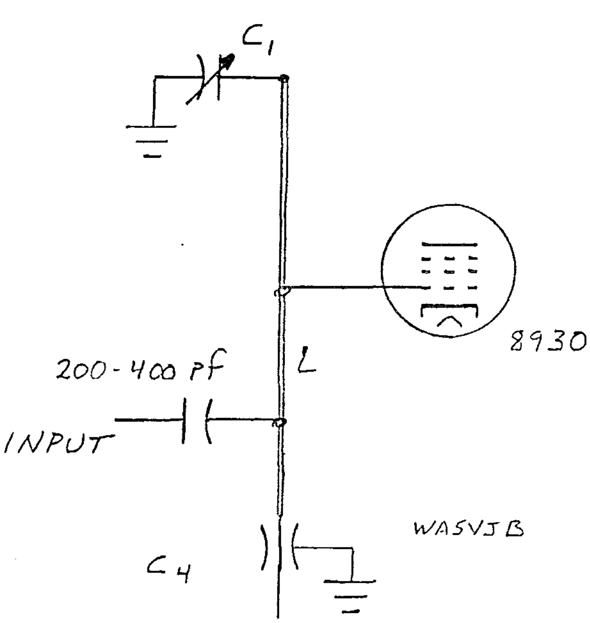
A. Remove the original input coupling capicator and it's hardware. Plug any holes to prevent air loss.

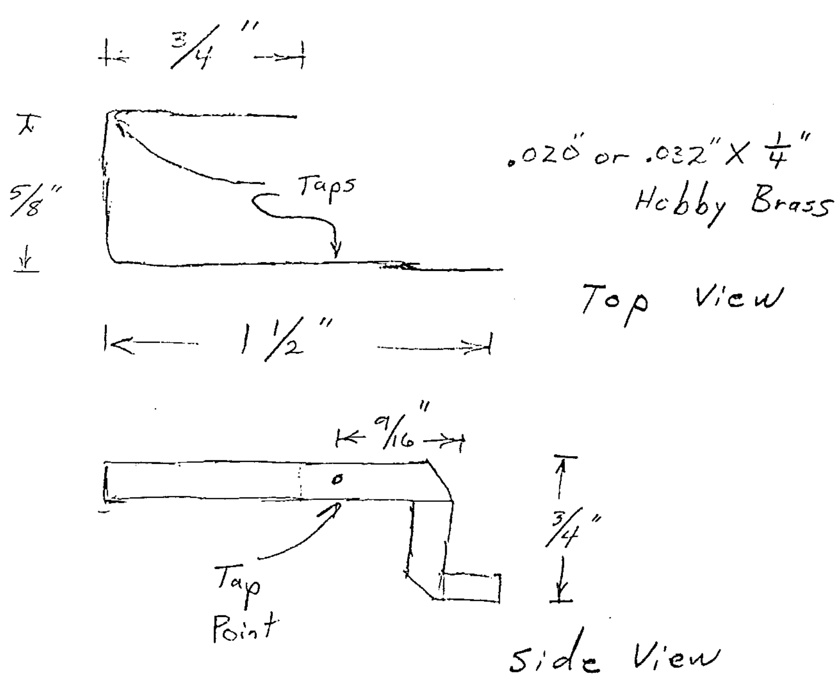
B. Remove C1 and saw off all but 2 or 3 plates. C1 will resonate as is, but the truning is VERY SHARP!

C. Install the new input inductor from C4 to C1 and run a 200 to 400 pf. coupling capacitor from the TNC connector to the tap point. Also install the tap for the grid connection.

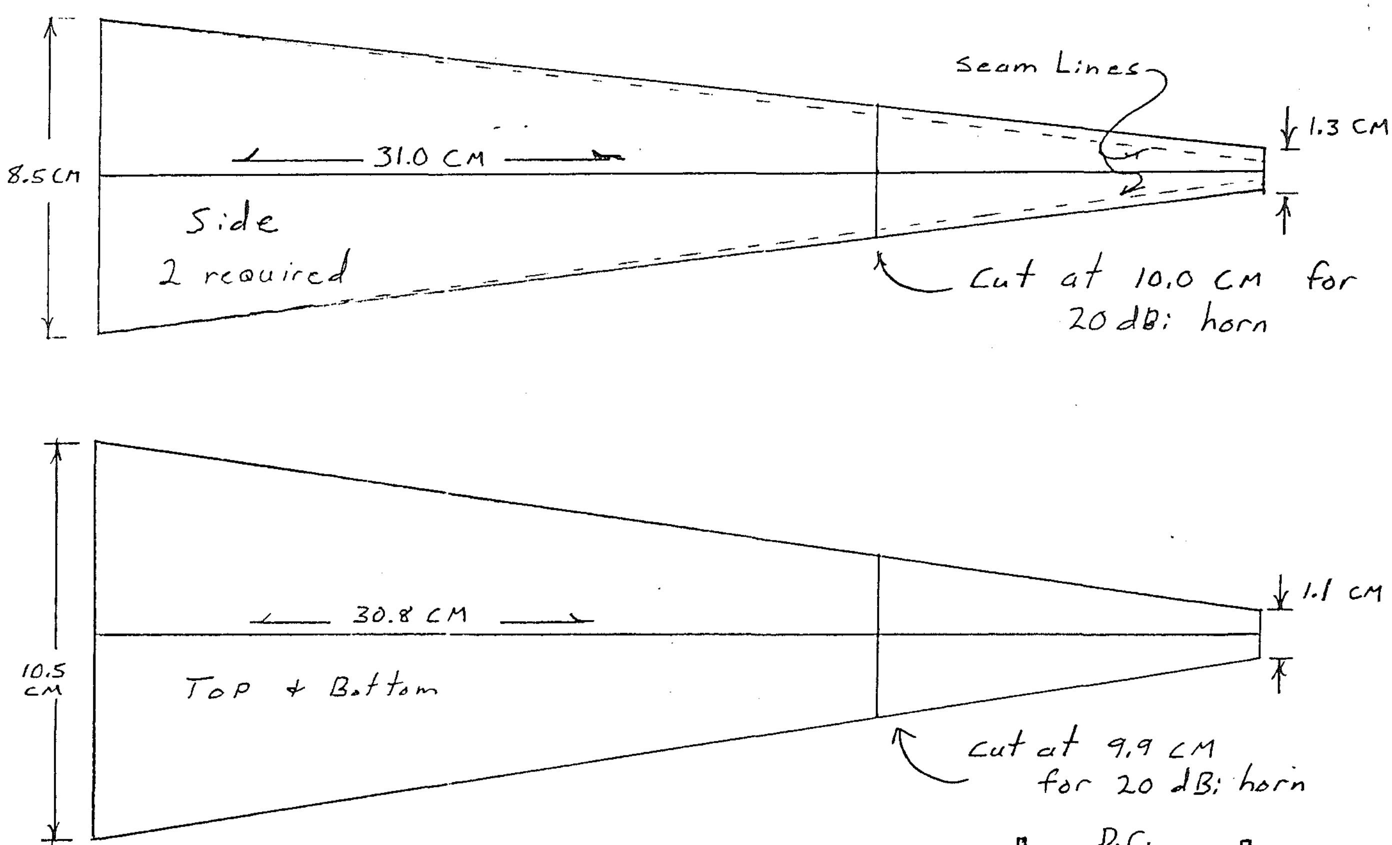
A quick check on a return loss bridge showed reflections from the circuit were 16 dB down. With 7 watts of drive I'm now getting in excess of 300 watts output from my AM6154 on 432 MHz. My thanks to N5MP for showing me this circuit.

Kent Britain
WA5VJB

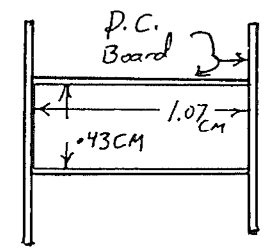




24 GHz Horn



25 dBi Calculated Gain



WAVE GUIDE
SIZE

WA5VJB
1-21-86

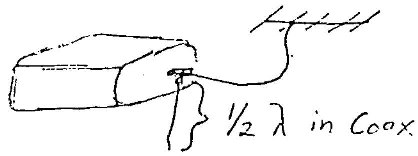
Reff. Electronic & Radio Engineering
4th edition
1955
McGraw Hill

1/2 Wave Stubs

Shortly after moving to a new QTH I noticed severe "CATV" leakage. A 30 over 59 carrier at 144.0 MHz and 59 birdies every 15 KHz.

So, I called the local cable company and firmly told them about their problem! They tightened up the connectors in the neighborhood but the birdies were still there. Another "chat" with the cable company and still the birdies. So I peaked on interferrence and went looking for the leak with a small beam and an IC-202. Nothing; no birdies, no leak; but it was so strong back at the house! Next I placed a 6 dB pad on the front end of my 2 meter system. The pad dropped all the birdies 20 dB. It was my fault; front end mixing. (I live about 7 miles from the home of 9 TV transmitters)

In talking with K5GW, Gearld said he had had a similar problem with TV CH4 and TV CH5 mixing to produce a strong carrier at 144 MHz. Gearld's suggestion was a 1/2 λ open stub.



A 1/2 wave open stub has no affect on the signal, but a 2 Meter 1/2 wave open stub becomes a 1/4 wave trap at 72 MHz. So I cut and installed a stub with dramatic results; the birdies were gone and the carrier dropped to less than S1.

Lately W5UN was also having birdie problems. But Dave didn't have the TV CH 4+5 combination, so I wondered how much it would affect other TV Channels. With a HP-608C signal generator and a HP-415B S.W.R. indicator I measured a 144 MHz ½ wave open stub's affect on the other T.V. Channels.

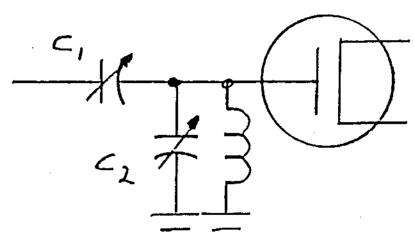
T.V. Channel	dB change	
2	-7	
3	-12	
4	-25	
5	-20	
6	-12	
7	-2	
8	-2	
9	-3	
10	-4	
11	-5	
12	-10	
13	-22	(note: 3/4 wave)

With the HP-415B in it's expanded scale, the stub "seemed" to induce .02 to .03 dB loss at 144 MHz. This is a very cheap price to pay for keeping alot of R.F. out of your front-end. Dave (W5UN) is now using a stub on his EME system and also experienced viritual elimination of his birdies

WA5VJB
Kent Britain

Tweeking Pre-amps

A few months ago W5UN dropped by my shack with his pre-amp. Now, Dave has unquestionably proven his ability to dig out weak signals, so I was suprised when his 144 MHz GaAs FET measured .9 dB N.F. Out comes the alignment tools and I quickly retune it to .4 dB N.F. Dave says; "That's fine, but it won't work in the system that way. The TV stations will tear it up!" (Note: W5UN lives less than 10 miles from most of Houston's TV and FM transmitters.)



When most GaAs FET pre-amps are tuned for best N.F. at 144 MHz, both C_1 and C_2 will be about 6 pf. Dave was tuning C_1 back to 2 or 3 pf and increasing C_2 to about 8 pf. This was greatly increasing the Q of the input circuit.

To find out what was happening we next measured the pre-amp's gain at 100 MHz and 200 MHz refferenced to the 144 MHz gain.

	Gain @ 100 MHz	Gain @ 200 MHz	144 MHz N.F.
C_1 & C_2 at 6pf	-30 dB	-30 dB	.4 dB
$C_1 \approx 3$pf $C_2 \approx 8$pf	-50 db	-50 db	.9 db

Basically Dave was trading ½ dB of Noise Figure for 20 dB more rejection of the TV and FM Broadcast stations. So if you live in a high RF environment you might want to keep that input coupling cap, C_1, tweeked a bit to the low capacitance side.

WA5VJB
Kent Britain

SOME TIPS ON HOW TO GET STARTED ON 144 MHZ EME

The amount of activity on 144 MHz EME is increasing dramatically. One of the reasons for this is that it simply is not that difficult, once you know how. Even single yagi stations with good horizons are making dozens of contacts! Of course, they have done everything right in setting up their stations.

Much frustration and disappointment can be avoided by getting off to the proper start; it is much easier to do it right the first time, instead of learning everything by your own mistakes! The following tips will help make your entry into 2 meter moonbounce much more successful and enjoyable.

1. PREAMPLIFIER - Use a good preamplifier for receiving and mount it right at the antenna. I mount my preamp, along with the switching relays, directly on the main power divider and run flexible RG-58/U coaxial cable around the rotator, where it changes to RG-8/U coax for the run to the shack. With the low prices of good transistors (MGF1202 GAASFET's capable of noise figures under .5 db are available from N6AMG for $12.00 including potage), there is no reason for not using a good one. The most popular circuit is the GAASFET design published by W6PO.

   To protect the preamplifier from switching transients that can be coupled over to the power line for the preamp, the 12 VDC for the preamp should be run up through the center conductor of the receiving coax, using a "bias tee".

   The coax from the preamp to the receiver need not be anything special (most GAASFET's have plenty of gain to overcome the line loss on the output of the preamp). Just be sure that you have enough gain to overcome the noise figure of your receiver; you should see the S meter deflect slightly upward when the preamp is turned on. However,if the meter deflects more than one or two S units, you are overdriving the receiver and should add attenuation ahead of it to assure maximum sensitivity.

2. TRANSMISSION LINE - You MUST get as much power to the antenna as possible. In addition to using a good power amplifier, this means good quality low-loss transmission line which is as short as possible. You may not fully appreciate it in the beginning, but every decibel makes a very big difference in the number of stations who will be able to contact you, especially if you are using a small antenna and/or have less than 1000 watts in the shack. If you are running only several hundred watts, don't give up by any means - there are many stations around the world who have made numerous contacts at those power levels; it just means it is even more important to reduce your feedline losses.

   PHASING LINES - The same advice is true for the antenna phasing lines as for the main transmission line - the lower the loss, the better. Remember, this is all line loss AHEAD of your preamp and can affect your signal to noise ratio quite dramatically.

4. RELAYS - You will need two relays mounted at the antenna, preferably right on the power divider, to reduce losses ahead of the preamp. The main antenna relay should be capable of handling high power and switches the antenna between your transmission line and the preamplifier relay. This relay is ideally a "center off" type.

   The preamplifier relay should be a high isolation type (Transco "Y" relays are very widely used for this application) which will switch the preamp between the main antenna relay and a 50 ohm termination resistor. This relay must be of a type which will leave the preamp terminated into the 50 ohm load whenever the transmitter is on OR the station is not in operation; in other words, this relay should be energized for receive.

   Make sure your relay contacts are clean to avoid additional losses ahead of the preamp. Also be certain that the relays are closed before power is actually applied to the amplifier; no relay or preamp will last very long if things are "hot switched". If your main antenna relay does not have an extra set of contacts on it to control your amplifier, you should build a simple sequencing circuit to insure that the coaxial relays have time to close before power is applied.

5. GROUND GAIN - If you are located on the level and have a flat, clear horizon, you will probably enjoy a certain amount of "ground gain". This comes from additive reflections when the moon is near the horizon and can amount to as much as an extra 6 db! Obviously, if you have a small station, this may be the only way to develop enough gain for successful moonbounce contacts and you should therefore try to take advantage of ground gain by operating during the hour after moonrise and the hour before moonset.

6. OPERATING TIMES - Because the moon moves closer (perigee) and farther (apogee) from the Earth during the course of the month, there is about a 2 db difference in signals attributable to this alone. You will generally be most successful on moonbounce if you operate near perigee.

   Another consideration is the background sky noise. The sky behind the moon is not always quiet and, at times (particularly during the part of each month that the moon is further south in the sky), it can be extremely noisy. The quieter the sky behind the moon, the easier it will be to hear moonbounce signals. The quietest time is generally just after the moon has passed through its most northerly declination for the month and is moving southward in the sky. Of course, if the sun is too close to the sun, it will also be too noisy to operate successfully and for that reason most stations avoid operating within one day of "new moon".

   Most of the random activity is found when the moon is on a northern declination and within a couple of hours before moonset in Europe; this is called the "European Window". Depending on your location, you may do better operating at a different time.

7. SEQUENCING - Make sure that you use the proper QSO procedures and transmitting sequences.

8. TRACKING- Knowing where to point your antennas so they are aimed at the moon is very important. Most stations use computers to calculate the moon position so they can operate whether the moon is visible or not. Ten years ago I wrote a simple computer program to provide this information and there are now many versions of this program for all kinds of small personal computers. If you have a small computer or know someone who does have one, you should have no problem locating a version of the program which will run on that computer and provide you the aiming information you will need.

8. PATIENCE - Please do not become discouraged and give up! There are many additional factors such as ionospheric absorption, faraday rotation, scintillation and libration fading, which may sound very confusing. Basically, it all means that there are lots of reasons why a station may not hear you at the same time you hear him, or why you may not hear anything at all on a given day. Conditions change, however, and later in the day or on another day your results can be entirely different!

If you follow the above guidelines, you will be well on your way to a good start on 2 meter moonbounce and will discover that moonbounce is not so mysterious and difficult after all. I am looking forward to our first QSO!

Good DX and VY 73,

Lance Collister

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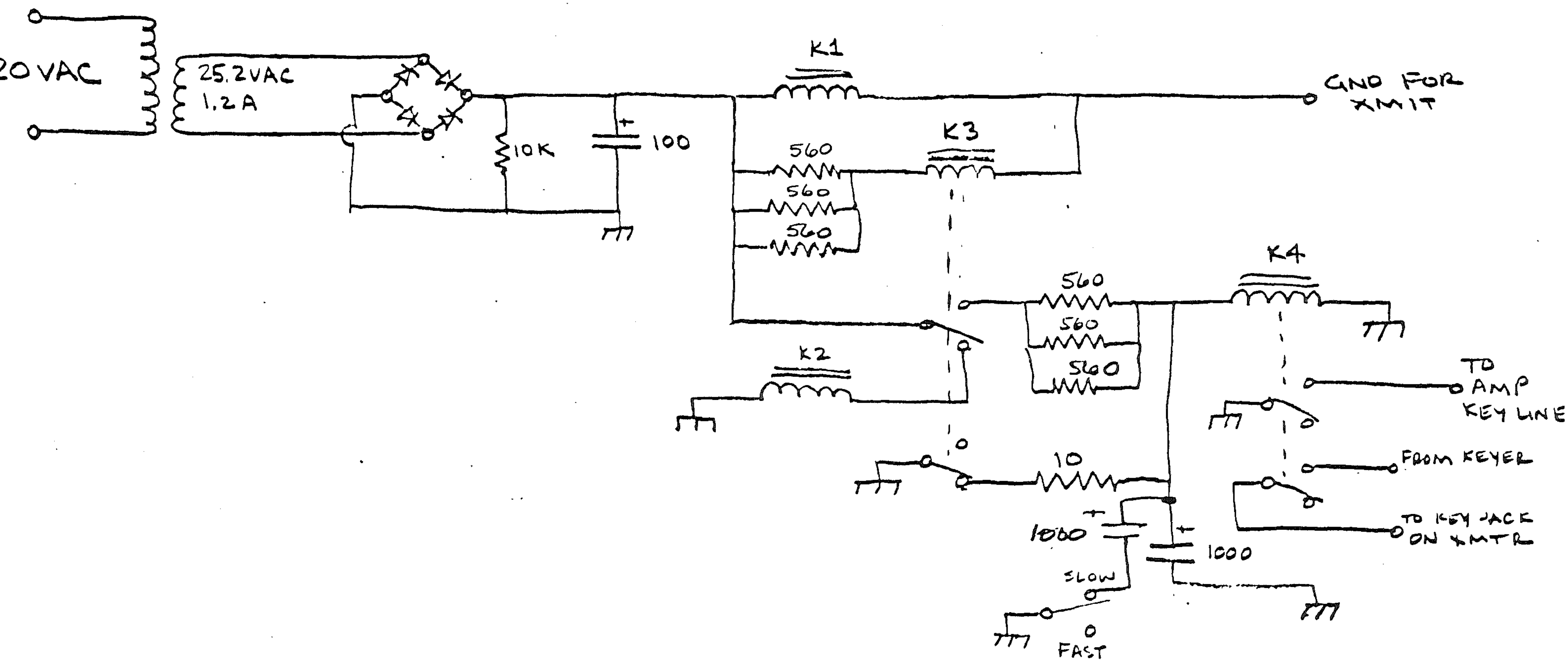
USA 59834

TEL: (406) 626-5728



NOTES

1. RELAYS SHOWN IN UNENERGIZED (RECEIVE) POSITION
2. ALL RESISTANCES IN OHMS. ALL RESISTORS 2 W
3. ALL CAPACITANCES IN µF. ALL CAPACITORS 50VDC.
4. ALL PARTS FROM RADIO SHACK
5. K1 28VDC TRANSCO COILS TO BE ENERGIZED DURING XMIT.
6. K2 28VDC TRANSCO COILS TO BE ENERGIZED DURING RCVE.
7. K K4 12VDC DPDT (RS # 275 206)

REPORTING SYSTEM

Though there has been discussion of modifying the meanings of the reports used on 144 MHz, the exchanges at the time this directory was prepared are defined as follows:

- T - Is sent when a signal is just barely detectable.
- M - Is sent when portions of callsigns have been copied.
- O - Is sent only after at least one complete set of callsigns has been copied.
- R - Is sent only after complete calls and "O" reports have been received by both stations.
- 73/SK - Can be sent after final R's have been received. (These are optional since the contact is complete as soon as one station receives final R's.

Because the "O" report is the only report which can be used to complete a contact under the definitions listed above, most stations never send "T" or "M" reports; instead, they use the time to send additional call sets which the other station may still be waiting to receive.

UTILIZATION OF THE SEQUENCE PERIOD

The first 90 seconds of each sequence is initially reserved for calls, with the final 30 seconds being used to send reports. If no reports can be sent, then the entire 2 minute sequence is used to send callsigns. Never mix the callsigns with the reports; keep the reports in the last 30 seconds to avoid confusion. It is also very important to alternate callsigns (SM7BAE DE W6PO SM7BAE DE W6PO); never send the same call twice in a row, since a signal rise which might enable you to copy a complete callsign set is useless if the only thing which comes across is a pair of the same callsigns. The only exception to this is when answering someone's random CQ; in those cases it is often helpful to send your callsign 3 times for each one of the CQ-er's callsign.

If complete callsign sets are not received or if only reports are received, call sets must continue to be sent. When complete call sets AND reports are received, "ROROROROROR" should be sent during the entire 2 minute sequence; if identification is given at all, it should be limited to one set of calls at the beginning and end of the sequence. Again, it is important to alternate - send "RORORO" (NOT "RRRR OOOO").

When RO's have been received, RRR's should be sent for the entire 2 minute sequence.

RST REPORTS

When signals are strong enough, standard RST reports can be exchanged. However, since the other station may not be hearing you as well as you [illegible] hearing him (which is not at all unusual, due to faraday rotation or differences in receiving or transmitting equipment), it is best to use the standard format and reporting system until the end of the contact and then send the RST reports along with 73's or SK's.

Date: Station: Freq: MHz

Time: to GMT Remarks:

EASTERN transmitting sequence	WESTERN transmitting sequence
00 - 02	02 - 04
04 - 06	06 - 08
08 - 10	10 - 12
12 - 14	14 - 16
16 - 18	18 - 20
20 - 22	22 - 24
24 - 26	26 - 28
28 - 30	30 - 32
32 - 34	34 - 36
36 - 38	38 - 40
40 - 42	42 - 44
44 - 46	46 - 48
48 - 50	50 - 52
52 - 54	54 - 56
56 - 58	58 - 60

FREQUENCIES USED

Almost all of the random CW activity is between 144.000 and 144.025 MHz. Schedules are usually made between 144.025 and 144.100 MHz. Remember that 144.045 to 144.055 is used for beacons in some parts of the USA and 144.050 is a CW calling frequency for tropo in Europe, so those are best avoided.

SSB OPERATION

When signals are strong enough for a possible SSB contact, both stations usually move up 100 kHz or 150 kHz from the CW QSO frequency. This is necessary because stations in the USA are not permitted to operate SSB below 144.100 MHz and the band plan in some parts of Europe requests all SSB activity to be above 144.150 MHz.

If the stations do QSY, it is usually easier to regain initial contact on CW and then switch to USB. The sequencing on SSB is usually 1 minute with the eastern station taking the first minute at the start of the hour (those minutes when a digital clock would be displaying an even minute). Signal reports are usually the RST system, but making both the "Readability" and "Signal" reports the same. Typical SSB reports would be "22","33","44" and "55". Additional clarification can be provided by actually counting out these signal reports, which works reasonably well even under weak signal conditions.

NEWSLETTERS

As of August 1984, there are several newsletters which contain information of interest to stations on 144 MHz EME:

2 Meter EME Bulletin Gene Shea, KB7Q, Editor 417 Staudaher Street Bozeman, MT 59715 USA	Rates: $12.00/yr (North America) $15.00/yr (Foreign) Published monthly and sent First Class or Airmail
VHF/UHF And Above Information Exchange Rusty Landes, KA0HPK, Editor P. O. Box 270 W.Terre Haute, IN 47885 USA	Rates:$15.00/yr(USA) $19.50/yr (Canada) $35.00/yr (Foreign) Published monthly and sent bulk rate in the USA, Air Mail to foreign
DUBUS Claus Neie, DL7QY, Editor D-7181 Rudolfsberg 24 West Germany	Published 4 times per year
Veron VHF Bulletin Henk Ripet, Editor Zuidbuurtseweg 1 3133 kc - Vlaardingen Netherlands	Rates:Free if you contribute information Published bi-monthly and sent Airmail worldwide

NETS

To help set up schedules for EME contacts and exchange information about EME on 144 MHz, the 2 Meter EME Net meets every Saturday and Sunday at 1700 UTC on 14.345 MHz. North and South American traffic is passed until 1800 UTC, at which time European and other DX stations are asked to call in.

The Central States VHF Society holds a net on 3.818 MHz at 0230 UTC Mondays (Sunday evening local time) to exchange general information relating to VHF and UHF topics.

There is also an EME meeting frequency of 145.950 MHz (downlink) on on amateur satellite AO-10.

144 MHZ EME OPERATING CONSIDERATIONS

In order to facilitate successful QSO's on 144 MHz, it is important to follow the accepted and proven guidelines described below. These procedures apply to both pre-arranged schedules and random contacts.

SCHEDULES AND SEQUENCES

Because faraday rotation at 144 MHz often completes one full cycle in an hour, most schedules are made for an hour period, using 2 minute sequences. It is accepted practice to have the eastern-most station transmit during the first 2 minutes of the hour and then alternate sequences with the western-most station. The terms "east" and "west" are defined with respect to the postion of the moon and have nothing to do with the International Dateline; for example, the station whose antenna would be pointing the farthest west, when aimed at the moon, is the eastern station. Note also that if a schedule should start on the half hour or on some other fraction of an hour, the sequencing does not become rearranged; the proper sequences are picked up so that when the schedule progresses to the top of the hour, the eastern station is still transmitting during the first 2 minute period. The table on the next page should eliminate any confusion regarding proper sequencing.

TIMING

It is very important that each station reset their clock using a time standard such as WWV every time they get on the air so that proper sequencing can be achieved.

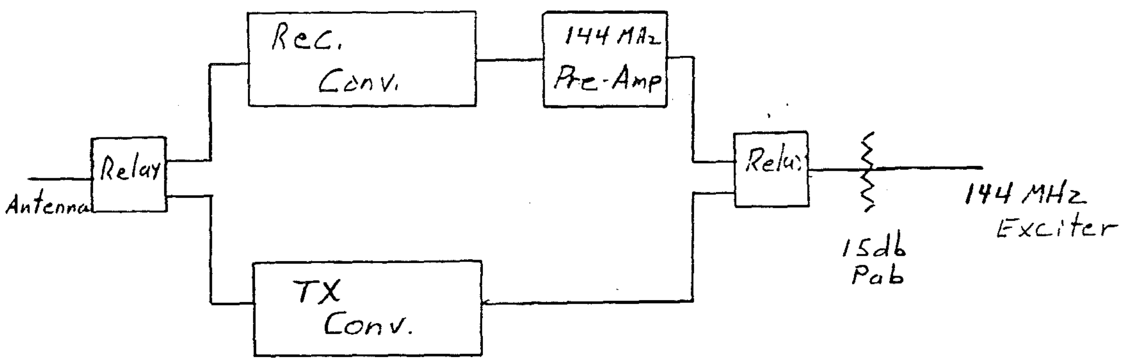
CW SPEED

Because signals are usually weak and most activity is in the CW portion of the band, CW is the predominant transmission mode. Best results can be obtained when speeds between 10 and 15 words per minute are used. This is because fading and flutter on EME signals can either break up really slow CW or cause entire letters or calls of fast CW to disappear.

CONTACT REQUIREMENTS

As in other modes of propagation, there are 3 basic requirements which must be met for a valid contact to take place:

1. Positive identification of callsigns.
2. Valid exchange of information. Typically, stations exchange signal reports to acknowledge receipt of callsigns.
3. Positive acknowledgement of the information exchange. Typically, R's are used to acknowledge that information has been exchanged, so one station winds up sending R's plus signal reports and the other station just finishes by sending R's.



Some of the new 2304 MHz and 1296 MHz transverters are now using GaAs FET mixers. Brief accidental transmissions back into the receive converters are fatal.

After several friends had lost their Microline 13cm Xverters I put an old 2 meter MOSFET pre-amp on the output of the 2304 MHz receive converter. This was followed by a T/R relay and the homebrew 15db pad is now used on both transmitt and receive.

If you do get enough power thru the 15db pad to blow anything, all you lose is a cheap MOSFET.

WA5VJB
Kent Britain

WA1JXN MOONTRACKING PROGRAM FOR IBM PC BASIC

I have made many revisions and updates to this program since it was first published in the EIMAC Technical EME Notes over ten years ago; unfortunately, most of the revisions were never published all together, but instead wound up appearing in partial forms as others translated more current versions of my original program to various computer languages and published those versions.

The following is a completely updated moontracking program, which includes all the modifications I have made over the years. It is designed to provide the most complete information for the EME amateur and was written to run in IBM PC BASIC.

The comment lines and the prompts in the program explain the general operation of the program and the features included. If additional clarification is required, please do not hesitate to contact me, but remember that I do not have manuals for other types of computers and will not be able to answer questions peculiar to computers other than IBM PC's.

This program and similar programs to track the sun and celestial noise sources are also available on diskette at no charge by sending a blank 5¼" diskette and self-addressed, stamped envelope for it to Gene Shea - KB7Q, 2 Meter EME Bulletin, 417 Staudaher Street, Bozeman, MT 59715.

Good luck and DX on EME!

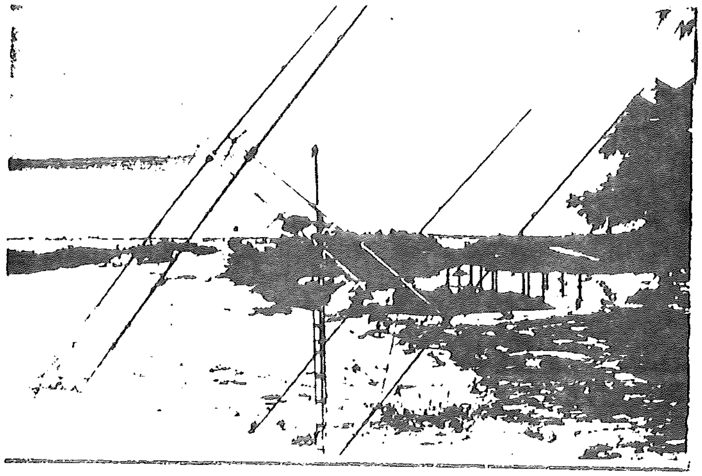
LANCE

Lance Collister WA1JXN
Box 73
Frenchtown, MT
USA 59834
TEL: (406) 626-5728

WA1JXN SUN AND MOON TRACKING PROGRAM REVISIONS

A bug has been found (thanks to the keen nose of K1MNS) in the latest IBM PC tracking programs, MOON.BAS and SUN.BAS. The symptom was erratic position calculations for the sun. The solution is very simple; just change the 3 following lines in both MOON.BAS <u>and</u> SUN.BAS:

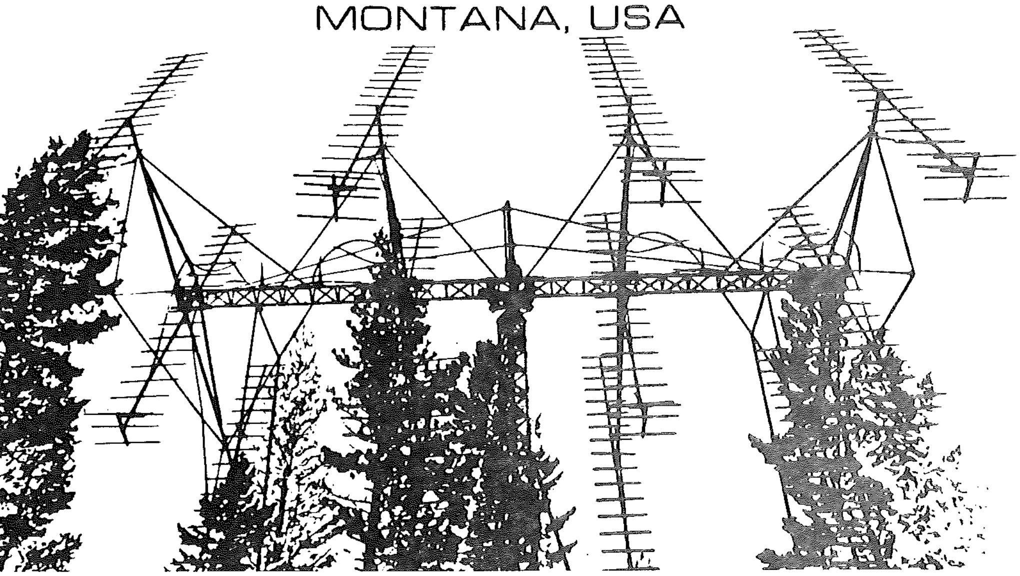
```
109 'REVISED MAY 28,1986
3725 SUNLON=FNC(.77691944444#+100.0021361#*T4)+FNC(.0053305556#-.00001333333#*T4
)*SIN(SUNM)+3.490659E-04*SIN(2*SUNM)
3733 IF LANGLE<PI*1.5 AND LANGLE>=PI/2 THEN LET SUNRA=SUNRA+PI
```



LANCE COLLISTER
TREASURE CAY
ABACO. BAHAMAS

WA1JXN/C6A

WA1JXN
MONTANA, USA



WA1JXN ANTENNA AS OF JAN 1, 1985:

16 X KLM 17 LBX YAGIS (17 elements) PHASED WITH 3/4" HARDLINE COAX AND FED WITH 1-5/8" COPPER GAS HELIAX.

```
100 'MOON.BAS
109 'REVISED MARCH 5,1986
110 '
120 'THIS PROGRAM WAS WRITTEN TO PROVIDE ACCURATE VISIBLE AZIMUTH AND ELEVATION
130 'COORDINATES FOR THE MOON AT ANY TIME AND DATE, FROM ANY LOCATION ON THE
140 'EARTH.  BECAUSE IT WAS WRITTEN PRIMARILY FOR AMATEUR RADIO OPERATORS WHO
150 'NEED MOON TRACKING DATA FOR EARTH-MOON-EARTH COMMUNICATIONS, SOME OF THE
155 'FEATURES AND PRINTOUT OPTIONS HAVE BEEN SPECIFICALLY DESIGNED TO PROVIDE
156 'INFORMATION THAT WOULD BE MOST USEFUL FOR THAT APPLICATION.
160 '
161 'SOME FEATURES OF THIS PROGRAM ARE:
162 '
163 '    1. PRINTOUT OF THE MONTH AND DAY OF THE WEEK IN ADDITION TO DATE
164 '    2. AUTOMATIC CALCULATION OF QTH LOCATOR CODE FROM INPUT COORDINATES
165 '    3. DAILY CALCULATION OF MOON DISTANCE AND SEMIDIAMETER FOR NOON GMT
166 '    4. DISPLAY OF NUMBER OF DAYS PAST APOGEE OR PERIGEE
167 '    5. GREENWICH HOUR ANGLE,RIGHT ASCENSION AND DECLINATION DISPLAYED
168 '    6. BACKGROUND SKY NOISE IS ESTIMATED FOR BOTH 144 AND 432 MHZ
169 '    7. "DB SENSITIVITY INDICES" (TAKING SKY NOISE AND MOON DISTANCE INTO
170 '       ACCOUNT) ARE CALCULATED FOR 144 AND 432 MHZ
171 '    8. CALCULATION OF MOON ACTIVITY "WINDOW", WITH DEFINITIONS AUTOMATI-
172 '       CALLY CHOSEN, DEPENDING ON YOUR (APPROXIMATE) IARU REGION.
173 '    9. A WARNING NOTE ("NM") DURING NEW MOON, AND PRINTOUT OF SOLAR
174 '       AZIMUTH AND ELEVATION INSTEAD OF SKY NOISE DURING THIS PERIOD
175 '   10. AUTOMATIC SKIP TO NEXT MOONRISE OR MOON WINDOW UPON MOONSET OR MOVE
176 '       OUT OF A SPECIFIED WINDOW (SUCH AS ONLY NEAR THE HORIZON), TO
177 '       INCREASE PROGRAM SPEED
178 '   11. AUTOMATIC DAY ADVANCE; YOU ONLY ENTER BEGINNING AND ENDING DATES
179 '
180 'SOME OF THE OPTIONS AVAILABLE AT RUN TIME ARE:
181 '
182 '    1. DEFAULT TO YOUR STATION ON A BLANK ENTRY FOR CALLSIGN
183 '    2. DEFAULT TO YOUR LOCATION ON YOUR CALLSIGN OR A BLANK CALLSIGN ENTRY
184 '    3. SELECTION OF HORIZON-ONLY PRINTOUT
185 '    4. SKIP ALL SUBSEQUENT INPUT OPTIONS BY ENTERING A BLANK AT CALLSIGN
186 '       OR "HORIZON ONLY?" PROMPTS
188 '    5. SPECIFY DIFFERENT ACTIVITY WINDOW REGION DEFINITIONS THAN NORMAL
197 '    6. SELECTION OF PRINTOUT ONLY DURING THE ACTIVITY WINDOWS, NORTH
198 '       DECLINATION, CERTAIN HOURS, OR ON GMT WEEKENDS
199 '    7. SIMULTANEOUS CALCULATION OF THE MOON'S AZIMUTH AND ELEVATION AT
200 '       YOUR LOCATION ALONG WITH THE PRINTOUT FOR THE OTHER STATION
201 '    8. VARIABLE TIME INCREMENTS FOR PRINTOUT
202 '    9. NUMBER OF ESTIMATED CALCULATIONS TO BE DONE IN BETWEEN ACTUAL
203 '       CALCULATIONS, FOR INCREASE IN PROGRAM SPEED (ACTUAL CALCULATIONS
204 '       ARE INDICATED BY A DOT AFTER THE "WINDOW" COLUMN ON THE PRINTOUT)
205 '   10. ENTRY OF A LOCATOR (PRECEDED BY ANY NON-NUMERIC AND NON-ALPHABETIC
206 '       CHARACTER) IN PLACE OF A CALLSIGN PERMITS AUTOMATIC CALCULATION
207 '       OF COORDINATES FOR THAT LOCATION
210 '
220 'THE OUTPUT DATA SHOULD BE ACCURATE TO WITHIN .5 DEGREES PROVIDED THE
230 'PROCESSOR IS CAPABLE OF PERFORMING CALCULATIONS WITH 8 SIGNIFICANT
240 'DIGITS.  THIS VERSION WAS WRITTEN IN IBM PC BASIC SPECIFICALLY TO RUN ON
250 'AN IBM PC/AT, ALTHOUGH THE PROGRAM SHOULD BE COMPATIBLE WITH ANY OF THE
260 'IBM PC'S OR OTHER "PC COMPATIBLES" WITH FEW (IF ANY) CHANGES. IT SHOULD
261 'PROVIDE ACCURATE DATA WELL INTO THE 21ST CENTURY AND DOES NOT REQUIRE
262 'ANY DAILY, MONTHLY OR ANNUAL PROGRAM OR ORBITAL UPDATES.
270 '
280 'OTHER VERSIONS OF THE PROGRAM, INCLUDING ONES IN DEC FORTRAN IV AND
285 'IBM BASIC FOR SYSTEMS 23,34 AND 36 HAVE BEEN WTITTEN BY THE AUTHOR,
290 'ALTHOUGH THE CODE IN THIS PARTICULAR PROGRAM IS THE MOST UP TO DATE.
295 '
296 'THIS PROGRAM IS FREE FOR ANYONE'S USE, PROVIDED THESE INTRODUCTORY REMARKS
297 'REMAIN AND CREDIT IS GIVEN TO THE AUTHOR.
310 '
320 'LANCE COLLISTER   WA1JXN
330 'P.O. BOX 73
335 'FRENCHTOWN, MT
340 'USA      59834
345 '
350 'TEL: (406) 626-5728
352 '
353 '
360 '*************************************************************************
362 LET TEMRA=60           'ENTER YOUR 144 MHZ RCVR TEMP HERE
363 LET TEMRB=80           'ENTER YOUR 432 MHZ RCVR TEMP HERE
366 LET NESTS=4 'ENTER DEFAULT NUMBER OF ESTIMATES BETWEEN ACTUAL CALCULATIONS
367 LET YCSIGN$="WA1JXN"  'ENTER YOUR CALLSIGN HERE
368 LET YLATDP=47.048333# 'ENTER YOUR LATITUDE IN DEGREES HERE
369 LET YLONDP=114.25556# 'ENTER YOUR LONGITUDE IN DEGREES HERE
370 '*************************************************************************
371 LET B1=0
372 LET E=2400
375 PI =3.141592656#
376 DIM H(51),RTEMA(51),RTEMB(51),WKDAY$(10)
377 LET TUPI =2*PI
378 LET RAD=TUPI/360
379 LET DEG=360/TUPI
380 DEF FNA(X)=INT(X*DEG*10+.5)/10
381 DEF FNB(X)=INT(X*100+.5)/100
382 DEF FNC(X)=(X-INT(X))*TUPI
383 DEF FNR(A,B)=INT(A*B+.5)/B
384 DEF FNL(X)=LOG(X)/LOG(10) 'COMMON LOGARITHM OF X
388 DEF FNJULIAN(AY,AM,AD)=367*AY-INT(7*(AY+INT((AM+9)/12))/4)+INT(275*AM/9)+AD-
676534! 'JULIAN DATE (MINUS 2397547.5) FOR 0000 HOURS GMT, YEARS 1900-2099.
389 DEF FNATAN2(S,C)=ATN(S/C)-SGN(S)*PI*(FIX(SGN(C)-.5))
392 '**********************LOAD SKY TEMPERATURE DATA**********************
393 FOR I%=1 TO 50
394 READ H(I%),RTEMA(I%),RTEMB(I%) 'RIGHT ASCENSION,136MHZ ,400MHZ SKY TEMPS
```

```
396 LET RTEMA(I%)=RTEMA(I%)*.87 '144 MHZ SKY TEMP IN DEGREES KELVIN
398 LET RTEMB(I%)=RTEMB(I%)*.83 '432 MHZ SKY TEMP IN DEGREES KELVIN
400 NEXT I%
410 DATA 0,275,24,.5,300,24.5,1,320,25,1.5,340,25.5,2,350,27
420 DATA 2.5,400,29,3,425,30,3.5,400,28,4,425,30.5,4.5,460,34.5
430 DATA 5,500,37.5,5.5,575,45,6,575,44.5,6.5,475,37.5,7,425,32
440 DATA 7.5,350,25.5,8,260,19.5,8.5,230,17.5,9,200,15,9.5,210,15.5
450 DATA 10,215,16.5,10.5,225,17.5,11,235,18,11.5,245,19,12,300,22.5
460 DATA 12.5,360,27.5,13,360,27.5,13.5,350,25,14,375,27,14.5,415,30
470 DATA 15,450,32.5,15.5,480,35,16,550,39,16.5,700,45,17,1000,55
480 DATA 17.5,1850,110,18,3800,180,18.5,2400,160,19,1000,80,19.5,600,52
490 DATA 20,425,32,20.5,375,28.5,21,375,27.5,21.5,375,27.5,22,340,25
500 DATA 22.5,280,22,23,280,22.5,23.5,275,23,24,275,23.5,24.5,300,24.5
680 '*******************START OF DATA INPUT SECTION******************
690 CLS
700 INPUT "What is the CALLSIGN";CSIGN$
705 IF CSIGN$=YCSIGN$ OR CSIGN$="" THEN 711 ELSE 725
711 LET ULATDP=YLATDP    'DEFAULTS TO YOUR LATITUDE
712 LET ULONDP=YLONDP    'DEFAULTS TO YOUR LONGITUDE
713 IF CSIGN$=YCSIGN$ THEN 770 'GIVES YOU A CHANCE TO USE PROMPTS
714 LET CSIGN$=YCSIGN$ 'DEFAULTS TO YOUR CALL,SKIPS PROMPTS ON BLANK ENTRY
720 GOTO 1150
725 LET FIRST=ASC(LEFT$(CSIGN$,1))
726 IF FIRST>90 OR  FIRST<48 THEN 728
727 IF FIRST>57 AND FIRST<65 THEN 728 ELSE 760
728 LET LCALL=LEN(CSIGN$)
729 LET X=0
730 IF LCALL=7 THEN 740
732 IF LCALL=5 THEN 733 ELSE 736
733 LET CSIGN$=CSIGN$+"MM"
734 GOTO 742
736 IF LCALL=3 THEN LET CSIGN$=CSIGN$+"55MM" ELSE 700
737 GOTO 742
740 LET X=.5
742 LET CSIGN$=RIGHT$(CSIGN$,6)
745 LET ULONDP=180-(ASC(MID$(CSIGN$,1,1))-65)*20-(VAL(MID$(CSIGN$,3,1)))*2-((ASC
(MID$(CSIGN$,5,1))-65)+X)/12 'LONGITUDE FROM LOCATOR
750 LET ULATDP=-90+(ASC(MID$(CSIGN$,2,1))-65)*10+VAL(MID$(CSIGN$,4,1))+((ASC(MID
$(CSIGN$,6,1))-65)+X)/24      'LATITUDE FROM LOCATOR
755 GOTO 770
760 INPUT "What is the LATITUDE in DEG,MIN,SEC (+ for north)";ULATDP,ULATMP,ULAT
SP
765 INPUT "What is the LONGITUDE in DEG,MIN,SEC (+ for west)";ULONDP,ULONMP,ULON
SP
770 INPUT "Do you only want printout near the horizon";ANS1$
780 IF ANS1$="" THEN 1150 'SKIP ALL THE PROMPTS ON A BLANK ENTRY TO THIS
790 IF ANS1$= "YES" THEN 800 ELSE 850
800 INPUT "Below what elevation in degrees do you want printout";BELEV
850 INPUT "Do you want printout only during north declination";ANS2$
860 INPUT "What moon activity window definition do you want (IARU Region #)";REG
ION
870 INPUT "Do you want printout only during European window";ANS3$
890 INPUT "Do you want printout only during N. American window";ANS4$
910 INPUT "Do you want printout only during the Asian window";ANS5$
970  INPUT "Do you only want printout on GMT weekends";ANS8$
975 INPUT  "Do you also want your own moon positions printed";ANS9$
980 INPUT "Do you want printout only between specific times";ANS6$
990 IF ANS6$="YES" THEN 1030  ELSE 1090
1030 INPUT "What are GMT beginning,ending times";B1,E
1090 INPUT "What is desired printout increment in minutes";DINC
1130 INPUT "How many estimated positions do you want between calcs";NEST$
1150 INPUT "What is beginning date (YY,MM,DD)";AY1,AM1,AD1
1210 INPUT "What is the ending date (YY,MM,DD)";EY,EM,ED
1220 '*********************END OF DATA INPUT SECTION*****************
1225 LET ULATD=ULATDP+SGN(ULATDP)*ABS(ULATMP)/60+SGN(ULATDP)*ABS(ULATSP)/3600
1230 LET ULATDP=INT(ABS(ULATDP))
1231 LET ULATMP=INT((ABS(ULATD)-INT(ABS(ULATD)))*60)
1232 LET ULATSP=INT((((ABS(ULATD)-INT(ABS(ULATD)))*60)-ULATMP)*60+.5)
1233 LET ULOND=ULONDP+SGN(ULONDP)*ABS(ULONMP)/60+SGN(ULONDP)*ABS(ULONSP)/3600
1234 LET ULONDP=INT(ABS(ULONDP))
1235 LET ULONMP=INT((ABS(ULOND)-INT(ABS(ULOND)))*60)
1236 LET ULONSP=INT((((ABS(ULOND)-INT(ABS(ULOND)))*60)-ULONMP)*60+.5)
1237 IF ULOND>-80 AND ULOND=<40 AND REGION<1 THEN LET REGION=1
1238 IF ULOND>40 AND ULOND=<160 AND REGION<1 THEN LET REGION=2
1239 IF ULOND>160 OR ULOND<=-80 AND REGION<1 THEN LET REGION=3
1240 GOSUB 3080
1241 LET ULATD=ULATD*RAD
1242 LET YLATD=YLATDP*RAD
1243 LET ULOND=ULOND*RAD
1244 LET YLOND=YLONDP*RAD
1246 IF ULATD>0 THEN LET LA$="N" ELSE LET LA$="S"
1247 IF ULOND>0 THEN LET LO$="W" ELSE LET LO$="E"
1248 LET BELEV=BELEV*RAD
1249 IF BELEV=0 THEN LET BELEV=100/DEG
1251 LET AY1=AY1+1900
1252 LET EY=EY+1900
1255 LET LON=ULOND
1256 LET LAT=ULATD
1260 IF DINC=<1.99 THEN LET DINC=15
1265 IF NEST$="" THEN LET NEST=NEST3 ELSE LET NEST=VAL(NEST$)
1268 IF ANS3$><"YES" AND ANS4$><"YES" AND ANS5$><"YES" THEN LET FLAG3=0 ELSE LET
 FLAG3=1
1270 LET MPOS=-1 'NO CALCULATIONS DONE YET
1280 LET FLAG4=0 'NO SETTING HORIZON WINDOW TIMES CALCULATED YET
1291 LET BJUL=FNJULIAN(AY1,AM1,AD1)
1292 LET EJUL=FNJULIAN(EY,EM,ED)
1295 LET DATEJ=BJUL-14
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1296 FOR I=1 TO 13
1297 LET DATEJ=DATEJ+1
1298 GOSUB 3800
1299 NEXT I
1300 LET DATEJ=BJUL
1310 '*****************START OF MAIN CALCULATING LOOP***********************
1311 GOSUB 2993 'CALCULATE DAY OF THE WEEK
1312 GOSUB 3600 'CALCULATE MOON DISTANCE AND PATH LOSS
1313 IF ANSB$="YES" THEN 1314 ELSE 1320
1314 IF WKDAY=1 OR WKDAY=7 THEN 1320 ELSE 1315
1315 LET MPOS=-1
1316 LET FLAG4=0
1317 GOTO 2580
1320 GOSUB 3700
1322 LET T3=DATEJ-35735!
1323 LET A=.0657098232#*T3
1328 LET FLAG1=2 'NO CALCULATIONS DONE YET
1330 IF MPOS<1 OR EL>0 THEN 1400
1340 IF B1>RTIME THEN 1390
1350 LET B=RTIME
1360 LET FLAG2=NEST
1370 LET MPOS=0 'MOON ABOUT TO RISE-PREPARE TO RESET RTIME WHEN IT RISES
1380 GOTO 1410
1390 LET MPOS=0
1400 LET B=B1
1410 IF FLAG4=3 THEN 1411 ELSE 1420
1411 LET B=STIME
1412 LET FLAG2=NEST
1413 LET FLAG4=1 'READY TO RESET STIME WHEN MOON COMES DOWN INTO HORIZON WINDOW
1414 IF B1>STIME THEN LET B=B1
1420 LET DIF1=B-INT(B/100+.5)*100+INT(B/100+.5)*60-(E-INT(E/100+.5)*100+INT(E/10
0+.5)*60)
1430 IF DIF1>0 THEN 1440 ELSE 1470
1440 IF DIF1<DINC THEN 1450 ELSE 2580
1450 LET B=E
1470 LET T=(B-INT(B/100)*100)/1440+INT(B/100)/24 'FRACTION OF THE DAY
1475 LET SUNRA=SUNRAS+T*.0186625# 'ESTIMATE RIGHT ASCENSION OF THE SUN
1476 IF SUNRA>TUPI THEN LET SUNRA=SUNRA-TUPI
1480 IF FLAG1<2 THEN 1490 ELSE 1530
1490 IF FLAG2<NEST THEN 1500 ELSE 1530
1500 LET FLAG2=FLAG2+1
1505 LET EST$=" "
1510 LET GAST=GAST+.016677*DINC 'ESTIMATE GREENWICH APPARENT SIDEREAL TIME
1515 LET RA=RA+DINC*.00016      'ESTIMATE LUNAR RIGHT ASCENSION
1520 GOTO 1775
1525 '**********CALCULATION OF LATITUDE AND LONGITUDE OF THE MOON************
1530 LET FLAG2=0
1535 LET EST$=CHR$(250) 'PRINTS OUT A DOT AFTER WINDOW FIELD FOR REAL CALCS
1540 LET T5=DATEJ-17472.5#+T
1550 LET D1=FNC(.751213#+.036601102# *T5)
1560 LET D2=FNC(.822513#+.0362916457# *T5)
1570 LET D3=FNC(.995766#+.00273777852# *T5)
1580 LET D4=FNC(.974271#+.0338631922# *T5)
1590 LET D5=FNC(.0312525#+.0367481957# *T5)
1600 LET DLON=D1+RAD*(.658*SIN(2*D4)+6.289*SIN(D2)-1.274*SIN(D2-2*D4)-.186*SIN(D
3)+.214*SIN(2*D2)-.114*SIN(2*D5)-.059*SIN(2*D2-2*D4)-.057*SIN(D2+D3-2*D4))
1610 LET S=D5+RAD*(.6593*SIN(2*D4)+6.2303*SIN(D2)-1.272*SIN(D2-2*D4))
1620 LET DLAT=RAD*(5.144*SIN(S)-.146*SIN(D5-2*D4))
1630 '**************CALCULATION OF RIGHT ASCENSION AND DECLINATION**********
1640 LET DEC1=COS(DLAT)*SIN(DLON)*.397821+SIN(DLAT)*.917463
1650 LET DEC2=ABS(DEC1)
1660 LET DEC=FNATAN2(DEC1,SQR(1-DEC2*DEC2))
1670 IF ANS2$="YES" OR FLAG3=1 THEN 1680 ELSE 1690
1680 IF DEC<0 THEN 1970
1690 LET RAC=COS(DLAT)*COS(DLON)/COS(DEC)
1700 LET RAS=(COS(DLAT)*SIN(DLON)*.917463-SIN(DLAT)*.397821)/COS(DEC)
1710 LET RA=FNATAN2(RAS,RAC)
1745 '*************CALCULATION OF GREENWICH APPARENT SIDEREAL TIME***********
1750 LET GMST=6.67170278#+(A-INT(A/24)*24)+1.0027379093#*T*24 'GREENWICH MEAN SI
DEREAL TIME IN HOURS
1755 LET OMEGA=(372.1133#-.0529539#*(T3+T))*RAD
1760 LET OMEGA=OMEGA-INT(SGN(OMEGA)*OMEGA/TUPI)*TUPI*SGN(OMEGA)
1765 IF ABS(OMEGA)<PI THEN LET OMEGA=OMEGA-TUPI*SGN(OMEGA)
1770 LET GAST=GMST+.00029*SIN(OMEGA) 'GREENWICH APPARENT SIDEREAL TIME IN HRS.
1775 LET GAST=GAST-INT(GAST/24)*24
1780 IF RA<0 THEN LET RA=TUPI+RA
1781 IF RA>TUPI THEN LET RA=RA-TUPI
1790 GOSUB 4000 'CALCULATE GHA AND ELEVATION
1800 IF EL<0 THEN 2090 ELSE 1840
1840 '******************CHECK TO SEE WHAT WINDOW MOON IS IN******************
1845 LET MOONWINDOW$ = " "
1850 IF DEC<0 THEN 1960
1855 ON REGION GOSUB 4200,4300,4400
1930 IF MOONWINDOW$="E" AND ANS3$="YES" THEN 2050
1940 IF MOONWINDOW$="N" AND ANS4$="YES" THEN 2050
1950 IF MOONWINDOW$="A" AND ANS5$="YES" THEN 2050
1960 IF FLAG3=0 THEN 2050 ELSE 1970
1970 IF DEC<-.1047 THEN 1315 ELSE 2530
1980 '**************CHECK FLAGS FOR MOONRISES AND SETS**********************
2050 IF MPOS=0 THEN 2060 ELSE 2140
2060 LET MPOS=1 ' MOON HAS JUST RISEN-SET RTIME
2070 LET RTIME=B
2080 GOTO 2140
2090 IF MPOS<0 THEN 2110 ELSE 2100
2100 IF MPOS=0 THEN 2530 ELSE 2130
2110 LET MPOS=0 'MOON HAS BEEN CALCULATED TO BE BELOW HORIZON-WAITING NOW TO CAL
CULATE FIRST RISE TIME
2120 GOTO 2530
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2130 IF RTIME>B THEN 1350 ELSE 2580 'JUMP TO NEXT RISE TIME
2140 IF EL<=BELEV THEN 2160
2145 IF FLAG4=2 THEN 2151 ELSE 2146 'MOON UP BUT NOT IN DESIRED HORIZON WINDOW-C
HECK TO SEE IF A SET TIME HAS BEEN DETERMINED
2146 IF MPOS=1 THEN LET FLAG4=1 'PREPARE TO SET STIME WHEN MOON COMES DOWN INTO
HORIZON WINDOW
2147 GOTO 2530
2151 LET FLAG4=3 'READY TO JUMP AHEAD TO SETTING HORIZON
2153 IF STIME>B THEN 1410 ELSE 2580
2160 IF MPOS=1 AND FLAG4=1 THEN 2170 ELSE 2210
2170 LET FLAG4=2 'MOON HAS RISEN ONCE AND STIME IS BEING SET
2180 LET STIME=B 'TIME AT WHICH MOON COMES DOWN BELOW CHOSEN ELEVATION
2210 GOSUB 4100 'CALCULATE AZIMUTH OF THE MOON
2255 '**************************CHECK FOR NEW MOON**************************
2256 LET RADIF=ABS(RA-SUNRA)
2257 IF RADIF>PI THEN LET RADIF=ABS(RADIF-TUPI)
2258 IF RADIF<.1134464 THEN LET NEWMOON$="NM" ELSE LET NEWMOON$="  " 'SEE IF SUN
 IS WITHIN 6.5° OF MOON
2270 IF FLAG1<2 THEN 2390 ELSE 2271
2271 '**************************PRINT OUT HEADINGS************************
2280 LET NM1=INT(AM1)
2305 GOSUB 3500 'DETERMINE MONTH OF THE YEAR
2310 LPRINT CHR$(12) 'FORM FEED
2320 LPRINT MO$;:LPRINT  USING " ##_,";INT(AD1);:LPRINT USING "####";INT(AY1);:L
PRINT TAB(18);:LPRINT USING "###_°";ULATDP;:LPRINT USING "##_'";ULATMP;:LPRINT U
SING "##";ULATSP;:LPRINT CHR$(34); " "; LA$;TAB(32);"MOON POSITION FOR ";CSIGN$;
TAB(62);
2325 LPRINT TAB(62);"RANGE: ";:LPRINT USING " ###,### _K_M";RANGE
2330 LPRINT WKDAY$;TAB(18);:LPRINT USING "###_°";ULONDP;:LPRINT USING "##_'";ULO
NMP;:LPRINT USING "##";ULONSP;:LPRINT CHR$(34); " "; LO$ ;TAB(34);"(PRINTED BY "
;YCSIGN$;")";TAB(62);GEE$;TAB(63);:LPRINT USING "_+## _D_A_Y_S";PDAYS;
2340 LPRINT USING "###.##_'_S_D";FNR(SEMIDIA,100)
2350 LPRINT "JD:";DATEJ+2397547.5#;TAB(18);"(QTH:";LOCATOR$;")"
2360 IF ANS9$="YES" THEN 2362 ELSE 2370
2362 LPRINT TAB(43);"MOON FOR ";YCSIGN$;TAB(62);"144 MHZ   432 MHZ"
2363 LPRINT "GMT";TAB(8);"NOTES";TAB(17);"W AZIMUTH";TAB(29);"ELEV";TAB(37);"DEC
";TAB(43);"AZIMUTH";TAB(53);"ELEV";TAB(62);"°K   DB   °K   DB"
2365 LPRINT "====";TAB(7);"========";TAB(17);"= =======";TAB(28);"======";TAB(36
);"=====";TAB(43);"=======";TAB(52);"======";TAB(61);"========= ========="
2369 GOTO 2390
2370 LPRINT TAB(62);"144 MHZ   432 MHZ"
2375 LPRINT "GMT";TAB(8);"NOTES";TAB(17);"W AZIMUTH";TAB(29);"ELEV";TAB(38);"GHA
";TAB(46);"DEC";TAB(52);"RT ASCN";TAB(62);"°K   DB   °K   DB"
2380 LPRINT "====";TAB(7);"========";TAB(17);"= =======";TAB(28);"======";TAB(36
);"=======";TAB(45);"=====";TAB(52);"=======";TAB(61);"========= ========="
2390 '***********************PRINT OUT DATA********************************
2395 IF T-FLAG1<2*DINC/1440 THEN 2410
2400 LPRINT 'LINE FEED IF MOON HAS SET PREVIOUSLY
2410 LET NB=INT(B*10+.5)/10
2412 LET H$=""
2413 IF NB<1000 THEN LET H$="0"
2414 IF NB<100 THEN LET H$="00"
2415 IF NB<10 THEN LET H$="000"
2416 LET GMT$=H$+RIGHT$(STR$(NB),(LEN(STR$(NB))-1))
2460 LET RAH=RA/TUPI*24
2470 LET IRAP1=INT(RAH)
2480 LET IRAP2=INT((RAH-IRAP1)*60)
2490 GOSUB 3015 'CALCULATE SKY TEMPS AND DB INDICES
2491 IF ANS9$= "YES" THEN  2492 ELSE 2507
2492 LPRINT GMT$;TAB(7);NEWMOON$;TAB(17);MOONWINDOW$;EST$;:LPRINT USING " ###.#
 ";FNA(AZ),FNA(EL);:LPRINT USING " ###.# ";FNA(DEC);
2493 LET LAT=YLATD
2494 LET LON=YLOND
2495 GOSUB 4000
2496 IF EL>= 0 THEN 2497 ELSE 2500
2497 GOSUB 4100
2498 LPRINT USING "  ###.# ";FNA(AZ),FNA(EL);
2500 LET LAT=ULATD
2501 LET LON=ULOND
2506 GOTO 2508
2507 LPRINT GMT$;TAB(7);NEWMOON$;TAB(17);MOONWINDOW$;EST$;:LPRINT USING " ###.#
 ";FNA(AZ),FNA(EL);:LPRINT USING "  ###.# ";FNA(GHA),FNA(DEC);:LPRINT USING " ##
_H";IRAP1;:LPRINT USING " ##_M";IRAP2;
2508 IF NEWMOON$="NM" THEN 2511 ELSE 2526
2511 LET MR=RA
2512 LET MD=DEC
2513 LET RA=SUNRA
2514 LET DEC=SUNDEC
2515 LET FLAG5=1
2516 GOSUB 4000
2517 IF EL>=0 THEN 2518 ELSE 2521
2518 GOSUB 4100
2519 LPRINT TAB(61);:LPRINT USING "####.# _A_Z";FNA(AZ);:LPRINT USING "  ###.# _
E_L";FNA(EL)
2520 GOTO 2522
2521 LPRINT TAB(62);"SUN BELOW HORIZON"
2522 LET RA=MR
2523 LET DEC=MD
2524 LET FLAG5=0
2525 GOTO 2529
2526 LPRINT TAB(61);:LPRINT USING "####";KTEMPA;:LPRINT USING "###.#";FNR(DBA,10
);:LPRINT USING " ###";KTEMPB;:LPRINT USING " ###.#";FNR(DBB,10)
2529 LET FLAG1=T
2530 LET B=FNR(B+DINC,1000)
2540 LET Z=B-INT(B/100)*100-60
2550 IF Z<0 THEN 1420 ELSE 2560
2560 LET B=INT(B/100)*100+100+Z
2570 GOTO 1420
```

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2580 GOSUB 2790
2590 LET DATEJ=FNR(DATEJ,10)
2610 IF DATEJ-EJUL>.5 THEN 2620 ELSE 1310
2620 LPRINT CHR$(12)
2625 LPRINT CHR$(12)
2630 GOTO 6000
2790 '****SUBROUTINE TO INCREMENT DAY AND CORRECT DATE FOR MONTH AND YEAR****
2800 IF AD1<28 THEN 2980 ELSE 2810
2810 IF AM1=2 THEN 2820 ELSE 2860
2820 IF AY1=400*INT(AY1/400) THEN 2850 ELSE 2830
2830 IF AY1=100*INT(AY1/100) THEN 2950 ELSE 2840
2840 IF AY1=4*INT(AY1/4) THEN 2850 ELSE 2950
2850 IF AD1<29 THEN 2980 ELSE 2950
2860 IF AD1<30 THEN 2980 ELSE 2870
2870 IF AD1=30 THEN 2880 ELSE 2920
2880 IF AM1=4 THEN 2950 ELSE 2890
2890 IF AM1=6 THEN 2950 ELSE 2900
2900 IF AM1=9 THEN 2950 ELSE 2910
2910 IF AM1=11 THEN 2950 ELSE 2980
2920 IF AM1=12 THEN 2930 ELSE 2950
2930 LET AY1=INT((AY1+1)*100+.5)/100
2940 LET AM1=0
2950 LET AD1=1
2960 LET AM1=AM1+1
2970 GOTO 2990
2980 LET AD1=AD1+1
2990 LET DATEJ=DATEJ+1 ' NOW ALSO INCREASE JULIAN DATE BY ONE DAY
2991 RETURN
2992 '********************SUBROUTINE TO CALCULATE GMT DAY OF THE WEEK**********
2993 LET WKDAY=1+DATEJ-INT(DATEJ/7)*7
2994 ON WKDAY GOTO 2995,2997,2999,3001,3003,3005,3007
2995 LET WKDAY$="SUNDAY"
2996 GOTO 3008
2997 LET WKDAY$="MONDAY"
2998 GOTO 3008
2999 LET WKDAY$="TUESDAY"
3000 GOTO 3008
3001 LET WKDAY$="WEDNESDAY"
3002 GOTO 3008
3003 LET WKDAY$="THURSDAY"
3004 GOTO 3008
3005 LET WKDAY$="FRIDAY"
3006 GOTO 3008
3007 LET WKDAY$="SATURDAY"
3008 RETURN
3015 '********SUBROUTINE TO CALCULATE BACKGROUND SKY TEMPERATURE**********
3016 LET DBR=.0000451906#*((RANGE-PRANGE)*(T-.5)+RANGE)-16.3636 'DB DEGRADATION
FROM MOON DISTANCE, COMPARED TO PERIGEE
3020 FOR I%=2 TO 50
3025 IF H(I%)>RAH THEN 3050
3030 NEXT I%
3050 LET KTEMPA=INT((RTEMA(I%)-RTEMA(I%-1))/.5*(RAH-H(I%-1))+RTEMA(I%-1))
3070 LET KTEMPB=INT((RTEMB(I%)-RTEMB(I%-1))/.5*(RAH-H(I%-1))+RTEMB(I%-1))
3071 LET DBA=DBR+10*FNL((TEMRA+KTEMPA)/(TEMRA+174))   '144 MHZ DB INDEX
3072 LET DBB=DBR+10*FNL((TEMRB+KTEMPB)/(TEMRB+12.45)) '432 MHZ DB INDEX
3073 RETURN
3075 RETURN
3080 '******SUBROUTINE TO CALCULATE LOCATOR FROM LAT & LON IN DEGREES******
3081 IF ULATD=90 THEN LET LOCATOR$="N POLE"
3082 IF ULATD=-90 THEN LET LOCATOR$="S POLE"
3083 IF LOCATOR$="" THEN 3084 ELSE 3100
3084 IF ULOND=-180 THEN LET ULOND=180
3085 LET ZLO=(180-ULOND)/20
3086 LET ZLA=(ULATD+90)/10
3087 LET ZA=INT(ZLO)
3088 LET ZB=INT(ZLA)
3089 LET ZLO=(ZLO-ZA)*10
3090 LET ZLA=(ZLA-ZB)*10
3091 LET ZC=INT(ZLO)
3092 LET ZD=INT(ZLA)
3095 LET LOCATOR$=CHR$(65+ZA)+CHR$(65+ZB)+CHR$(48+ZC)+CHR$(48+ZD)+CHR$(65+INT((Z
LO-ZC)*24))+CHR$(65+INT((ZLA-ZD)*24))
3100 RETURN
3500 '***********SUBROUTINE TO DETERMINE MONTH OF THE YEAR******************
3511 IF NM1=1 THEN LET MO$="JAN"
3512 IF NM1=2 THEN LET MO$="FEB"
3513 IF NM1=3 THEN LET MO$="MAR"
3514 IF NM1=4 THEN LET MO$="APR"
3515 IF NM1=5 THEN LET MO$="MAY"
3516 IF NM1=6 THEN LET MO$="JUN"
3517 IF NM1=7 THEN LET MO$="JUL"
3518 IF NM1=8 THEN LET MO$="AUG"
3519 IF NM1=9 THEN LET MO$="SEP"
3520 IF NM1=10 THEN LET MO$="OCT"
3521 IF NM1=11 THEN LET MO$="NOV"
3522 IF NM1=12 THEN LET MO$="DEC"
3550 RETURN
3700 '***CALCULATION OF SUN'S RIGHT ASCENSION AND DECLINATION AT 0 HRS GMT*****
3723 LET T4=(DATEJ-17472.5)/36525!
3724 LET SUNM=FNC(.9957667#+99.997361#*T4 )
3725 SUNLON=FNC(.7769194#+100.00214#*T4)+FNC(.0053306#-.0000133#*T4)*SIN(SUNM)+.
0000556#*SIN(2*SUNM)
3726 LET EPSILON=FNC(.0651444#-.0000361#*T4)
3730 LET SUNRA=ATN(COS(EPSILON)*TAN(SUNLON))
3731 LET LANGLE=SUNLON-INT(SUNLON/TUPI)*TUPI
3733 IF LANGLE<PI*1.5 AND LANGLE>=PI/4 THEN LET SUNRA=SUNRA+PI
3735 LET SUNRAS=SUNRA-INT(SUNRA/TUPI)*TUPI
3740 LET SUNDEC=SIN(EPSILON)*SIN(SUNLON)
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3741 LET SUNDEC=FNATAN2(SUNDEC,SQR(1-SUNDEC*SUNDEC))
3745 RETURN
3800 '*****SUBROUTINE TO CALCULATE GEOCENTRIC MOON DISTANCE AT GMT NOON******
3801 LET PRANGE=RANGE
3803 LET T8=(DATEJ-53997!) 'TIME AT NOON
3804 LET F2=FNC(.374897#+.03629164709#*T8)
3805 LET F3=FNC(.259091#+.0367481952#*T8)
3806 LET F4=FNC(.827362#+.0338631919B#*T8)
3808 LET F8=FNC(.993126#+.00273777B5#*T8)
3810 LET RANGE=60.36298-3.27746*COS(F2)-.57994*COS(F2-2*F4)-.46357*COS(2*F4)-8.9
04001E-02*COS(2*F2)+.03865*COS(2*F2-2*F4)-.03237*COS(2*F4-F8)-.02688*COS(F2-2*F4
)-.02358*COS(F2-2*F4+F8)-.0203*COS(F2-F8)+.01719*COS(F4)+.01671*COS(F2+F8)
3815 LET RANGE1=.01247*COS(F2-2*F3)+.00704*COS(F8)+.00529*COS(2*F4+F8)-.00524*CO
S(F2-4*F4)+.00398*COS(F2-2*F4-F8)-.00366*COS(3*F2)-.00295*COS(2*F2-4*F4)-.00263*
COS(F4+F8)+.00249*COS(3*F2-2*F4)-.00221*COS(F2+2*F4-F8)+.00185*COS(2*F3-2*F4)
3816 LET RANGE2=-.00161*COS(2*F4-2*F8)+.00147*COS(F2+2*F3-2*F4)-.00142*COS(4*F4)
+.00139*COS(2*F2-2*F4+F8)-.00118*COS(F2-4*F4+F8)-.00116*COS(2*F2+2*F4)-.0011*COS
(2*F2-F8)
3817 LET RANGE=RANGE+RANGE1+RANGE2
3820 LET SEMIDIA=936.74867#/RANGE 'GEOCENTRIC SEMIDIAMETER IN MINUTES OF ARC
3825 LET RANGE=RANGE*6378.16 'CHANGE DISTANCE FROM EQUATORIAL EARTH RADII TO KM
3840 IF PRANGE>RANGE THEN 3860
3842 'MOON GETTING FARTHER FROM EARTH
3843 IF GEE$<>"P" THEN 3846 ELSE 3870
3846 LET GEE$="P"
3848 GOTO 3866
3860 'MOON GETTING CLOSER TO EARTH
3862 IF GEE$<>"A" THEN 3864 ELSE 3870
3864 LET GEE$="A"
3866 LET PDAYS=0
3870 LET PDAYS=PDAYS+1
3900 RETURN
4000 '*******************SUBROUTINE TO CALCULATE ELEVATION*********************
4002 LET GHA=GAST*.2617994-RA
4004 IF GHA<0 THEN 4005 ELSE 4006
4005 LET GHA=GHA+TUPI
4006 IF GHA>TUPI THEN LET GHA=GHA-TUPI
4013 LET UHA= LON -GHA
4014 LET ELSIN=COS( LAT )*COS(UHA)*COS(DEC)+SIN(DEC)*SIN( LAT )
4015 LET ELCOS=SQR(1-ELSIN*ELSIN)
4016 LET EL=FNATAN2(ELSIN,ELCOS) 'UNCORRECTED ELEVATION
4017 IF FLAG5=1 THEN 4025
4018 LET ELCORS=6378.16*COS(EL)
4019 LET ELCORC=RANGE-6378.16*SIN(EL)
4020 LET ELCORD=FNATAN2(ELCORS,ELCORC) 'CORRECTION FACTOR DUE TO EARTH DIAMETER
4021 LET EL=EL-ELCORD
4025 LET FEL=EL
4029 IF EL<0 OR  EL>.27925 THEN 4050 'SKIP ATMOS CORRECTION
4030 LET ZD=PI/2-EL
4032 LET SINREF=.9986047*SIN(.9967614*ZD)
4034 LET SINREF=FNATAN2(SINREF,SQR(1-SINREF*SINREF))
4035 LET ELCORA=1.04329E-03*(196.5411*(ZD-SINREF)-.6393802*ZD) 'VISIBLE ATMOSPHE
RIC REFRACTION CORRECTION FACTOR AT 50*F AND 1015 MB PRESSURE
4040 LET EL=EL-ELCORA
4050 RETURN
4100 '*******************SUBROUTINE TO CALCULATE AZIMUTH***********************
4110 LET AZCOS=SIN(DEC)/(COS(LAT)*COS(FEL))-SIN(LAT)/COS(LAT)*(SIN(FEL)/COS(FEL)
)
4120 LET AZSIN=SIN(LAT)*SIN(DEC)+COS(LAT)*COS(DEC)*COS(UHA)
4130 LET AZSIN=SIN(UHA)*COS(DEC)/SQR(1-AZSIN*AZSIN)
4140 LET AZ=FNATAN2(AZSIN,AZCOS)
4150 IF AZ<=0 THEN LET AZ=AZ+TUPI
4160 RETURN
4200 '******SUBROUTINE TO DETERMINE MOON WINDOW FOR IARU REGION 1 STATIONS*****
4205 IF GHA<PI THEN 4245
4210 'CHECK TO SEE IF IN ASIAN WINDOW (2 HOURS FOLLOWING FRANKFURT MOONRISE)
4220 IF DEC=>-.74545*GHA+3.421194 AND DEC=<-.74545*GHA+3.799083 THEN LET MOONWIN
DOW$="A"
4230 'CHECK TO SEE IF MOON IS IN EUROPEAN WINDOW
4240 IF DEC=>-.74545*GHA+3.799083 THEN LET MOONWINDOW$="E"
4244 GOTO 4290
4245 IF DEC=>.8075099*GHA-.7186963 THEN LET MOONWINDOW$="E"
4250 'CHECK TO SEE IF MOON IS IN NORTH AMERICAN WINDOW
4260 IF DEC=<.80751*GHA-.718696 AND DEC=>.80751*GHA-1.128051 THEN LET MOONWINDOW
$="N"
4290 RETURN
4300 '******SUBROUTINE TO DETERMINE MOON WINDOW FOR IARU REGION 2 STATIONS*****
4310 '  CHECK TO SEE IF IN EUROPEAN WINDOW
4320 IF DEC<=.80751*GHA-.7186963 AND DEC>=.80751*GHA-1.128051 THEN LET MOONWINDO
W$="E"
4330 '  CHECK TO SEE IF IN NORTH AMERICAN WINDOW
4340 IF DEC<=.80751*GHA-1.128051 AND DEC<=-1.3572416#*GHA+3.350332 THEN LET MOON
WINDOW$="N"
4350 '  CHECK TO SEE IF IN ASIAN WINDOW
4360 IF DEC>=-1.357242*GHA+3.350332 AND DEC<=-1.357242*GHA+4.038211 THEN LET MOO
NWINDOW$="A"
4390 RETURN
4400 '******SUBROUTINE TO DETERMINE MOON WINDOW FOR IARU REGION 3 STATIONS*****
4410 'CHECK TO SEE IF IN NORTH AMERICAN WINDOW
4420 IF DEC=>-1.357242*GHA+3.350332 AND DEC=<-1.357242*GHA+4.038211 THEN LET MOO
NWINDOW$="N"
4430 'CHECK TO SEE IF IN ASIAN WINDOW
4440 IF DEC=>-1.357242*GHA+4.038211 AND DEC=<-.74545*GHA+3.421194 THEN LET MOONW
INDOW$="A"
4450 'CHECK TO SEE IF IN EUROPEAN WINDOW
4460 IF DEC=>-.74545*GHA+3.421194 AND DEC=<-.74545*GHA+3.799083 THEN LET MOONWIN
DOW$="E"
4490 RETURN
6000 END
```

A GaAsFET PREAMP FOR THE ICOM IC-1271A

by Dave Hallidy, KD5RO

The ICOM IC-1271A is rapidly becoming a very popular transceiver for use on the 23cm band by both newcomers and oldtimers alike. It is a compact, 10 watt, all-mode unit with full band coverage (1240-1300 MHz). If it has one shortcoming, that is its receiver. That's not to suggest that the receiver is totally deaf, but in order to have a radio with 60MHz of receive coverage, some compromises had to be made. Out of the box, the transceiver exhibits about a 4-5dB Noise Figure on receive with about 16 dB of conversion gain at the 133 MHz i.f.. This isn't terrible, but does leave room for improvement. Since no preamp was available from ICOM, I set out to build one of my own. I elected to use a Single Gate type GaAsFET device because I believe that, in general, they offer a somewhat lower noise figure than Dual Gate designs. Another requirement was small size. Since I had no provisions for mast- mounting the preamp (certainly a more desirable solution), the unit had to be installed in the available space inside the rig. The following is a description of my preamp's construction and the very gratifying results I have had with it.

CONSTRUCTION

Credit for the basic circuit design must go to Kent Britain, WA5VJB. I used his MGF1402 design as published in the 1986 ARRL HANDBOOK ,but I sized it to fit the space available in the 1271 and shielded it to improve the input/ output isolation.

Figure 1 shows the schematic diagram and component values. I have tried several different GaAsFET devices in this preamp including NEC and Mitsubishi types, all with excellent results.

Figure 2 shows the dimensions and parts placement inside the shielded box. There are several items worthy of note here: First, because of the physical arrangement of the coax from the receive side of the T/R relay to the receiver input filter, it was impossible to safely remove the cable and replace it with semi-rigid (which I would have preferred). Instead, I removed the end going into the filter and fed this through a small hole into the preamp. I flared the braid and soldered it around the circumference of the entry hole. Second, I treated the output cable the same way- braid soldered around the circumference of both the exit hole of the preamp and the entry hole to the filter. Small Teflon coax lends itself well to this application because it isn't destroyed by the heat. Third, the source leads of the transistor MUST be as short as possible. Since I had arranged the box with a shield down the middle, I soldered the Source bypass capacitors to the shield- one on each side of the hole in the shield (Further Note: I used Trapezoidal capacitors in this location- they are more difficult to obtain than chip types, but are easier to use and allow the transistor to be placed closer to the shield. If you can't find the trapezoidal units, then use chip caps installed at an angle to lower the overall profile). I then soldered R1, the Source resistor, directly to one of the capacitors and the shield. Make sure R1 has essentially no leads as these add inductance. Next the GaAsFET is soldered in place, with the Gate lead floating in the input compartment and the Drain protruding through the hole into the output compartment. I soldered the input trimmer capacitor directly between the center conductor of the input coax and the Gate of the FET, so that it can be adjusted from above. Fourth, I mounted the biasing components on the outside of the box. This wasn't necessary, but it was easier. I fed the regulated D.C. into the box with the feedthru capacitor labelled C5.

Figure 3 shows the location of the preamp inside the transceiver. Power for the preamp can be obtained from the filter board, if desired. When the Front- Panel "PREAMP" switch is depressed, 12 volts appears on the blue wire plugged into the filter board.

I constructed the box out of double- sided PC board material (.062" G-10). If you use this technique, make sure you solder BOTH sides of the board material to the bottom (ground). This will improve the overall stability by reducing board capacitance. Sheet brass could of course also be used to build the box. I put a top on the first one that I built, but I have built others without a top cover and they did not exhibit any tendency toward instability. If you do put on a top, be sure to leave a hole for adjustment of the input trimmer.

PERFORMANCE

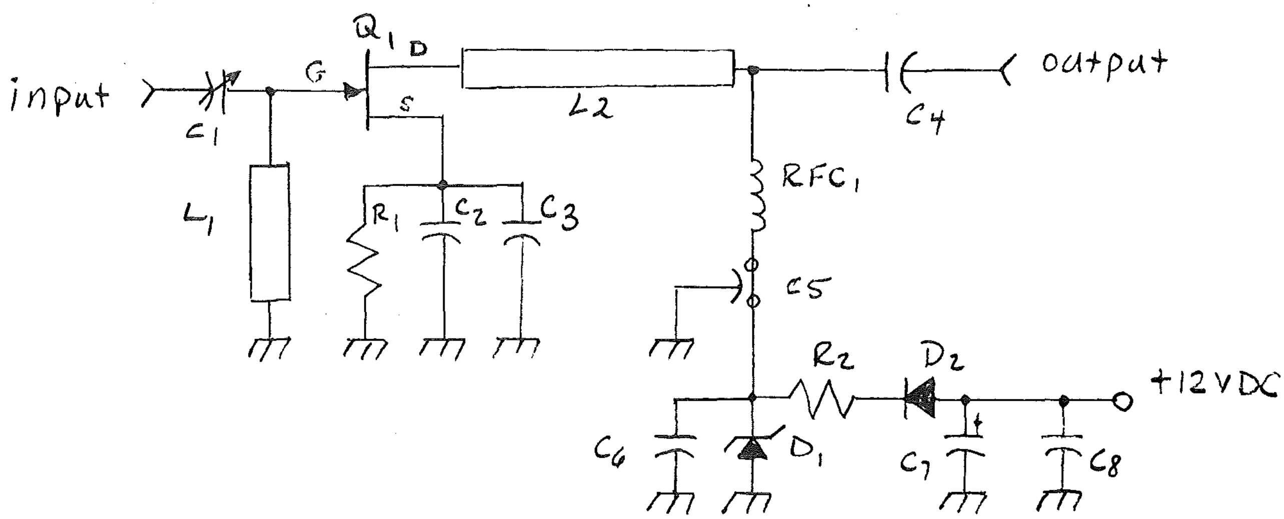
I ran some before and after tests to measure the performance of the preamp and these are shown in the following table:

FREQUENCY MHz	NF/CONV GAIN (dB) BEFORE	NF/CONV GAIN (dB) AFTER
1240	5.95/12.70	1.55/27.8
1250	5.40/14.20	1.52/29.0
1260	4.95/15.25	1.45/30.5
1270	4.70/16.10	1.40/32.0
1280	4.52/16.55	1.30/32.75
1290	4.59/16.48	1.30/32.6
1296	4.72/16.20	1.30/32.25
1300	4.85/15.90	1.30/32.0

Further, the image response at 1063 MHz was measured at -65dB.

On the air, the results have been most gratifying. The preamp brought the receiver to life, enabling comfortable copy of signals that were difficult to hear before.

One further bit of development still needs to be done. I have not tried installing the preamp between the input filter and the receive converter. Theoretically, this might further improve the receiver's performance, but given the location of the preamp with respect to the filter and converter, is a fairly difficult task. If anyone has tried this, I would be interested to hear about your results.



C_1 - .3 to 3pf piston trimmer

$C_{2,3,4}$ - 200 to 1000pf ceramic chip capacitor

C_5 - 470pf feedthru capacitor

$C_{6,8}$ - .05µf disc ceramic capacitor

C_7 - 4.7µf 16WVDC electrolytic capacitor

D_1 - 3.9V, 1W Zener (1N4730)

D_2 - 1N914 or equivalent

L_1 - Brass strip .020" thick, .125" wide, 1.25" long (not including 1/8" lip) mounted 1/8" above ground plane

L_2 - piece of No.24 wire, 3/4 inch long

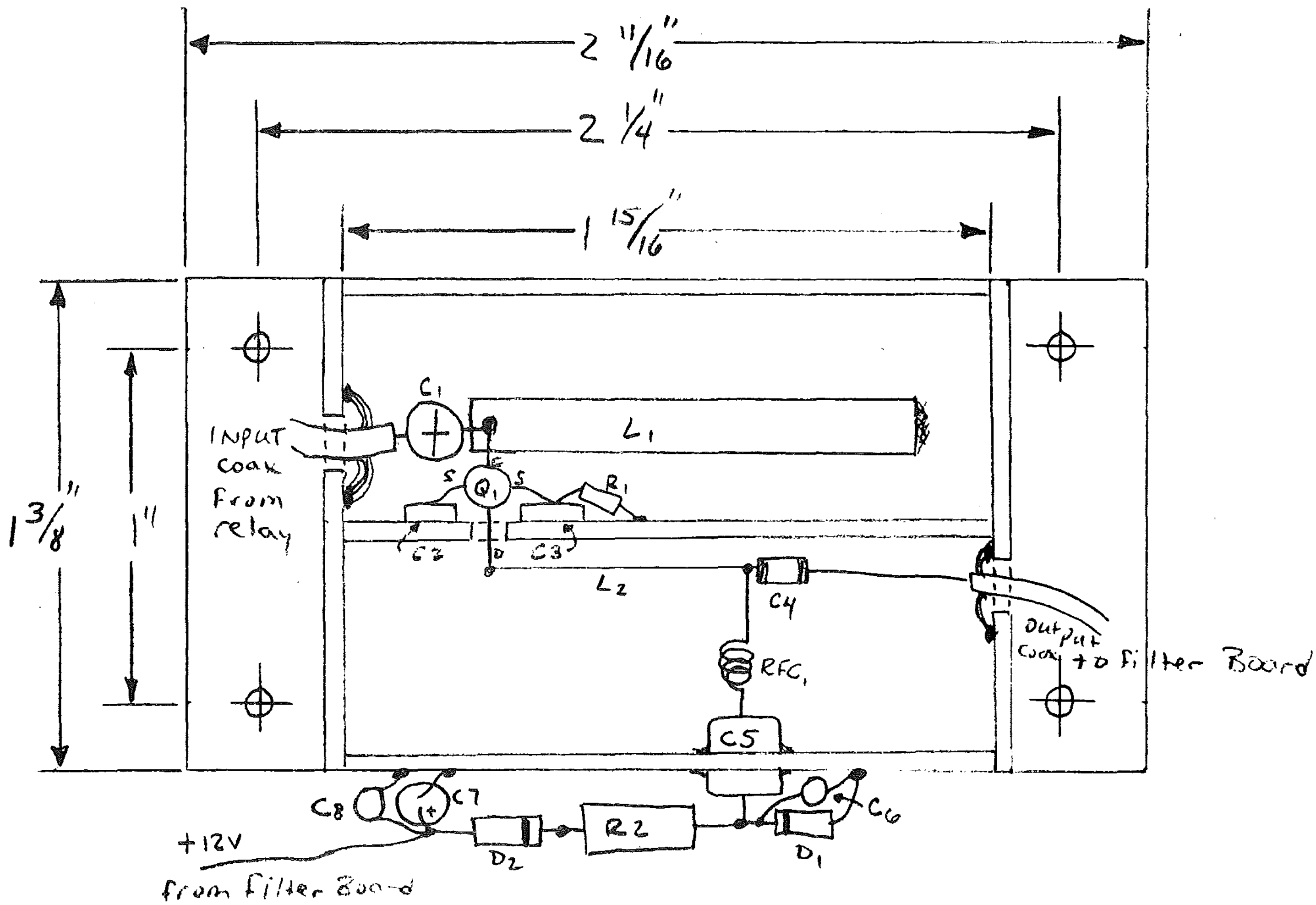
Q_1 - MGF1402, NE72084, etc.

R_1 - 100Ω 1/8W carbon composition

R_2 - 220Ω 1 watt resistor

RFC_1 - 6 turns No 24 enam. 1/8" I.D, close wound

FIGURE 1



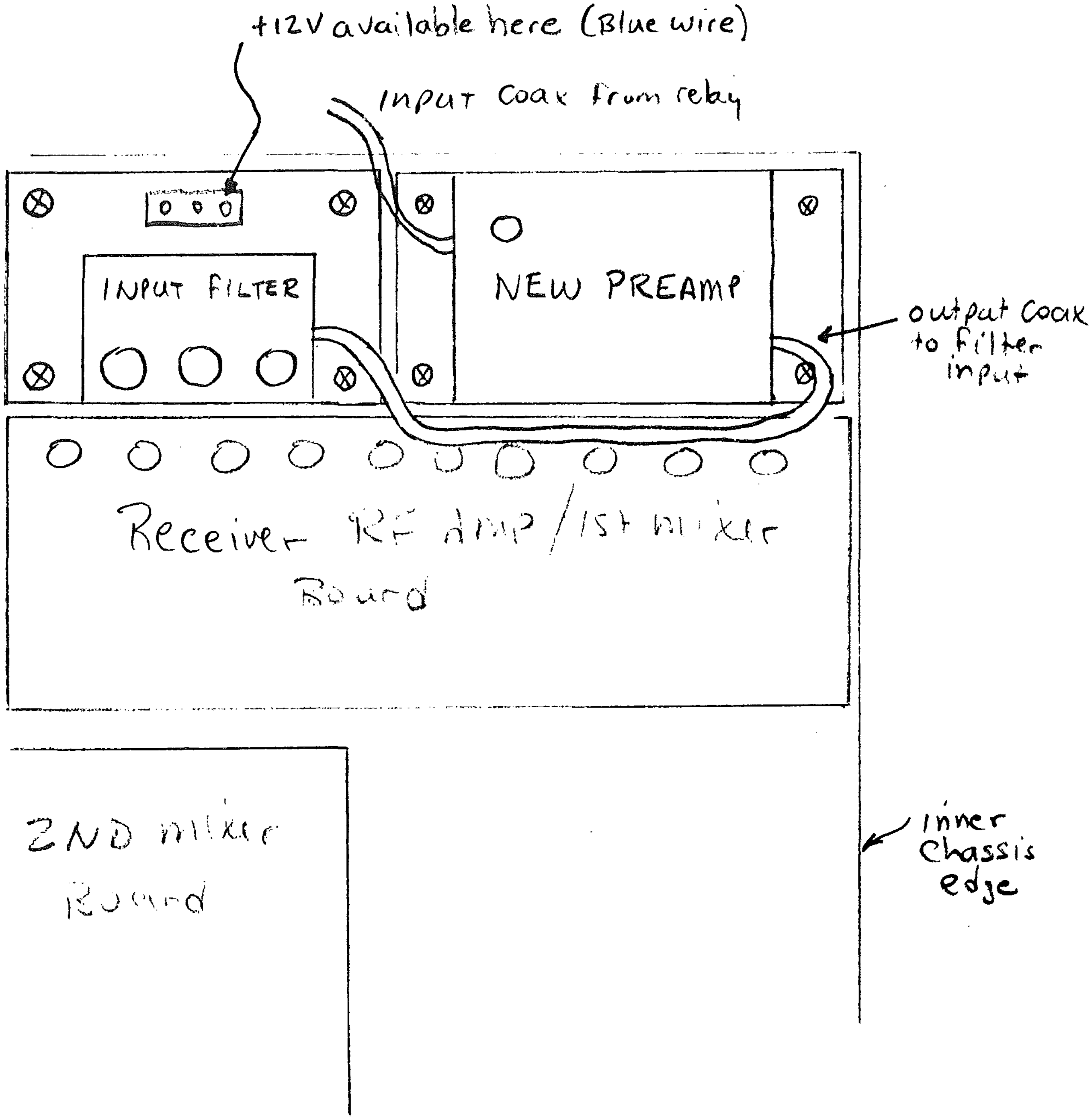
Note: Drawing is twice actual size. Dimensions are given

make walls as low as possible - 1/2" is sufficient height.

hole locations (input output, drain lead) are shown approximate

Figure 2

4 Rear of Radio 4



↓ Front ↓

Figure 3, actual Size

Reference Table of Rigid Rectangular Waveguide Data and Fittings

EIA WG DESIGNATION WR ( )	RECOMMENDED OPERATING RANGE FOR TE_{10} MODE		CUT-OFF FOR TE_{10} MODE		RANGE IN $2\lambda/\lambda_c$	RANGE IN λ_g/λ	THEORETICAL PEAK POWER RATING LOWEST TO HIGHEST FREQUENCY MEGAWATTS	THEORETICAL ATTENUATION LOWEST TO HIGHEST FREQUENCY (dB/100 ft.)	MATERIAL ALLOY	JAN WG DESIGNATION RG( )/U	JAN FLANGE DESIG.		EIA WG DESIGNATION WR ( )	DIMENSIONS (inches)				WALL THICKNESS NOMINAL
	FREQUENCY GHz	WAVELENGTH (cm)	FREQUENCY GHz	WAVELENGTH (cm)							CHOKE UG( )/U	COVER UG( )/U		INSIDE	TOL.	OUTSIDE	TOL.	
2300	0.32–0.49	93.68–61.18	0.256	116.84	1.60–1.05	1.68–1.17	153.0–212.0	.051–.031	Alum.				2300	23.000–11.500	±.020	23.250–11.750	±.020	0.125
2100	0.35–0.53	85.65–56.56	0.281	106.68	1.62–1.06	1.68–1.18	120.0–173.0	.054–.034	Alum.				2100	21.000–10.500	±.020	21.250–10.750	±.020	0.125
1800	0.41–0.625	73.11–47.96	0.328	91.44	1.60–1.05	1.67–1.18	93.4–131.9	.056–.038	Alum.	201			1800	18.000–9.000	±.020	18.250–9.250	±.020	0.125
1500	0.49–0.75	61.18–39.97	0.393	76.20	1.61–1.05	1.62–1.17	67.6–93.3	.069–.050	Alum.	202			1500	15.000–7.500	±.015	15.250–7.750	±.015	0.125
1150	0.64–0.96	46.84–31.23	0.513	58.42	1.60–1.07	1.82–1.18	35.0–53.8	.128–.075	Alum.	203			1150	11.500–5.750	±.015	11.750–6.000	±.015	0.125
975	0.75–1.12	39.95–26.76	0.605	49.53	1.61–1.08	1.70–1.19	27.0–38.5	.137–.095	Alum.	204			975	9.750–4.875	±.010	10.000–5.125	±.010	0.125
770	0.96–1.45	31.23–20.67	0.766	39.12	1.60–1.06	1.66–1.18	17.2–24.1	.201–.136	Alum.	205			770	7.700–3.850	±.005	7.950–4.100	±.005	0.125
650	1.12–1.70	26.76–17.63	0.908	33.02	1.62–1.07	1.70–1.18	11.9–17.2	.317–.212 .269–.178	Brass Alum.	69 103		417A 418A	650	6.500–3.250	±.005	6.660–3.410	±.005	0.080
510	1.45–2.20	20.67–13.62	1.157	25.91	1.60–1.05	1.67–1.18	7.5–10.7						510	5.100–2.550	±.005	5.260–2.710	±.005	0.080
430	1.70–2.60	17.63–11.53	1.372	21.84	1.61–1.06	1.70–1.18	5.2–7.5	.588–.385 .501–.330	Brass Alum.	104 105		435A 437A	430	4.300–2.150	±.005	4.460–2.310	±.005	0.080
340	2.20–3.30	13.63–9.08	1.736	17.27	1.58–1.05	1.78–1.22	3.1–4.5	.877–.572 .751–.492	Brass Alum.	112 113		553 554	340	3.400–1.700	±.005	3.560–1.860	±.005	0.080
284	2.60–3.95	11.53–7.59	2.078	14.43	1.60–1.05	1.67–1.17	2.2–3.2	1.102–.752 .940–.641	Brass Alum.	48 75	54A 585	53 584	284	2.840–1.340	±.005	3.000–1.500	±.005	0.080
229	3.30–4.90	9.08–6.12	2.577	11.63	1.56–1.05	1.62–1.17	1.6–2.2						229	2.290–1.145	±.005	2.418–1.273	±.005	0.064
187	3.95–5.85	7.59–5.12	3.152	9.510	1.60–1.08	1.67–1.19	1.4–2.0	2.08–1.44 1.77–1.12	Brass Alum.	49 95	148B 406A	149A 407	187	1.872–0.872	±.005	2.000–1.000	±.005	0.064
159	4.90–7.05	6.12–4.25	3.711	8.078	1.51–1.05	1.52–1.19	0.79–1.0						159	1.590–0.795	±.004	1.718–0.923	±.004	0.064
137	5.85–8.20	5.12–3.66	4.301	6.970	1.47–1.05	1.48–1.17	0.56–0.71	2.87–2.30 2.45–1.94	Brass Alum.	50 106	343A 440A	344 441	137	1.372–0.622	±.004	1.500–0.750	±.004	0.064
112	7.05–10.00	4.25–2.99	5.259	5.700	1.49–1.05	1.51–1.17	0.35–0.46	4.12–3.21 3.50–2.74	Brass Alum.	51 68	52A 137A	51 138	112	1.122–0.497	±.004	1.250–0.625	±.004	0.064
90	8.20–12.40	3.66–2.42	6.557	4.572	1.60–1.06	1.68–1.18	0.20–0.29	6.45–4.48 5.49–3.83	Brass Alum.	52 67	40A 136A	39 135	90	0.900–0.400	±.003	1.000–0.500	±.003	0.050
75	10.00–15.00	2.99–2.00	7.868	3.810	1.57–1.05	1.64–1.17	0.17–0.23						75	0.750–0.375	±.003	0.850–0.475	±.003	0.050
62	12.4–18.00	2.42–1.66	9.486	3.160	1.53–1.05	1.55–1.18	0.12–0.16	9.51–8.31 — — 6.14–5.36	Brass Alum. Silver	91 — 107	541 — —	419 — —	62	0.622–0.311	±.0025	0.702–0.391	±.003	0.040
51	15.00–22.00	2.00–1.36	11.574	2.590	1.54–1.05	1.58–1.18	0.080–0.107						51	0.510–0.255	±.0025	0.590–0.335	±.003	0.040
42	18.00–26.50	1.66–1.13	14.047	2.134	1.56–1.06	1.60–1.18	0.043–0.058	20.7–14.8 17.6–12.6 13.3–9.5	Brass Alum. Silver	53 121 66	596 598 —	595 597 —	42	0.420–0.170	±.0020	0.500–0.250	±.003	0.040
34	22.00–33.00	1.36–0.91	17.328	1.730	1.57–1.05	1.62–1.18	0.034–0.048						34	0.340–0.170	±.0020	0.420–0.250	±.003	0.040
28	26.50–40.00	1.13–0.75	21.081	1.422	1.59–1.05	1.65–1.17	0.022–0.031	— — — — 21.9–15.0	Brass Alum. Silver	— — 96	600 — —	599 — —	28	0.280–0.140	±.0015	0.360–0.220	±.002	0.040
22	33.00–50.00	0.91–0.60	26.342	1.138	1.60–1.05	1.67–1.17	0.014–0.020	— — 31.0–20.9	Brass Silver	— 97		383 —	22	0.224–0.112	±.0010	0.304–0.192	±.002	0.040
19	40.00–60.00	0.75–0.50	31.357	0.956	1.57–1.05	1.63–1.16	0.011–0.015						19	0.188–0.094	±.0010	0.268–0.174	±.002	0.040
15	50.00–75.00	0.60–0.40	39.863	0.752	1.60–1.06	1.67–1.17	0.0063–0.0090	— — 52.9–39.1	Brass Silver	— 98		385 —	15	0.148–0.074	±.0010	0.228–0.154	±.002	0.040
12	60.00–90.00	0.50–0.33	48.350	0.620	1.61–1.06	1.68–1.18	0.0042–0.0060	— — 93.3–52.2	Brass Silver	— 99		387 —	12	0.122–0.061	±.0005	0.202–0.141	±.002	0.040
10	75.00–110.00	0.40–0.27	59.010	0.508	1.57–1.06	1.61–1.18	0.0030–0.0041						10	0.100–0.050	±.0005	0.180–0.130	±.002	0.040
8	90.00–140.00	0.333–0.214	73.840	.406	1.64–1.05	1.75–1.17	0.0018–0.0026	152–99	Silver	138	—	—	8	0.080–0.040	±0.0003	0.156 DIA	±.001	—
7	110.00–170.00	0.272–0.176	90.840	.330	1.64–1.06	1.77–1.18	0.0012–0.0017	163–137	Silver	136	—	—	7	0.065–0.0325	±0.00025	0.156 DIA	±.001	—
5	140.00–220.00	0.214–0.136	115.750	.259	1.65–1.05	1.78–1.17	0.00071–0.00107	308–193	Silver	135	—	—	5	0.051–0.0255	±0.00025	0.156 DIA	±.001	—
4	170.00–260.00	0.176–0.115	137.520	.218	1.61–1.05	1.69–1.17	0.00052–0.00075	384–254	Silver	137	—	—	4	0.043–0.0215	±0.00020	0.156 DIA	±.001	—
3	220.00–325.00	0.136–0.092	173.280	.173	1.57–1.06	1.62–1.18	0.00035–0.00047	512–348	Silver	139	—	—	3	0.034–0.0170	±0.00020	0.156 DIA	±.001	—

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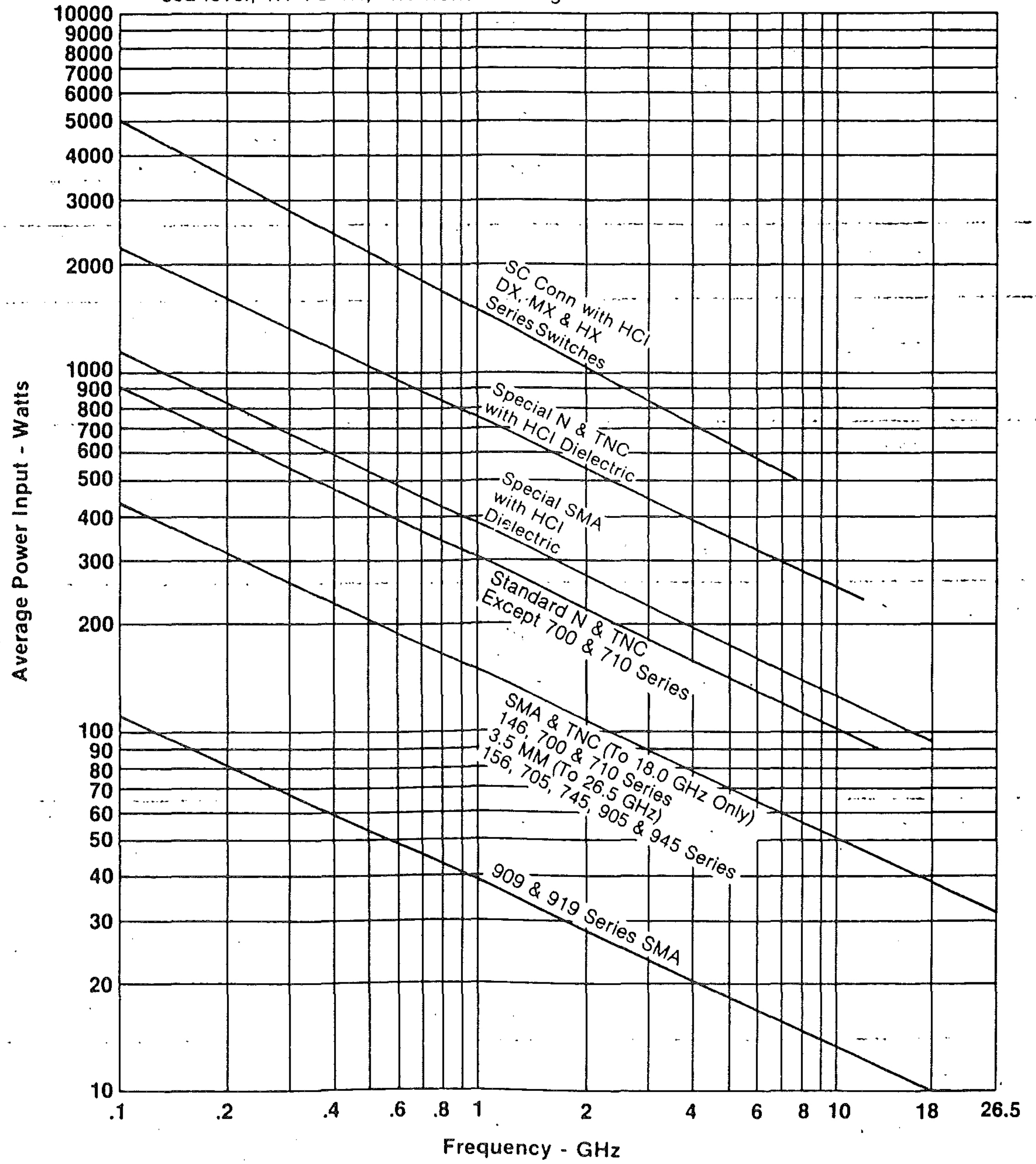
CW Power Capability Vs Frequency Chart

*For higher VSWR, derate power level as shown below:

VSWR	DERATING FACTOR	VSWR	DERATING FACTOR
1.5:1	.96	4.0:1	.74
2.0:1	.90	4.5:1	.71
2.5:1	.85	5.0:1	.69
3.0:1	.80		.50
3.5:1	.77		

This chart is based on the following conditions: ambient temperature 40°C, sea level, 1:1 VSWR, and nonswitching



TRANSCO PRODUCTS, INC.

TPI

COAXIAL SWITCH
TYPE DO
DATA SHEET 103A

RF CIRCUIT	**SPDT**
ACTUATOR	**Fail-Safe**
CONNECTOR	**SMA**
FREQUENCY	**0-18 GHz**

DESCRIPTION

The Type DO coaxial switch has RF geometry optimized for SMA connectors and operates over a 0-18 GHz frequency band. It is also available with or without Indicators. Transco's design mechanically links indicating switches to the rotating armature for positive indication.

Actuator features:
1. Balanced rotating armature
2. Low current required to develop the actuating torque

This design features a dual magnetic field for high efficiency and long life reliability . . . also excellent shock/vibration characteristics.

This switch is part of the Type D family of switches featuring different RF connectors and frequencies.

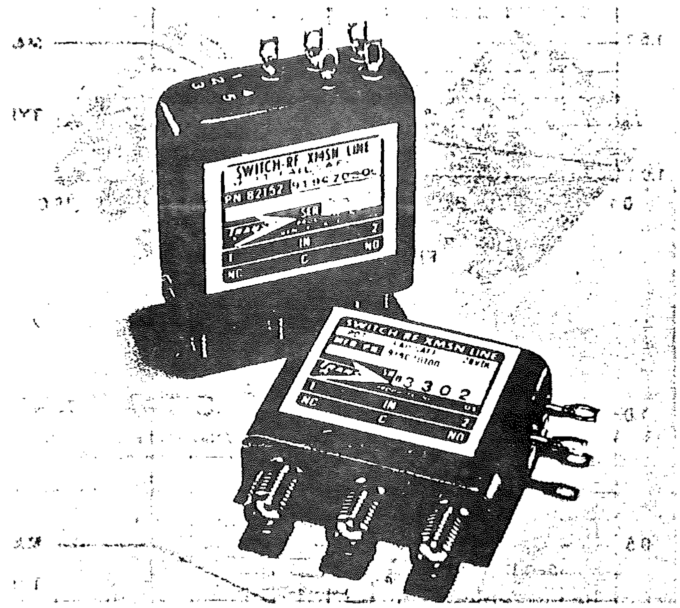
TYPE	CONN.	FREQ.
D	N	12 GHz
DO	SMA	18 GHz
DX	SC	6 GHz

STANDARD PRODUCTS

P/N	SCHEMATIC	
919C70100	1	
919C70200	2	
919C70100-8	1	● Qualified Product List MIL-S-3928/15-01
919C70200-8	2	● Qualified Product List MIL-S-3928/15-10

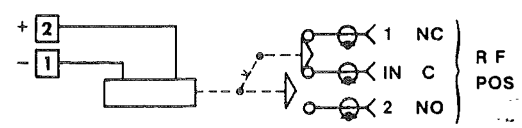
SPECIAL CONFIGURATION

Actuating Voltage
Transient Circuit
Mounting Configuration
Terminal Location
TTL Logic Circuit **(For dimensions and circuit diagrams, see page 20)**



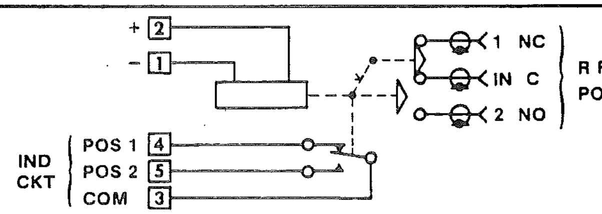
SCHEMATIC

#1. FAILSAFE



ENERGIZE TO CONNECT IN TO 2 (POS 2)
SHOWN IN FAILSAFE POSITION (POS 1)

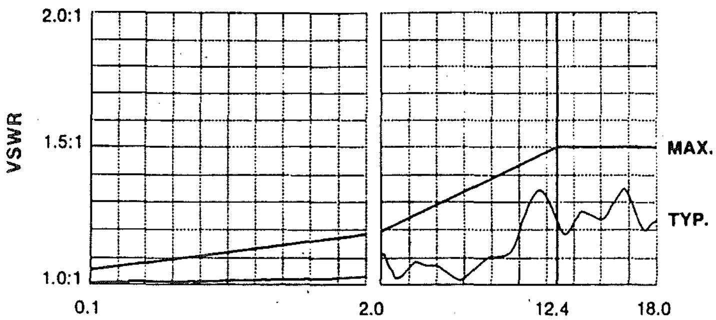
#2. FAILSAFE WITH INDICATOR



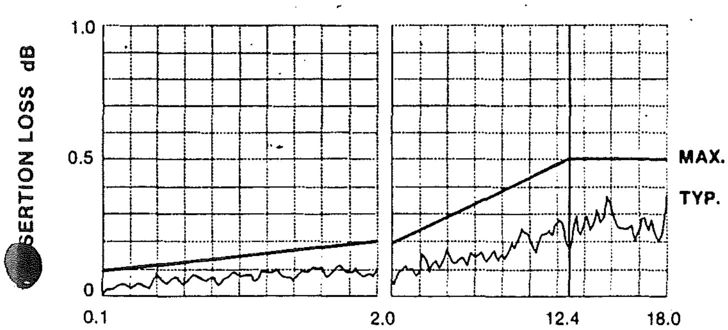
ENERGIZE TO CONNECT IN TO 2 (POS 2)
SHOWN IN FAILSAFE POSITION (POS 1)

SPECIFICATIONS

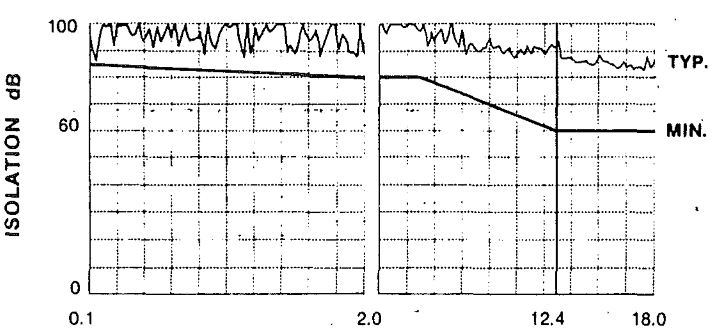
Typical RF data of a production switch; computer printouts below:



FREQUENCY (GHz)



FREQUENCY (GHz)



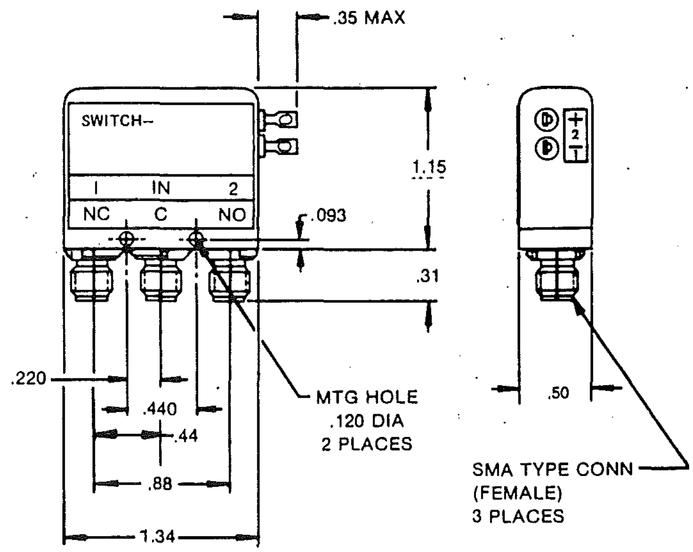
FREQUENCY (GHz)

LOWER FREQUENCY

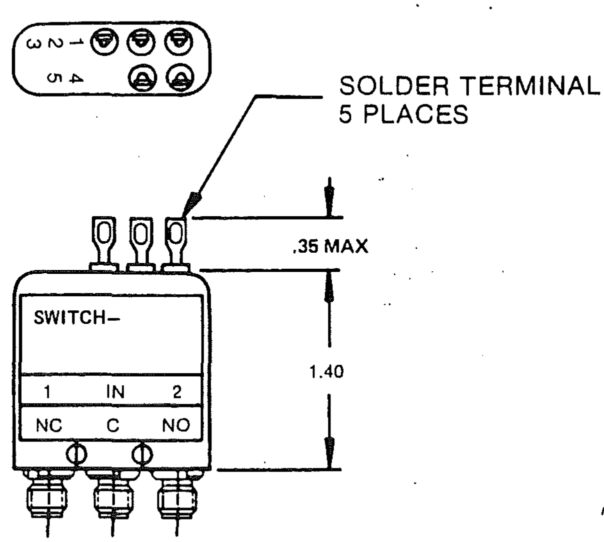
At 10 MHz, typical values are: Isolation, 100 dB; VSWR, 1.05:1; Insertion Loss, 0.05 dB. Because of the inherently good RF performance at lower frequencies, this product line is not tested below 2 GHz except upon request.

ACTUATOR VOLTAGE	20 to 30 Vdc
COIL RESISTANCE	290 ohm min.
CURRENT	120 mA max @ 28 Vdc & 20°C
SWITCHING TIME	20 mS
RF CONTACTS	break-before-make
IMPEDANCE	50 ohms nominal
TEMPERATURE	-55°C to 85°C
VIBRATION	20 g's sine/random
LIFE	1,000,000 cycles min
WEIGHT	919C70100 1.25 max 919C70200 1.35 oz max

DIMENSIONS



919C70100



919C70200 With Indicator
DIM. NOT GIVEN ARE SAME AS 919C70100

COAXIAL SWITCH
TYPE D
DATA SHEET 103C

RF CIRCUIT	**SPDT**
ACTUATOR	**Fail-Safe**
CONNECTOR	**TNC & N**
FREQUENCY	**0-12.4 GHz**

DESCRIPTION

The Type D Coaxial SPDT Switch has RF geometry optimized for TNC & N connectors and operates over a 0-12.4 GHz frequency band. It is also available with or without indicators. Transco's design mechanically links indicating switches to the rotating armature for positive indication.

Actuator features:
1. Balanced rotating armature
2. Lower current required to develop the actuating torque
3. Dual holding power—permanent magnet plus electromagnet

This design features a dual magnetic field for high efficiency and long life reliability ... and excellent shock/vibration characteristics.

This switch is part of a Transco family of switches. Other types in this family are referenced below.

TYPE	CONN	FREQ
DO	SMA	18 GHz
DX	SC	6.5 GHz

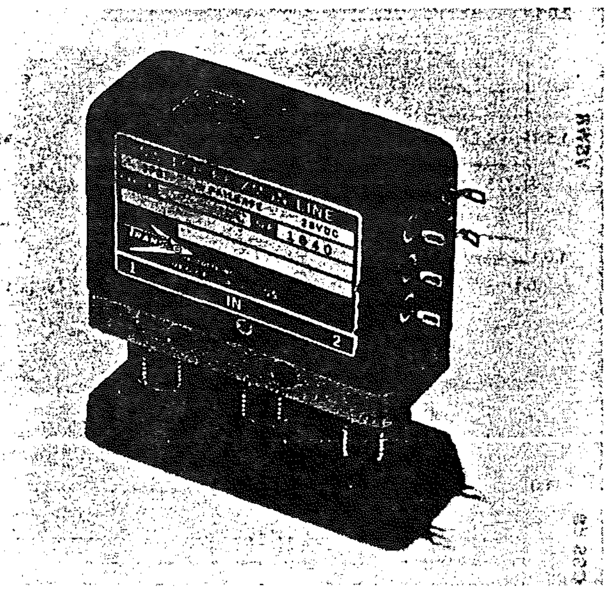
DESIGNED TO MEET
MIL-S-3928/10-04 (810C00100)
MIL-S-3928/10-05 (810C00200)

STANDARD PRODUCTS

P/N	CONN	SCHEMATIC
810C00100	N	1
810C00200	N	2
810C30100	TNC	1
810C30200	TNC	2

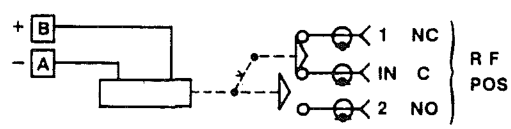
SPECIAL CONFIGURATION

Actuating Voltage
Transient Circuit
Mounting Configuration
Terminal Location
TTL Logic Circuit



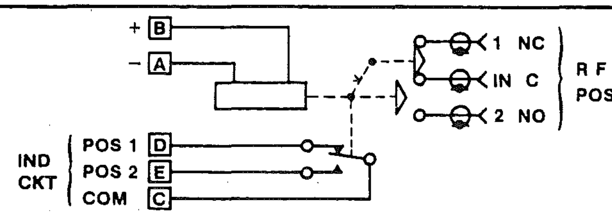
SCHEMATIC

#1. FAIL-SAFE



SHOWN IN FAIL-SAFE POSITION (NC)
ENERGIZE TO CONNECT POSITION 2 (NO)

#2. FAIL-SAFE WITH INDICATOR CIRCUIT

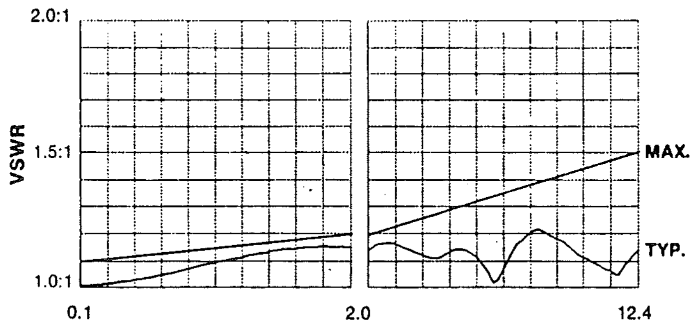


SHOWN IN FAIL-SAFE POSITION (NC)
ENERGIZE TO CONNECT POSITION 2 (NO)

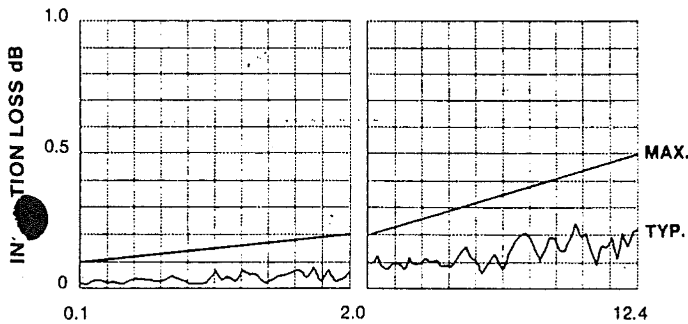
SPECIFICATIONS

Typical RF data of a production switch; computer printouts below:

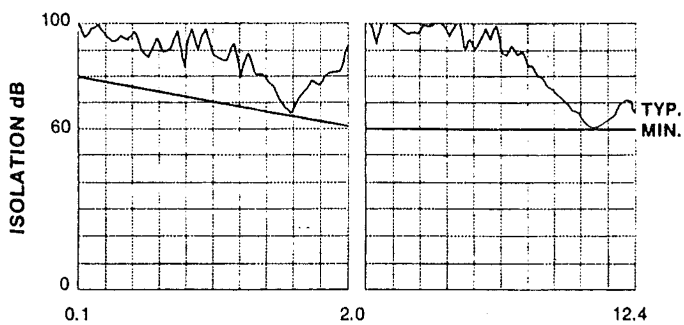
TYPE N SHOWN



FREQUENCY (GHz)



FREQUENCY (GHz)



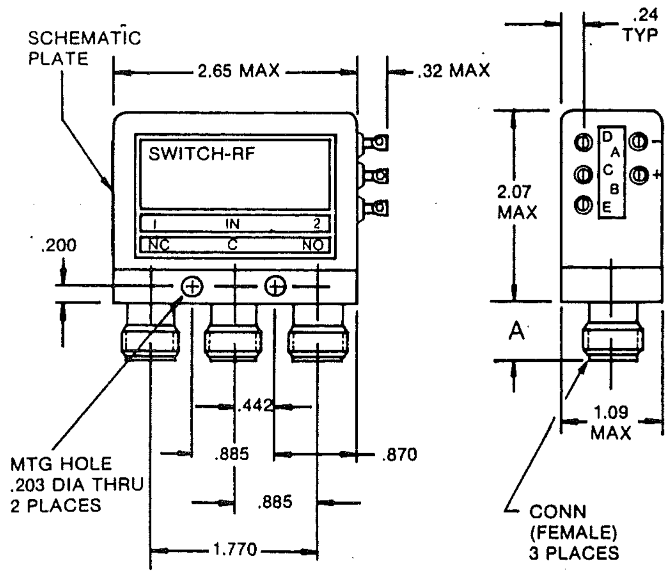
FREQUENCY (GHz)

LOWER FREQUENCY

At 10 MHz, typical values are: Isolation, 100 dB; VSWR, 1.05:1; Insertion Loss, 0.05 dB. Because of the inherently good RF performance at lower frequencies, this product line is not tested below 2 GHz except upon request.

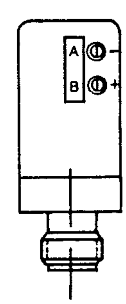
VOLTAGE	20 to 30 Vdc
COIL RESISTANCE	190 ± 10 ohms @ 20°C
CURRENT	160 mA max @ 28 Vdc & 20°C
SWITCHING TIME	20 mS max RF to RF
RF CONTACTS	break-before-make
IMPEDANCE	50 ohms nominal
TEMPERATURE	-55°C to 85°C
VIBRATION	20 g's sine/random
LIFE	100,000 cycles min
WEIGHT	8 oz max

DIMENSIONS



810C00200 SHOWN

CONN	A
N	.60
TNC	.56



810C00100 SHOWN

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE

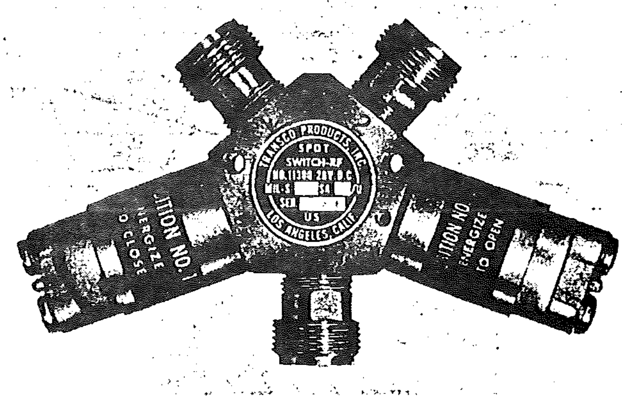
COAXIAL SWITCH

TYPE Y

DATA SHEET 100

RF CIRCUIT	**SPDT**
ACTUATOR	***Selective**
CONNECTORS	**N, TNC, BNC**
FREQUENCY	**0-11 GHz**

* Solenoid for each RF position.



DESCRIPTION

The Type Y was designed by Transco to meet the requirement for a small, economical coaxial switch having good RF characteristics over a broad bandwidth (0 to 11 GHz) with 1,000,000 cycle reliability.

The two independently operating solenoids allow make-before-break or break-before-make operation. RF positions can be both on or both off simultaneously. Solenoids can be supplied normally open or normally closed so FAIL-SAFE operation is easily provided by solenoid selection. Switches may be stacked (placed one on top of the other using the same mounting screws) for multi-pole operation.

Please see below for the part number with desired (1) RF connectors and (2) schematic . . . solenoid

DESIGNED TO MEET MIL-S-3928/7

PRODUCTS

STANDARD

P/N	SCH.	CONN.
11300	1	N
13730	1	TNC
13300	1	BNC

SPECIAL

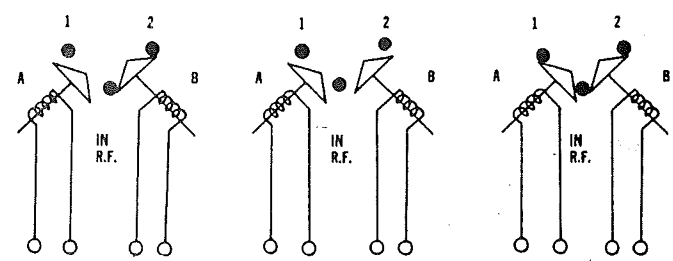
P/N	SCH.	CONN.
11100	2	N
11200	3	N
13710	2	TNC
13720	3	TNC
13100	2	BNC
13200	3	BNC

SPECIAL CONFIGURATIONS

Type C or Type HN connectors.

SCHEMATICS

#1 #2 #3



#1	#2	#3
POSITION #1 OPEN POSITION #2 CLOSED	BOTH POSITIONS OPEN	BOTH POSITIONS CLOSED

(All solenoids shown in de-energized position.)

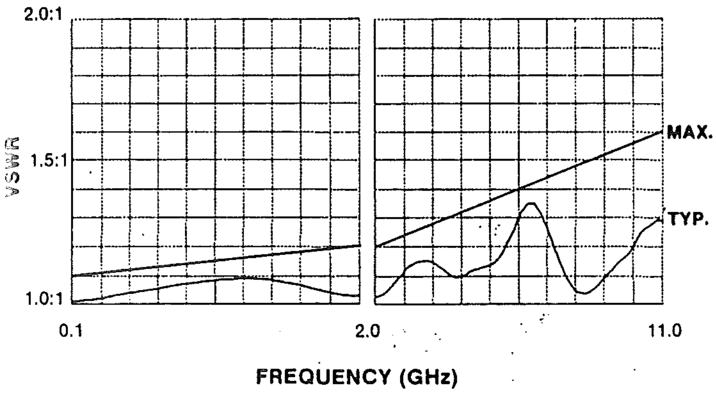
FEDERAL STOCK NUMBERS

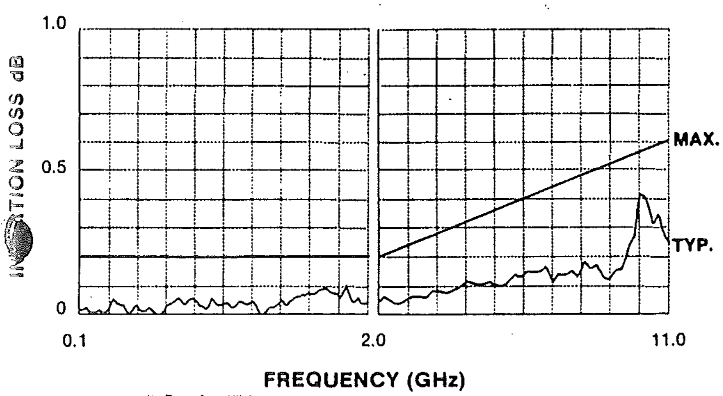
The Type Y Switch has been in service since 1951 and has been assigned many Federal Stock Numbers. For your convenience, a partial listing of FSN is shown below:

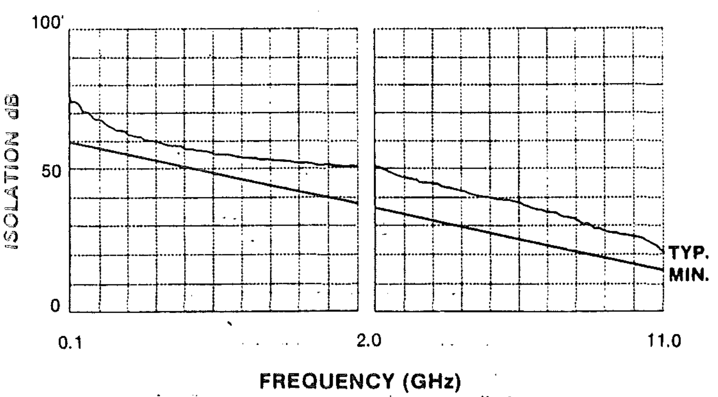
Transco P/N	FSN	Transco P/N	FSN
11100	5945-072-4498	11483	5985-949-5681
11200	5985-557-5721	11600	5985-296-4614
11300	5985-504-3605	11735	5985-833-7115
11300-30	5985-899-6329	11800	5985-586-7023
11300-50	5985-685-9292	11840	5985-879-4312
11335	5985-754-9168	11935	5985-852-9214
11350	5985-669-9093	11992	5985-819-5335
11400	5985-660-9786	13350	5985-818-6965

SPECIFICATIONS

Typical RF data of a production switch; computer printouts below:







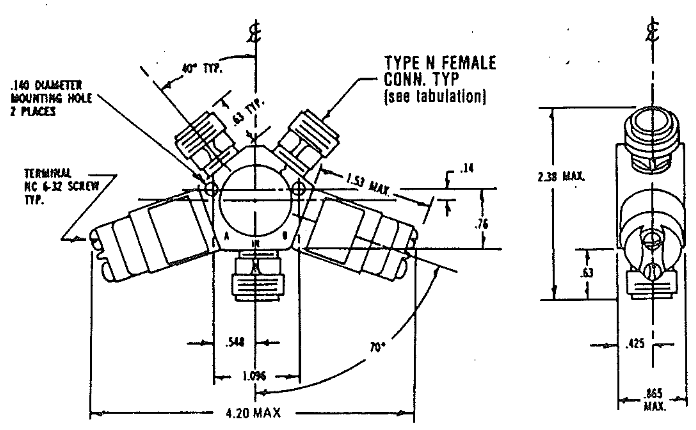
LOWER FREQUENCY

At 10 MHz, typical values are: Isolation, 75 dB; VSWR, 1.05:1; Insertion Loss, 0.05 dB. Because of the inherently good RF performance at lower frequencies, this product line is not tested below 2 GHz except upon request.

POWER	500 watts@1 GHz 10 kW peak
TEMPERATURE	-54°C to 85°C
VIBRATION	20 g's to 500 cps
OPERATING TIME	10 milliseconds nominal
LIFE	1,000,000 operations minimum
WEIGHT	6 oz. max
ACTUATOR VOLTAGE	28 Vdc nominal
RF CONNECTOR	Type N, TNC, BNC
MIL SPECIFICATIONS	MIL-E-5272, MIL-T-5422 MIL-S-3928

SOLENOID DATA	**28 Vdc nominal**
Rated Voltage	18-30 Vdc
Dropout Voltage	0.5-10 Vdc
Rated Current Per Coil	.23 amps @ 26V
Rated Power Per Coil	7 watts
Coil Resistance @ 20° C	101-123 ohms

DIMENSIONS



SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

COAXIAL SWITCH
TYPE TK
DATA SHEET 118

RF CIRCUIT	**SPDT**
ACTUATOR	**Latching**
CONNECTOR	**LT**
FREQUENCY	**0-5 GHz**

DESCRIPTION

Designed specifically for use in airborne electronics countermeasures systems, this motor actuated type switch can be used at very high RF power levels. The unit is lightweight yet operates over a very wide frequency range with excellent RF performance. Extremely rugged and reliable, it requires no holding power. It incorporates transmitter interlock circuitry and radio noise filtering.

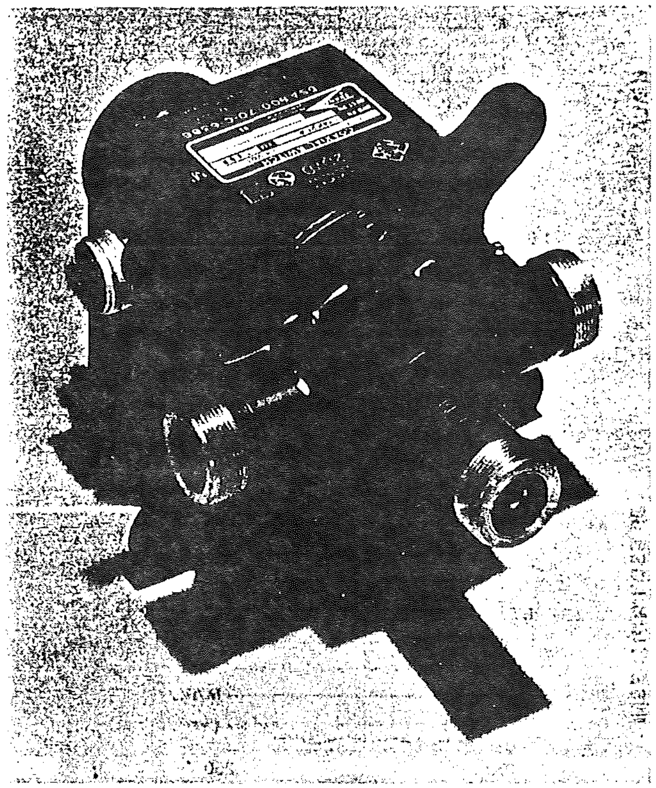
STANDARD PRODUCT

P/N C14K2CA

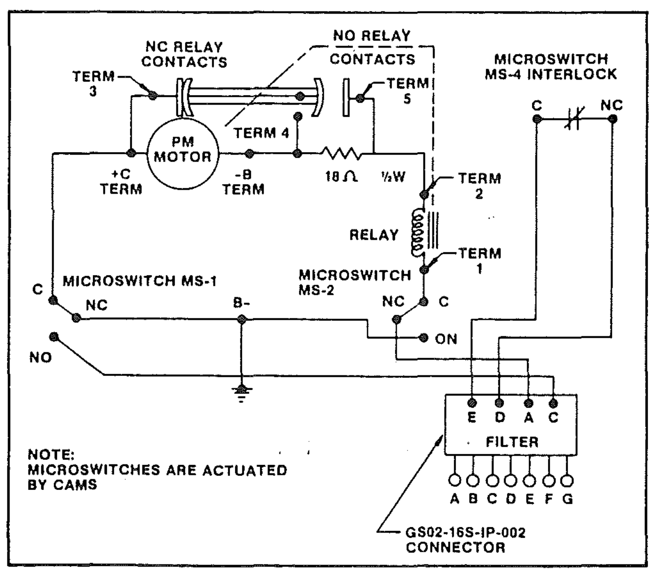
SPECIAL CONFIGURATION

RF Connectors LC & HN
Actuator Voltage 115 Vac
Actuator Frequency —
60 cps & 400 cps

CONN PIN	REMARKS
A	POSITION 2 (+24 VDC)
B	GROUND
C	POSITION 1 (+24 VDC)
D	INTERLOCK
E	INTERLOCK
F	SPARE
G	SPARE

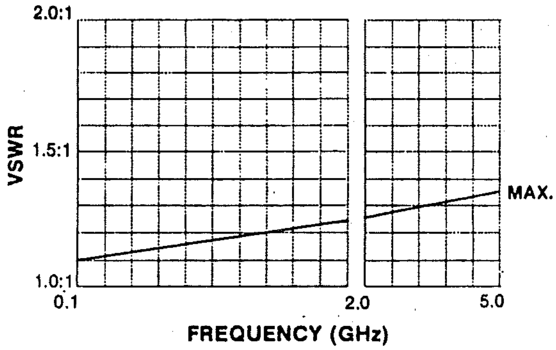


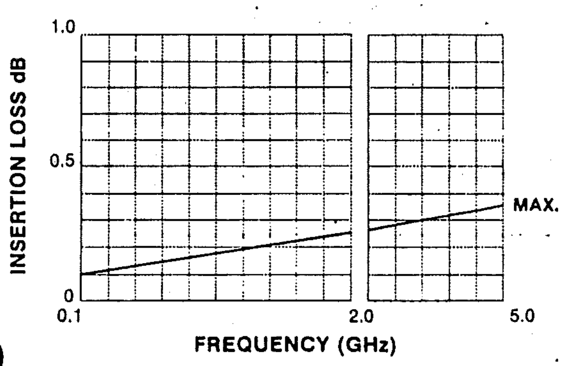
SCHEMATIC

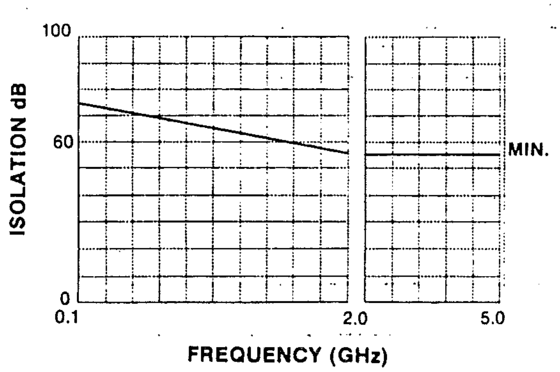


TRANSCO PRODUCTS, INC.

SPECIFICATIONS

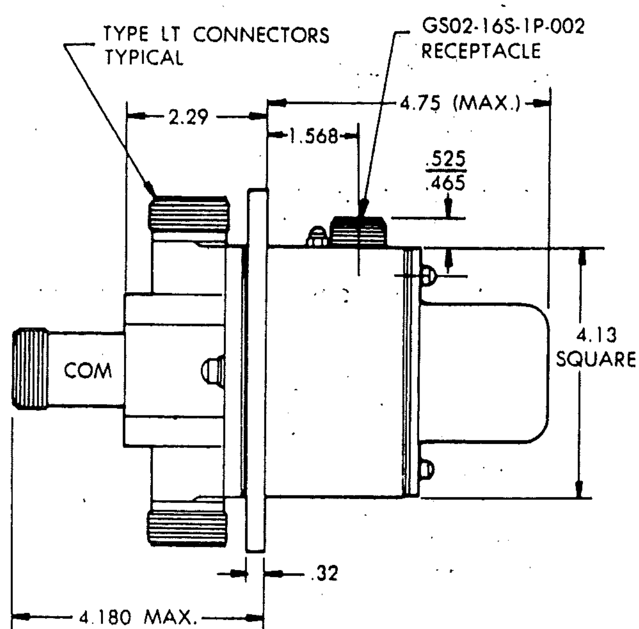


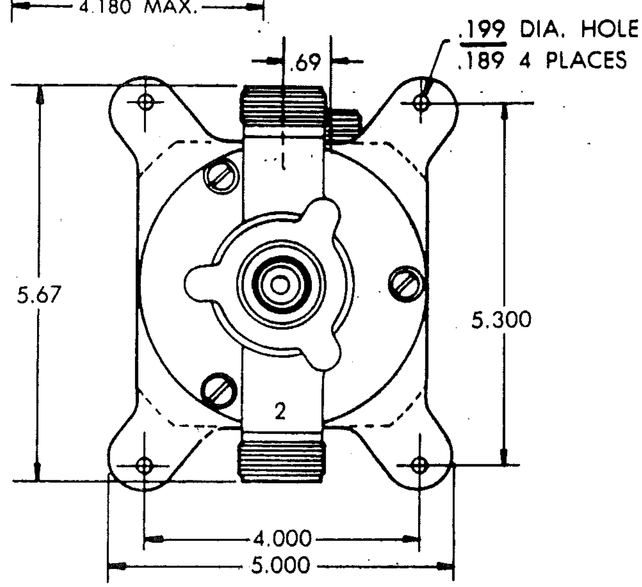




VOLTAGE	20 to 30 Vdc
CURRENT	1.5 amps average @ 24 Vdc
SWITCHING TIME	0.5 sec for 180° rotation
RF CONTACTS	break-before-make
IMPEDANCE	50 ohms nominal
RF POWER	400 watts c.w. @ 5 GHz & 60,000 ft altitude
VIBRATION	MIL-E-5272 procedure I
TEMPERATURE	-55°C to 74°C
LIFE	100,000 actuations min
WEIGHT	6.3 lbs

DIMENSIONS





COAXIAL SWITCH

TYPE A

DATA SHEET 102

RF CIRCUIT	**SP3T & SP4T**
ACTUATOR	**Selective**
CONNECTOR	**N**
FREQUENCY	**0-11 GHz**

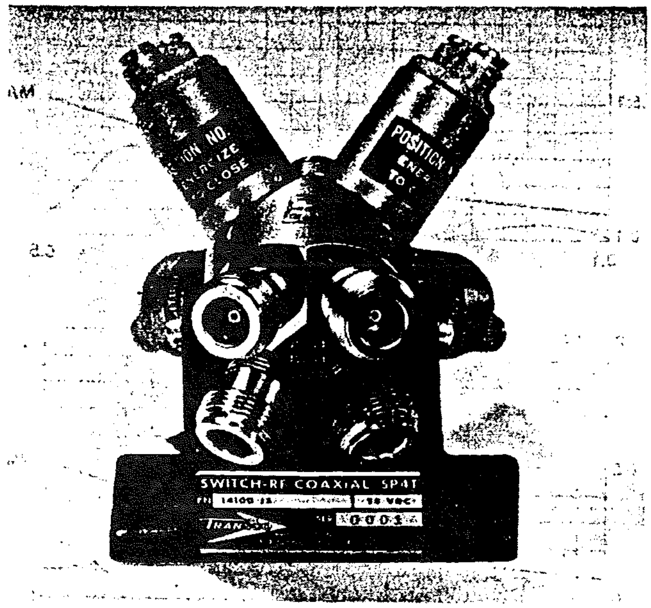
DESCRIPTION

The Type A was designed by Transco to meet the requirements for an economical coaxial switch having good RF characteristics over a 0-11 GHz band width with 1,000,000 cycle reliability.

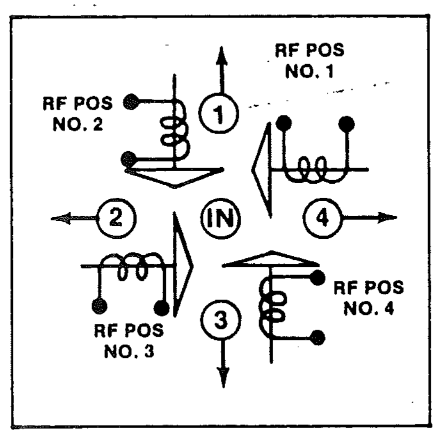
Wide flexibility in complex circuit switching is provided by independently operating solenoids. The four solenoid design allows complete control over make-before-break or break-before-make operation and contact of all positions at the same time. Fail-safe is easily provided by solenoid selection that will switch to a safe position when power is removed.

The Type A can be supplied with the solenoids either normally OPEN or normally CLOSED. Please see the STANDARD PRODUCTS CHART for the model number to meet your requirement.

DESIGNED TO MEET MIL-S-3928



SCHEMATIC



SPECIAL CONFIGURATION

Solenoid Voltages
Other RF Conn

STANDARD PRODUCTS

VOLT	SP4T SINGLE POLE – 4 THROW					SP3T SINGLE POLE–3THROW				
	Connector N	*R F POSITION				Connector N	*R F POSITION			
		1	2	3	4		1	2	3	4
28 Vdc	14100**	0	0	0	0	14701	NONE	0	0	0
	14300	0	0	0	C	14704	0	0	0	NONE

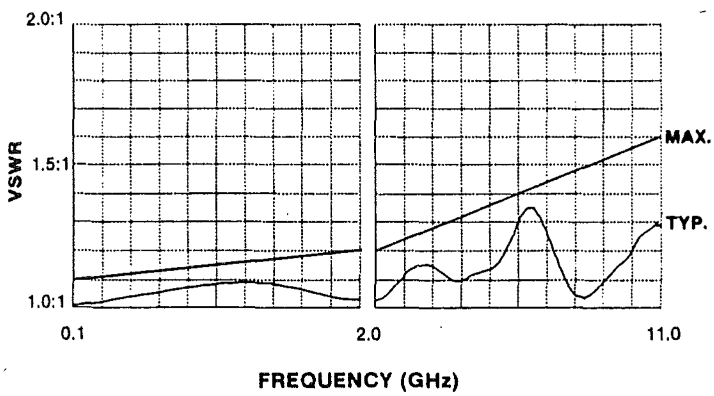
* 0=Solenoid Normally Open, C=Solenoid Normally Closed

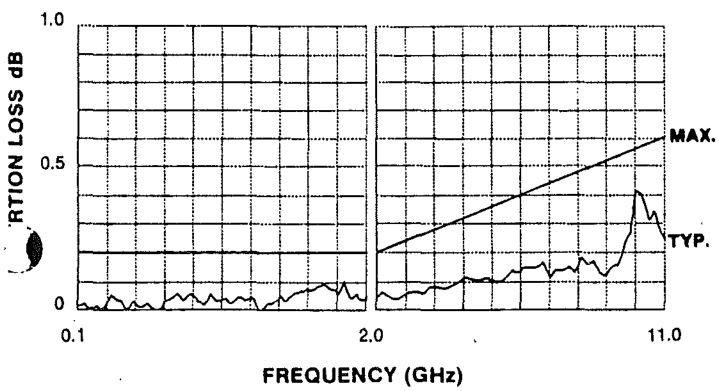
**P/N 14100 MEETS MIL-S-3928/7-24

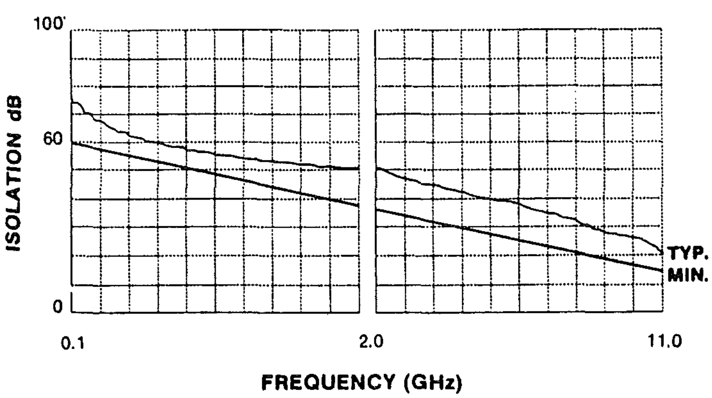
TRANSCO PRODUCTS, INC.

SPECIFICATIONS

Typical RF data of a production switch; computer printouts below:





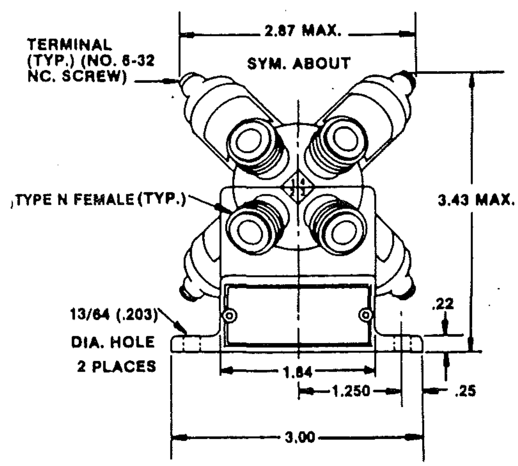


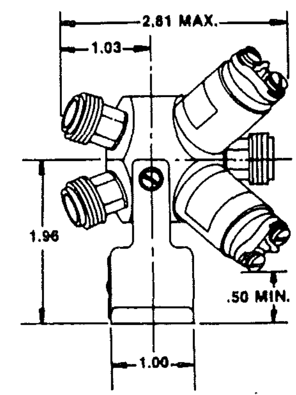
LOWER FREQUENCY

At 10 MHz, typical values are: Isolation, 100 dB; VSWR, 1.05:1; Insertion Loss, 0.05 dB. Because of the inherently good RF performance at lower frequencies, this product line is not tested below 2 GHz except upon request.

SOLENOID DATA	28 Vdc nominal
RATED VOLTAGE	18-30 Vdc
DROPOUT VOLTAGE	0.5-10 Vdc
RATED CURRENT PER COIL	.23 amps @ 26V
RATED POWER PER COIL	7 watts
COIL RESISTANCE @ 70°F	101-123 ohms
SWITCHING TIME	10 mS nominal
RF CONTACTS	break-before-make or make-before-break
IMPEDANCE	50 ohms nominal
RF POWER	300 watts c.w. (3000 MHz & sea level)
VIBRATION	20 g's to 500 cps
TEMPERATURE	-55°C to 85°C
LIFE	1,000,000 operations min
WEIGHT	11 oz SP3T, 13.5 SP4T

DIMENSIONS





NOTE: SP3T LESS 1 SOLENOID & 1 CONNECTOR

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

432 MHz ANTENNAS

ANTENNA TYPE	GAIN dBd		PATTERN E x H	BOOMLENGTH ^	feet	SIDELOBES E x H	-dB	FB dB	STACKING inches
11 el Cushcraft	5.0		34 x 36	2.6	6.0	17e	13e	18e	34 x 32
20 el CC Colinear	10.1		35 x 37	--	---	12e	10e	15	40 x 30
8 el Quagi	11.1		36 x 40	2.1	4.6	13	11	11	42 x 36
17 el CUE-DEE	11.5		34ex 36e	3.6	8.1	17e	13e	20e	46 x 40
11 el Tilton	11.8	f,g	34 x 36	2.6	6.0	17	13	19	46 x 40
12 el CC 410B	12.4		33 x 34	2.3	6.0	15	14	21	46 x 46
13 el W6QKI	13.3		27 x 29	3.4	7.8	12	9	18	50 x 44
13 el K2RIW	13.5		27 x 29	3.4	7.8	13	10	15	52 x 46
16 el KLM 16 LB	13.5		24 x 25	5.3	12.0	11	9	16	54 x 46
15 el Long QUAGI	13.7		26 x 29	5.3	11.5	13	11	16	54 x 50
24 el KOUDZ	13.7	m	27 x 28	3.7	8.4	13	10	17	52 x 50
27 el KLM 440-27	13.8		28 x 32	5.3	12.0	15	13	20	54 x 46
15 el W0EYE/NBS	13.9		27 x 29	4.2	9.6	15	13	20	55 x 48
15 el ARRL/NBS	14.0	a	27 x 29	4.2	9.6	15	13	20	55 x 48
17 el W0EYE/NBS	14.1	n	27 x 29	4.2	9.6	16	14	22	56 x 49
88 el J-BEAM	14.5		26 x 28	5.6	12.0	15e	13e	20e	58 x 54
19 el K2RIW	14.9		26 x 27	5.6	12.8	17	15	15	60 x 56
18 el mod K2RIW	14.9	j	26 x 27	5.2	11.7	16	15	15	60 x 56
21 el F9FT	15.1	b	24 x 26	6.6	15.0	14	13	20	60 x 56
20 el KLM 20LBX	15.3	u	25 x 27	5.4	12.3	16	14	20	62 x 58
26 el DL9KR	15.5	u,i	24 x 25	6.1	13.8	17	15	28	64 x 60
22 el K1FO/W1EJ	15.7		23 x 24	6.1	13.9	16	15	22	66 x 62
24 el Cush. 424B	15.8		20 x 21	7.5	17.1	12	10	22	62 x 52
22 el DL6WU	15.8	u,h	23 x 24	6.9	15.6	16	15	23	66 x 62
24 el K1FO	16.2	c	22 x 23	7.5	17.1	17	16	24	68 x 63
28 el W1JR/DL6WU	17.0	u	21 x 22	9.3	21.1	15	14	20	70 x 64
30 el KLM 30LBX	17.3	u	19 x 20	9.6	21.9	16	14	22	72 x 66
31 el W1JR/DL6WU	17.5	u	19 x 20	10.4	23.7	15	14	24	75 x 69
31 el K1FO/DL6WU	17.7	u	19 x 20	10.4	23.7	17	16	26	80 x 76
32 el K1FO	17.7	d	19 x 20	10.5	23.9	17	16	24	80 x 76
33 el K1FO/W1EJ	17.8	l	19 x 19	10.5	24.2	16	15	22	82 x 78

a Dimensions per ARRL Handbook (page 33-23 1985 edition)
b Is designed for 435 MHz. Gain peak is 15.3 dBd at 436 MHz. The design should give 0.2 dB more gain with an improved driven element.
c Is a modified 424B using a single reflector and 22 directors.
d This yagi is made mostly out of Cushcraft 424B parts.
e Indicates estimate
f Is tuned to 440 MHz. Retuned to 432 MHz gain would be 12.6 dBd.
g Design based on Greenblum information.
h Is designed for 435 MHz. Gain peak is 16.0 dBd at 436 MHz.
i Uses 8 element screen reflector.
j Is modified K2RIW 19 using a single reflector.
k Front to back figures are adjusted to take into account strong rear lobes that are not exactly at 180°.
l This design theoretically has 18.0 dBd. Range measurements have been lower.
m Is a 13 el K2RIW yagi with a corner reflector added.
n Is 15 element NBS with Tri-reflector added.
u Design based on DL6WU information.

Gain figures should be within 0.2 dB and are given for 432.0 MHz.

IF YOUR YAGI IS NOT ON THIS LIST IT IS BECAUSE YOU HAVE NOT PUBLISHED ANY INFORMATION ON IT !!!!!!!

Compiled by K1FO Last revised 6-11-86

```
5 REM KA1GT PARAMETRIC LOOP YAGI DESIGN
10 DIM A(38)
20 A(1) = 3.1
21 A(2) = 4.05
22 A(3) = 5.17
23 A(4)=6
25 A(5) = 7.78
26 A(6) = 9.560001
27 A(7) = 10.81
28 A(8) = 13.12
30 FOR X = 1 TO 30
40 A(X+8) = 13.12+X*3.56
50 NEXT
60 INPUT "FREQUENCY OF DESIGN IN MHZ";F
70 FC = 1296/F
72 FOR X = 1 TO 38
75 A(X) = A(X)*FC
77 NEXT
80 R1 = 9.67
90 DE = 9.229999
100 DIM B(36)
110 FOR X = 1 TO 11
120 B(X) = 8.25
130 NEXT
140 INPUT "27 OR 38 ELEMENT VERSION ?";N
142 IF N = 27 THEN GOTO 150
144 IF N = 38 THEN GOTO 150
146 GOTO 140
150 FOR X = 12 TO 18
160 B(X) = 8
170 NEXT
180 IF N = 27 THEN GOSUB 500
190 IF N = 38 THEN GOSUB 600
200 FOR X = 1 TO 36
210 B(X) = B(X) * FC
215 NEXT
220 R1 = R1 * FC
230 DE = DE * FC
240 INPUT "BOOM DIAMETER ?  INCHES" ;B
250 INPUT "ELEMENT WIDTH ?  INCHES" ;W
260 INPUT "ELEMENT THICKNESS ?  INCHES";T
265 PRINT ""
266 PRINT ""
270 B1 = B/FC
271 W1 = W/FC
272 T1 = T/FC
280 IF B1 < .5 THEN GOSUB 700
290 IF B1 > 2.1 THEN GOSUB 700
300 IF T1 < .028 THEN GOSUB 750
310 IF T1 >.063 THEN GOSUB 750
320 IF W1<.1 THEN GOSUB 800
330 IF W1 > .375 THEN GOSUB 800
340 B2 = ((B1-.5)+(B1-.5)^2)*2.88
350 FOR X = 1 TO (N-2)
360 B(X) = B(X) +(B(X)/100)*B2
365 NEXT
370 DE = DE+DE*B2/100
380 R1 = R1 + R1 *B2/100
390 W2 = (.1875-W1)*4.8
400 FOR X = 1 TO (N-2)
410 B(X) = B(X)+(B(X)/100)*W2
420 NEXT
```

KA1GT LOOP YAGI
DESIGN PROGRAM

TRANSLATED TO
IBM BASIC BY
WA5VJB

```
422 DE =DE +  DE*W2/100
424 R1 = R1 + R1*W2/100
430 T2 = (T1-.028) *(.6/.031)
440 FOR X = 1 TO (N-2)
450 B(X) = B(X)+ ((B(X)/100)*T2)
460 NEXT
470 DE = DE + DE * T2/100
475 R1 = R1 + R1 *T2/100
480 RA = 4.5
481 RB = 5.5
485 RA = RA * FC
486 RB = RB * FC
495 GOTO 1000
500 FOR X = 19 TO 25
510 B(X) = 8
520 NEXT
530 RETURN
600 FOR X = 19 TO 36
610 B(X) = 7.7
620 NEXT
630 RETURN
700 PRINT "BOOM DIAMETER IS OUTSIDE THE RANGE OF PARAMETRIC STUDY."
701 PRINT "CALCULATIONS CONTINUE WITH EXTRAPOLATED DATA"
710 RETURN
750 PRINT "MATERIAL THICKNESS IS OUTSIDE THE RANGE OF PARAMETRIC STUDY."
751 PRINT " CALCULATIONS CONTINUE WITH EXTRAPOLATED DATA"
760 RETURN
800 PRINT "ELEMENT WIDTH IS OUTSIDE THE RANGE OF PARAMETRIC STUDY."
810 PRINT "CALCULATIONS CONTINUE WITH EXTRAPOLATED DATA"
820 RETURN
1000 PRINT "DATA FOR LOOP YAGI FOR USE AT ";F;" MHZ"
1010 PRINT ""
1020 PRINT "BOOM DIAMETER ";B;" IN"
1030 PRINT "ELEMENT WIDTH ";W;" IN"
1040 PRINT "ELEMENT THICKNESS ";T;" IN"
1045 PRINT "REFLENCTING SCREEN ";(INT(RA*1000))/1000;" X ";(INT(RB*1000))/1000
1046 PRINT ""
1047 PRINT "ALL DIMENSIONS IN INCHES"
1048 PRINT ""
1049 PRINT "ELEMENT              DISTANCE       LENGTH"
1050 PRINT "                     FROM SCREEN"
1051 PRINT"                                    (CIRCUMFERENCE)"
1052 PRINT ""
1055 PRINT "R1",(INT(A(1)*1000))/1000,(INT(R1*1000))/1000
1060 PRINT "DE",(INT(A(2)*1000))/1000,(INT(DE*1000))/1000
1070 FOR X = 1 TO N-2
1075 L = (INT(B(X)*1000))/1000
1076 L1 =(INT(A(X+2)*1000))/1000
1080 PRINT "D";X,L1,L
1090 NEXT
1100 END
Ok
```

```
RUN
FREQUENCY OF DESIGN IN MHZ? 2304
27 OR 38 ELEMENT VERSION ?? 27
BOOM DIAMETER ?  INCHES? .5
ELEMENT WIDTH ?  INCHES? .2
ELEMENT THICKNESS ?  INCHES? .032
```

DATA FOR LOOP YAGI FOR USE AT 2304 MHZ

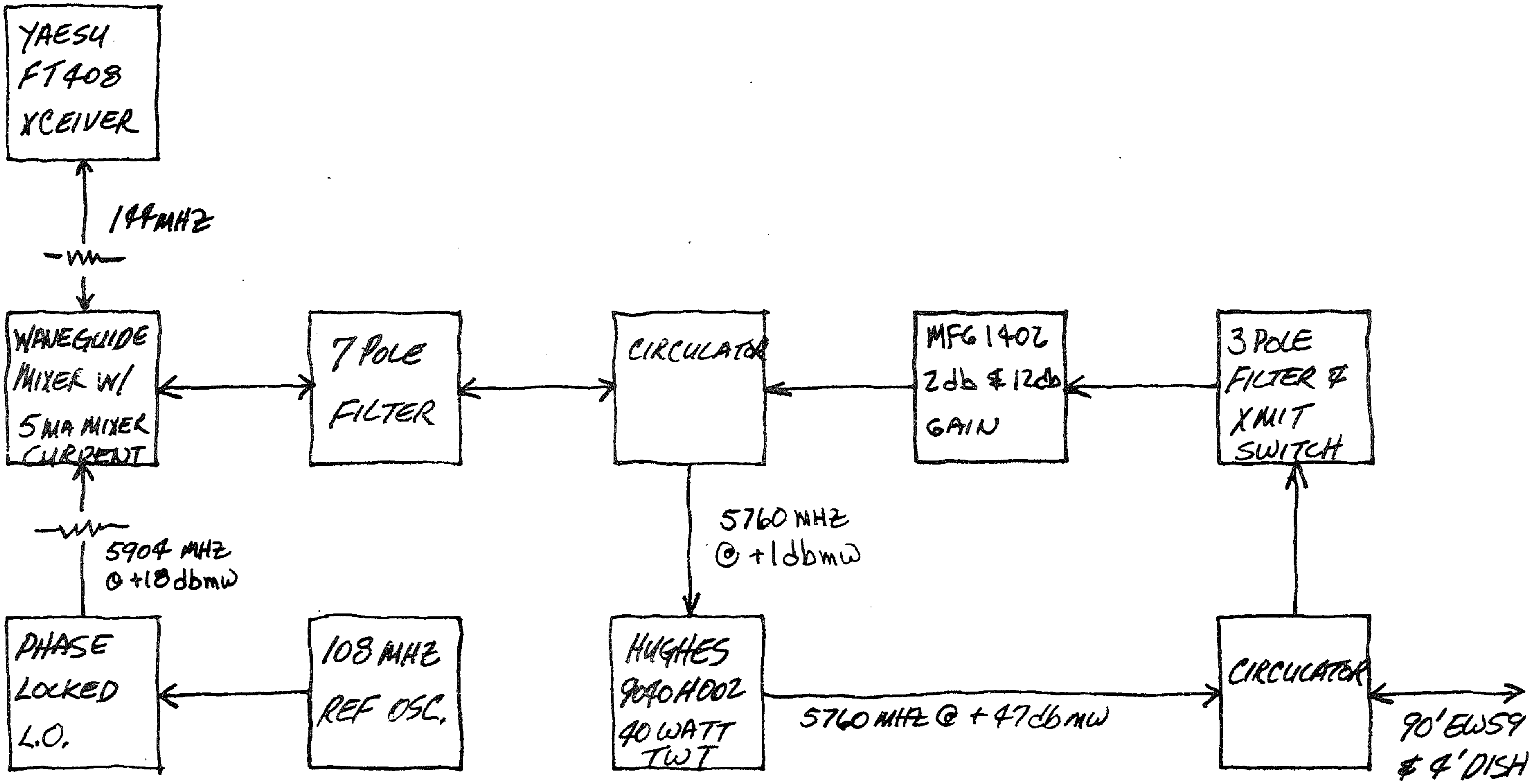
BOOM DIAMETER .5 IN
ELEMENT WIDTH .2 IN
ELEMENT THICKNESS .032 IN
REFLECTING SCREEN 2.531 X 3.093

ALL DIMENSIONS IN INCHES

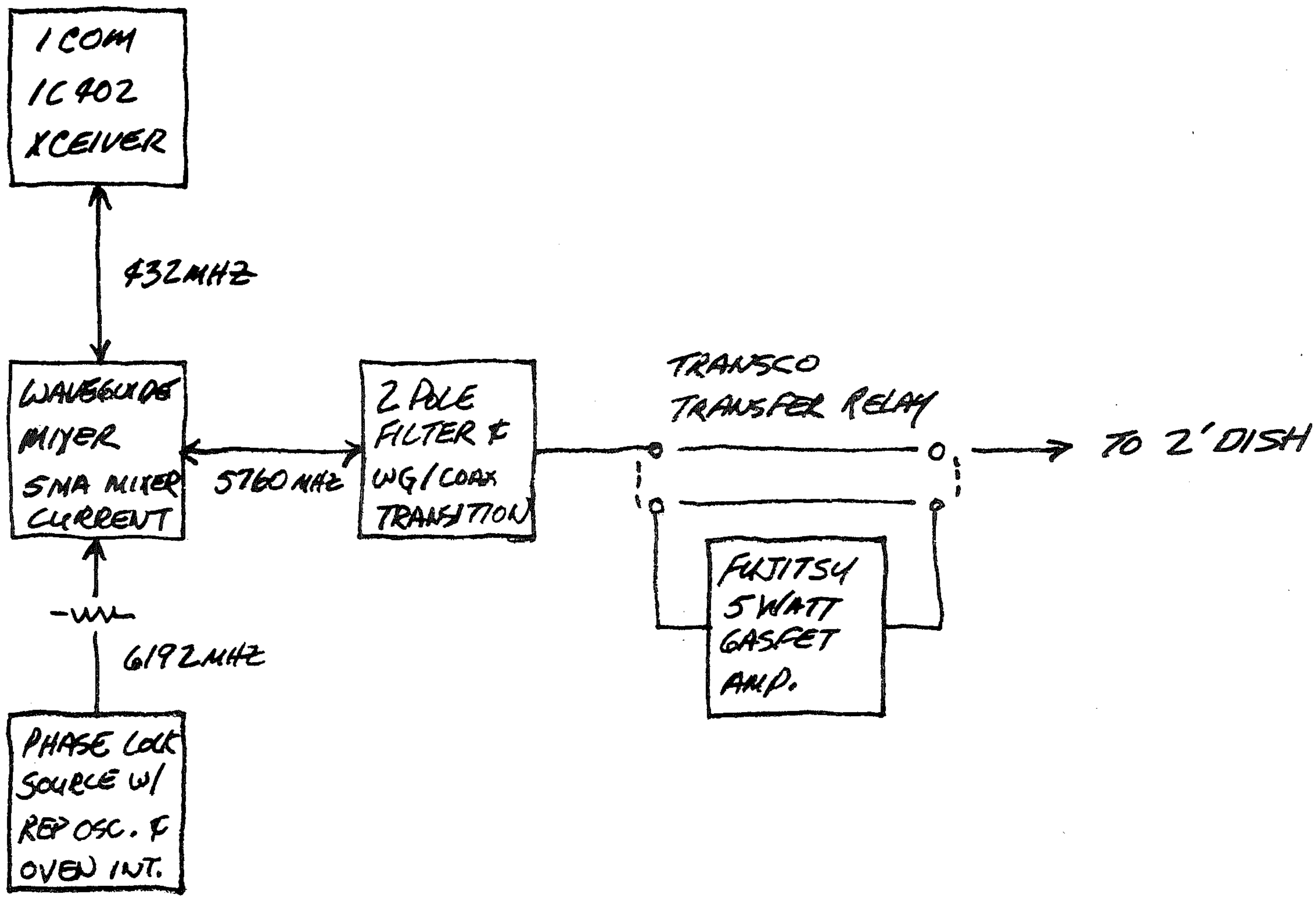
ELEMENT	DISTANCE FROM SCREEN	LENGTH (CIRCUMFERENCE)
R1	1.743	5.51
DE	2.278	5.259
D 1	2.900	4.7
D 2	3.375	4.7
D 3	4.376	4.7
D 4	5.377	4.7
D 5	6.00	4.7
D 6	7.38	4.7
D 7	9.382	4.7
D 8	11.385	4.7
D 9	13.387	4.7
D 10	15.39	4.7
D 11	17.392	4.7
D 12	19.395	4.558
D 13	21.397	4.558
D 14	23.4	4.558
D 15	25.402	4.558
D 16	27.404	4.558
D 17	29.407	4.558
D 18	31.41	4.558
D 19	33.412	4.558
D 20	35.415	4.558
D 21	37.417	4.558
D 22	39.42	4.558
D 23	41.422	4.558
D 24	43.425	4.558
D 25	45.427	4.558

Ok

SAMPLE DESIGN



5760 MHZ STATION
K5PJR HOME



5760 MHZ STATION

K5PJR PORTABLE

The Record Breaking Aurora of Feb. 8, 1986

Correlation of A/K Index with distribution of Auroral Ionization

Presented By

Jon K. Jones M.D. NOØY

The great aurora of Feb. 8, 1986 was one of the best in the last 20 years. The intense ionization supported numerous 432 MHz contacts including a new record North American qso between WB5LUA and W3IP at 1181 miles, as well as countless 144 MHz contacts including the new North American DX record for this mode set by WBØDRL and KA1ZE. This event was widespread as well, with stations in southern California and Florida able to participate. This presentation will review the solar events that caused the aurora, summarize amateur activity during the event's peak, and attempt to correlate the Boulder, CO K index with the southernmost distribution of auroral ionization for a given frequency as estimated from reported Qsos for that band. The concept of the Auroral Oval and it's relationship to solar activity will be discussed.

The source of the Feb. 8 aurora was a sun spot group that began emitting strong bursts of radio noise beginning Feb. 3. This flare was termed a M2/1B class of flare by the National Oceanic and Atmospheric Administration (NOAA). The most intense burst of 245 MHz radio noise was recorded at 1013Z on Feb. 7. This was approximately 30 hours prior to the peak of the radio aurora on the 8th at 2100Z, and this flare is suspected as the source of the charged particles causing the most intense ionization.

This intense ionization supported many 432 MHz contacts, and allowed stations far further south than usual to make auroral qsos on this band. From data complied from W3EP/4, Emil noted that stations as far south as Dallas, TX(EM-12) and Charleston, SC(FM-02) were able to make 432 MHz auroral contacts.

The distribution of auroral ionization as a function of frequency was derived from 432 MHz logs of reported contacts. The contacts for each hour of the aurora on 432 MHz were plotted on separate ARRL Grid Locator maps. The location of the ionization that supported communications for the stations was estimated, using the established spatial characteristics of radio aurora as a guide. Radio aurora forms ionization in planes parallel to the geomagnetic field lines. The intersect of these lines with a line tangent to the earth's surface is called the magnetic dip angle, I. For radio aurora signals to be audible, the angle ϕ_1 of the incident radio signal must nearly equal the angle ϕ_2 of the reflected signal.(see diagram) In addition, radio aurora occurs in a limited region in the ionosphere at a height of 70 miles. For the purposes of this study, this meant that radio aurora must be located approximately 200-750 miles geomagnetic north of a station for it to be useful. In addition, the incident and reflected signal angles must be nearly equal. Finally, beam headings noted during qsos were also utilized to estimate the location of the aurora ionization. When these factors were combined, a reasonable estimate of the location of the ionization that two stations were bouncing their signals off of could be made. These locations were plotted on the maps submitted to the Procedings for 144 MHz and 432 MHz.

These showed that the southernmost zone of auroral ionization capable of supporting 432 MHz communications was at about 54^0 geomagnetic north during the peak of the aurora. A similar map prepared for 144 MHz revealed that the southern edge of the auroral oval on this band was at 50^0 g. north. The K_p 7 and 9 lines are the "average" southern limit of radio aurora edge for a K index of 7 and 9 respectively.

In addition, the geographical area of stations able to make auroral contacts was plotted, based entirely on reported contacts. These correspond well with the estimated ionization maps.

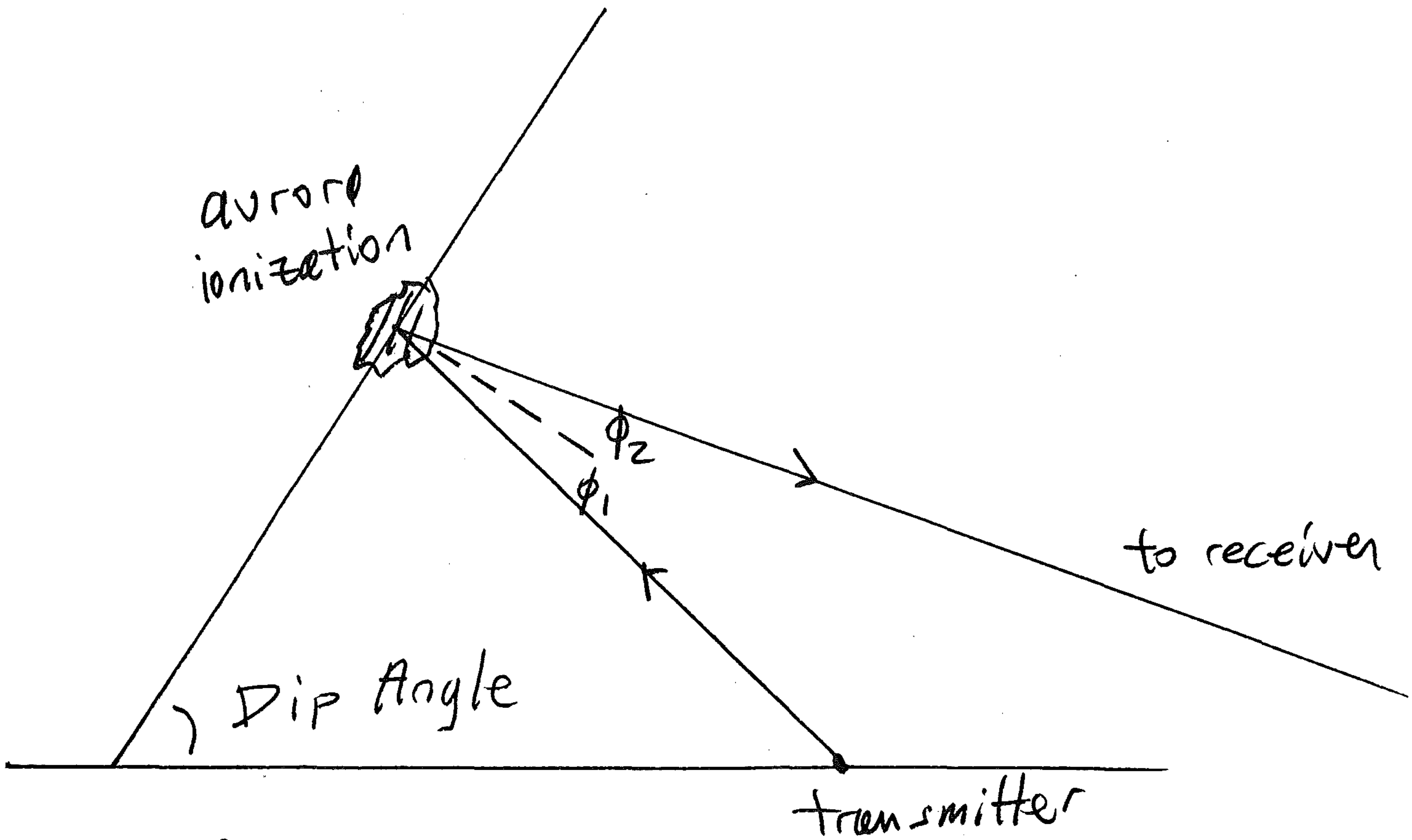
It is interesting to note that the aurora "extended" further south on 2 meters than on 70 cm. Apparently there is a gradient of ionization in the leading edge of the aurora, with intensity of ionization increasing as one goes geomagnetically north.

The concept of the "auroral oval" is important to understanding the way an auroral opening works. The oval is a region of activity fixed in space above the earth. It is centered on the geomagnetic north pole, which is located at the northwest corner of Greenland, at 78.5^0 N and 69^0 W. From figure 2, note that the oval goes further south over the night side of the earth. The width of the oval is also wider at night. During a major solar storm, the oval expands rapidly toward the equator, increases in width, and often breaks up into loops and patches. Note that for a given level of ionization, the oval is wider and further south on the night side. Had the Feb. 8 aurora started at 0100Z on the 9th, it would have likely extended further south and been wider than it was. 432 MHz contacts may have been possible from AZ to the mid west, south TX to FL, and VP7 to the upper mid west. Two meters may have been open from the Carribean to the south east U.S. As it was, it was an excellent opening. Note, that for a given reported K index, there will be more aurora, and further extension south at night than during the day.

Appreciation is gratefully extended to the following amateurs for their help and contributions to this study. A special thanks to Emil, W3EP/4 and Bob, NI8O for their detailed logs and maps. Others contributing: KFØM, KBØDW, W7HAH, KØUS, W9IP/2, W5FF, W4GJO, K4QIF, W3IP, NØLL, WAØTKJ, WBØDRL, KØTLM, WBØYSG, W7CNK, K6PVS, K7ICW, W6OUU, KØBFT, N8CKH, WØETT, and WBØDGF. Thanks!

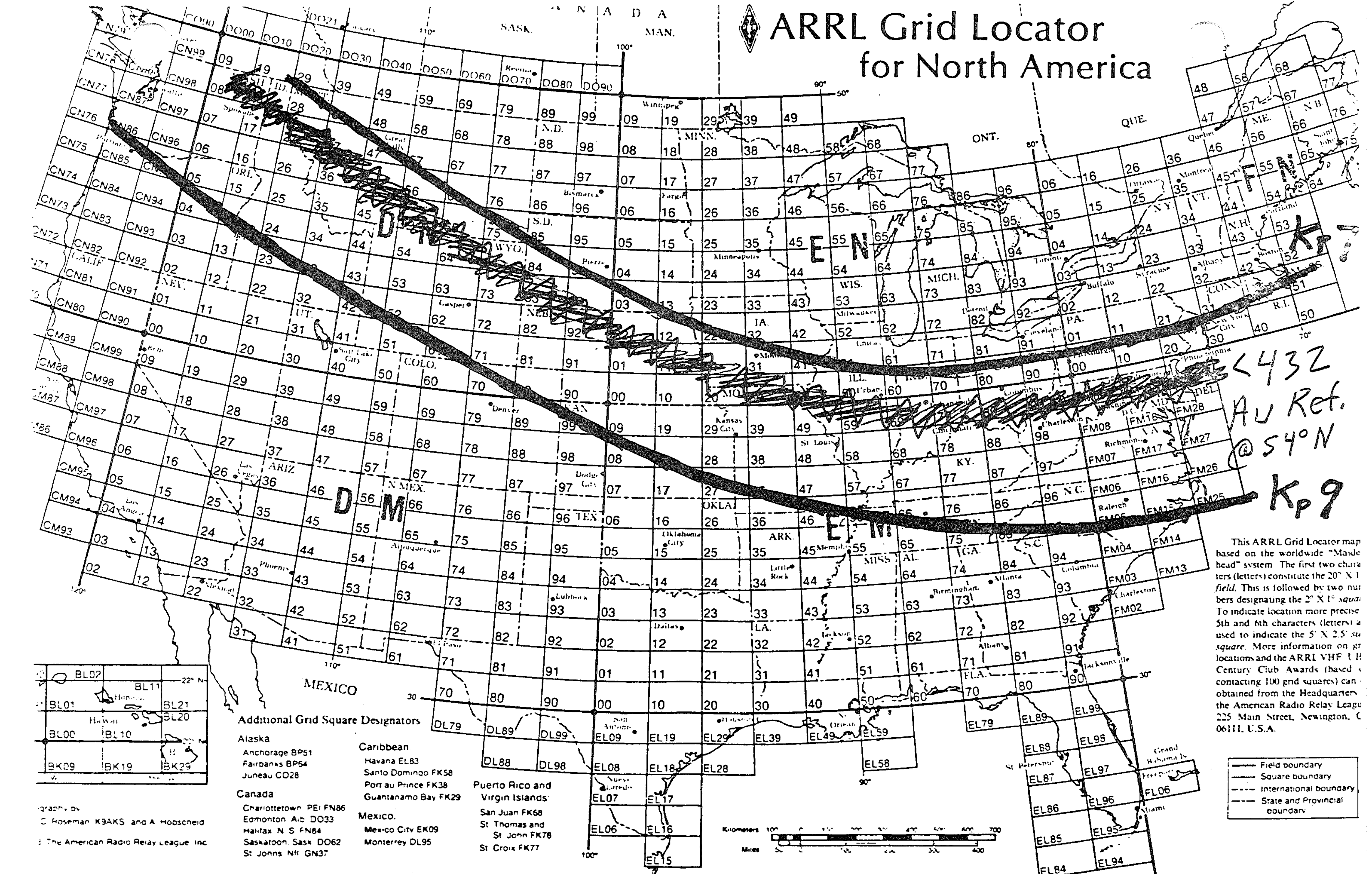
Bibliography

1) The World Above 50 MHz B. Tynan, W3XO, QST May, 1986.
2) The Midwest VHF Report R. Cox, WBØDGF Feb., and March issues, 1986.
3) Miller, R., "Radio Aurora", QST Jan.1985, pp.14-18.
4) Dyce, R. "More About VHF Auroral Propagation," QST, Jan. 1955. pp.11-15.



Geometry of Aurora Reflection

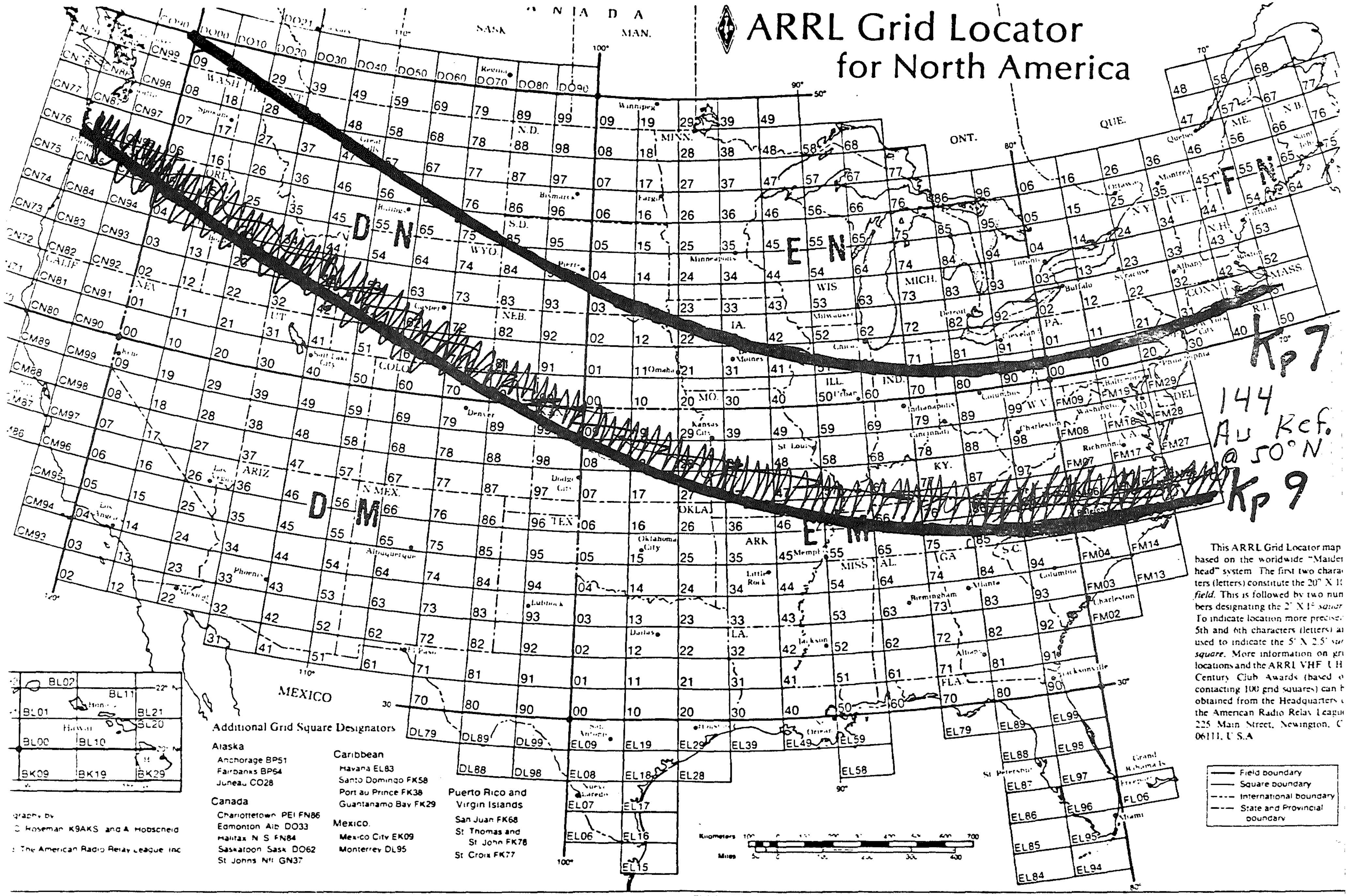
P VE3CIE



Estimated zone of Radio Aurora Oval Southern Edge

Supporting 432 MHz Echoes 2100-2300 utc 2/8/86

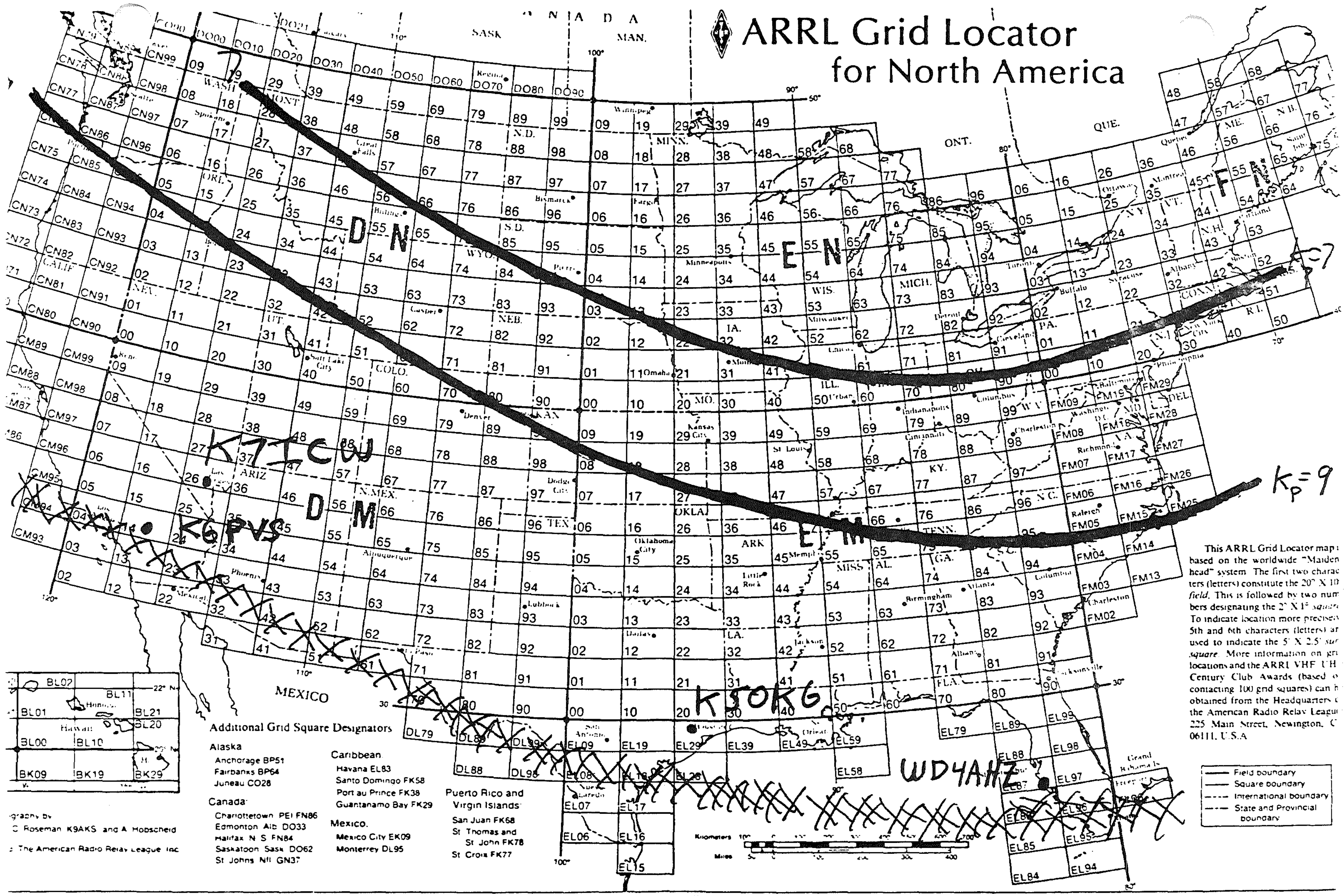
(compiled from reported 432 MHz QSOs)



Estimated Zone of Radio Aurora Oval Southern Edge

Supporting 144 MHz Echoes 2100-2300ut 2/8/86

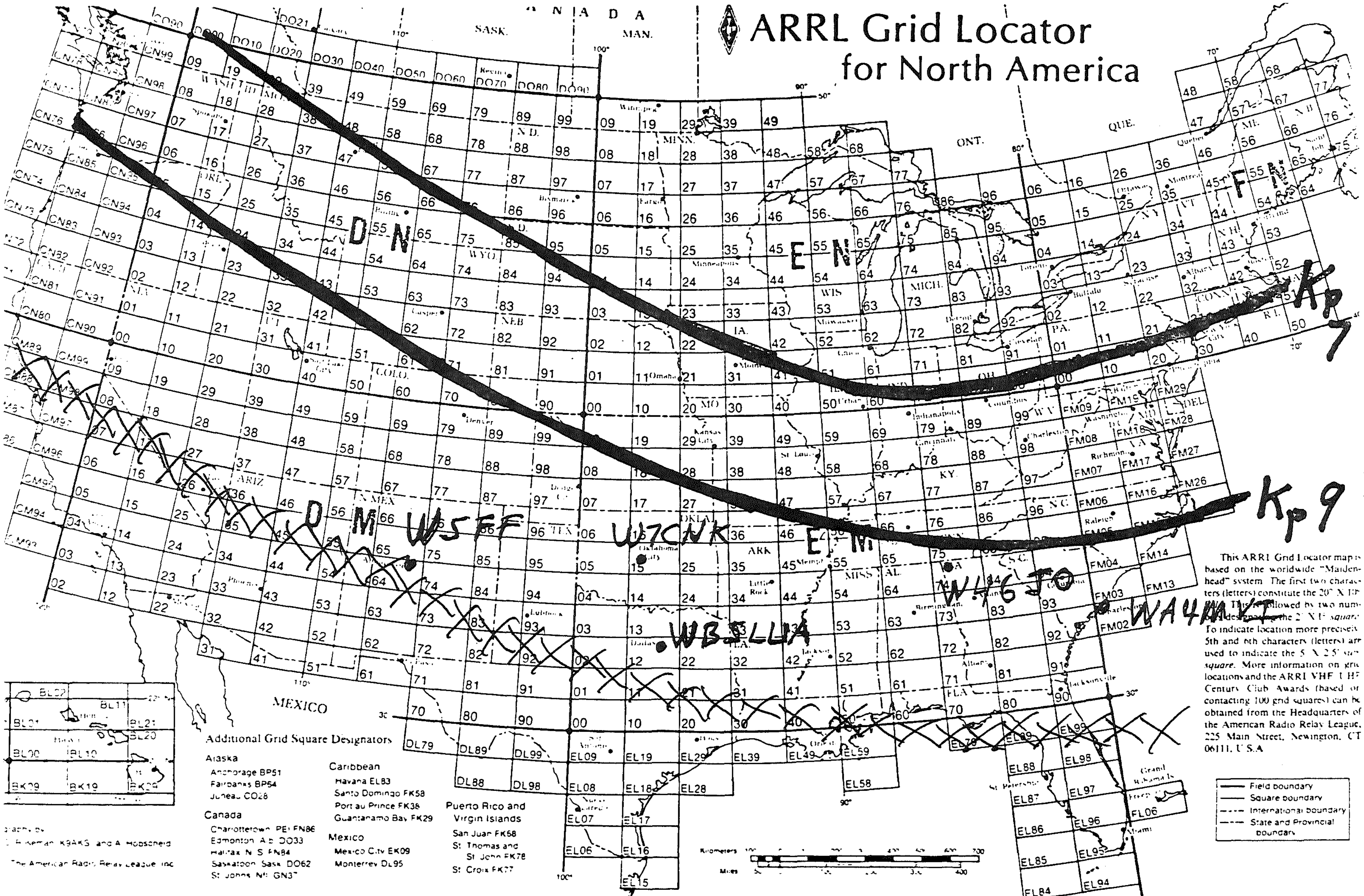
(compiled from reported 144MHz Qsos)



Estimated Southernmost Boundry for Aurora

144 MHz QSOs 2100-2300 UTC 2/8/86

~750 miles <u>geomagnetic</u> south from Aurora Ionization



Estimated Southernmost Boundry for Aurora

432 MHz QSOs 2100-2300 utc 2/8/86

Limit is ~ 750 miles south from auroral ionization

AMSAT MODE-S TRANSPONDER

by

WILLIAM D. McCAA Jr., KØRZ

June 29, 1986

Background

It is hoped that the addition of an S-band transponder on Phase-3C would help the transition of the average amateur satellite user into the microwave frequencies. The ready availability of good low cost crystal controlled receiving equipment in the MDS (2150-2160 MHz.) service can find immediate application in receiving a Phase-3C transponder in the 2400-2450 MHz. band.

Introduction

The S band output, Mode-S, transponder described herein has been developed for flight in the AMSAT Phase-3C satellite which is scheduled for launch in Mid 1987, on the first flight of the Arienne 4 launcher. Since this transponder is an add on to a Phase-3 type satellite, the power consumption and physical size had to be held to the constraints of the satellite's origional design. Thus power efficiency and size became major design considerations. The transponder's current drain from the satellite's 14.0 VDC buss is 0.54 Amps.

The transponder will operate either in the PSK (400 baud) beacon mode or transponder mode, 30 kHz. bandwidth, usable for both NBFM and SSB and have an EIRP of +17 dBW. The spacecraft S band antenna is a left hand circular 15 turn helix.

The Mode-S transponder uses a portion of the Mode-B transponders receiver. A buffered output at 53 MHz. is taken from the Mode-B receivers first IF after AGC. The Mode-S transponder thus can be operated only when the mode-B receiver is active, while the Mode-S beacon can be operated at any time. The uplink power at 435 MHz. required for access will be the same as that required for mode-B (about 1000 Watts EIRP max.).

Transponder Construction Status

The Mode-S transponder is completed. It has undergone Thermal-vacuum testing in the Phase-3C spacecraft in May, 1986, and is presently being bench operated on extended burn-in.

Link Calculations at 2.4 GHz.

Transmitter output power at antenna	+0 dBW
Spacecraft antenna gain (15 turn helix)	+17 dBic
Spacecraft EIRP	+17 dBW
Free space path loss (40,000 km @ 2.4 GHz.)	-192 dB
Signal level at receive antenna	-175 dBW
Receive antenna gain (1 meter dish @ 50%)	+25 dBic
Signal level at receiver	-150 dBW
Receiver sensitivity (75K, 20 kHz.BW)	-160 dBW
Received signal to noise ratio	+10 dB

INPUT AND OUTPUT FREQUENCIES

The following details the frequencies used in the Mode-S transponder.

INPUT FREQUENCY TO THE S BAND TRANSPONDER (Fin)	435.625 MHz.
Input frequency from Mode-B transponder	53.305 MHz.
Local crystal controlled oscillator (LO1)	42.605 MHz.
Local crystal controlled oscillator (LO2)	41.930 MHz.
IF frequency including filter (IF=Fin-LO1-382.32)	10.700 MHz.
IF FILTER BANDWIDTH	30 KHz.
Beacon injection oscillator (BO)	10.630 MHz.
3XLO2 injection frequency	125.790 MHz.
1st upconversion frequency (FI=3XLO2+IF)	136.490 MHz.
18X3XLO2 injection frequency	2264.220 MHz.
2nd upconversion frequency (Fout=54XLO2+FI)	2400.710 MHz.
OUTPUT FREQUENCY FROM THE S BAND TRANSPONDER (Fout=Fin+56XLO2-382.32=57XLO2+IF)	2400.710 MHz.
BEACON OUTPUT FREQUENCY (FB=57XLO2+BO)	2400.640 MHz.

Modulation

The transponder is a soft limiting type that will be suitable for use by one or two NBFM signal or four simultaneous SSB signals. The nonlinearity introduced by the amplifier and limiter does not limit its usefulness to CW or FM only. Since the received signal to noise ratio will be less than 20 dB, SSB can be used thru the transponder as the intermod products are generally below 20 dB and thus below the received noise level. This technique is being used sucessfully in the Mode-L transponder on OSCAR-10.

General Comments On The Transponder Use

It is necessary to point out that this transponder is intended for purely experimental and educational purposes. Through using it, it is hoped that the satellite users will gain operational and technical experience in receiving microwave frequencies from an amateur radio satellite.

The transponder can be used for normal voice and data communications via narrow band FM, CW or SSB modulation. Doppler shifts can be quite significant, up to 50 KHz. depending where the satellite is in its orbit. Doppler should be a minimun at apogee, and it is planned that the transponder or beacon will operate only at apogee.

Receiving SSB and CW requires less receiver bandwidth than NBFM. With reduced bandwidth, the required receiver sensitivity or antenna size decreases for a given signal to noise ratio. However, SSB and CW reception at 2401 MHz. requires excellent receiver frequency control via a crystal controlled converter. With NBFM modulation, the ground station receiver could use AFC to overcome receiver drift and doppler.

Mechanical Packaging

The transponder is packaged in two separate housings.

PACKAGE 1   S-TX

This module contains the following:
S-Band mixer, S-Band amplifier, and 18X multiplier. It is mounted at the arm end next to Mode-B receiver. Package size is 1Ø.Ø" X 2.23" X 3.ØØ".

PACKAGE 2   S-IF

This module contains the following:
VHF stages, 1ØVDC converter, Beacon generator, 42 MHz. oscillators, 3X multiplier, and IHU interface. It is mounted on top of the Mode-B transmitter. Package size is 13.85 X 4.12" X 1.5".

Development Team

The development of this Mode-S transponder has been shared among many amateurs. The specific task leaders are listed below:

TASK AREA	RESPONSIBLE PERSONS	
Project Coordination, Construction	Bill, McCaa,	KØRZ
S-Band Housing	Ray Uberecken,	AAØL
S-Band Miltiplier, and Mixer	Steve Ernst,	WBØWED
Local Oscillators and 3X Mulitplier	Chuck Hill,	KYØS
VHF Mixers, IF Amp, Control,	Gordon Hardman,	KE3D
Placement, Spacecraft Interface	Jan King,	W3GEY
S-Band RF Power Amplifier	Chip Angle,	N6CA
S-Band Antenna	Hans Van de G.	ZS6AKV

Submitted by:
George Chaney, W5JTL.
218 Katherine Dr.,
Vicksburg, Ms.

THE MECHANICS OF IT

Described in this paper will be a number of special tools and methods of accomplishing things related to VHF/UHF construction projects. They will deal mostly with antennas and transmission lines.

Shown in the drawings of Fig. 1 is a boom carrier which can be a valuable aid in preparation of booms for Yagi antennas. It is similar in many respects to the one described by Don Hilliard, WØPW, in the proceedings of the 1296 Conference at Estes Park (1985). This is not a copy of Don's work, but has been used by the author for a number of years.

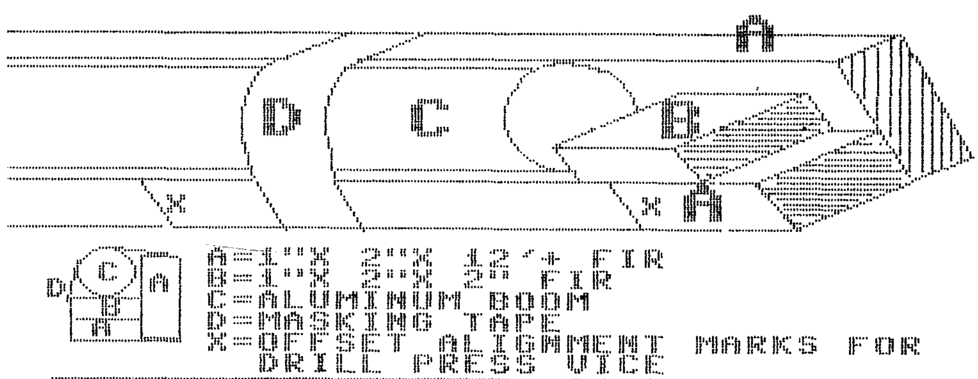
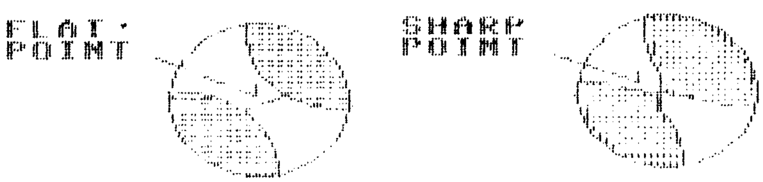


FIG 1 DRILL PRESS BOOM CARRIER

The bottom portion of the carrier should be slightly wider than the diameter of the tubing to be drilled, and the vertical portion equal to or less than boom diameter. The boom is held in place with masking tape, with one end resting against a wood block as shown in the drawing. In this way, we can achieve uniformity of element placement when preparing a number of identical antennas. It is not necessary to measure or mark the the boom itself, as this can be done on the carrier. The carrier is held in a drill press vice, fixed to the drill press table so that the boom is centered under the chuck. A vertical line on the edge of the carrier (it will be offset from the actual point of drilling) is aligned with the edge of the vice jaw, tightened and drilled almost as rapidly as this can be written. These vertical lines are measured and marked corresponding with the element spacing. It is necessary to support the carrier on either side of the drill press at points about one-half of the carrier length. If you don't have sufficient room in the shop, or a convenient door or window, it may be necessary to temporarily move the drill press outside. This may require some very careful planning, to coincide with the XYL's shopping tour or other temporary absense.

At this point, some comment about drill bits is in order. Ordinary drill bits do not have a true point. The portion across the exposed end of the web forms a chisel type point. It will tend to "walk or wander" until it arbitrarily decides just where the hole is to be commenced. Split point drills are much more docile in this respect. They have a portion of the web ground off, so that each cutting edge extends to the exact center of the drill bit. With these drills, you - not the drill bit - make the decision as to the precise location of the hole to be made. Using the carrier described, the holes on each side of the boom can be made at the same time without fear of unduly enlarging the hole on the top side, and without the necessity of making pilot holes or indentations. Split point drills may be difficult to find in the local hardware store, but are available from tool houses catering to the machine shop trade, and are carried in the Sears tool catalog. Fig. 2 illustrates the difference between ordinary and split point drills.



REGULAR DRILL SPLIT POINT DRILL

Split point drill bits have the web ground away at the point, so that the two cutting edges meet and form a true point. Large sizes do not require a pilot hole.

FIG. 2

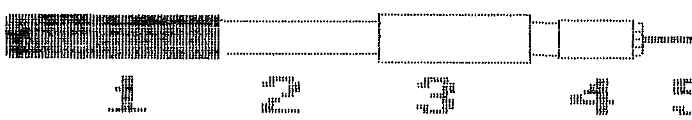
If you don't have a drill press, or access to one, the carrier may still serve a good purpose. The boom to be drilled can be placed in the carrier, with the use of shims, so that it is approximately centered on the inside vertical edge of the carrier, where a straight line may be scribed lengthwise. Turn it 180 degrees and do likewise. This will mark the lines in which element holes are to be drilled. With the aid of a short piece of tubing that is a sliding fit over the boom, scribe annular lines around the boom which coincide with element spacing. At each point of intersection of the lines make a slight indentation with a center punch. With a hand leld electric drill, using a split point drill, make the holes,top side only, turning the boom over 180 degrees to make them on the other side. The elements will be square with the boom and in alignment.

COAX AND CONNECTPRS

Coax connectors for hardline cost more than most of us are willing to pay, or the budget will permit. Over the past several years, I have made many different kinds, and will describe here the ones which I believe are worthy of attention.

Although aluminum hardline is declining in its use by amateurs, it is very simple and easy to make a PL-259 type connector for it, which will have 50 ohms constant inpedance. It is shown in Fig. 3 and needs no further description here.

FIG 3



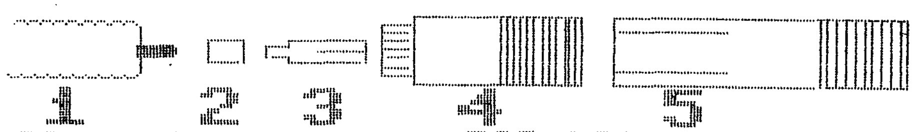
50 OHM 1/2" ALUMINUM HARDLINE
CONSTANT Z PL-259

1. Coax jacket.
2. Coax outer conductor.
3. Outer threaded sleeve from PL-259.
4. Spacer sleeve.9/16"OD X 1/2"ID X 1/2" L. 1/2 of a 3/8"copper sleeve coupler tinned. 1/16"of coax protrudes. Cut slits 1/8"apart. Fold fingers over end of sleeve and trim off excess.
5. Center conductor of coax is .159"OD, will enter SO-239 but should be filed down to .154". The connector can be fitted to 1/2" 75 ohm hardline if a 5/32"hobby brass tube is soldered over the center conductor

The principal fault of the SO-239 is its dielectric material. If the solid dielectric is removed it will be almost 50 ohms. They cannot be used satisfactorily in making adaptors for hardline because of the quality of metal from which they are made.

Coax threads - both N and UHF type - are 5/8" diameter with a pitch of 24 tpi. You probably wont find them in most hardware stores, but taps and dies can be had from the large tool supply houses. They are designated as NEF (national extra fine). A set, tap and die, cost me slightly less than $30.00. The die is adjustable and can be set to cut tight or loose threads. The pleasure, enjoyment and perhaps accomplishment they have provided is well worth it. With hard drawn copper water tubing or brass pipe of 5/8"OD, threads can be made to accomodate the threaded sleeve of a PL-259. A high quality adaptor for 1/2 or 7/8" hardline is easily made.

Hard drawn copper water tube comes in three grades of wall thickness, K,L and M. It is 1/8" greater in diameter than its nominal size. 1/2" tube is actually 5/8" OD. Grade K, the heavy wall type, is the type we will use. Threads can be cut on grade L , but very little material is left. M grade is too thin to thread. The specified wall thickness for the K grade tubing of this size is 0.049", but I have found it to be slightly less, having an ID of about 0.533", which will prove to be helpful. The center connecting part of the S0-239, when expanded with an S0-239 center pin is 7/32" or 0.218" diameter. With an outer conductor ID of 0.503" we can achieve an impedance of 50.1 ohms. I have found that 17/32" hobby brass tubing is a perfect mating fit inside the 1/2" K grade copper tube that I am presently using. Since the wall thickness of hobby brass is 0.014", this will give us the 0.503"ID we seek. Fig 4 shows two versions of UHF adaptors for Andrew 1/2" Heliax. Each of them will be as close to 50 ohms constant impedance as an N type connector.



CONSTANT Z F-UHF FOR LDF 4-50 HELIAX

1. LDF 4-50 Heliax, center bare 1/4"
2. 7/32 OD X 5/16 L hobby brass tubing. Splice between center conductor and S0-239 center pin.
3. S0-239 Center. Small diameter rear part removed.
4. Type K hard drawn copper water pipe. nominal 1/2". It is 5/8"OD X 1"Long. Threaded 5/8"NEF. Insert 17/32"OD X 1 1/4" L. hobby brass tube. Fingers cut, formed to shape, soldered to coax.
5. Alternate outer sleeve. Slit 4 places to form fingers. Slighty expand fingers. Force it over coax and clamp it in place.

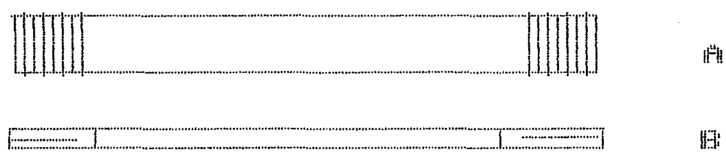
FIG. 4

The PL-259 of the Teflon dielectric type has an impedance of 47 ohms. If your 50 ohm coax is not mil.spec. it may very well vary this much or more from the nominal impedance. I experimentally bored out the insulating material of some PL-259's and found that a Teflon plug, with a 0.157" concentric hole in it, could readily be pressed into it. A center pin of 5/32" hobby brass tube can be soldered to the coax center conductor before it is inserted in the PL-259, similar to the assembly of a male N connector. I have always suspected, but have no proof, that the PL-259 would be improved if the center pin could be soldered at the other end, where the center conductor enters it.

I have experimented with fabricating a connector to substitute for the PL-259, using 1/2" ID brass to hold the Teflon insulator, but came up with impedance of slightly less than 49 ohms. I do not believe the very slight discontinuity of 47 ohms is significant.

Double male and double female UHF connectors, of the "barrel" type, are easily made.

For the male type, we will need a piece of 17/32" hobby brass tube of the desired length, two pieces of 9/16" hobby brass tube, each 1/2" long, two outer threaded sleeves from PL-259's, one piece of of Teflon rod, 1/2" diameter, with a 7/32" hole through the center, and one piece of 7/32" dia. brazing rod or hobby brass tube, 3/4" longer than the connector, to make center pins. Put them together as shown in Fig. 5 (A) and you will have a 49 ohm connector.



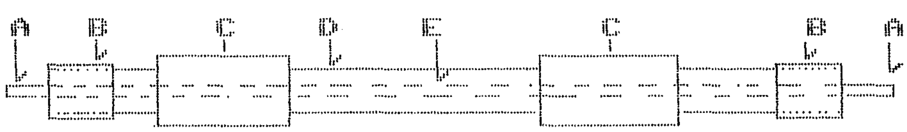
UHF F-F CONSTANT Z

A - 1/2"TYPE K HARD DRAWN COPPER WATER TUBE. THREADED EACH END 5/8"NEF. INSIDE SLEEVE FULL LENGTH 17/32"HOBBY BRASS TUBE,SOLDERED EACH END.

B - CENTER CONDUCTOR. 7/32"HOBBY BRASS TUBE. SO-239 CENTER CONDUCTOR SOLDERED TO EACH END.

NO CENTER INSULATOR IS REQUIRED IN THIS CONNECTOR, AS EACH END WILL BE SUPPORTED BY THE CENTER PINS OF MALE CONNECTOR

FIG 5



M-M UHF CONNECTOR - Z=49 Ω

A - CENTER CONDUCTOR 5/32"BRASS.

B - SLEEVE SOLDERED TO OUTER CONDUCTOR 9/16"HOBBY BRASS - .6"LONG.

C - OUTER THREADED SLEEVE FROM PL-259.

D - OUTER CONDUCTOR -17/32"HOBBY BRASS.

E - DIELECTRIC MATERIAL - 1/2" TEFLON ROD, CENTER DRILLED 5/32". MAY BE IN MULTIPLE SECTIONS IF LONG CONNECTOR IS DESIRED.

FIG 5(A)

The female kind is much simpler. It will need no insulators to support the center conductor, which will be provided by the male center pins. This will make an excellent "through the wall" type of coaxial feedthrough.

Fig. 5 shows construction details.

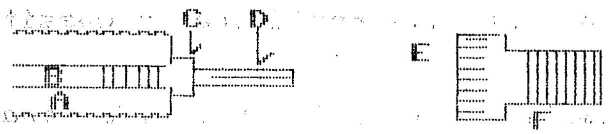
7/8" UHF ADAPTORS.

Adaptors for 7/8" hardline can be made with the use of plumbing type copper sleeve couplings. These couplings are made for the purpose of joining sections of water tube. They may be either straight or reducing. The ID of the coupling is the OD of the tube it is designed to couple. A 3/4" coupling sleeve is 7/8" ID, and a 3/4" to 1/2" reducer coupling is 7/8"ID on one and 5/8"ID on the other. The large end can be soldered to the outer conductor of 7/8" hardline, but it will be a butt joint. I do not regard this as being acceptable. Since the sleeve is much longer than will be needed, a portion of it can be cut into fingers which are folded out and over the hardline outer conductor and clamped or soldered to it. The wall thickness of the sleeve requires an excessive amount of heat for soldering. This degrades the foam dielectric and possibly releases damaging gasses. My preference is to bore the portion of the sleeve coupling which will mate with the coax, to a wall thickness of about 0.015". It is then sliced into fingers with a Dremel tool and slitting saw or silicon carbide disc. These fingers can be soldered to the coax outer conductor with minimum damage to the foam.

The small end, for the female UHF, is made from a short threaded piece of 1/2" copper pipe, with internal sleeve of 17/32" hobby brass tube. Cut off most of the small end of the coupling reducer, leaving about 1/8" to accommodate the threaded pipe, and solder it in place.

The center conductor of Heliax LDF 5-50 is a copper tube slightly less than 5/16" ID. A threaded brass plug ,of this diameter will self tap into the center conductor and make a very good and secure connection. There is an automotive type brass fitting, with hex head and hole in it which will accept the back end of the center conductor of an SO-239, with a pipe thread that will self tap into the center conductor of this coax. I do not know the designation of this fitting, but found it when brousing through the brass fitting stock of my friendly auto parts dealer. Perhaps you can do likewise.

The older type 7/8"Heliax, with convoluted corrugation, uses a tubular center conductor which is about 5/16"OD, with an ID of approximately 0.260". I have been unable to find any fitting or die that has thread which will self tap into it, except 7mm. It is larger than need be and requires considerable force to screw it in. If the adaptor plug is tapered, so as to leave only one or two full threads, it will be much easier to put in. Illustrations of these connectors are shown in Fig. 6, which gives sufficient details of construction.



FEMALE UHF TO 7/8"HELIAX ADAPTOR
A=COAX BODY
B=CENTER CONDUCTOR
C=THREADED COPPER PLUG,SELF TAPPING IN
CENTER CONDUCTOR.5/16"NF FOR LDF. 7mm
FOR OLDER TYPE.
D=CENTER CONNECTOR FROM SO-239
E=3/4"TO 1/2"COPPER REDUCER COUPLING,
SHORTENED, SLITTED.
F=SHORT SECTION OF 1/2"TYPE K COPPER
WATER TUBE, THREADED 5/8"NEF.

FIG 6

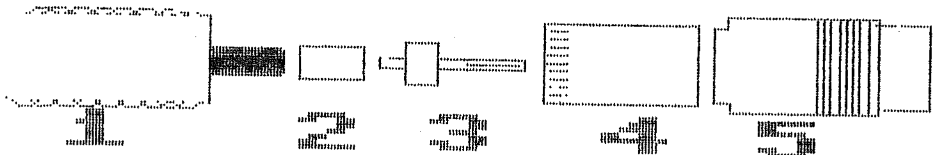
In assembling each of the female UHF adaptors described, it is necessary to first install the center connector. Since it will be rigid after installation, attention should be given to see that it is in alignment with the body of the coax, although it need not be perfect. When the outer conductor is installed, a wood or Teflon alignment plug, with a center hole providing no more than 0.002" clearance for the expanded center connector, and like clearance for the ID of the outer conductor, will assure good alignment.

If the mating PL-259 is modified as previously described, and the center hole in the Teflon plug is enlarged a few thousandths of an inch, this will permit some movement of the center pin to compensate for slight misalignment. Any mating male UHF connector must have the locating pins (which mate with the serrated edge of SO-239's) filed off to permit full contact of the outer conductors.

N TYPE ADAPTORS

The UG-58 type connectors (chassis type N female) are made of brass. With the flange removed they may readily be soldered to copper fittings. There is one precautionary measure that should be taken before any soldering is done. Due to the bulk of the metal, some time must be consumed in the application of heat. Likewise, heat does now quickly dissapate.The Teflon insulation will undergo considerable expansion in this process. The insulator is crimped in. It may be that the heat permits the crimp to partially release. Whatever the cause may be, more often than not we will be left with a loose insulator and this is not good. Additional crimping should be done,either before or after soldering. It can be done with a screwdriver blade held against the metal, and a light blow with a hammer, at several points around it. Another method is to hold a socket wrench against the crimped metal, and apply a sharp blow with a hammer. In the connectors to be described, we will avoid the necessity of this precaution.

In making N type female adaptors for both 1/2" and 7/8" Heliax, the center connector and insulator are removed as a unit by turning off the crimped extension in a lathe. Fig. 7 shows details of the 1/2" version. About 1/4" of center conductor is left protruding from the coax. The coupling sleeve is made of brass, 7/32 OD, with .189" (#12 drill) hole for the LDF 4-50 center conductor, and .120" (#31 drill) hole for the center connector. The length of the sleeve, (4) in Fig. 7 will depend on the length of the center conductor sleeve (2). Since the outer sleeve will not fit over the Heliax outer conductor, fingers must be cut in the sleeve, folded out, and then folded down to conform to the shape of the coax outer conductor, and soldered in place. During assembly, a centering plug should be in the open end of the UG-58, with the mating male pin in place, to assure that things will be in alignment when finished. The outer conductor should be cleaned with very fine abrasive before soldering.



N FEMALE TO FIT HELIAX LDF 4-50

1. Coax body, 1/4" center cond. exposed.
2. Coupling sleeve, center conductors.
3. Center pin and insulator removed from UG-58.
4. Outer conductor sleeve, hobby brass, 17/32 OD. Soldered to UG-58 body. Slits on coax end. Fingers folded out conformed to coax outer conductor.
5. UG-58 body, flange removed and base diameter reduced to accept outer sleeve coupler (4).

FIG 7

Fig. 8 shows details of N female adaptor for 7/8" Heliax. The UG 58 flange is lathe turned to a diameter of 0.875", and soldered in one-half of a 3/4" copper sleeve coupling. After soldering, the coupling is placed in the lathe chuck, open end out, and bored to leave a wall thickness of about 0.015" for the fingers to be cut. The boring should not extend into the main body of the sleeve where the Teflon plug will be. The Teflon plug is 0.875"OD with a 0.400" hole. Thickness of the plug will depend on thickness of the hex head of the brass screw (2) in Fig. 8. If used, the Teflon should fill the cavity, but be sure it is not too long, which would prevent seating of the UG-58 insulator in the UG-58 body.

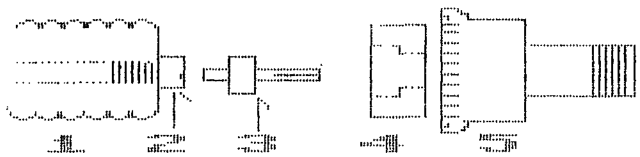


FIG 8

N FEMALE - ANDREW HELIAX LDF 5 50

1. Coax body.
2. 5/16"NF brass - 5/16 hex head.Center drilled .120".Self tapped into hollow center conductor.
3. Center pin removed from UG-58. Solin .120" hole in (2).
4. PTFE dielectric plug. Fills cavity. Enlarged part decreases dielectric constant to maintain constant Z.
5. Outer body. Section of sleeve coupling 3/4"copper.Mating portion expanded,slits made for fingers which are shaped to conform and soldered to coax.UG-58 body soldered in the outer end.

If the Teflon filler plug is not used - and it is not necessary - it is best to use 3/8" hex brass to make the screw for the center connector. I don't know how to calculate impedance with a hex center conductor, but we will not have a gross discontinuity with these materials.

WATERPROOFING

It is obvious that, so far, no provision has been made to keep moisture out of the described adaptors. Needless to say, it is mandatory that this be done. I use Coax Seal, or some generic version of it, at every place of possible moisture entry, with heat shrink tubing or tape over it.

DRILL GUIDES

There are many occasions when we need to drill a hole, accurately centered in a shaft, rod or even a coax center conductor. They are in common use, but I feel it is appropriate to make brief mention here. They can be made with a drill press, by putting the rod with which it is to be made in the vertical vee of a drill press vice, centered under the chuck. Drill the small hole first, and then change drills, without moving the rod, to the larger size, and drill to the required depth. They can be fabricated from hobby brass tubing, using successive telescoping sizes for diameter reduction, and soldered together. This method, if it will yield the required diameters, does not require the use of any machinery. By placing the large diameter on the part to be drilled, with the drill bit in the smaller diameter, a concentric hole can be drilled with a hand held electric drill. I have used this to put the center pin of an N connector on RG-331 coax. It is useful for drilling the center conductor of large coax, to minimize heatsinking when soldering to it. For LDF-4-50 Heliax, two pieces of hobby brass can be used. The large diameter is made with 7/32" brass tubing and smaller diameter with 3/16" tubing. This will permit removal of 5/32" of metal and greatly reduce the amount of heat required for soldering. Fig.9 shows the cross section of a drill guide.

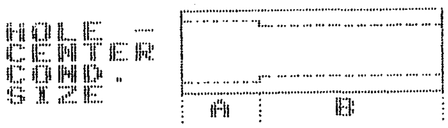
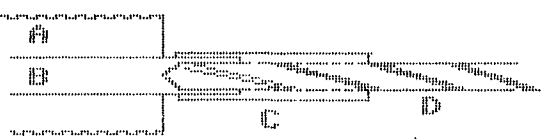


FIG. 9

HOLE-DRILL SIZE

DRILL GUIDE FOR DRILLING SOLID CENTER CONDUCTOR OF COAX.
MATERIAL = BRASS OR STEEL ROD.
A-NEAREST SIZE EQUAL TO OR LARGER THAN COAX CENTER CONDUCTOR, NOT MORE THAN .005"OVERSIZE. MAY REQUIRE FRACTION, LETTER,NUMBER OR METRIC DRILL.LENGTH AT LEAST ONE DIAMETER.
B-ANY DESIRED SIZE NOT LARGER THAN DIAMETER SEC.A MINUS .03".

There is a very excellent 7/8" hardline (I don't know who makes it) with copper corrugated outer conductor, and copper covered aluminum center conductor. The diameter of the center conductor is about 0.335". The first connectors I made for this coax were for WB4NXY. Finger stock was used to connect the center conductors. Later, N5BLZ wanted some connectors for the same type of coax and sent me enough of it to experiment with. I found that it could be drilled to a wall thickness of about 0.011",to a depth of 1/2", using a 5/16" split point drill, and a drill guide as shown in Fig. 10. It could be tinned with a 40 watt soldering iron. It would be impossible to get this center conductor to soldering heat without great damage to the foam insulation, unless considerable metal is removed.



DRILL GUIDE FOR 7/8" SOLID CENTER COND. COAX.
A= COAX BODY
B= CENTER CONDUCTOR
C= DRILL GUIDE.DRILL SIZE 5/16".COAX CENTER CONDUCTOR DRILLED SIZE "R" (.339")- BODY 3/8"BRASS.
D= 5/16"SPLIT POINT DRILL BIT.

FIG.10

Finally, a suggestion is offered about protecting foam insulation from heat of soldering, and flux spatter. In putting some adaptors on 1/2" Heliax, I noticed that the insulation was not left clean, and had some heat damage. On a "re-do from start", two layers of aluminum foil were wrapped around the coax, with the end folded down over the foam insulation. After completing the soldering, the heat shield was removed, revealing minimum heat damage and clean, white insulation.

de W5JTL

THE GREAT AURORA OF FEBRUARY 7-9, 1986

By Emil Pocock, W3EP

It is hardly news to devoted VHF amateurs that the aurora of February 7-9, 1986, was one of the very best of the past several decades. Two-meter stations in all continental states, ranging from the Gulf Coast to the Canadian border, made aurora contacts. Fig. 1, which shows the grids with reported 144-MHz activity, was created from the logs of 61 stations that responded to my appeals for data.* Over 1000 contacts are represented. Many 144-MHz stations reported completing paths over 1500 km (932 miles), and WAØTKJ and WBØDRL claimed a new world record of 2169 km (1348 miles) with KA1ZE. Activity on 432 MHz was nearly as widespread, but there were fewer stations making contacts. Fig. 2 was derived from the logs of 11 reporting 70-cm stations. Only two contacts 1500 km or longer appeared in these logs. Activity on 220 MHz was sparse, and while 50-MHz contacts were common, only three six-meter logs were received.

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* Many thanks to those who provided complete logs: WA1OUB, W1ENE, W2AUD, N2BJ, W2RS, K2LWR, W9IP/2, VE2DUB, W3CWG, K3ONW, KA3B, W3IP, WA4AHZ, KS4S, K4QIF, K4KAE, W4HR, N4MM, N4AR, W2GU/4, W4GJO, W3EP/4, K5UGM, W5VY, KA5EBL, K5SW, K5YY, W5SFW, W5FF, WA6LHD, K6PVS, WA8LLY/6, N6CW, W7IUV, WA7ADK, W7HAH, W7IDZ, K7ICW, WB8TEI, N8CKH, NI8O, K9MRI, AA9D, AF9Y, K9HMB, K8VGE, KU9L, WB9WMM, WD9FSA, WB9UQE, WØEMS, WBØDMK, KBØHH, KØTLM, WBØBWE, KFØY, WØETT, WØVN, WBØQMN, WBØYSG, WBØDRL, WAØTKJ, NØLL, and KØUS. Other stations provided useful reports and comments: K2UYH, WA2TEO, WB8BMF, and W9LBD. I also want to thank those column and newsletter editors who published my requests for logs, including K1LPR, WB2WIK, WA6IJZ, WBØDGF, and KCØW.

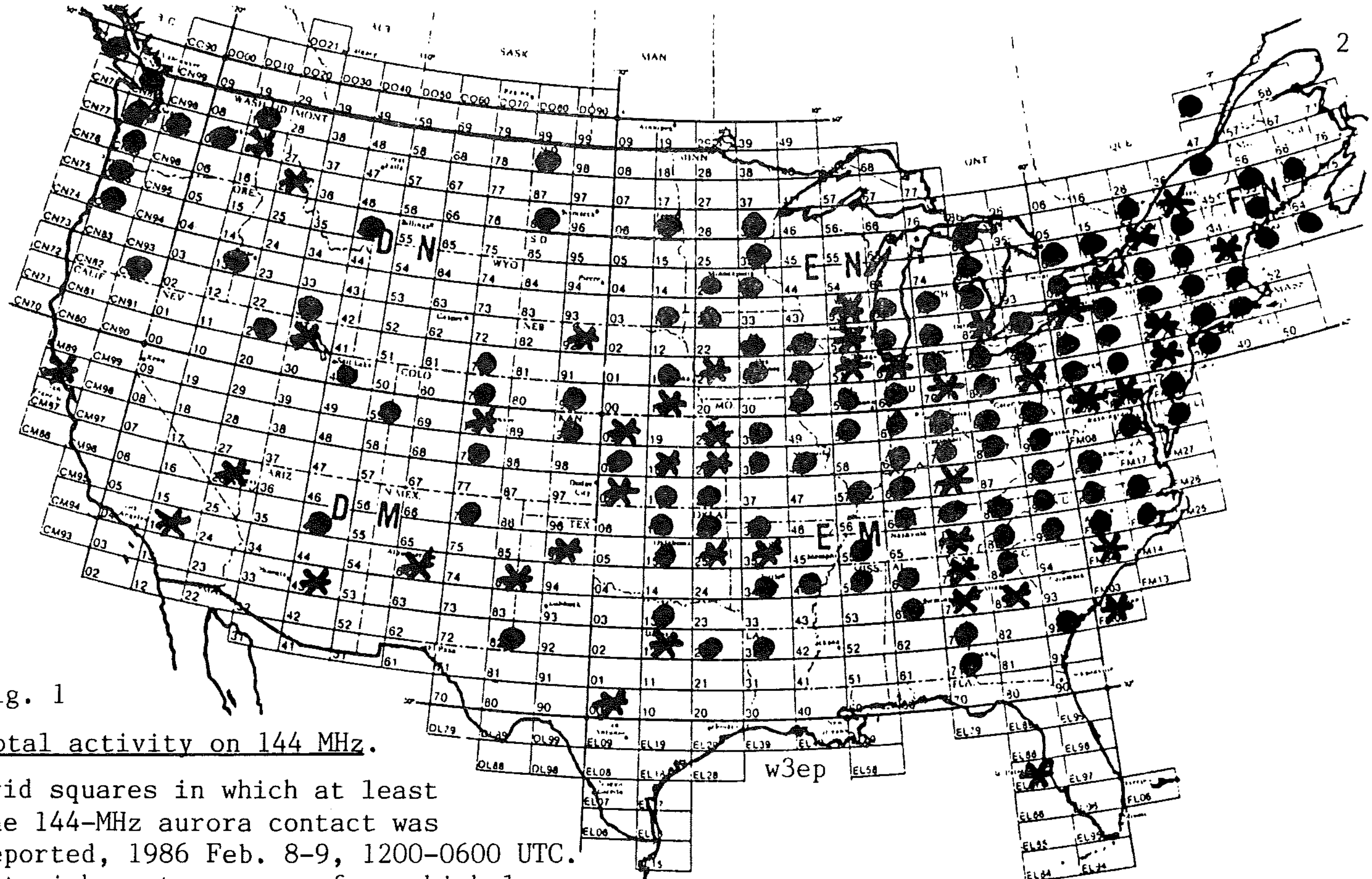


Fig. 1

Total activity on 144 MHz.

Grid squares in which at least one 144-MHz aurora contact was reported, 1986 Feb. 8-9, 1200-0600 UTC. Asterisks note squares from which logs were received.

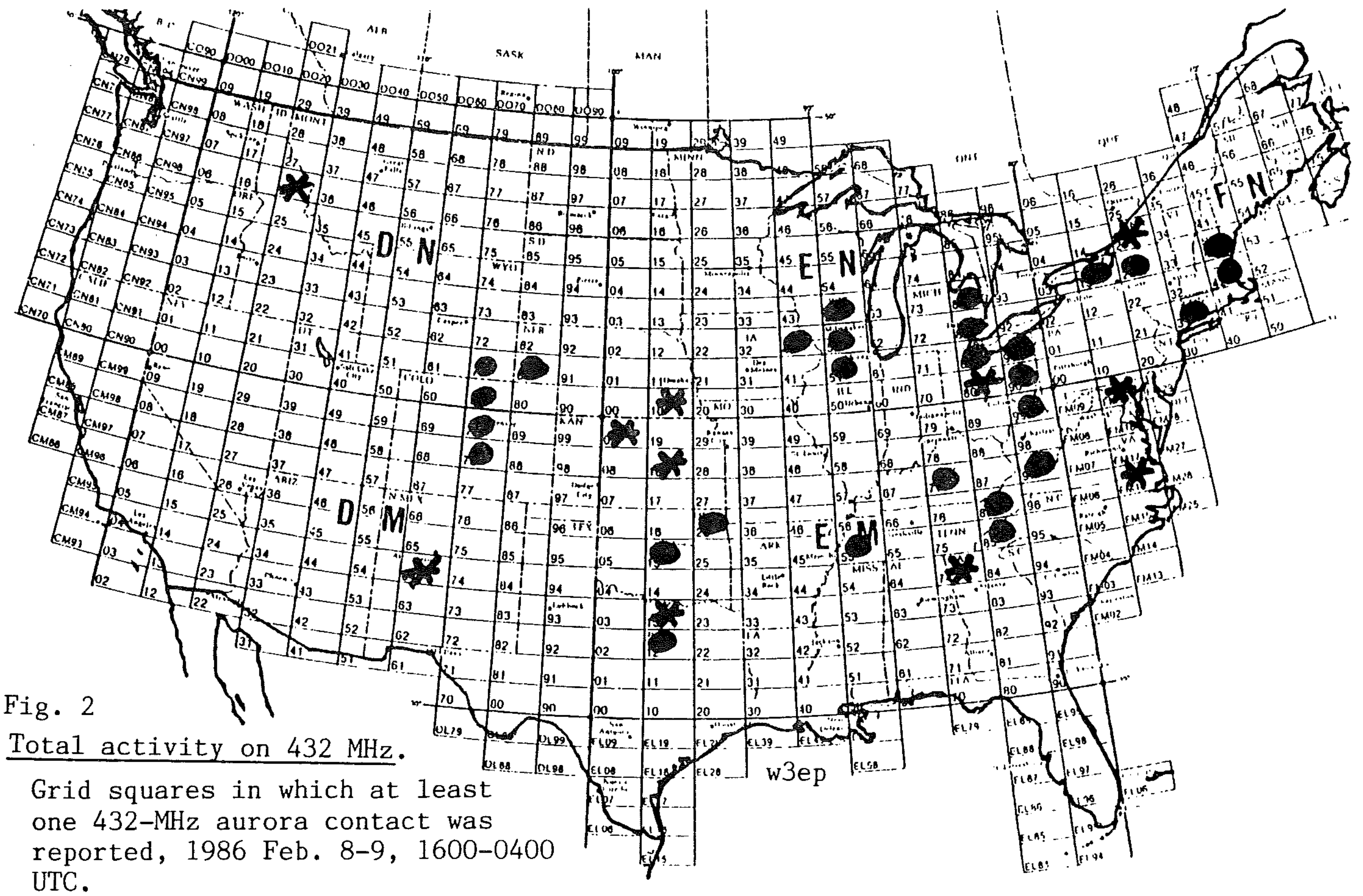


Fig. 2

Total activity on 432 MHz.

Grid squares in which at least one 432-MHz aurora contact was reported, 1986 Feb. 8-9, 1600-0400 UTC.

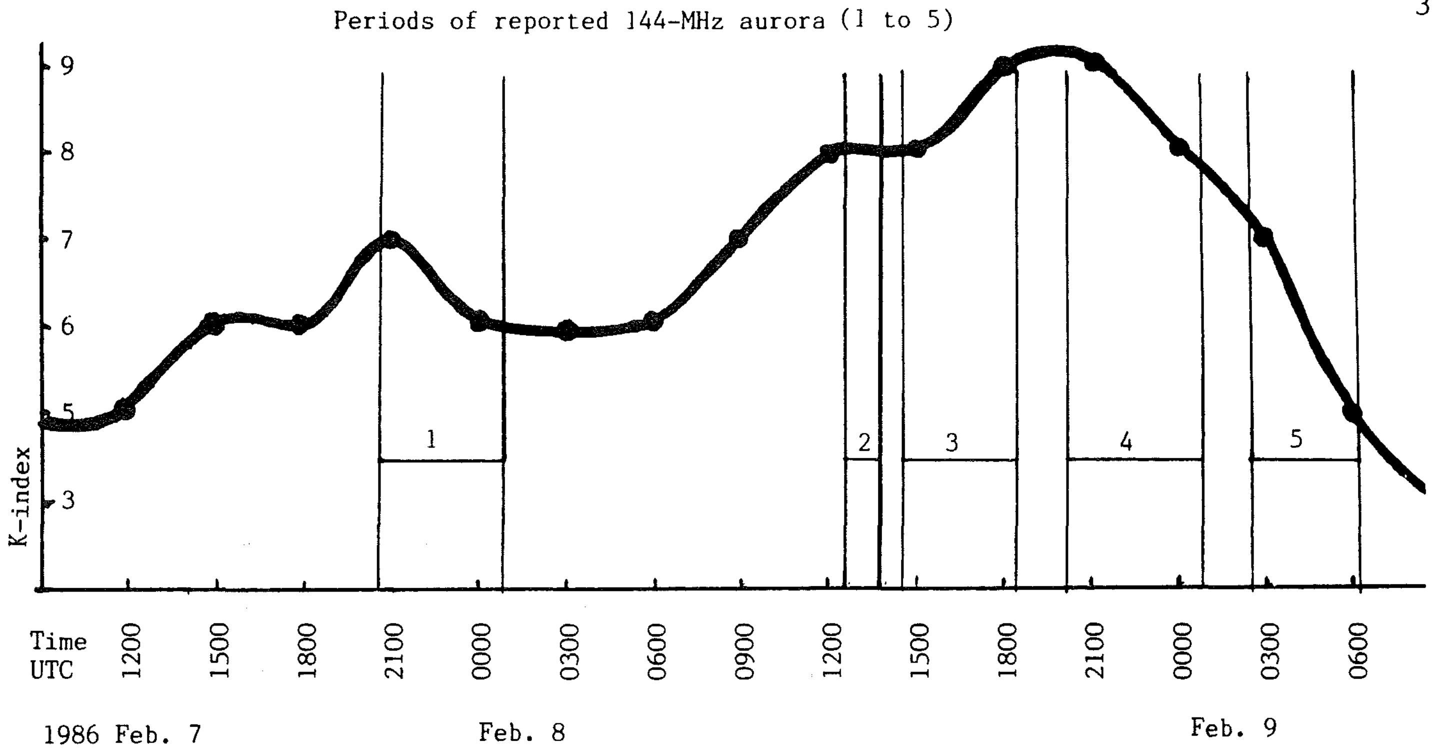


Fig. 3

K-index and Periods of Radio Aurora Activity

Smoothed Fredericksburg K-indices from "Preliminary Report and Forcast of Solar Geophysical Data," 11 February 1986. Two-meter aurora activity determined from the logs of 61 144-MHz amateur stations.

Several stations reported attempts at 1296-MHz aurora contacts, but none was successful. This report, therefore, focuses on 144 MHz.

The Aurora on 144 MHz through Time

Two-meter aurora activity fell into five distinct time periods during February 7 to 9 UTC. (All times and dates are UTC unless otherwise noted.) Consistent with commonly held notions that auroras often accompany high K-index values, Fig. 3 shows that the K-index was 5 or greater during the periods of radio aurora activity. Through the late evening and early morning hours (local eastern time), no aurora contacts were reported. It is possible, of course, that aurora was present but that few persons took advantage of it due to the time of day. Certainly the fourth period (Feb. 8-9, 2020-0151) was the most spectacular. Stations as far south as central Florida and south Texas worked into the aurora, signals were exceptionally strong, and most of the contacts in excess of 1500 km were made during this time.

Period 1 (Feb. 7-8, 2045-0110): Only a few stations, primarily in the northeastern part of the country, reported aurora at this early time. Activity was sparse and there was nothing unusual about the contacts made. The K-index was unusually high, having reached 7 near the beginning of the period.

Period 2 (Feb. 8, 1245-1335): The K-index held at 8 during the morning hours local eastern time, but only three stations reported making aurora contacts. See Fig. 4. Aurora is most uncommon before noon local time, and it may have caught even the most experienced aurora operators by surprise. Apparently, the aurora died away for nearly an hour before returning, although this hiatus may have been a result of the sparsity of reports.

Period 3 (Feb. 8, 1448-1833): As the K-index built from 8 to an incredible 9, stations from the southern Great Lakes region to as far south as a line from Oklahoma to South Carolina were making aurora contacts soon after 1500. See Fig. 5. The first contacts in the Pacific Northwest were reported during the following hour, while the aurora showed signs of receding in the East. See Fig. 6. From 1700 to 1830, the geographical extent of auroral affects remained unchanged (see Fig. 7), until 1830 when no further contacts were made.

Period 4 (Feb. 8-9, 2020-0151): Aurora returned with a vengance at about 2020 and very quickly affected the eastern half of the country from the Great Lakes to the Gulf Coast. See Fig. 8. The K-index was actually beginning a long decline from a peak of 9 when this most spectacular session began. The first contacts over 1500 km were made, including at least two notable contacts near the theoretical limit for aurora at 2000 km. See Fig. 9. Relatively fewer contacts were reported from the Pacific Northwest and the Rocky Mountain region, but the lower population density must be considered in comparing the activity on the east and west coasts.

The next hour, 2200 UTC, brought a slight expansion of aurora coverage to include south Texas and central Florida. See Fig. 10. There was a noticeable

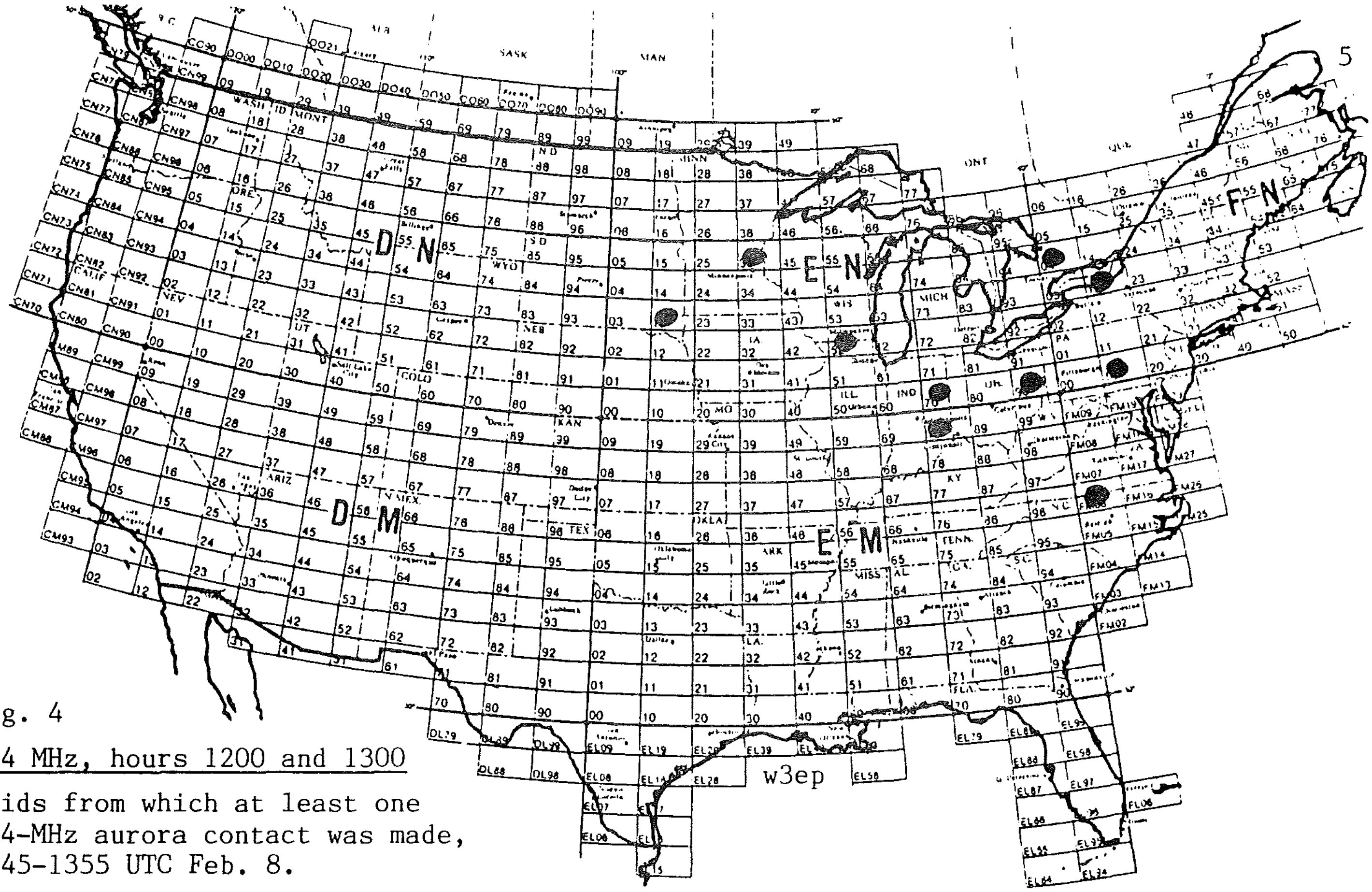


Fig. 4

144 MHz, hours 1200 and 1300

Grids from which at least one 144-MHz aurora contact was made, 1245-1355 UTC Feb. 8.

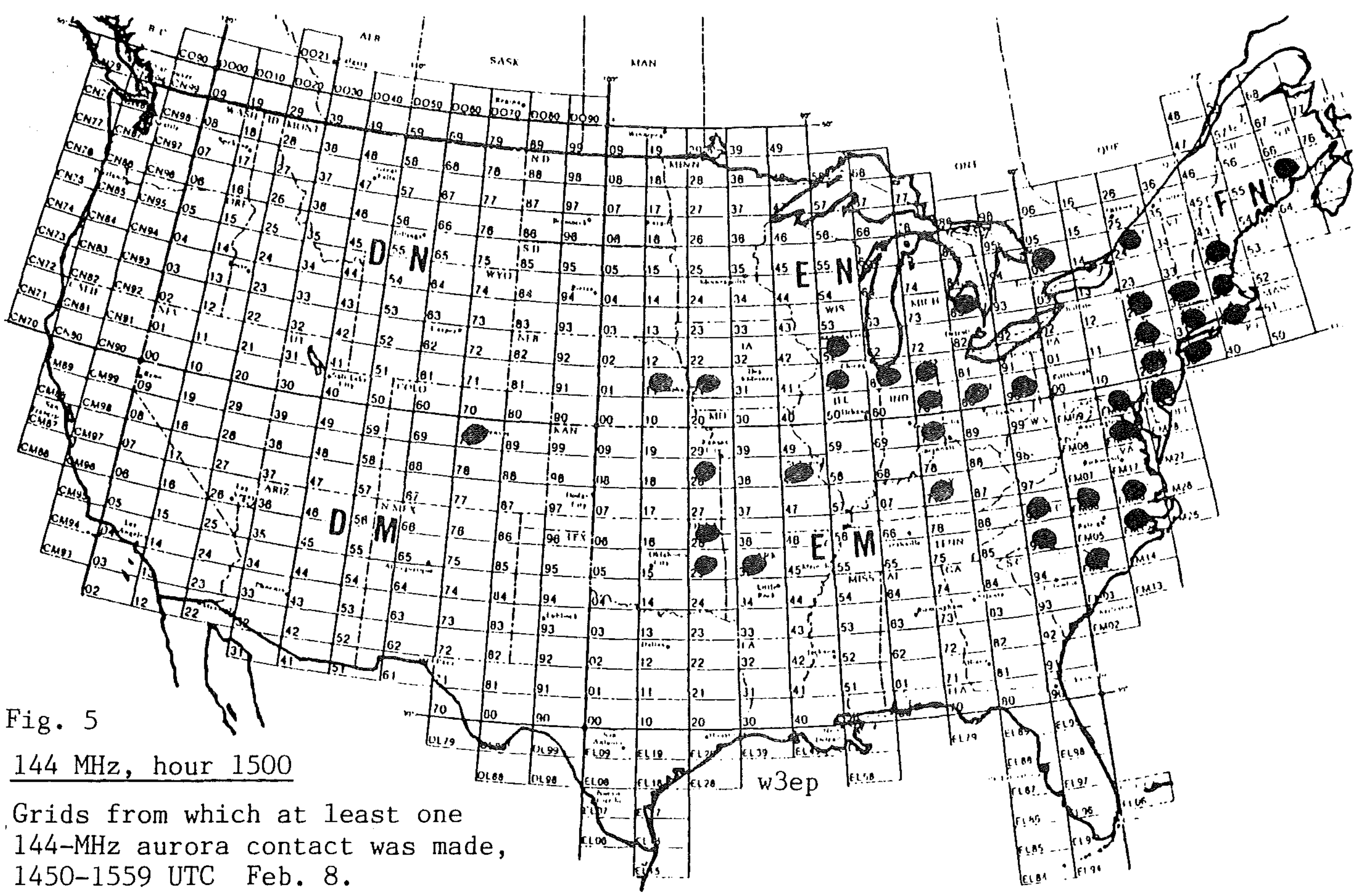


Fig. 5

144 MHz, hour 1500

Grids from which at least one 144-MHz aurora contact was made, 1450-1559 UTC Feb. 8.

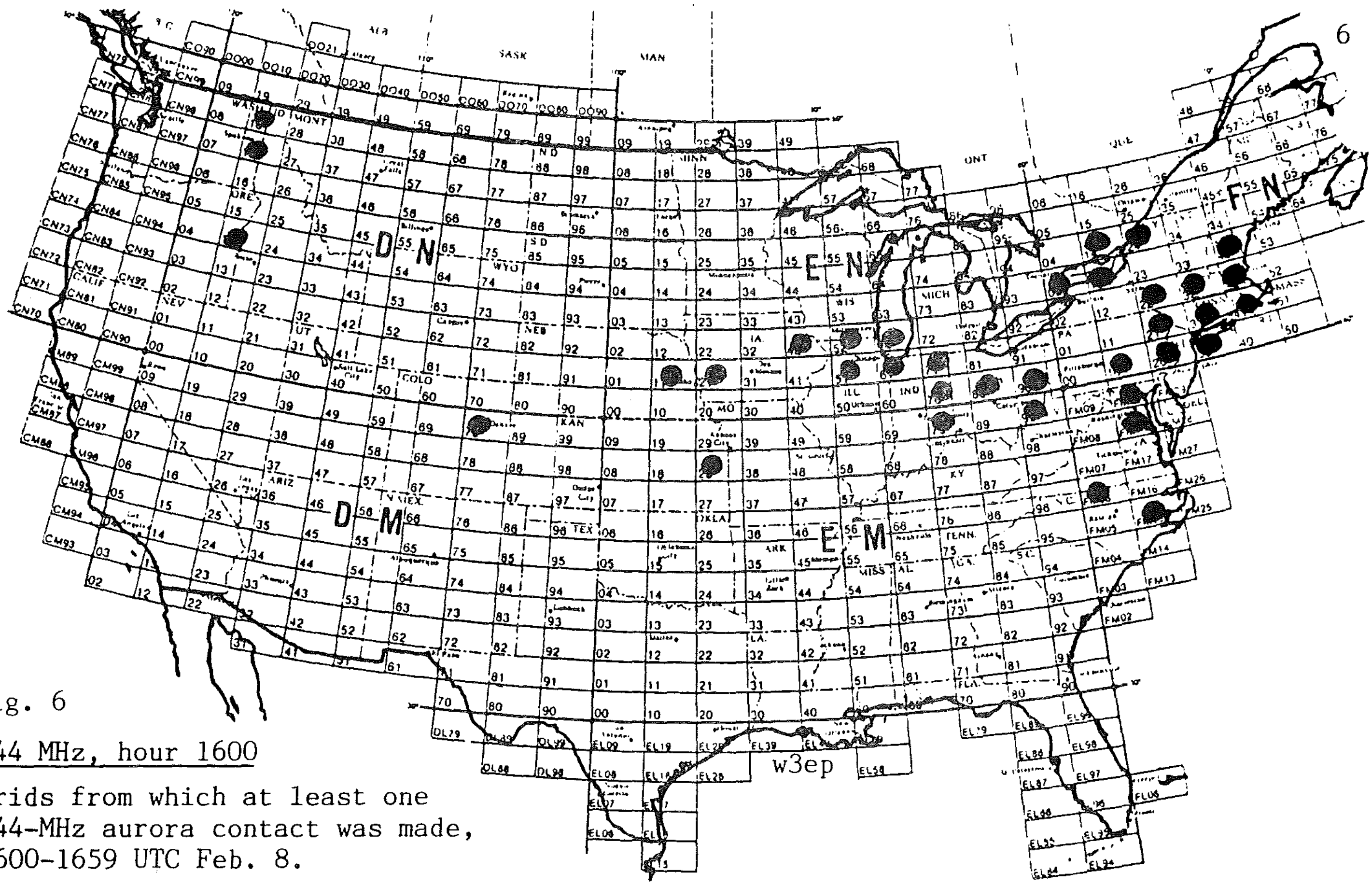


Fig. 6

144 MHz, hour 1600

Grids from which at least one 144-MHz aurora contact was made, 1600-1659 UTC Feb. 8.

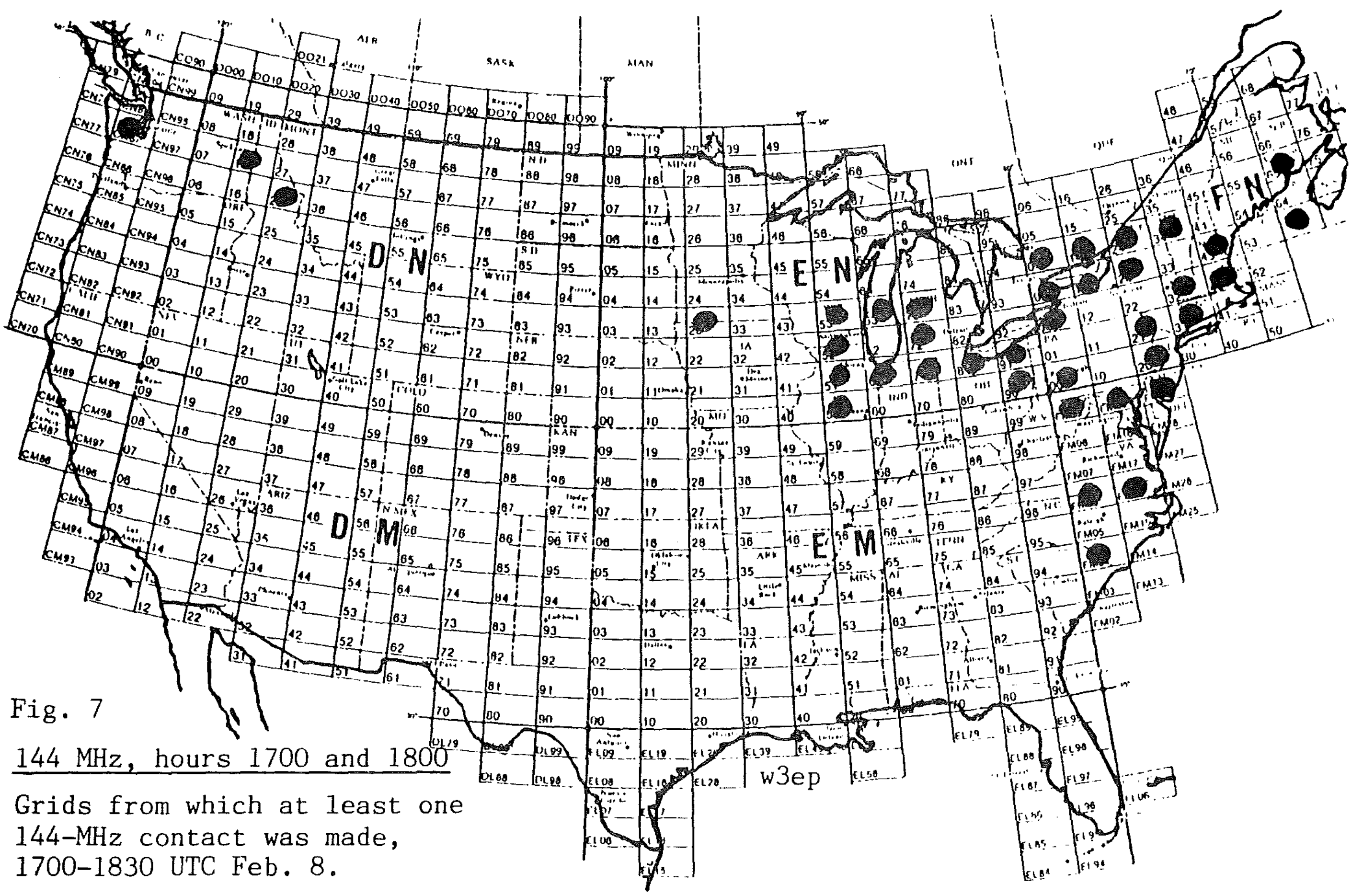


Fig. 7

144 MHz, hours 1700 and 1800

Grids from which at least one 144-MHz contact was made, 1700-1830 UTC Feb. 8.

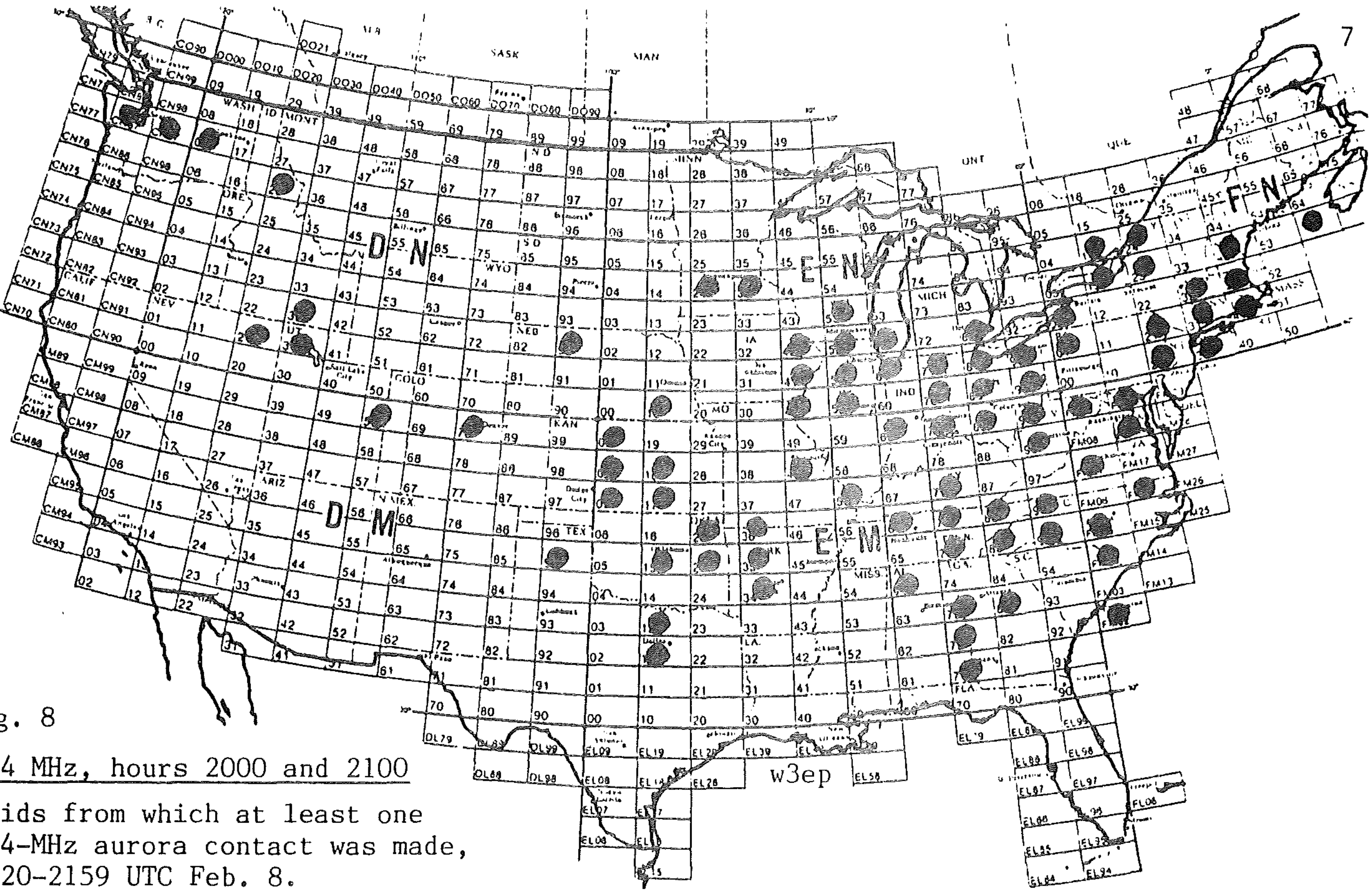


Fig. 8

144 MHz, hours 2000 and 2100

Grids from which at least one 144-MHz aurora contact was made, 2020-2159 UTC Feb. 8.

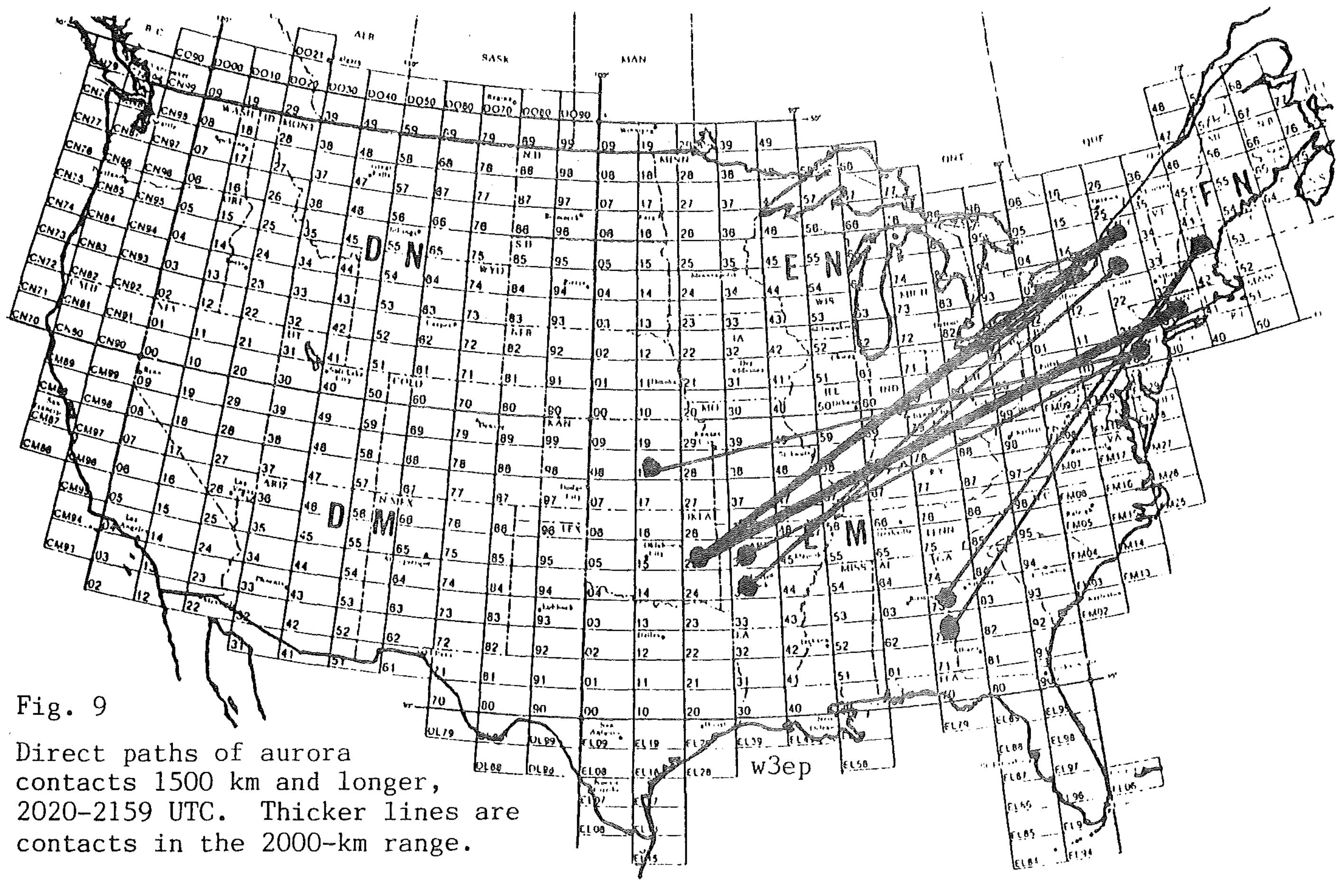


Fig. 9

Direct paths of aurora contacts 1500 km and longer, 2020-2159 UTC. Thicker lines are contacts in the 2000-km range.

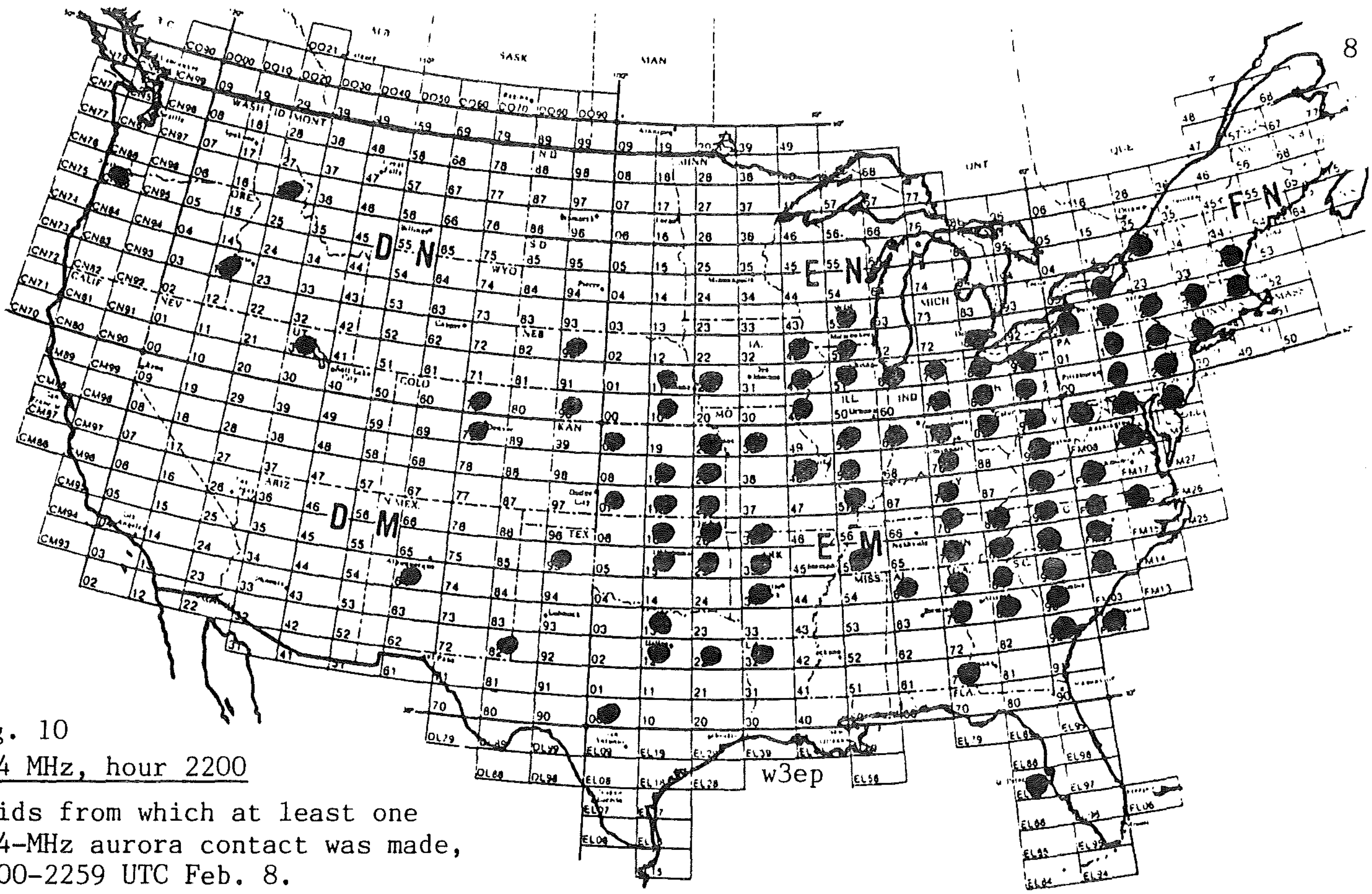


Fig. 10

144 MHz, hour 2200

Grids from which at least one 144-MHz aurora contact was made, 2200-2259 UTC Feb. 8.

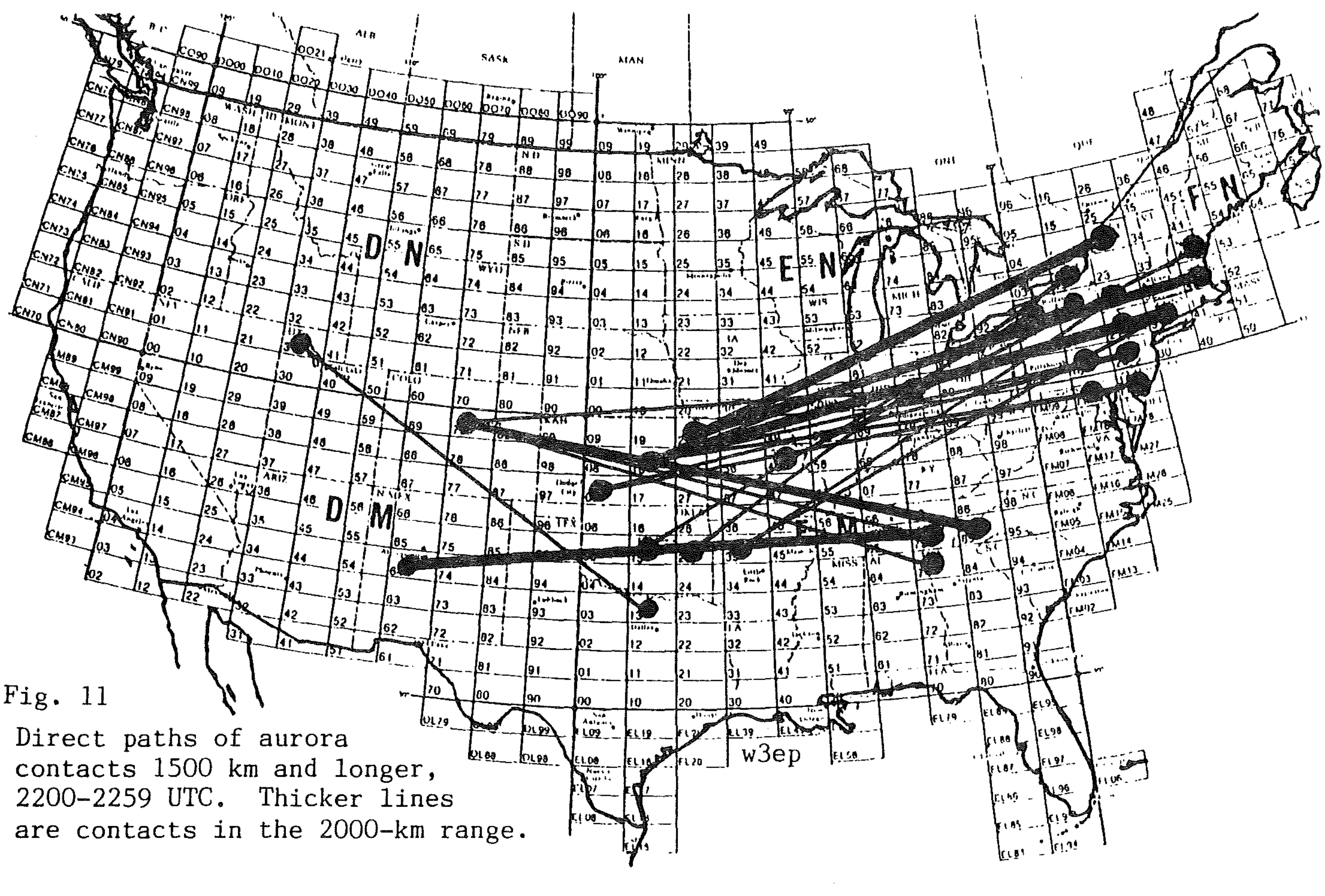


Fig. 11

Direct paths of aurora contacts 1500 km and longer, 2200-2259 UTC. Thicker lines are contacts in the 2000-km range.

westward shift to stations making use of aurora, as well as a proliferation of contacts in the 1500-2000 km range. The longest reported contact of the three-day event was made during this hour (and duplicated the next hour). See Fig. 11. During UTC hour 2300, stations as far south as the Gulf states were still making aurora contacts. As the aurora continued to show a westward drift, several stations in the Southwest reported their first contacts. See Fig. 12. Stations in the West also made contacts in excess of 1500 km across the Rocky Mountains, as long-distance paths also showed a tendency to drift westward with time. See Fig. 13.

The aurora showed signs of receding in the East during the first hour of the new UTC day, but it was probably the best hour for stations in the Far West and Southwest. See Fig. 14. Fewer long-distance contacts were made, and most of these were across the center of the country. See Fig. 15. During UTC hour 0100, the aurora showed definite signs of weakening in the East (Fig. 16), and fewer 1500-km contacts were made (Fig. 17). No contacts were reported after 0151 UTC. Perhaps two-meter operators were simply exhauseted by more than five hours of fantastic aurora conditions!

<u>Period 5</u> (Feb. 9, 0248-0616): Aurora suddenly returned for one last stand at 0248, allowing stations as far south as northern Alabama and Texas to make aurora contacts once again. See Figs. 18 and 19. Many stations reported that conditions were erratic, spotty, and not as "solid" as they had been earlier in the day. Only one 1500-km contact was reported. Conditions seemed to deteriorate as the K-index continued falling from 7 to 5 between 0300 and 0600 UTC. By 0400, only stations in the northeastern quarter of the country were still reporting aurora contacts. See Fig. 20. After 0500, few contacts were reported at all, and none after 0616.

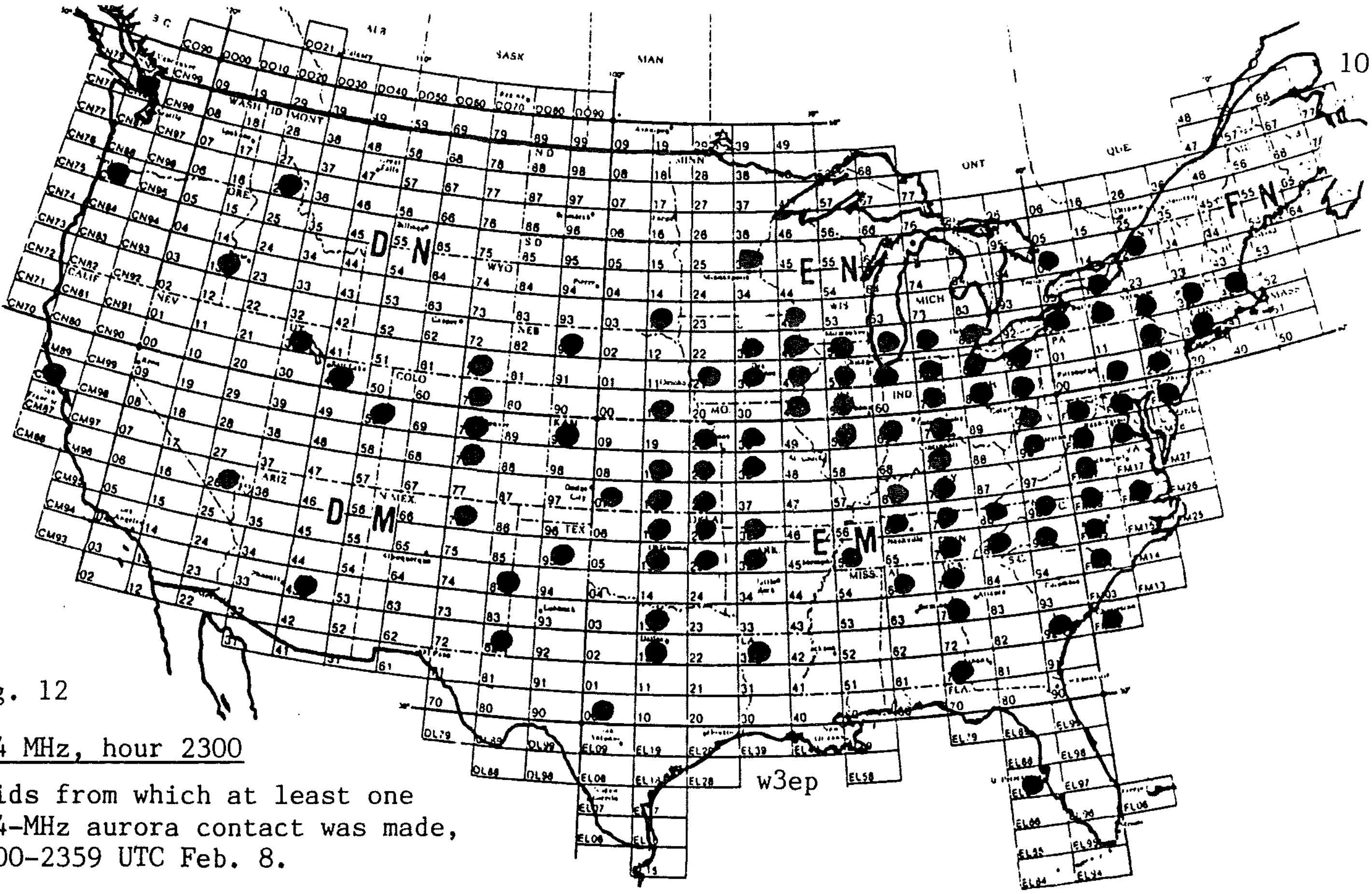


Fig. 12

144 MHz, hour 2300

Grids from which at least one 144-MHz aurora contact was made, 2300-2359 UTC Feb. 8.

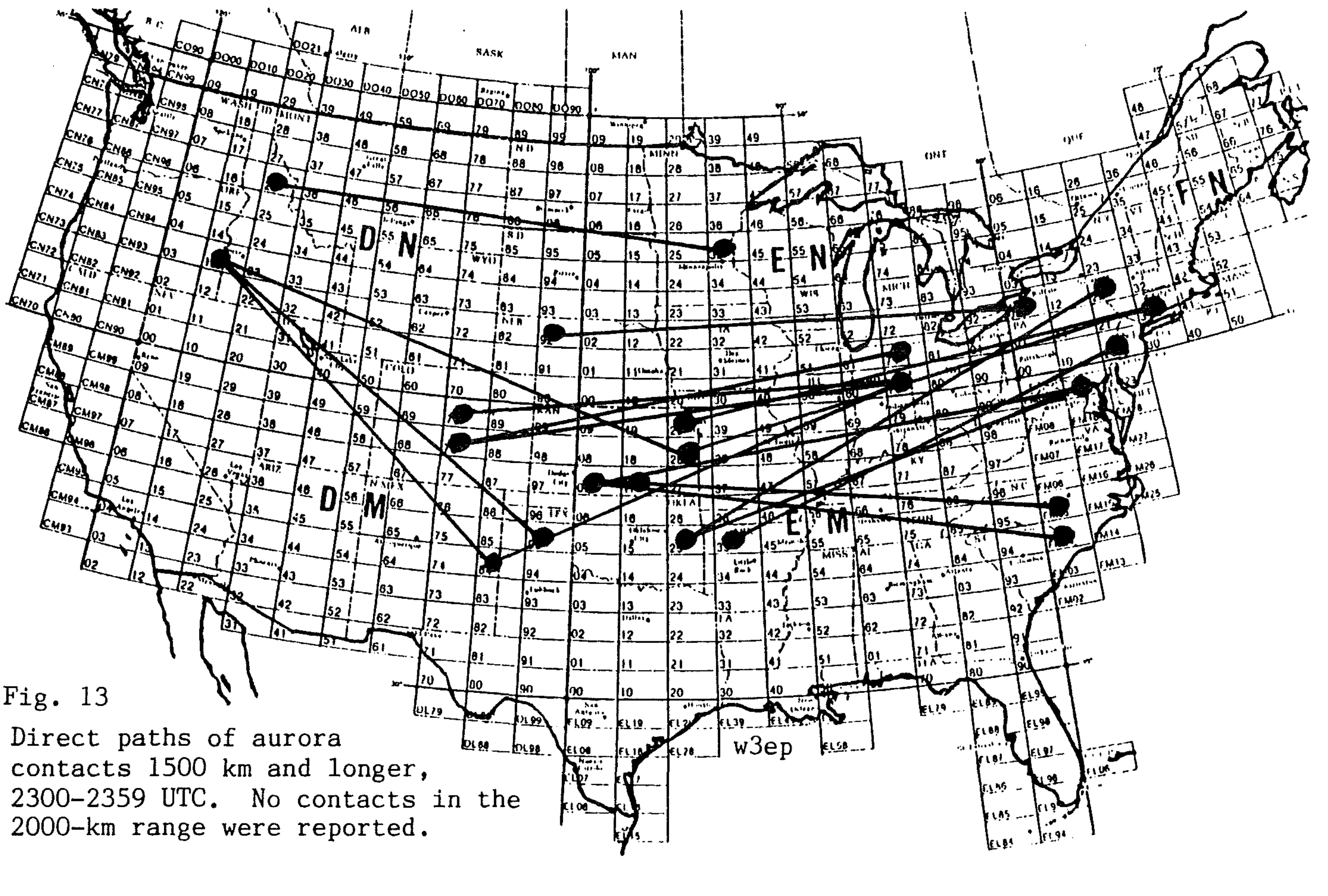


Fig. 13

Direct paths of aurora contacts 1500 km and longer, 2300-2359 UTC. No contacts in the 2000-km range were reported.

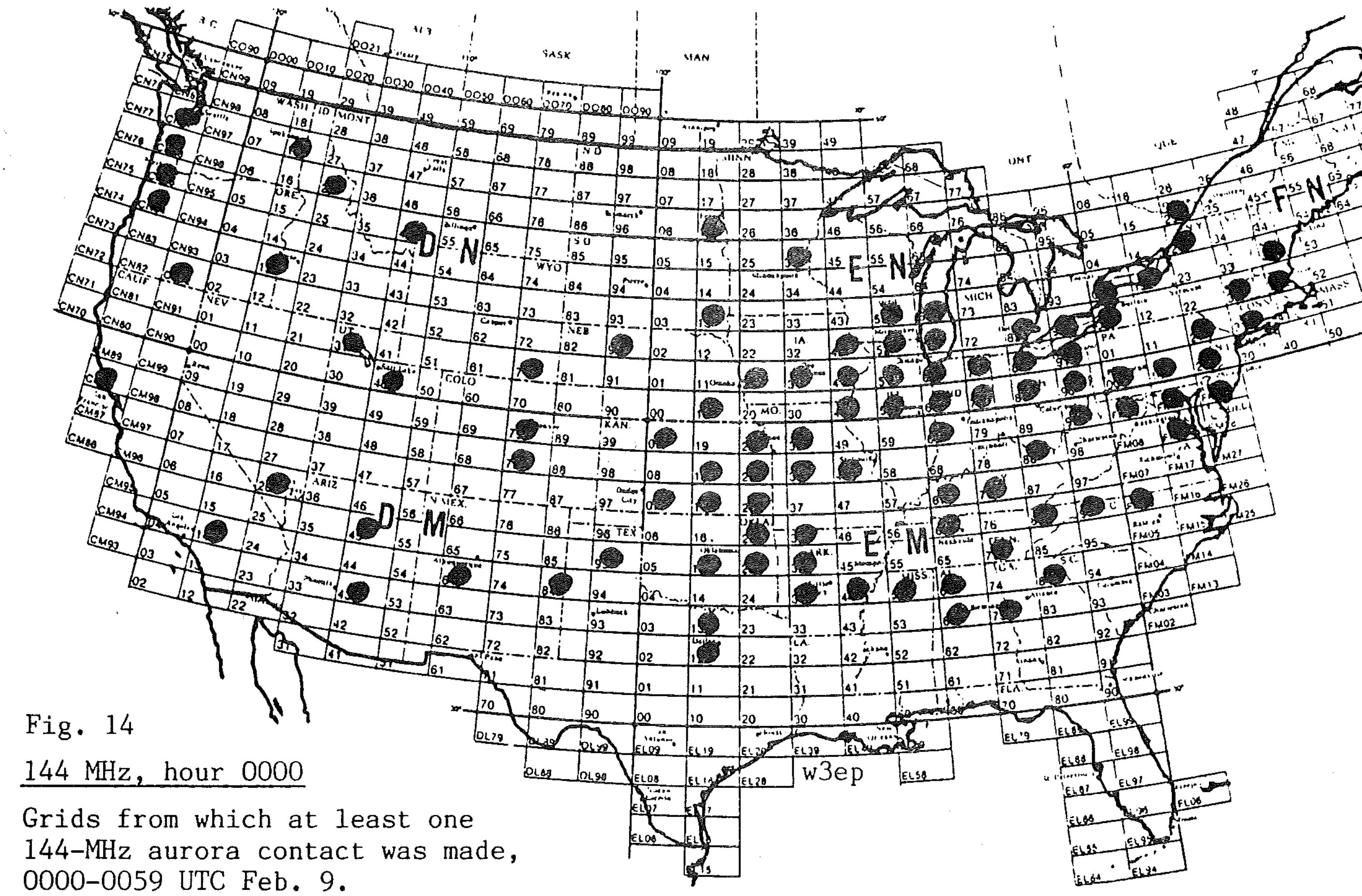


Fig. 14

144 MHz, hour 0000

Grids from which at least one 144-MHz aurora contact was made, 0000-0059 UTC Feb. 9.

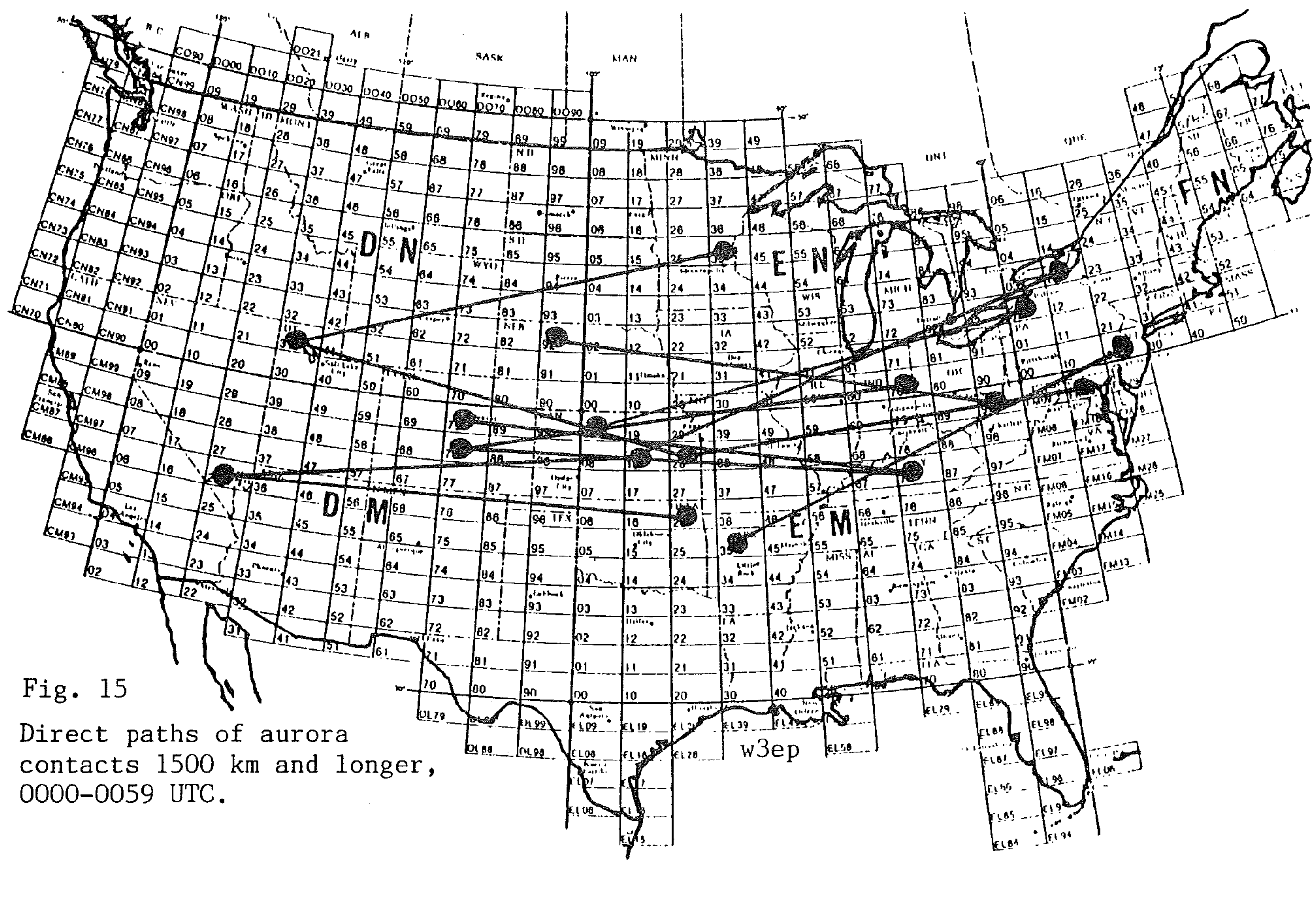


Fig. 15

Direct paths of aurora contacts 1500 km and longer, 0000-0059 UTC.

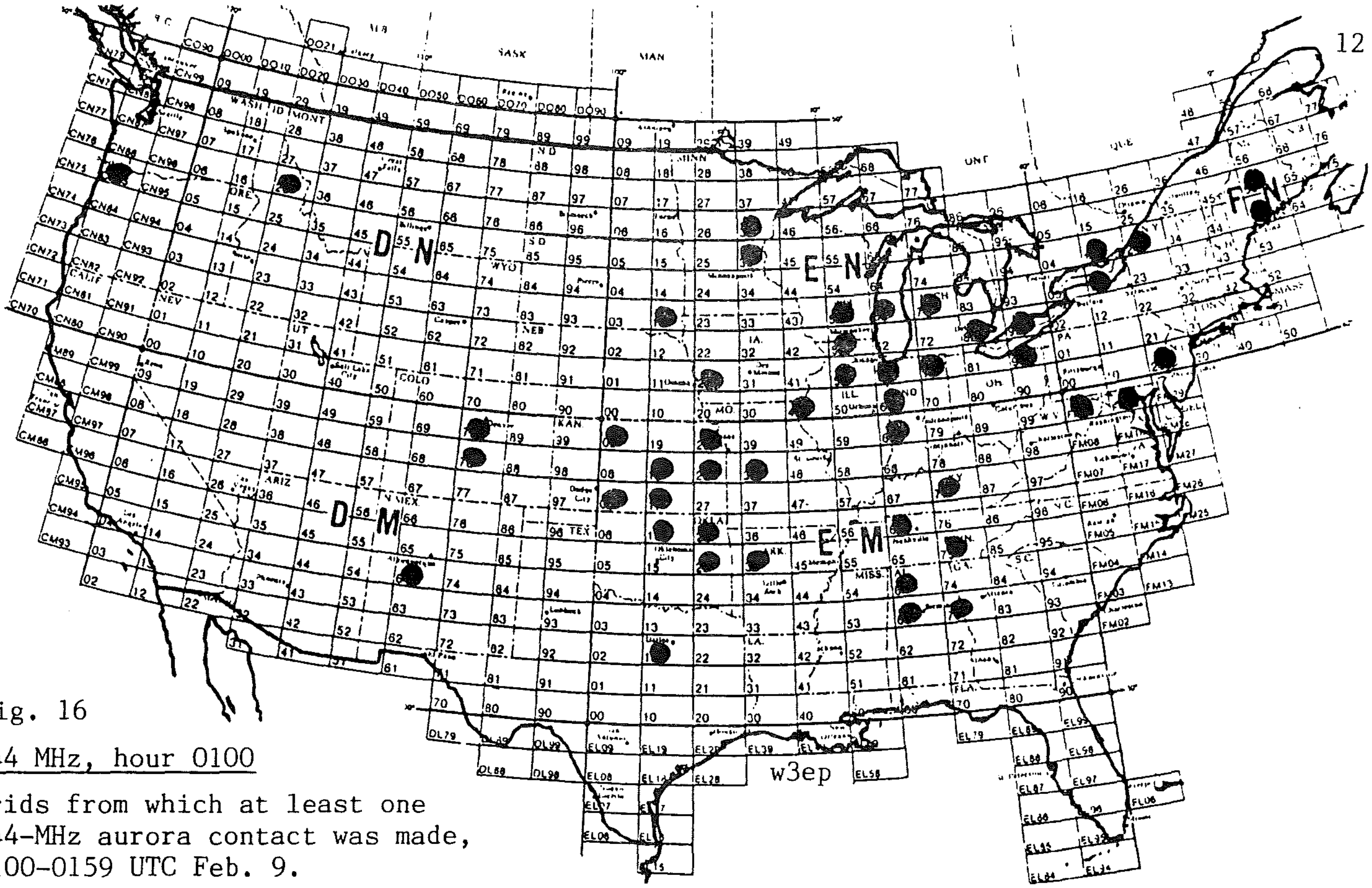


Fig. 16

144 MHz, hour 0100

Grids from which at least one 144-MHz aurora contact was made, 0100-0159 UTC Feb. 9.

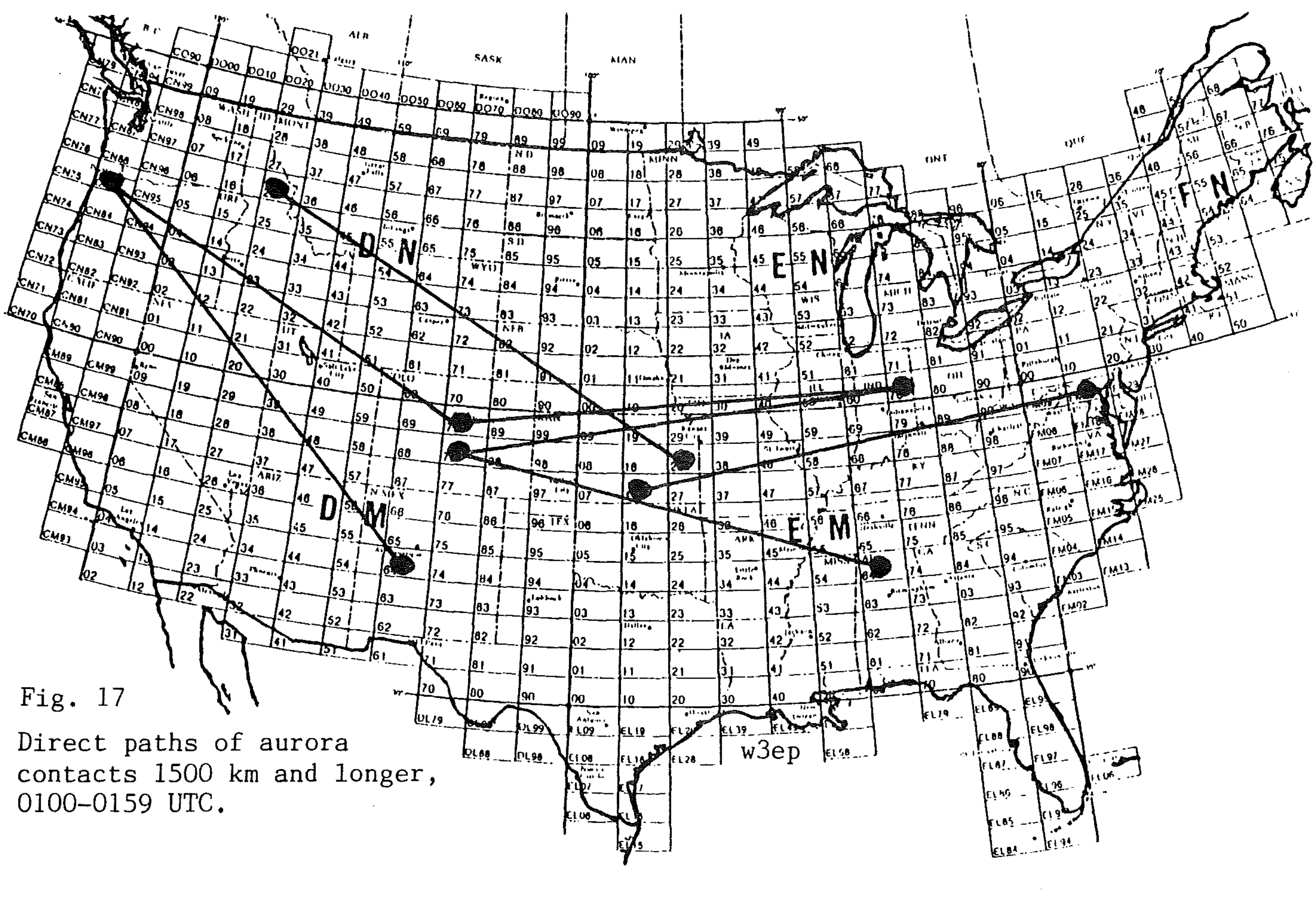


Fig. 17

Direct paths of aurora contacts 1500 km and longer, 0100-0159 UTC.

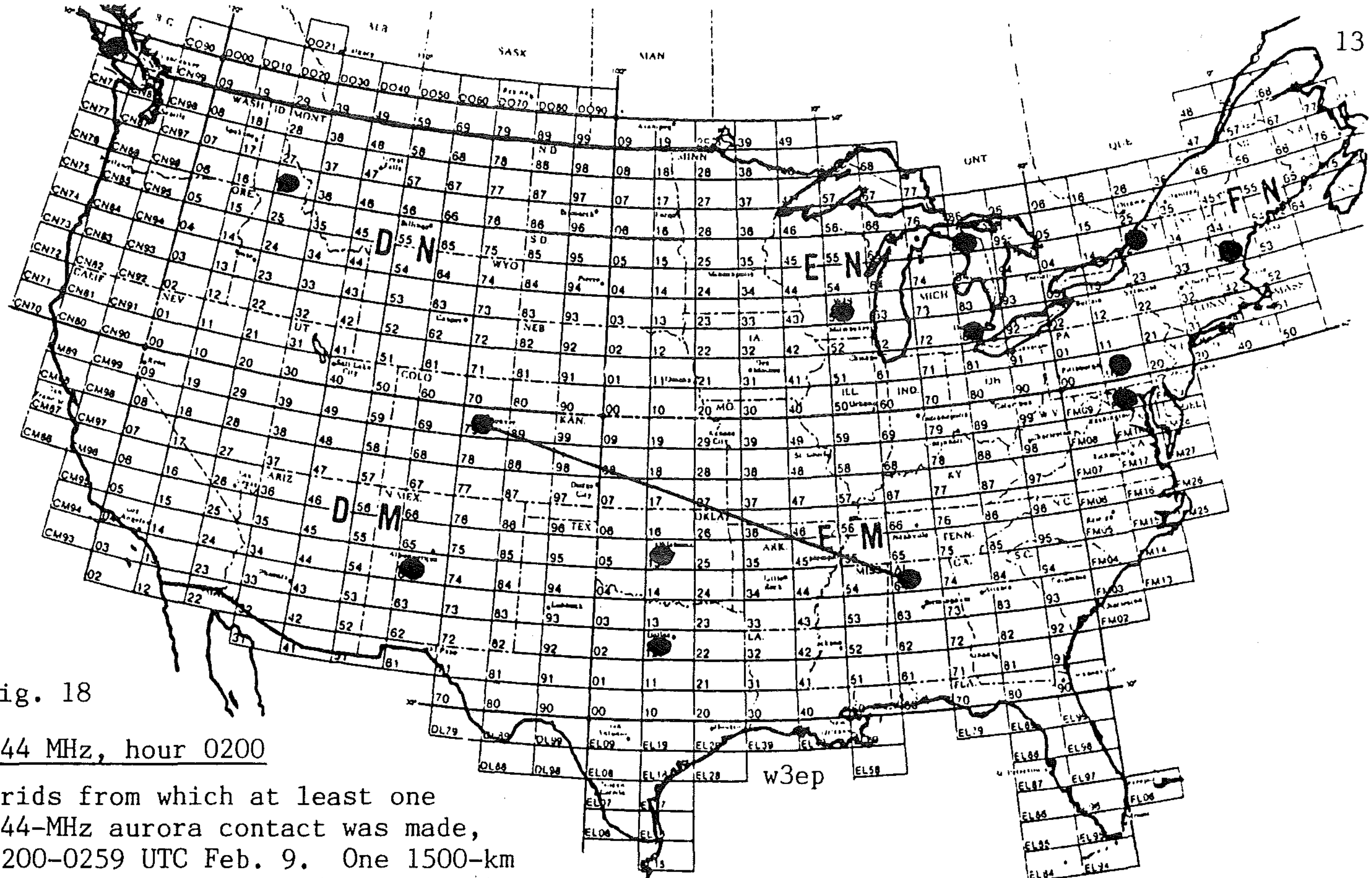


Fig. 18

144 MHz, hour 0200

Grids from which at least one 144-MHz aurora contact was made, 0200-0259 UTC Feb. 9. One 1500-km contact was reported (solid line).

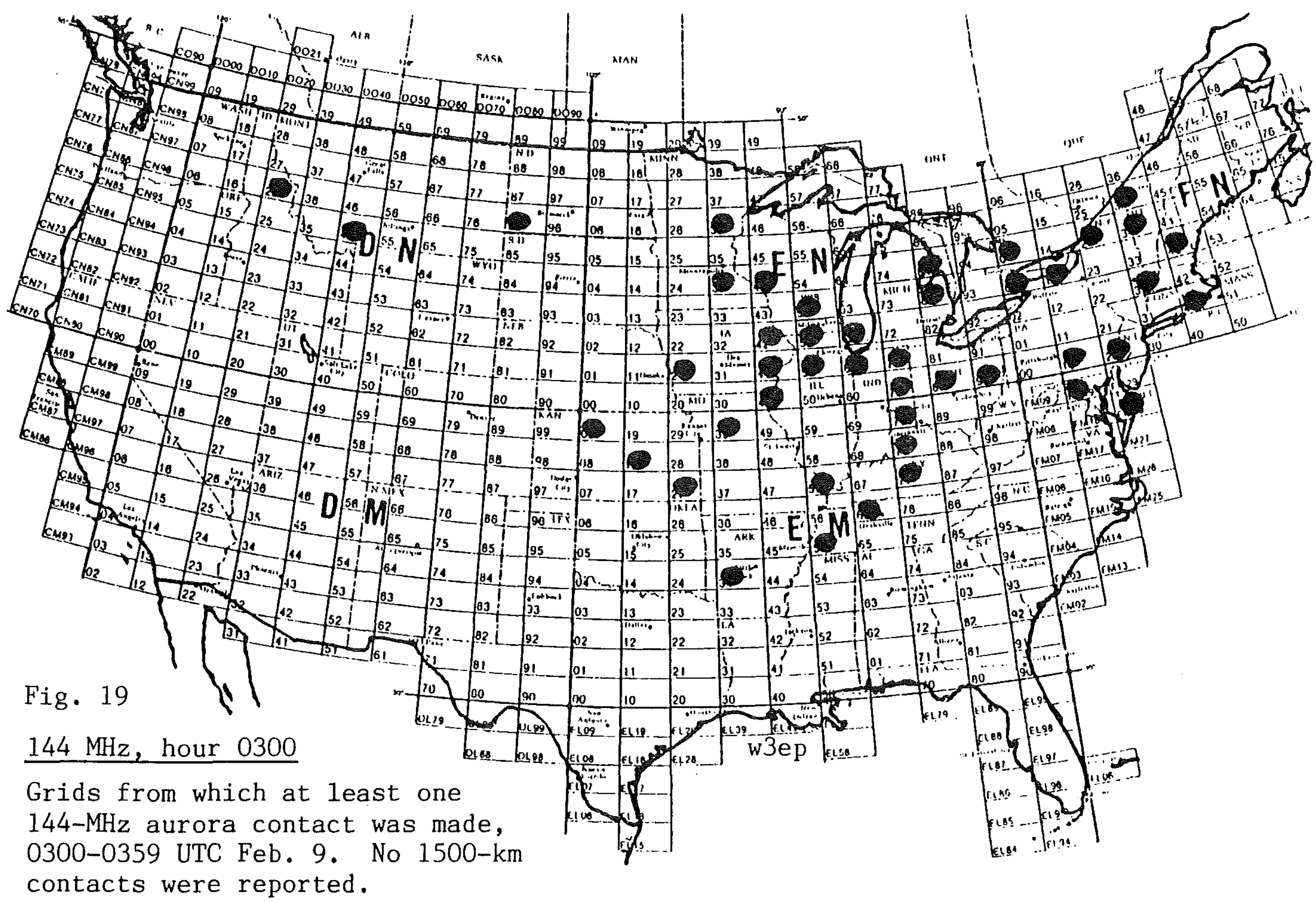


Fig. 19

144 MHz, hour 0300

Grids from which at least one 144-MHz aurora contact was made, 0300-0359 UTC Feb. 9. No 1500-km contacts were reported.

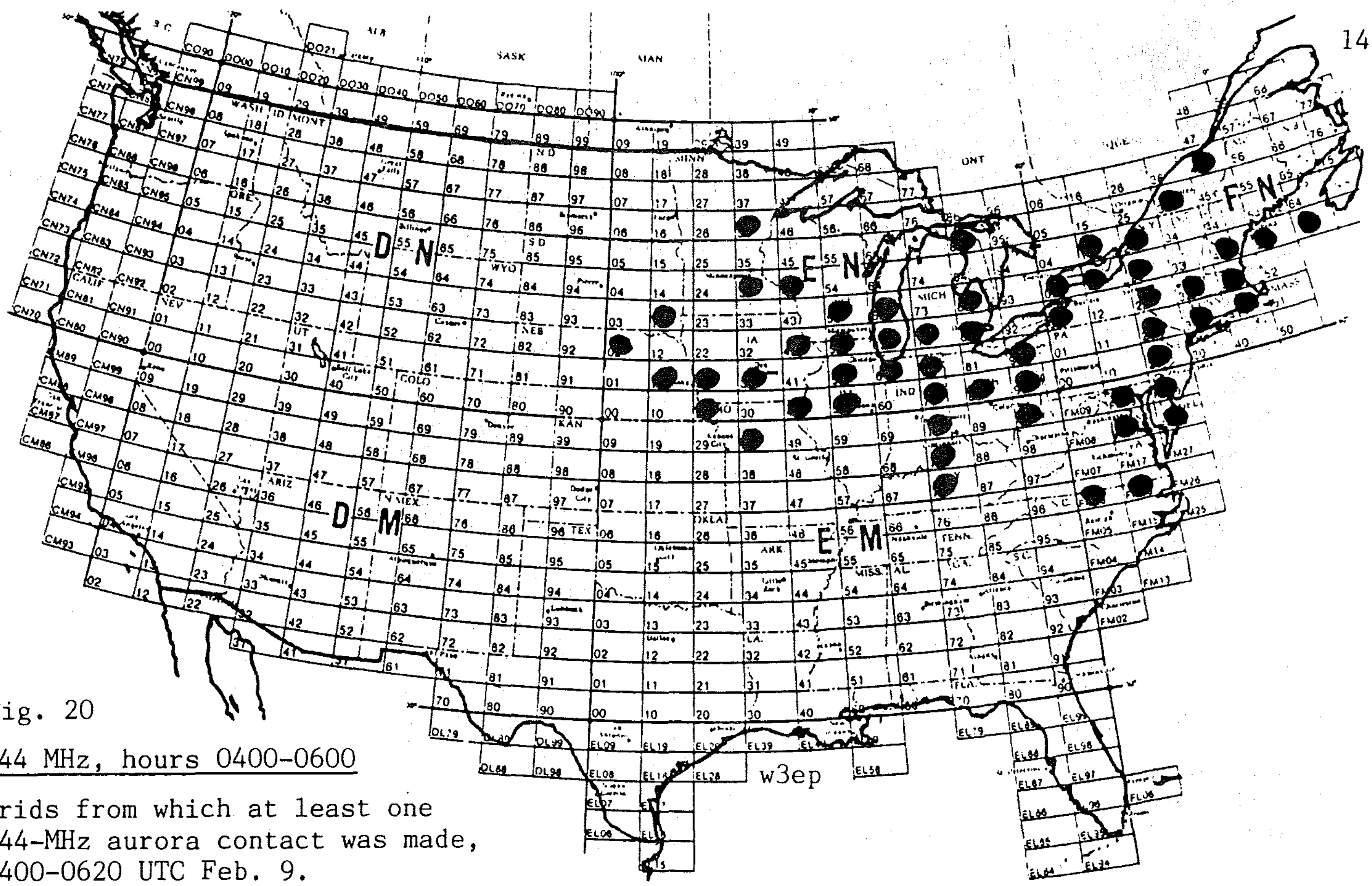


Fig. 20

144 MHz, hours 0400-0600

Grids from which at least one 144-MHz aurora contact was made, 0400-0620 UTC Feb. 9.

Sample Aurora Analyses

Extensive professional and amateur studies have shown that radio signals between 20 MHz to above 1000 MHz may be reflected by the leading edge of radio aurora (the aurora front) in the E-layer of the ionosphere--about 110 km (68 miles) altitude. Lest there be any confusion, it should be noted that radio aurora and visual aurora are different but related phenomenon. The presence and location of visual aurora are not reliable guides to radio aurora conditions. The colorful aurora that often accompanies the invisible radio aurora may extend from somewhat below the E-layer to as high as 650 km altitude (more than 400 miles!). Conversely, radio aurora may be present without any visual display at all.

Because the radio aurora resides only in the E-layer, stations making aurora contacts can be no further than 1000 km south of the aurora front. The aurora will appear below the radio horizon for more distant stations. Reflections may

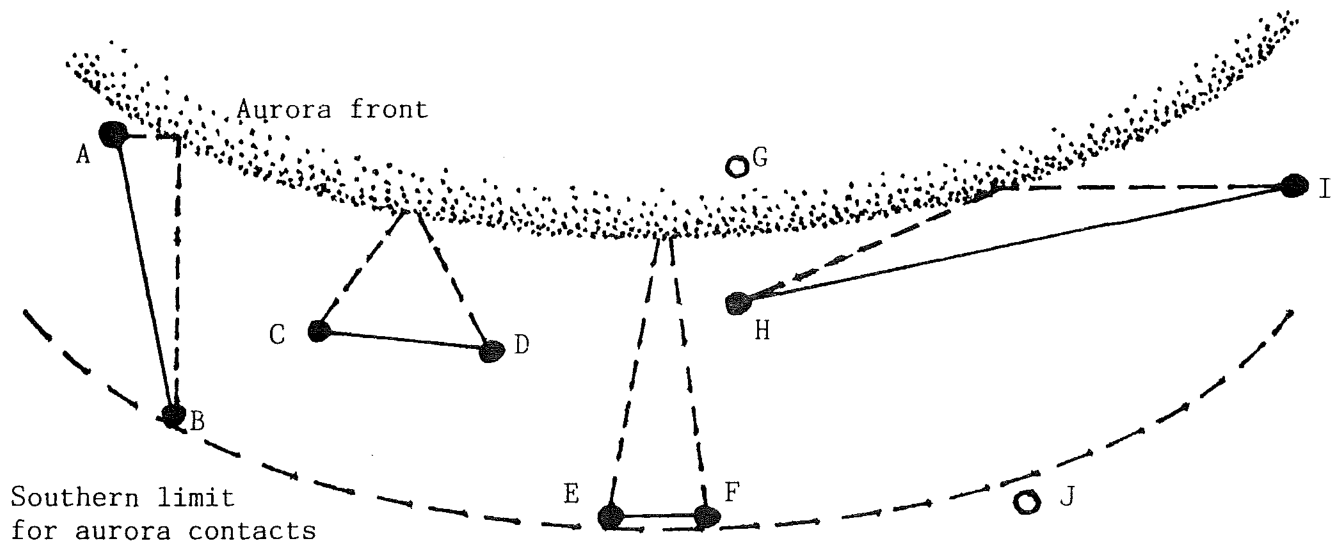


Fig. 21

Path geometry of aurora contacts

There are many possible aurora-reflected radio paths. Dashed lines indicate actual typical radio paths reflected by the aurora front. The solid lines show the direct path. Stations must be no further than 1000 km south of the aurora front in order to make aurora contacts. Stations beyond 1000 km (J) or stations north of the aurora (G) cannot make use of this propagation mode. Stations may be very close, even directly under the aurora (A). Those near the 1000-km limit make only short-distance contacts, measured along the direct path (E to F). The longest contacts are made along paths parallel and relatively close to the aurora front (H to I).

take on many different configurations, as Fig. 21 shows. It is evident that north-south paths cannot exceed 1000 km, and the very longest aurora contacts, about 2000 km, must lie roughly parallel and adjacent to the aurora front.

These basic principles can be useful in analyzing an actual aurora. Fig. 22 shows the distribution of grids with reported 144-MHz aurora contacts during one 15-minute period. A short time span was chosen so that it could be assumed that the aurora front did move move significantly. The southern limit of stations making use of the aurora can be plotted (the dashed line). It can then be assumed that the aurora front must have been no more than 1000 km further north. Because there was virtually no aurora activity in the western part of the country, it may also be assumed that the aurora did not extend all the way across the continent. The plots of two spectacular 2000-km contacts are consistent with this analysis.

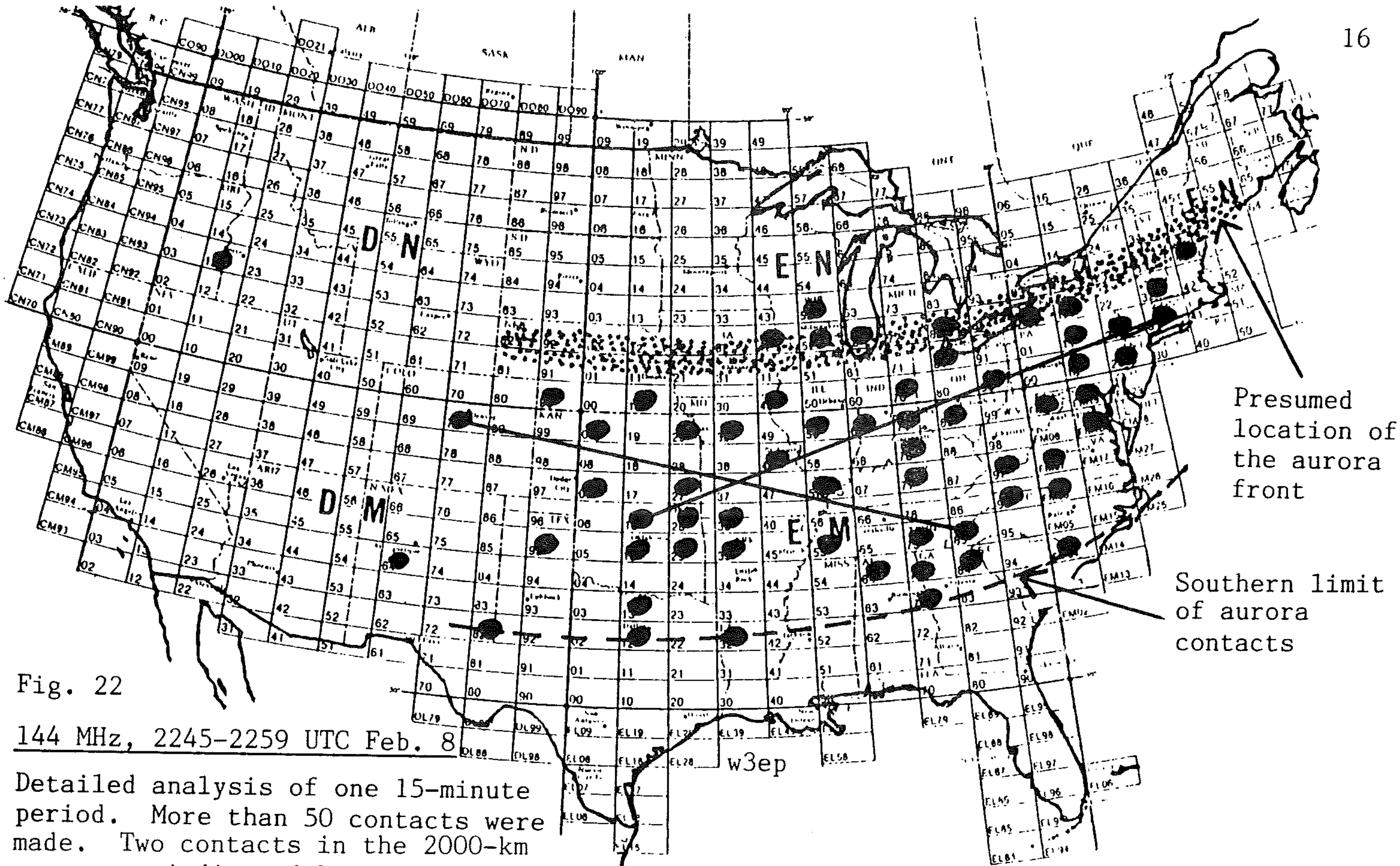


Fig. 22

144 MHz, 2245-2259 UTC Feb. 8

Detailed analysis of one 15-minute period. More than 50 contacts were made. Two contacts in the 2000-km range are indicated by solid lines.

The maximum theoretical distances that can be worked via aurora reflections suggests that an elipse, with a minor (north-south) axis of 1000 km and a major (east-west) axis of 2000 km can be drawn for any location that would define the extreme limits in all directions that could be worked by any aurora. Such an aurora boundary elipse has been drawn in Fig. 23 with its center on grid EM29. The elipse may need to be titled slightly to conform to actual aurora conditions, because the major axis is assumed to be parallel to the aurora front. It should be observed that the coverage for any particular aurora will be considerably smaller than the area of the whole elipse, depending on where the aurora front is situated in relation to the target station in grid EM29.

An actual application of the aurora boundary elipse can clarify this point. When the grids worked by a single station are plotted over a relatively short period of time (short enough to insure that the aurora has not moved significantly in the interim), it is possible to plot the approximate location of the radio

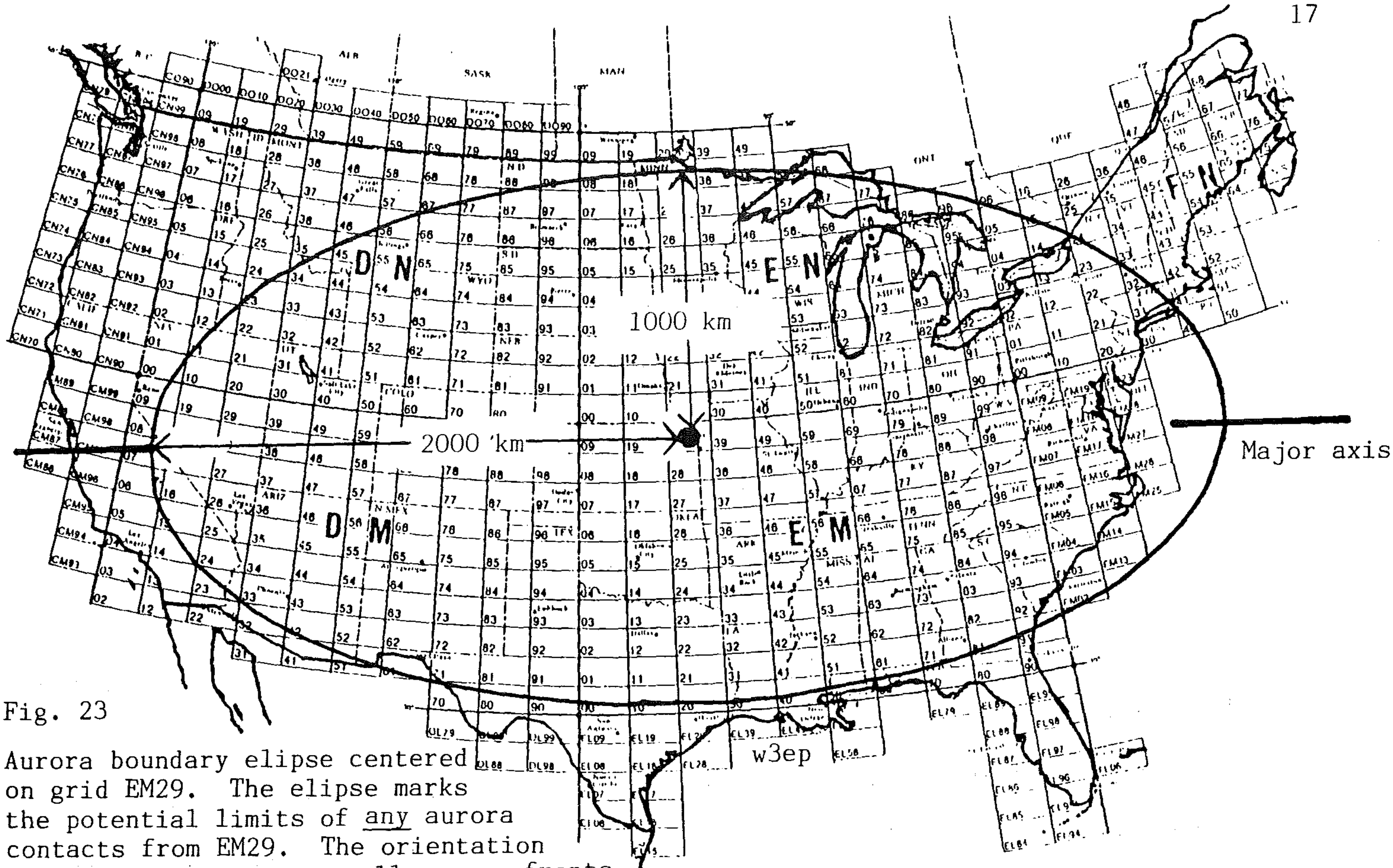


Fig. 23

Aurora boundary elipse centered on grid EM29. The elipse marks the potential limits of <u>any</u> aurora contacts from EM29. The orientation of this elipse assumes all aurora fronts will lie parallel to the major axis.

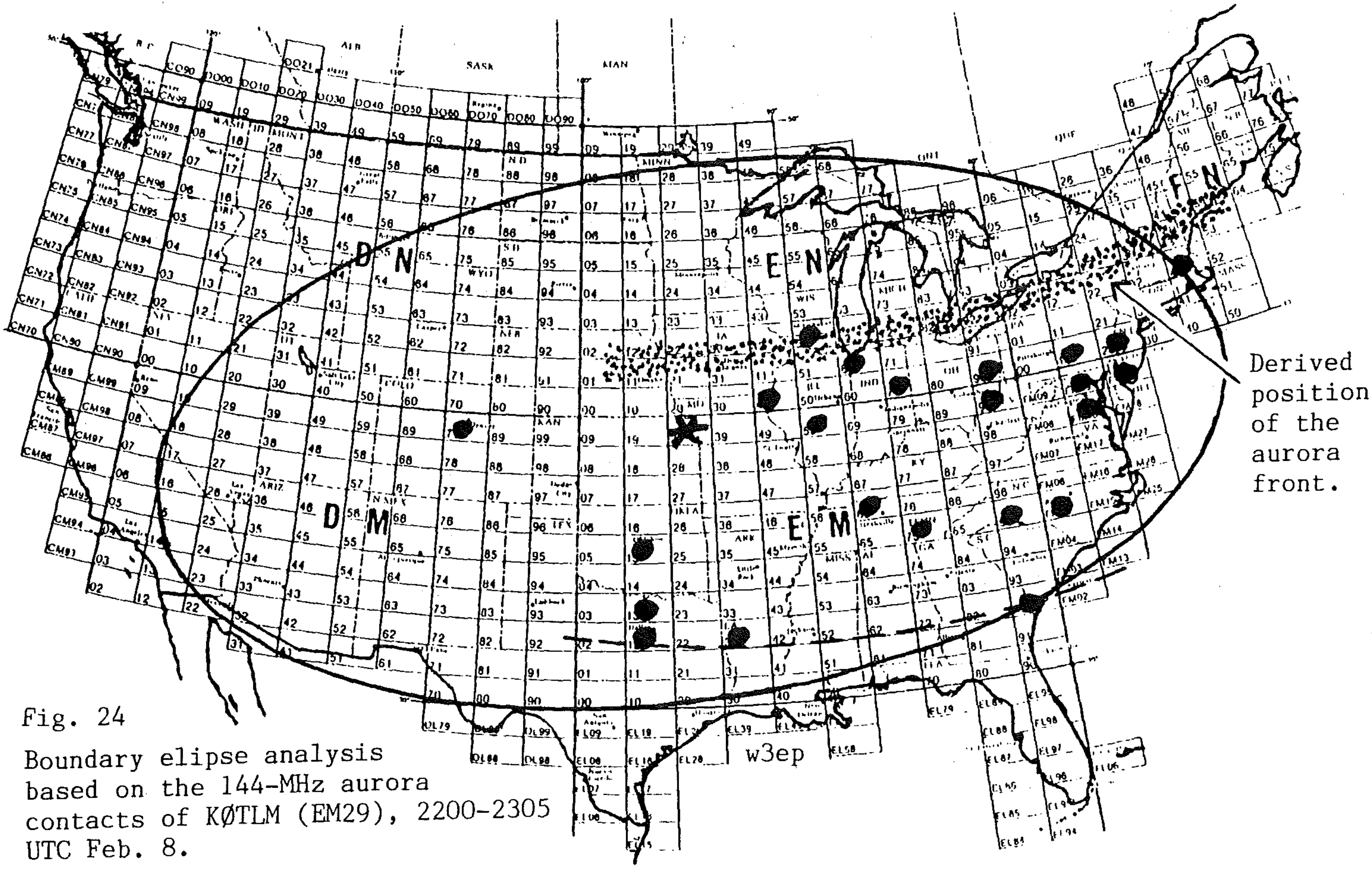


Fig. 24

Boundary elipse analysis based on the 144-MHz aurora contacts of KØTLM (EM29), 2200-2305 UTC Feb. 8.

aurora front and also determine the potential working range. The stations worked by KØTLM (EM29) over a 65-minute period between 2200 and 2305 UTC, Feb. 8, are plotted in Fig. 24. The position of the aurora front was determined by measuring 1000 km north of the most southerly line of grids worked. The potential range for KØTLM was thus bounded in the north by the aurora, south for 1000 km, and east to the boundary elipse. The western limits were uncertain, but certainly no further than the elipse. There is reasonably good correspondance between Fig. 24, based on the data from a single station's log, and the map of Fig. 22, which was based on the data from many stations during the same time period. It appears that KØTLM probably worked to the very limits of what was theoretically possible for him during hour 2200, except perhaps to the west. This conclusion is reinforced when his results are compared with a plot of all the grids that reported activity that hour, Fig. 10. Perhaps KØTLM could have added stations in grids DM64 and DM82 to his log.

A slightly different variation on this analysis scheme is shown in Fig. 25, a plot of all the grids worked by WA7ADK (DN31) over a relatively long period of time. WA7ADK's coverage was quite remarkable, reaching the theoretical limits of the boundary elipse in nearly all directions. This was possible because during the nearly seven hours that WA7ADK was active making 144-MHz contacts, the aurora front moved from near the Canadian border as far south as WA7ADK's location, and then receded north again. The great southerly extent of the aurora in the western part of the country and its movements over a several-hour period gave WA7ADK a rare opportunity. It is evident he made very good use of it.

Similar analyses can be madefor any station and location, even while the aurora is in progress. Indeed, if active aurora stations have on hand a supply of blank grid maps with an aurora boundary elipse drawn in for one's location, such on-the-spot analyses could aid in working aurora more effectively. The opportunities for making long-range contacts, for example, could be forcast if

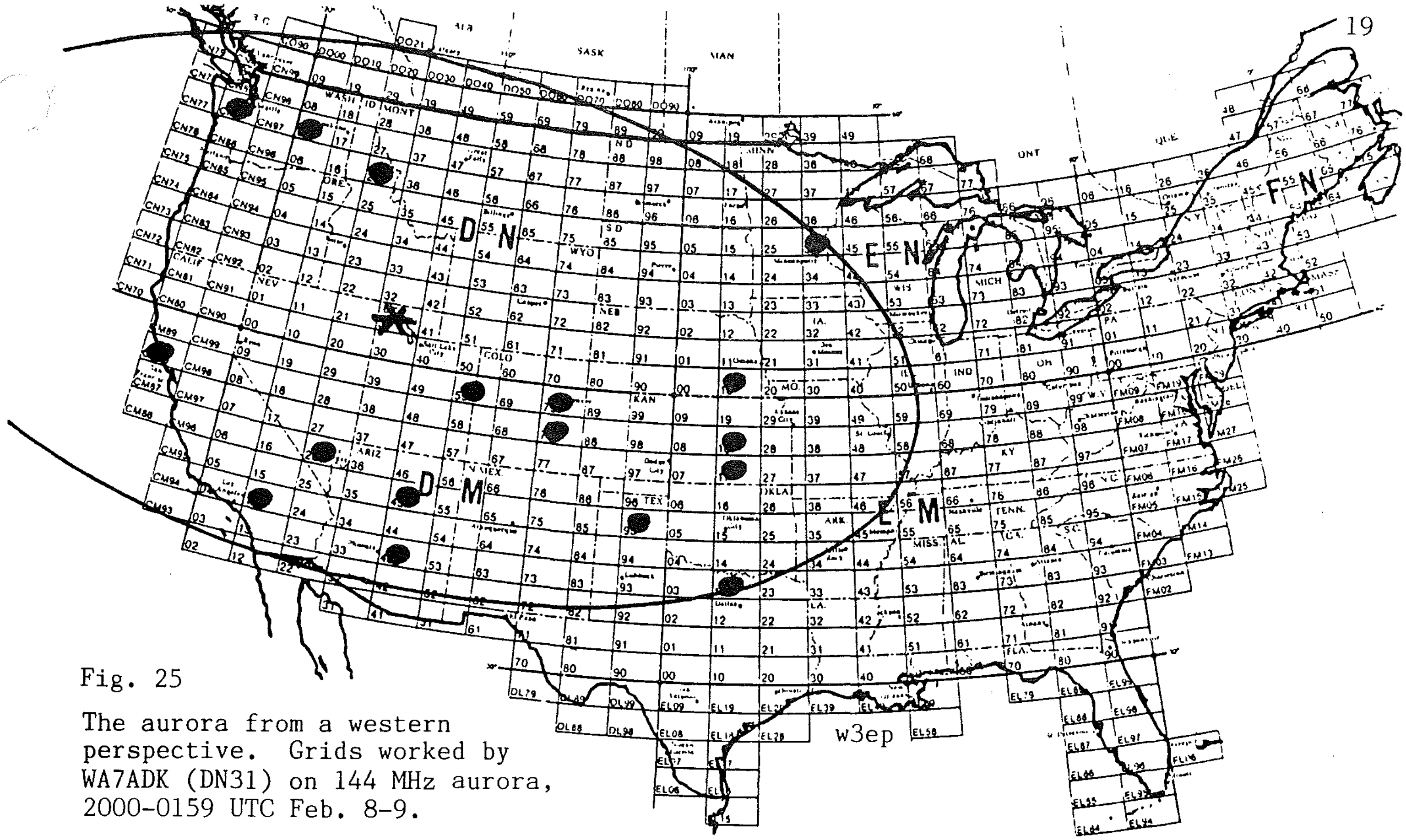


Fig. 25

The aurora from a western perspective. Grids worked by WA7ADK (DN31) on 144 MHz aurora, 2000-0159 UTC Feb. 8-9.

the location of the aurora front can be determined.

Aurora boundary elipse analyses can also dramatically demonstrate the different perspectives of the aurora from various locations. Stations in the Chicago area, for example, worked stations to the south almost exclusively, as Fig. 26 demonstrates for a selected four-hour period. The aurora front probably lay nearly overhead these stations; their coverage extended nearly to the limits of what was possible. At the same time, stations on Lookout Mountain, Tenn.-Ga., perceived the aurora quite differently, as shown in Fig. 27. Nearly all the stations worked from Lookout Mountain were to the north, as the southerly limit for aurora contacts lay within 100 km or so of the Tennessee-Georgia border. Like the Chicago stations, those in the south also worked to the limits of their boundary elipse.

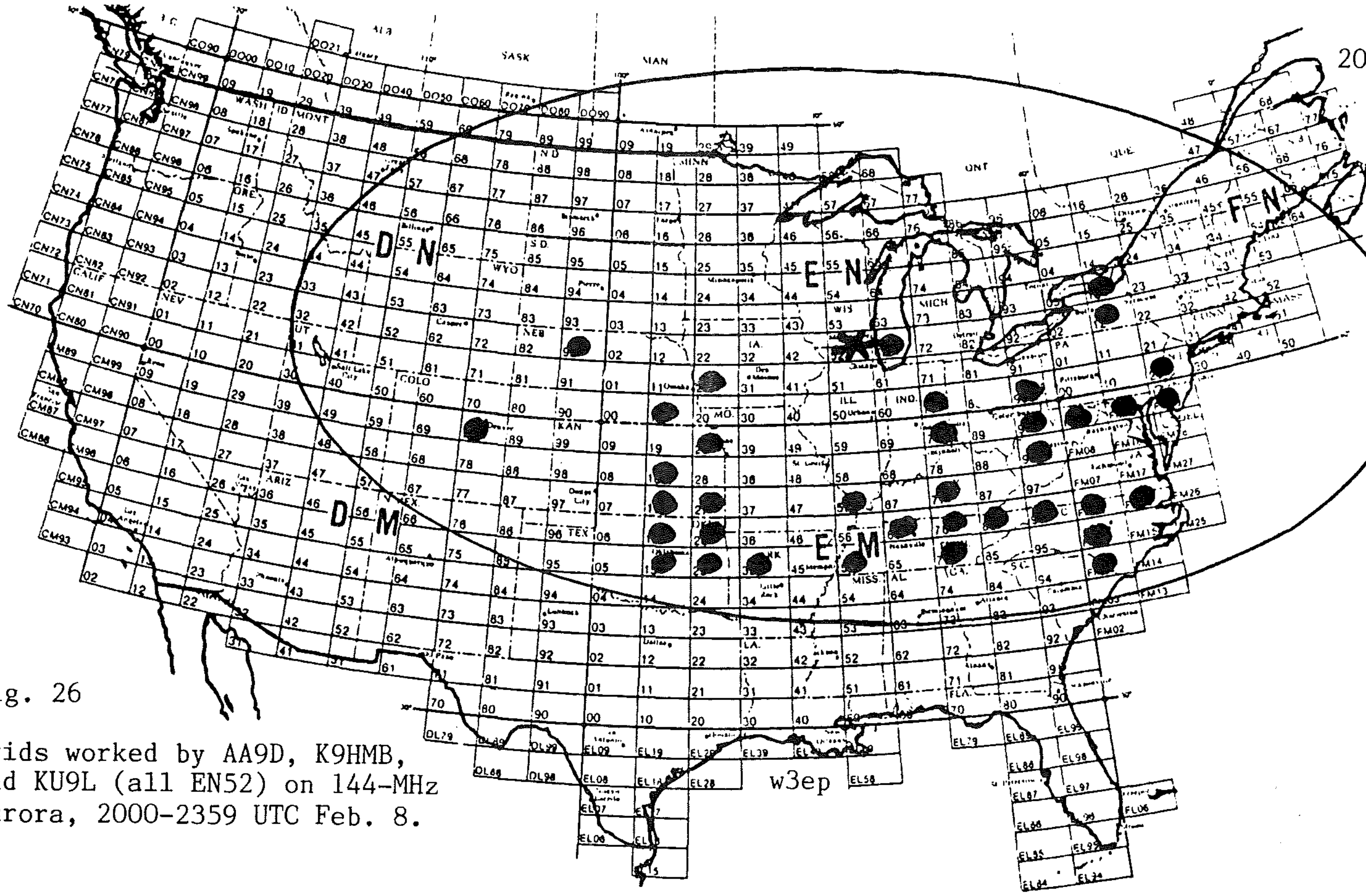


Fig. 26

Grids worked by AA9D, K9HMB, and KU9L (all EN52) on 144-MHz aurora, 2000-2359 UTC Feb. 8.

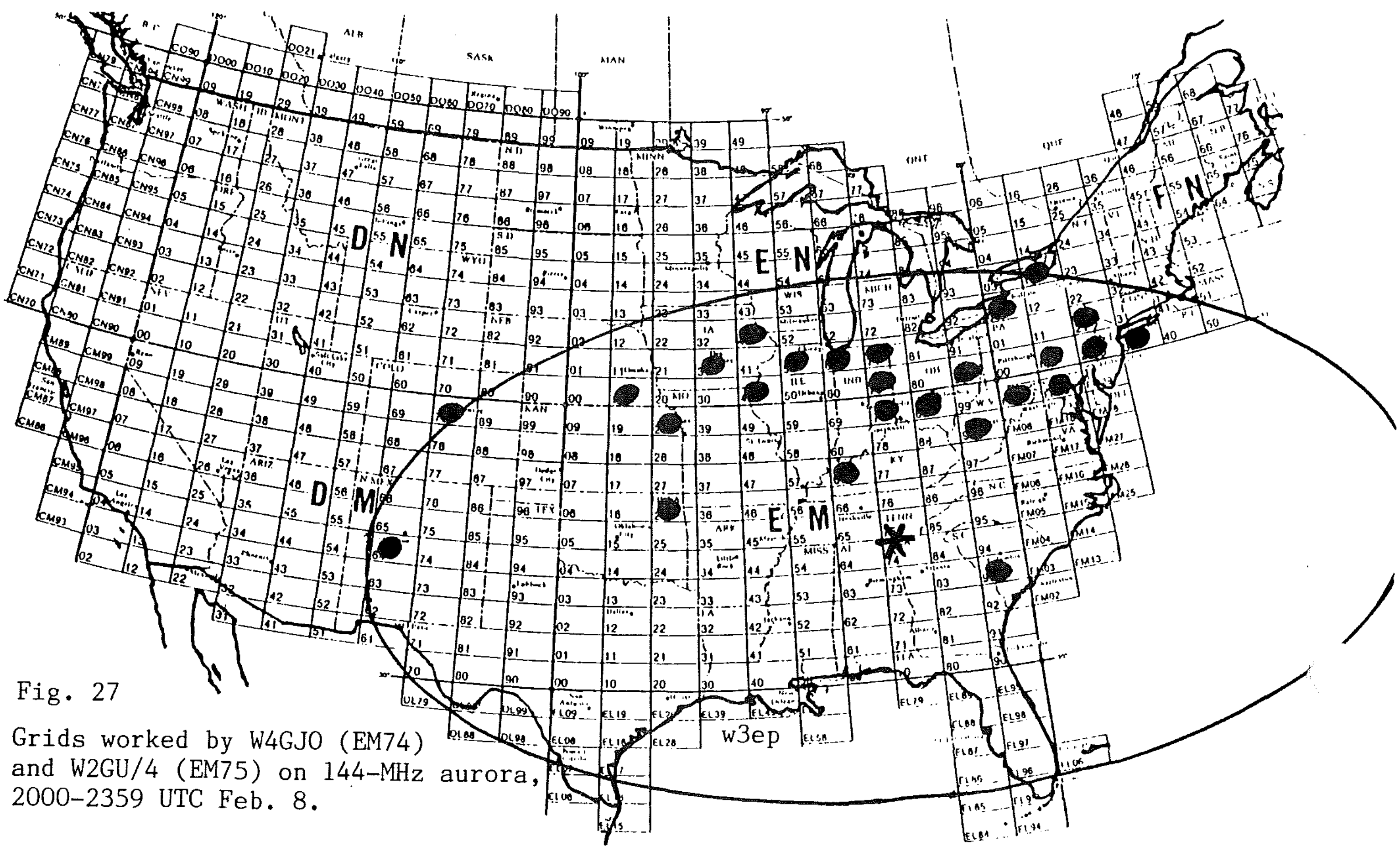


Fig. 27

Grids worked by W4GJO (EM74) and W2GU/4 (EM75) on 144-MHz aurora, 2000-2359 UTC Feb. 8.

Conclusions

From several different perspectives, this was one of the most memorable and widespread aurora in many years. Aurora was worked from the Canadian border (though many northern stations were left out altogether!) to the Gulf, and along both Atlantic and Pacific coasts. Aurora conditions were favorable to some part of the country for more than 19 hours during a 35-hour period during Feb. 7-9 UTC. A new world record of 2169 km on 144 MHz stretched the theoretical aurora range by 169 km, while several other stations made extraordinary 2000-km contacts as well. Several stations made aurora contacts on 432 MHz beyond 1500 km, and even 10-watt stations using single yagi antennas completed their first aurora contacts. Many stations, as indicated by aurora boundary elipse analyses, worked to the full potential the aurora offered.

Although this was an unusual aurora event, the observations and experiences of Feb. 7-9 could be applied easily to aurora practices and expectations in the future. The widespread use of grid-square locators has facilitated propagation analysis at the same time it has given a boost to VHF and UHF activity. Grid locators also make "instant analysis" possible.

Notes and Sources

A short introduction to radio aurora is Richard Miller, "Radio Aurora," QST (Jan. 1985), 14-18. More on aurora studies and an introduction to the idea of the boundary elipse can be found in G. R. Jessop, ed., VHF/UHF Manual (Potters Bar, Eng.: Radio Society of Great Britain), 2.20-2.27.

Announcement to CSVHF Society members who contributed logs for this study: Please consider this to be your promised report on results of my aurora study. If you are reading a borrowed copy of the CSVHFS Proceedings and have not received a copy of this report, please drop me a line and I will get one out to you pronto. Thanks again!

<u>USING THE EIMAC 3CX800A7 AT 432MHz</u>

6/17/86

by Russ Miller, N7ART

When the 3CX800A7 was first introduced I felt it ought to be worth a try at 432MHz, expecially since I was already looking for more power for EME. At that time I gave a call to Bob Sutherland, W6PO, and he kindly provided some info on the tube, enough that I had a starting point toward building an amplifier. The result is described herein, after 2 prototypes to improve the performance of the amplifier.

I picked the 3CX800A7 for several reasons, it has a reasonable price, uses a $5.00 socket, has lots of plate dissipation, is a triode that can be operated grounded-grid, requires low heater current and has a conventional tube base.

<u>CIRCUIT DESCRIPTION</u>

The amplifier uses a stripline plate circuit and a rather different input circuit in the cathode. This particular circuit will provide a 50 ohm input match to the complex cathode impedance (at 432MHz) of 1.02/1. It has a second advantage, only one tuning control! The match remains effective over a relatively wide frequency range.

The input tuning capacitor, C1, is made from a Johnson 160 series. I used a Johnson 160-104-28 with all the stator plates removed except 3 and all the rotor plates removed except 4. Attached to this capacitor is a 3/16" copper line, L1. The other end of L1 is attached to a central tie point on the tube socket. Coil L2 is attached to L1 at a point that achieves the correct input match. The entire input circuit and tube socket are contained within an enclosed chassis box with all leads well by-passed.

Cathode bias is supplied by a zener diode in a conventional manner. There is a protection circuit included in the biasing scheme to prevent damage due to excessive plate current should the zener fail.

The amplifier is somewhat different in the metering of grid current, since the grid is grounded directly to the chassis for stability. Metering is accomplished by placing a meter in series with the cathode and in the plate circuit. Grid current is the difference between the plate current and cathode current. This has one distinct advantage, the HV power supply B- can be directly grounded instead of floating above ground.

The plate circuit uses a 1/16" thick copper stripline to provide thermal stability. The line is supported by two Teflon standoffs made from 1/2" Teflon rod and tapped for 8-32 screws. Plate tuning is accomplished with a "flapper" plate that is spring loaded at its pivot point using two layers of .010 shim stock, obtainable at most hardware stores. A 1/4" threaded rod is used to tune the flapper. The end of the rod contacting the flapper has a small piece of Teflon threaded-on to prevent RF current flow on the rod. RF output coupling is provided by a 1" diameter copper disc, 1/16" thick, soldered to a short, threaded, 1/4" brass shaft. The threaded shaft is screwed into a brass nut soldered to the stripline. Once adjusted, a second nut is used to secure the shaft. The other half of the RF output coupling is an identical disc attached to an "N" fitting on the chassis.

Cooling is provided by a Pamotor 4-11/16" square, 100cfm, 115V muffin fan for a degree of quietness not possible with squirrel-cage blowers. The fan is mounted on the plate compartment cover at the end opposite the tube. This provides direct cooling of the plate line to help promote thermal stability. To prevent modulation of the RF by the fan blades and to keep RF leakage low, a 5/16" wire mesh is placed between the fan and the cover. Cooling of the cathode compartment is through three holes drilled near the tube socket. The air exhaust is through an Eimac SK-1906 chimney.

CONSTRUCTION

The entire amplifier is built on two chassis, the kind that have a lid with folded-over edges. One chassis contains the cathode circuitry and is 5" X 7" X 2". The plate compartment is 12" X 8" X 3". The cathode compartment requires no special treatment, however the plate compartment will need to be modified with the addition of 3/4" X 3/4" aluminum angle (non-anodized), riveted to the sides of the chassis so the cover can be firmly fastened down. 8-32 screws are used, spaced 1-1/2" apart.

The 3CX800A7 uses a special but inexpensive 11-pin socket. Before attaching to the chassis, remove pin 11 and bend pins 4 and 7 over and solder to the tube socket integral mounting ring. This is to allow clearance for a brass or copper tie plate that is the central connecting point for cathode pins 1,2,3, 8,9,10. Mount the two chassis together and cut a hole just the diameter of the round portion of the socket and mount it on the cathode compartment side. Follow the cathode compartment sketch for the proper orientation.

When mounting C1, use an adaptor coupling on the capacitors 3/16" shaft to allow the use of a plastic 1/4" shaft. This is to prevent RF flow on the shaft.

The grid mounting ring can be constructed using finger-stock and the Eimac 720359 collet or built using the insides of a 4CX250B screen-grid by-pass capacitor. The anode connection can be made by soldering finger-stock to the stripline, sizing the hole for the anode accordingly. However, leave room for a chimney especially if you elect to use the Eimac SK-1906.

The plate choke and by-pass capacitor were selected so there isn't a sneak, series resonance, in concert with the networks in the cathode that could be shock-excited and cause unexplained arcovers in the anode circuit.

There are several methods that can be used to obtain the required 13.5V heater voltage so this is left to the builder. Eimac recommends a tolerance of only ±0.6V. I use a transformer that is rated, under load, at 13.0V.

TUNE-UP

The tube heater requires a 3-minute warmup time and cooling air must be applied when the heaters are turned on and left on for 2 minutes when turned off. Never apply drive without plate voltage being present.

Connect a wattmeter and dummy load to the amplifier output jack and apply a low plate voltage, preferably about 1000V. With 10W of drive applied (grid current must never exceed 60ma), tune C1 until plate current is indicated. Tune C2 for RF output as indicated on the wattmeter. Before going further, check the input VSWR and move the tap point where L2 connects to L1 for the least reflected power. Once the tuning is in the ballpark, full HV can be applied and the output checked. With 2000V and a plate current of 500ma, adjust C2 and C3 for maximum output. If the spacing of C3, as shown on the output coupling sketch, is followed, very little adjustment will be necessary. Recheck the input VSWR.

Maximum recommended plate voltage is 2250V under load. With a plate voltage of 2000V, the amplifier will produce 600W output easily at 432MHz. Drive requirements will vary with the tubes but at least 50W is required. At higher outputs, C1 and C2 will have to be retuned.

After 2-1/2 years I am still using this amplifier and receiving good signal reports. It has served me well, giving absolutely no problems. It is unconditionally stable and requires little to no retuning once it is set up.

Please note, no attempt has been made to describe a front panel arrangement since everyone's requirements are different.

SPECIAL PARTS

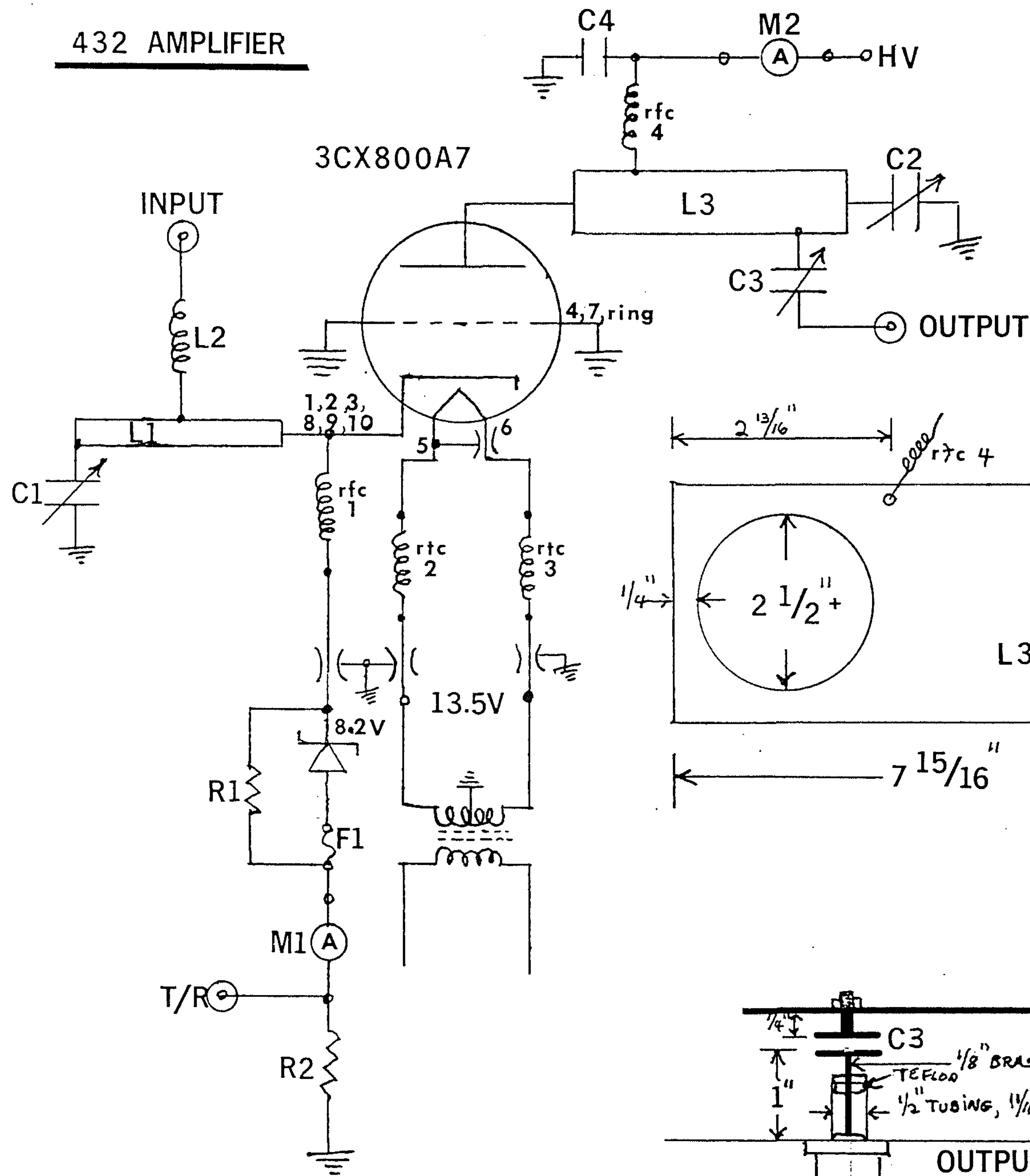
Socket - Johnson 124-311-100 or Eimac SK-1900
Chimney - Eimac SK-1906
Zener - 8.2V, 50W
Feed-thru's - 500pf, 500V

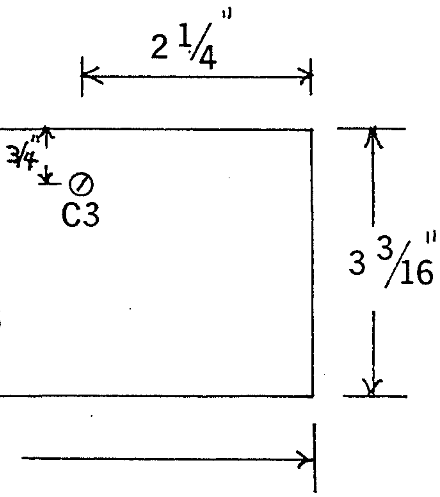
PARTS LIST

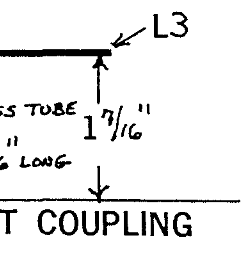
C4- 500 pf, 7.5kv transmitting capacitor
F1- 1.5Amp, fast-blow fuse
M1,M2- 0-1.5Amp meters
R1- 250 ohm, 10W
R2- 10k, 25W
RFC 1- 31T #26, 3/16" I.D., close-wound
RFC 2,3- 12T #22, 3/16" I.D., close-wound
RFC 4- 11T #24, 3/16" I.D., close-wound

#

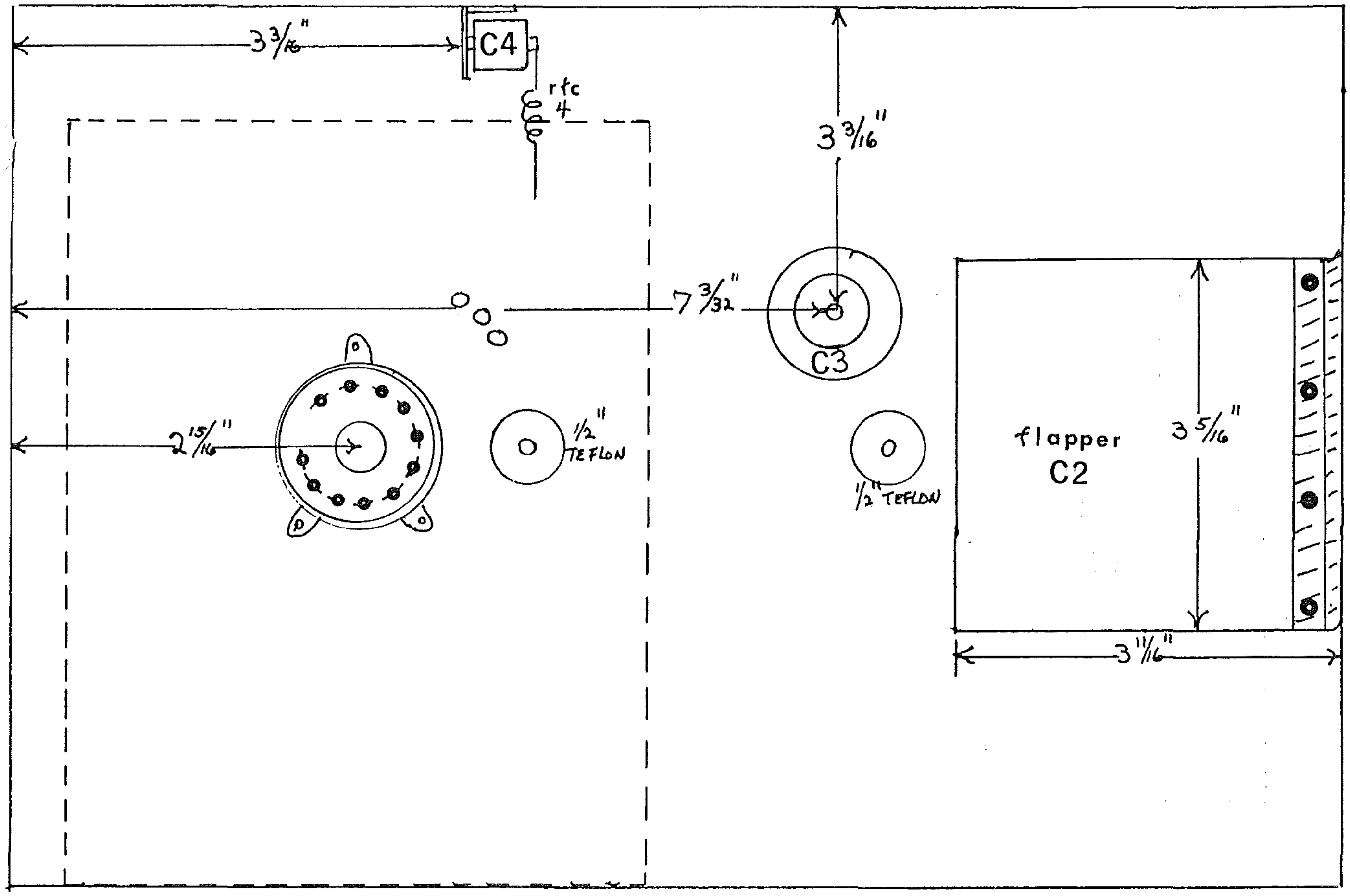
432 AMPLIFIER

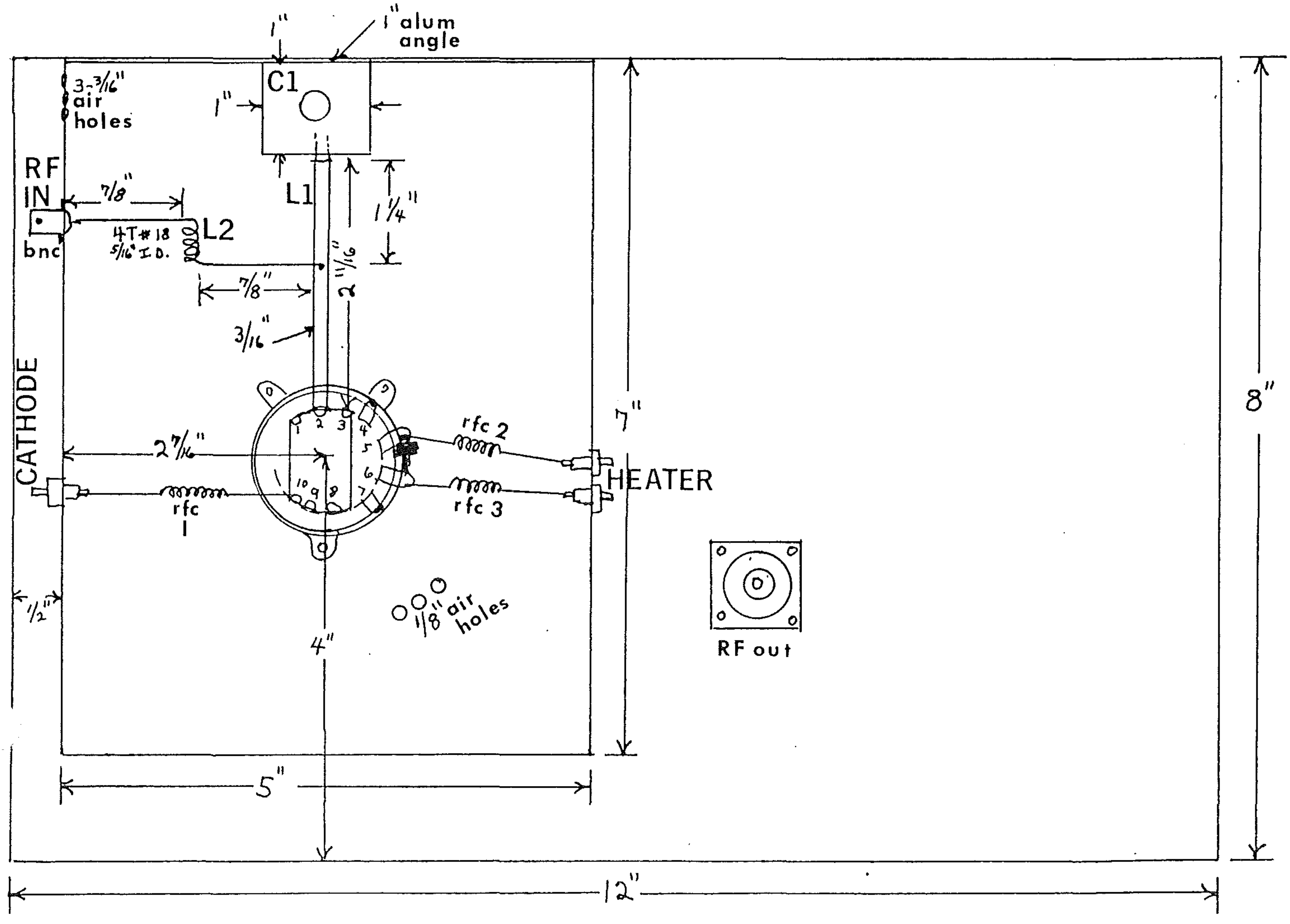


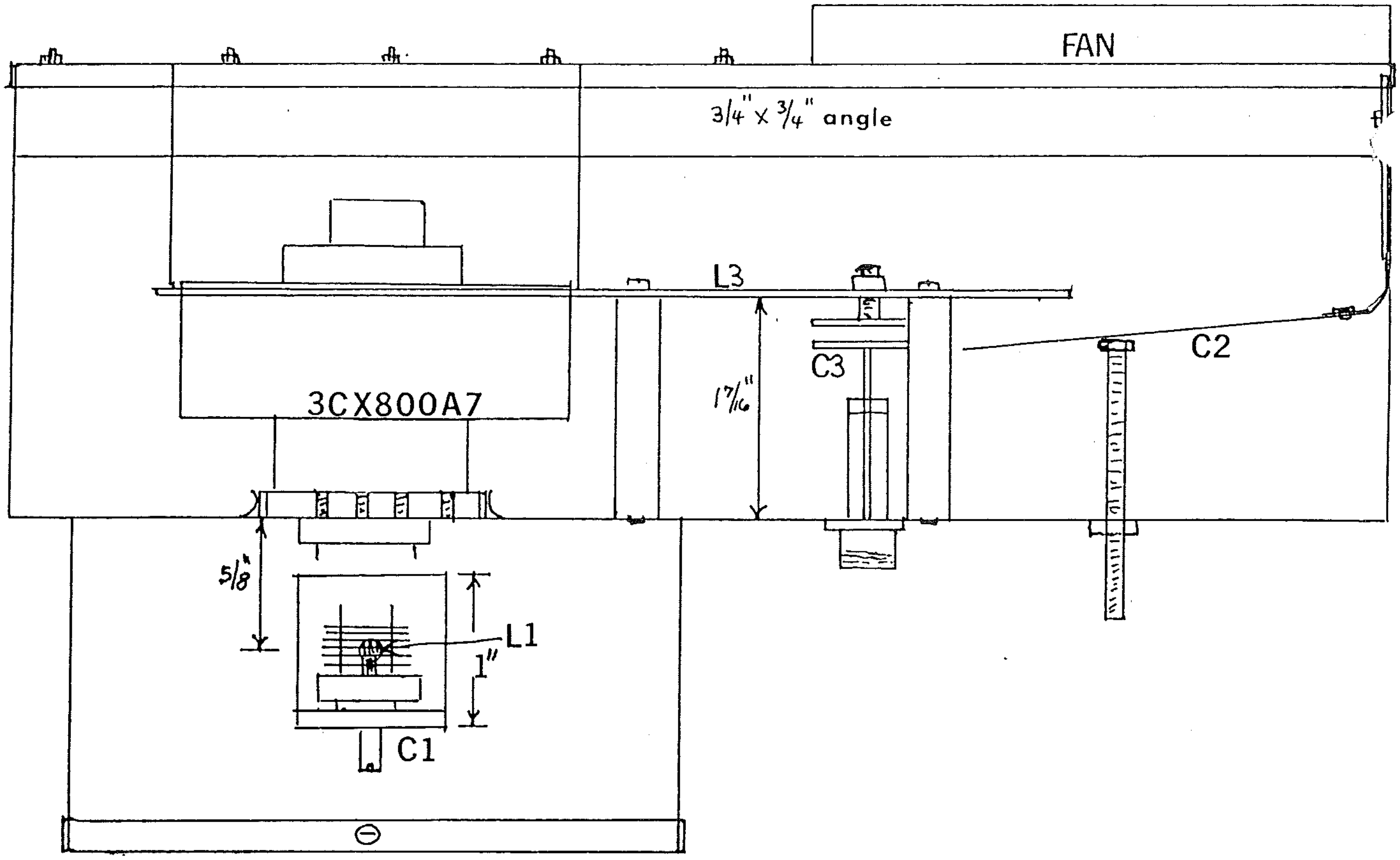




OUTPUT COUPLING


3 3/16"
C4
rfc
4
3 3/16"
7 3/32"
C3
2 15/16"
1/2"
TEFLON
1/2" TEFLON
flapper
C2
3 5/16"
3 11/16"


1"
1" alum
angle
C1
1"
3-3/16"
air
holes
RF
IN
bnc
7/8"
L2
4T # 18
5/16" I.D.
L1
1 1/4"
2 11/16"
7/8"
3/16"
CATHODE
2 7/16"
rfc
1
rfc 2
rfc 3
HEATER
7"
8"
1/2"
1/8" air
holes
4"
RF out
5"
12"


FAN
3/4" x 3/4" angle
L3
3CX800A7
1 7/16"
C3
C2
5/8"
L1
1"
C1

903MHz Up/Down Converter - 2 Meter I.F.

by Russ Miller, N7ART

The goal of this project was to develop a simple and clean 903MHz converter system that would allow the use of a 2 Meter transceiver as the receive I.F. and transmitter exciter. Before I began the project I set a few standards that were felt necessary. They are stability, low harmonic content and good performance.

LOCAL OSCILLATOR

The local oscillator was built on a piece of 1/16" thick, double-sided, fiberglass PC board. This is a readily available material obtainable from many sources including Radio Shack. The basic oscillator is a modified Butler using JFET's. The crystal is series resonant, 3rd overtone, in an HC-6/U holder. For the sake of stability and lower harmonic content, all of the multiplier stages are 2N5179's, using double-tuned LC networks and operated as doublers. This particular transistor is predictable, stable, and operates well at 903MHz. The output of the L.O. is fed thru a low-pass filter made up of C9 and L9, L10. The result is a clean, 759MHz mixer injection signal at a level of approximately +7 dBm as measured on a Hewlett-Packard spectrum analyzer.

MIXERS

The up/down mixers are mounted on a separate piece of 1/16", double-sided, PC board. The 903MHz to 144MHz mixer uses the Minicircuits SRA-2CM double-balanced mixer. The output of the mixer feeds a matching termination to keep an approximate 50 ohm impedance present to all unwanted frequencies and provide additional filtering of unwanted signals before they reach the JFET I.F. amplifier. The LC networks that make up the matching termination, L1, C1 and L2, C2 are resonant at 144MHz. The choice of a simple grounded-gate JFET was made since tests with higher gain, grounded-source MOSFETS indicated a stability problem and consequent low-level spurious noise as observed on the spectrum analyzer.

The 144MHz to 903MHz mixer also uses an SRA-2CM double-balanced mixer. The 903MHz output from the MRF-901 is +4 dBm. The ideal maximum 144MHz drive level to the mixer is Ø dBm. This will require a pad such as the one shown which is satisfactory for a transceiver with adjustable output set for approximately 1½ watts. Do not exceed +3 dBm 144MHz drive at the mixer input pin. With a +10 dBm 144MHz input at the mixer pin 1, the 903MHz output only goes up 2 dB but the harmonic content takes a drastic leap upward.

The following is the measured 903MHz output levels with the specified 144MHz input levels.

144MHz Input	903MHz Output
-40 dBm	-36 dBm
-30 dBm	-25 dBm
-20 dBm	-14 dBm
-10 dBm	- 4 dBm
Ø dBm	+ 4 dBm

With Ø dBm 144MHz input, the +4 dBm 903MHz output contains the following harmonics:

Ø to 625MHz - All harmonics at least -68 dBm or lower (-72 dBc)
Approx. 626MHz -57 dBm
759MHz (L.O.) -34dBm
Above 760MHz - All harmonics -62 dBm or lower

As can be seen, the harmonics are all very low and the only signal which needs additional attenuation is the L.O. 759MHz signal. This can be accomplished by using a band-pass filter. Many are described in various articles.

CONSTRUCTION
The layout and etching of the boards is quite easy using direct-etch dry transfers and etching solution, available from Radio Shack. All the circuitry is layed out on the bottom of the boards using the dry transfers. The holes for mounting all the components, which mount on top of the board, are then drilled. The top of the boards is covered with clear Mylar packing tape. Using an Exacto-Knife, cut out the areas in the Mylar where you don't want the components that are poked-thru to be grounded. When done, etch the board.

Be sure to keep the 2N5179 transistor leads short. The 2N5179 that is used to drive the MRF-901 is mounted a little differently to keep the lead length short. Instead of poking the leads thru the board from the top, drill a hole the diameter of the transistor case and insert the transistor from the bottom (circuit side). Bend the leads over and solder. When mounting the MRF-901, drill a hole the diameter of the case to allow the transistor leads to sit flush on the board (on the circuit side).

The use of stripline construction has been avoided because of the difficulty in precise duplication, except in one area, the base of the MRF-901. The ½" X 1" stripline is necessary but easy to duplicate. Be sure shields of PC board or brass are used where called-for to keep the harmonic content low and for stability. Where chip caps are used, do not substitute. Be careful when soldering to the Johanson style piston trimmers. Solder them quickly or the seals will desolder and the capacitor will be useless.

One word of note, the L.O. is switched between mixers using an ultra-miniature relay, not the best choice, but it works. I would recommend a sub-min coax relay such as sold by Dick Smith Electronics.

TUNEUP
The L.O. should be tuned, up to the 379.5MHz doubler, using a grid-dip meter. Next, tune up the 903 to 144 converter by touching a small screwdriver to pin 3 of the DBM. Tune in a local 2 meter signal near the low end of the band and adjust C1, C2 and C3 for max signal. Apply a 903MHz signal to the converter and adjust the L.O. 759MHz doubler and C9 in the low-pass filter for max signal. Next, apply 144MHz drive at as low a level as possible to the 144 to 903 up-converter from some source other than the transceiver you have been using and have connected to the 903 to 144 converter. Tune the 2N5179 and MRF-901 transmitter stages for max signal as heard thru the down-converter on the 2 meter receiver. This is a rudimentary procedure but it will get you in the ballpark.

CONCLUSION

The up/down converter system is a simple building block that can be expanded by adding a GASFET pre-amp and transmitter amplifiers. There are antennas now available for 903MHz and more being developed. Amplifiers can be constructed using solid-state block modules or tubes, or you can try local contacts barefoot.

PARTS LIST

Local Oscillator-

C1,C2,C3,C4- 3-10pf trimmer - Radio Shack 272-1338
C5,C6- .8-10pf Johanson trimmer
C7,C8,C9- .6-6pf Johanson trimmer
C10,C11- gimmick, bifilar, #28 wire, 3/16" long
L1- 8½T #26 on a 3/16" slug-tuned coil form
L2- 4½T #24 on a 3/16" slug-tuned coil form
L3,L4- 3T #24, 3/16" dia.
L5,L6- 1T #20, ¼" dia.
L7,L8- See schematic
L9,L10- 1T #24, 1/8" dia.
RFC- #64 ferrite bead w/1T #24
Feed-thru's- 500pf solder-in
All resistors ¼W - carbon preferred

Converter-

C1,C3- 3-10pf trimmer - Radio Shack 272-1338
C2- 10-60pf trimmer - Radio Shack 272-1340
C4,C5,C6,C7- .6-6pf Johanson trimmer
L1- 4T #22, on a 3/16" dia slug-tuned coil form
L2- 1T #24, 1/8" dia.
L3- 6T #18, ¼" dia, tapped at 1 3/4T
L4 thru L7- See schematic
RFC 1- 20T #30, 1/8" dia.
RFC 2- 10T #30, 1/8" dia.
RFC 3,4- 8T #24, 1/8" dia.
U1,U2- Minicircuits SRA-2CM DBM
FB- #64 ferrite bead
RY-1- Radio Shack 275-241 relay, 12vdc coil
Feed-thru's- 500pf solder-in

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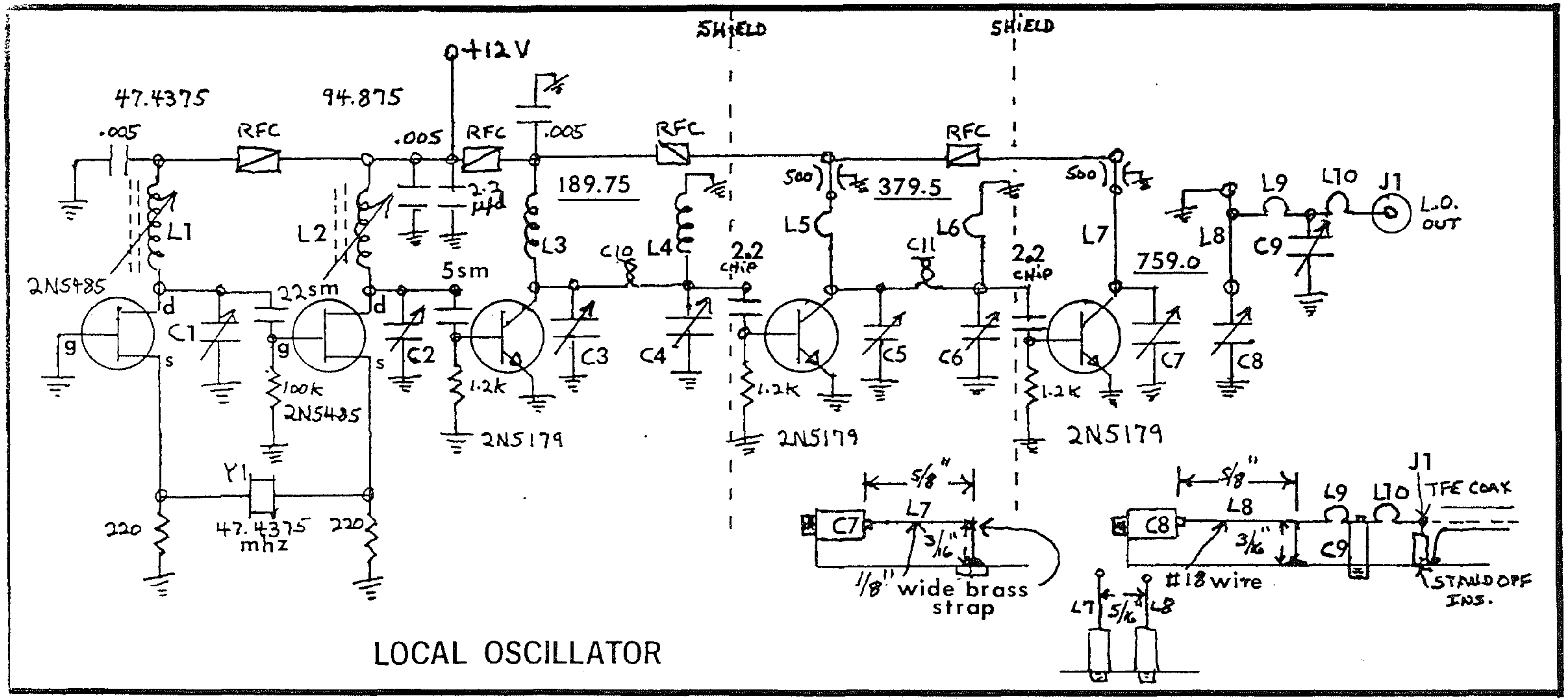
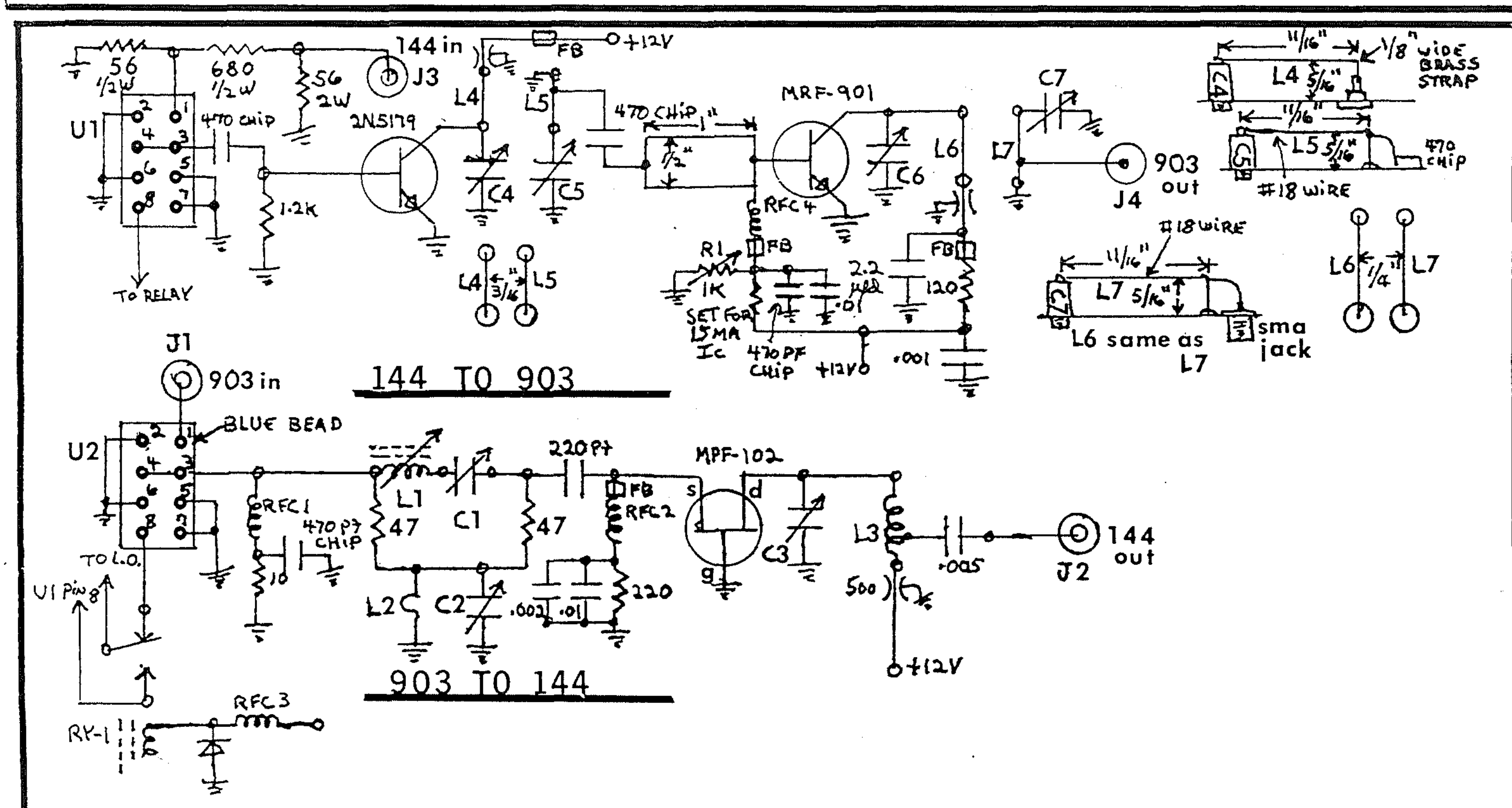
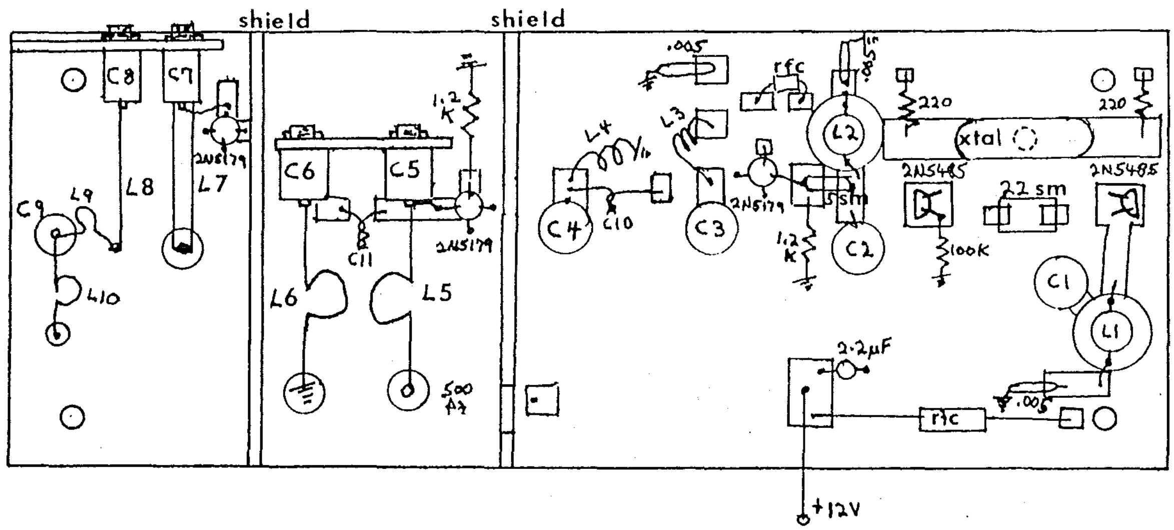


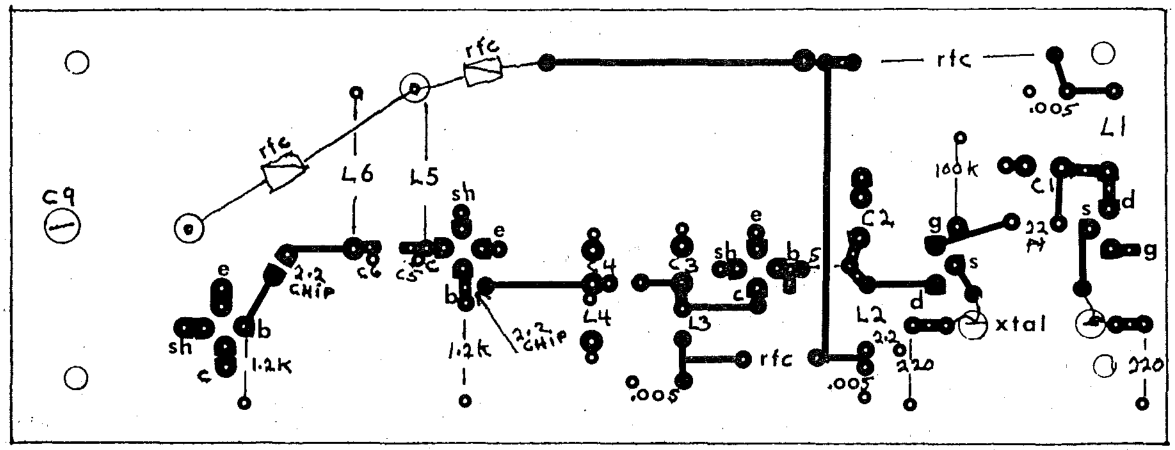
LOCAL OSCILLATOR
+12V
SHIELD
SHIELD
47.4375
94.875
189.75
379.5
759.0
.005
RFC
2.2 µfd
L1
L2
L3
L4
L5
L6
L7
L8
L9
L10
J1
L.O. OUT
C1
C2
C3
C4
C5
C6
C7
C8
C9
C10
C11
2N5485
22sm
5sm
100k
1.2k
2N5179
2.2 CHIP
500
Y1
47.4375 mhz
220
5/8"
3/16"
1/8" wide brass strap
#18 wire
5/16"
TFE COAX
STANDOFF INS.

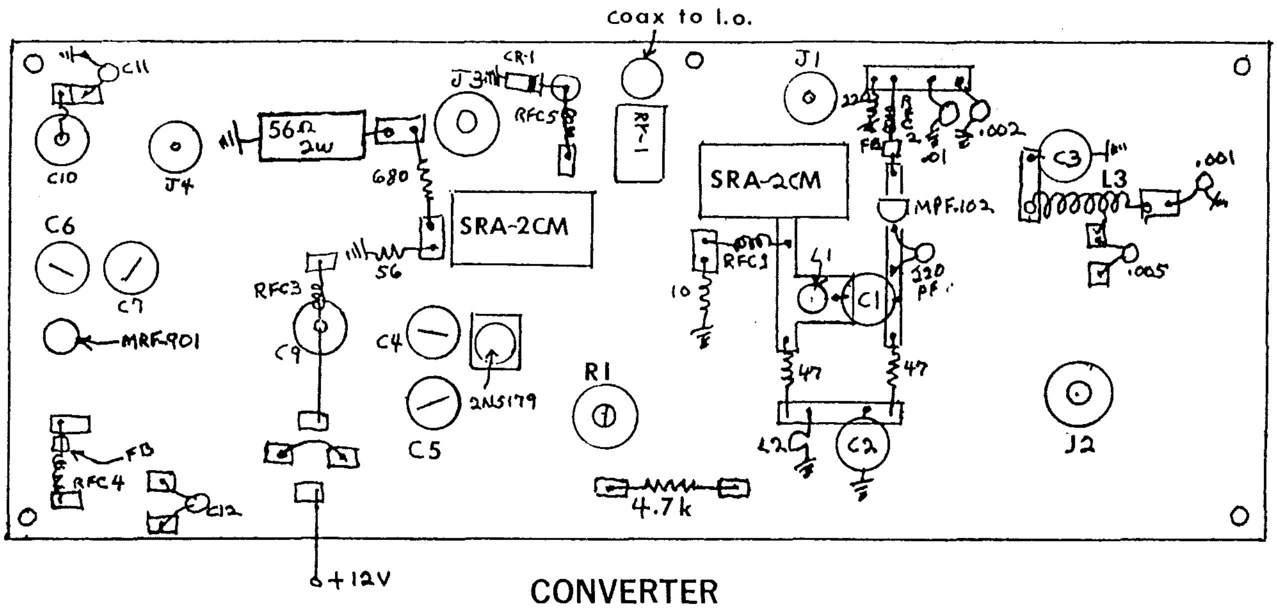


144 TO 903
903 TO 144
144 in
FB
+12V
56 1/2W
680 1/2W
56 2W
J3
U1
470 CHIP
2N5179
1.2K
TO RELAY
L4
L5
C4
C5
3/16"
MRF-901
C6
L6
L7
C7
903 out
J4
RFC 4
R1
1K
SET FOR 15MA Ic
470PF CHIP
2.2 µfd
.01
120
.001
11/16"
1/8" WIDE BRASS STRAP
5/16"
#18 WIRE
470 CHIP
L6 same as L7
sma jack
1/4"
J1
903 in
U2
BLUE BEAD
TO L.O. U1 Pin 8
RFC1
470 PF CHIP
10
L1
C1
47
220 PF
RFC2
MPF-102
C3
L3
.005
J2
144 out
500
L2
C2
.002
.01
220
RY-1
RFC3

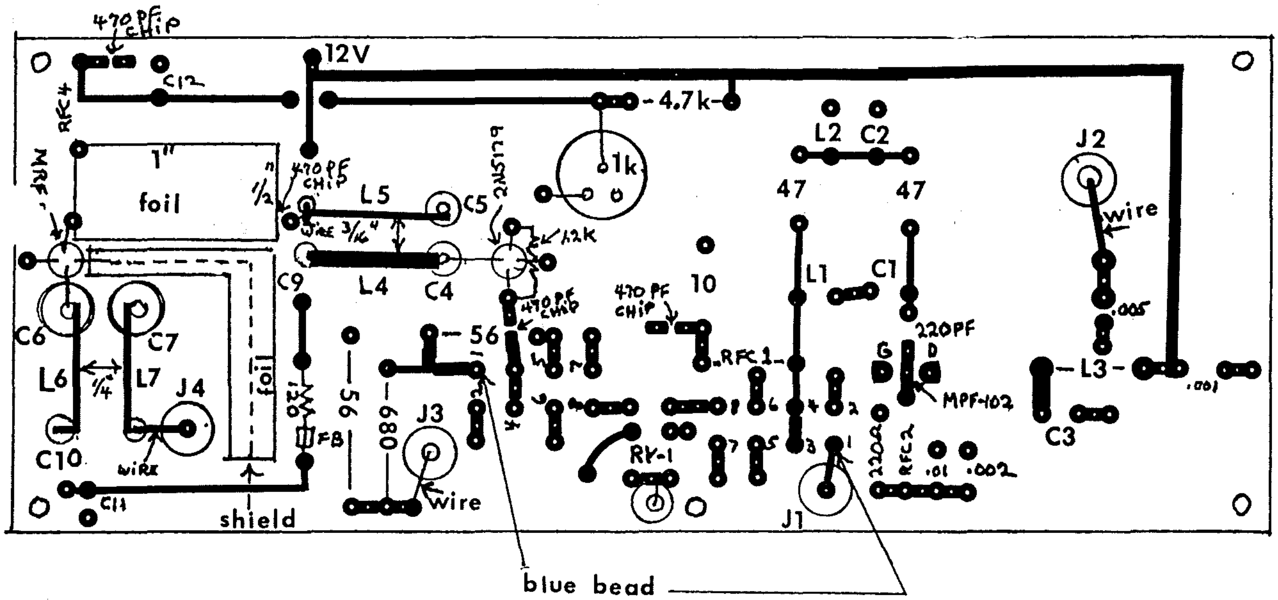


LOCAL OSCILLATOR




coax to l.o.
C11
CR-1
J3
J1
RFC5
RV-1
56Ω 2W
C10
J4
680
SRA-2CM
SRA-2CM
MPF-102
C3
L3
.001
.005
.002
.01
FB
C6
C7
56
RFC3
RFC1
220 PF
MRF-901
C9
C4
2N5179
C1
R1
47
47
C5
L2
C2
J2
FB
RFC4
C12
4.7k
+12V

CONVERTER


470 PF chip
12V
C12
4.7k
RFC4
1"
foil
L2
C2
J2
MRF
470 PF CHIP
1/2"
L5
C5
2N5179
1k
47
47
wire
wire 3/16"
1.2k
C9
L4
C4
470 PF CHIP
470 PF CHIP
10
L1
C1
.005
C6
C7
56
220PF
G
D
L6
1/4
L7
J4
foil
RFC 1
L3
.001
120
680
56
J3
MPF-102
C3
C10
wire
FB
RV-1
220Ω
RFC2
.01
.002
C11
shield
wire
J1
blue bead

THE PARABOLIC DISH - FACT AND MYTH

by Russ Miller, N7ART

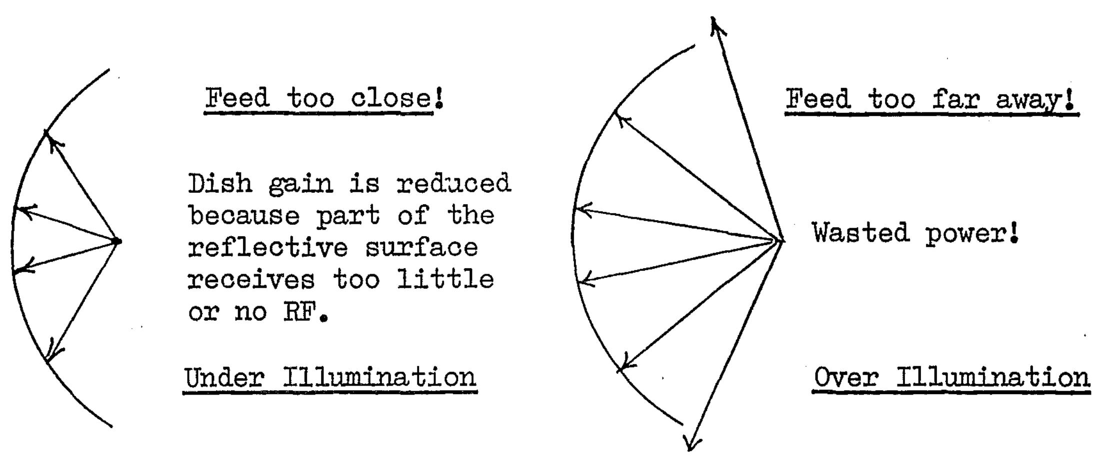
It seems so little information is available to the amateur regarding dishes that most do not attempt to try them. Here are some basics and definitions that might help those interested.

1. <u>What frequency will a dish work at?</u>
   In practical use, any frequency where the gain of the dish is greater than a home-built or off-the-shelf antenna system. For instance, the gain of a 16' dish at 2 meters is only 14.7dB. Many single Yagis are available with 15dB gain. At 1296MHz the same dish has a gain of 33.8dB. With a gain like that you probably don't have enough room in the backyard to put up enough Yagi's to equal it.

2. <u>What does the size of the dish have to do with the gain?</u>

At 432MHz Size	Gain (eff 55%)	At 1296MHz Size	Gain (eff 55%)
8'	18.8dB	8'	27.8dB
10'	20.7dB	10'	29.7dB
12'	22.3dB	12'	31.2dB
16'	24.8dB	16'	33.8dB
20'	26.8dB	20'	35.7dB
25'	28.7dB	25'	37.7dB

3. <u>What is a focal point?</u>
   This is an often misunderstood term. The focal point is where the feed antenna (usually some form of dipole) fully illuminates the dish. For instance:



4. <u>What is the f/D ratio? What is it used for?</u>
   This is a mathematical expression for the focal point divided by the dish diameter. If a 12' dish has a focal point of 6' then its f/D ratio is 0.5. The f/D figure is used in calculating the desired face curve on a dish. The reason for using a particular face curve is so it will work with a particular type of feed system.

5. <u>Should I be concerned with the f/D ratio?</u>
Very definitely, Yes! There are simply some dishes, commercially made, that do not lend themselves to amateur use because it is too difficult to construct a feed that will work. For instance, a simple ½wave dipole mounted ¼wave above a flat reflector has a nominal beamwidth of 60° at the half-power points (110° at the 10dB points). This is wide enough for a dish with an f/D of .53. But, some dishes have an f/D of .35, requiring a feed with a 10dB beamwidth of 142°! A dipole feed won't work with this type of dish and now a feed that will work becomes difficult and complex to build. You'll definitely need to seek advice from those few individuals who have tried wide-aperture feeds.

6. <u>How do you mount a feed in front of a dish?</u>
There are two basic ways. One is to put the feed on the end of a pipe extending to the center of the dish and use 3 non-metallic guys or plastic pipes anchored to the dish rim. The other method requires a very rigid dish rim. Here, 3 rigid pipes are used to support a feed in front of the dish.

7. <u>Does the material on the face of the dish make a difference?</u>
Yes! A lot of consideration has to be given to the size of the dish, the frequency of operation and your local environment. If you occasionally get winds with gusts to 70mph (or better), you'd better reconsider or you may wind up with a dish that looks like a Taco! Solid dishes can fare well if they are small and mounted very solidly. Larger dishes just won't live too well unless the overall wind resistance is reduced. Many dish users have 1" galvanized chicken wire as a dish covering. It works extremely well and doesn't affect the forward gain too much as shown below:

<u>1" galv. chicken wire</u>

Freq	Loss
432	0.1dB
903	0.5dB
1296	1.0dB
2304	3 to 6dB

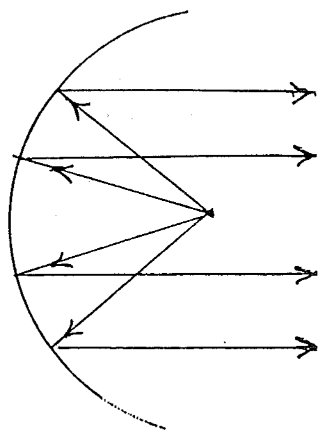
8. <u>If I build a dish, how accurate does the dish curvature have to be?</u>

Freq	1dB loss	2dB loss
432	± 3 in.	± 4½ in.
903	± 1½ in.	± 2¼ in.
1296	± 1 in.	± 1-5/8 in.
2304	± 5/8 in.	± 3/4 in.

9. <u>If I buy a small dish, will it work if I add on to it and make it larger?</u>
Probably not! In any event the gain realized won't be much unless the feed can illuminate the extra area! Here you may wind up needing a wide-aperture feed.

10. Can I change the f/D ratio of an already constructed dish?
No! The curvature of the dish determines the ratio.

11. Just what is a Parabolic Curve?
It is a special curve so that when RF energy emanating from a feed strikes the surface of the curve it will be reradiated as parallel energy.



12. What is feed efficiency?
Basically, it is perfect illumination of the dish. In the real world this just doesn't happen and in practice it usually winds up being around 55% or so and all calculations of dish gain are based on that figure.

13. How about a stressed dish?
They are difficult to get right and larger dishes (much above 12') just don't produce the gain you probably want and usually it is tough to maintain their shape over a period of time.

14. What about a spherical dish?
Whatever you have heard about spherical dishes can be quickly dispelled. If they worked so great the dish manufacturer's would all build them.

15. Can I build a dish?
You certainly can! The formula and explanation of its use is contained in many books. Once a curve has been mathematically determined, saw the ribs out of exterior plywood. Mount them on a solidly braced 4' diameter center section of plywood. Use aluminum tubing around the rim to hold the shape and use tubing around the ribs about halfway between the center and the rim.

16. What is dish blockage?
It is caused by the material used in a feed system such as the plane (flat) reflector behind the dipole. It will cause some signal blockage and resultant loss if its size is kept rather large. It is best to keep the reflector size to 1 wavelength or less.

17. <u>What are dish side lobes?</u>
There are usually two predominant side lobes, the 1st and 2nd minors. They won't get in your way unless you don't get the dish pointed in the right direction. In that case you may hear a signal alright but the level will be considerably reduced. A 10' dish at 1296MHz with a beamwidth of 5.3° has the peak of the 1st minor at 9° and the 2nd minor at 13.3°.

18. <u>Should I be concerned about dish beamwidth?</u>
Somewhat! It is dependent upon the frequency you are considering operation at. Too narrow a beamwidth makes siting the dish very tricky. If it is used on the moon for EME, too narrow a beamwidth makes tracking the moon very tedious! The following are beamwidths for various frequencies using the same size dish:

Freq	Dish Size	Beamwidth
432MHz	20'	8°
903MHz	20'	4°
1296MHz	20'	2.8°
2304	20'	1.57°

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