CENTRAL STATES VHF SOCIETY

Welcome to the 18th Annual Central States VHF Society Conference. We hope you enjoy the program of activities and your visit to Cedar Rapids. It is a privilege and an honor for me to serve as President of this prestigious group of amateurs. This year we have undertaken publishing the proceedings of the conference. The proceedings will relieve the speakers from the burden of copying their material for handout. It will also provice a means of distributing this material to all conference attendees as well as those unable to attend. Lastly, it is hoped that the proceedings will become an established part of every future conference 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:

Barry Buelow, WAØRJT	Program Chairman
Patty Buelow	Ladies Program
Elizabeth Blocksome	Ladies Program
Al Groff, KØVM	Registration
Al Ward, WB5LUA	Prizes/Wilson Award Chmn
Emily Ward	Ladies Prizes
John Fox, WØLER	Chambers Award Chmn
Ken Kucera, KAØY	Conference Comm.
Bob Drake, WØRAP	Conference Comm.

I also want to recognize those listed on the program whose diligent work make up our technical program.

Your CSVHF Society officers and board of directors are:

Rod Blocksome, KØDAS, Pres.
Barry Buelow, WAØRJT, V-Pres.
Ed Fitch, WØOHU, Sec'y
Joe Muscanere, WA5HNK, Treas.
Tom Bishop, KØTLM
Ken Kucera, KAØY
Ed Gray, WØSD

Tom Clark, W3IWI
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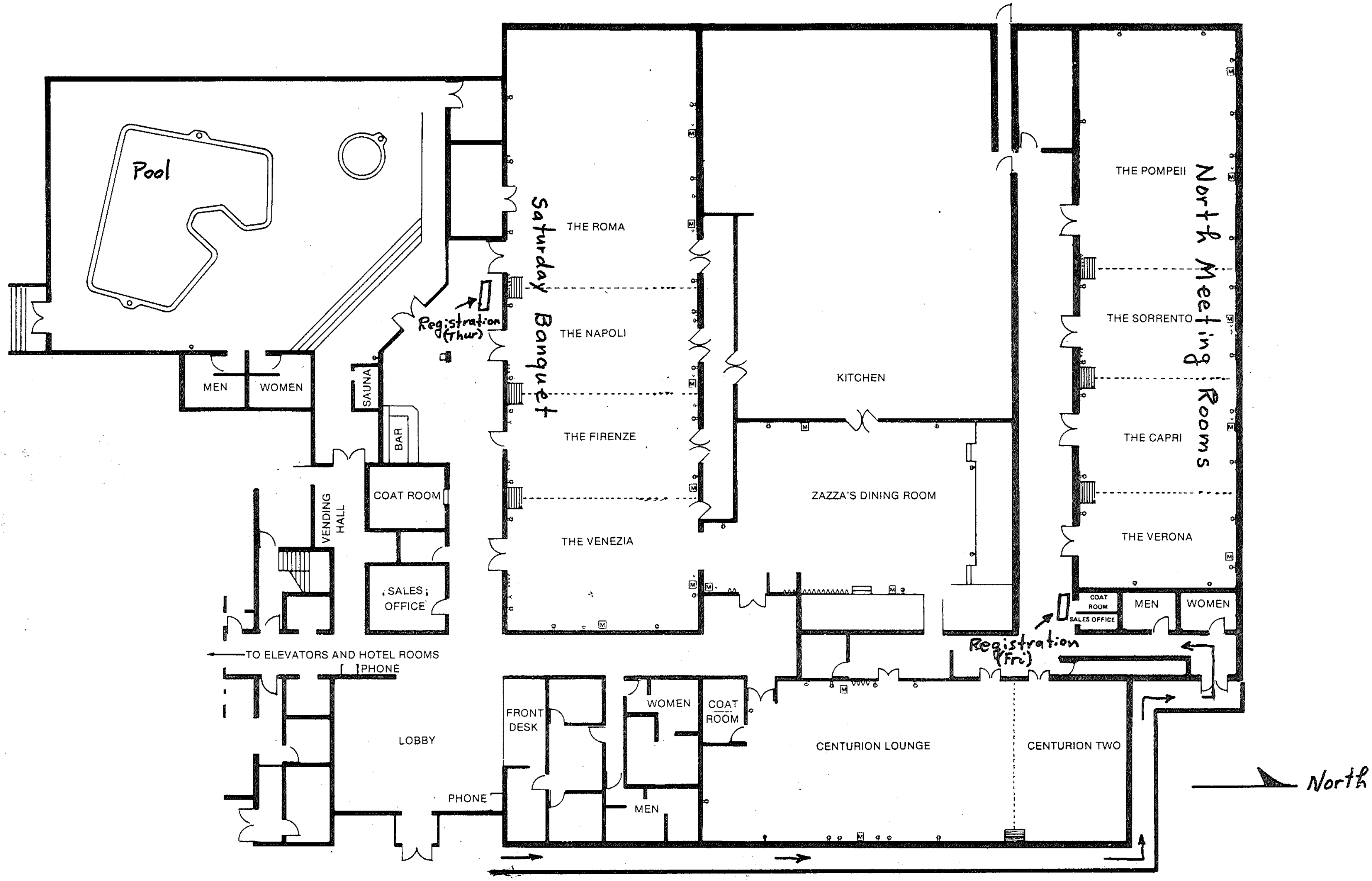
Russ Wicker, W4WD
Al Ward, WB5LUA
Marshall Williams, K5MB
Louie Anciaux, WB6NMT
Jim McKim, WØCY
Marc Thorson, WBØTEM

Best of 73's

Rod, KØDAS


Pool
MEN
WOMEN
SAUNA
BAR
COAT ROOM
VENDING HALL
SALES OFFICE
TO ELEVATORS AND HOTEL ROOMS
PHONE
LOBBY
PHONE
FRONT DESK
WOMEN
MEN
COAT ROOM
Registration (Thur)
Saturday Banquet
THE ROMA
THE NAPOLI
THE FIRENZE
THE VENEZIA
KITCHEN
ZAZZA'S DINING ROOM
CENTURION LOUNGE
CENTURION TWO
North Meeting Rooms
THE POMPEII
THE SORRENTO
THE CAPRI
THE VERONA
COAT ROOM
SALES OFFICE
MEN
WOMEN
Registration (Fri)
North

18th Annual CSVHF Conference Schedule, 1984

Thursday, July 27	
5:00 - 9:00PM	Registration open
7:00 - 10:00PM	Cash Bar and snacks, Roma Room
9:00 - 10:00PM	Board of Directors Meeting, Firenze Room
Friday, July 28	
7:00 - 2:00PM	Registration open, North Meeting Rooms
8:30AM	Welcome and General Information
8:40AM	Quiet-Preamps at Work, Paul Shuch, N6TX
9:50AM	Coffee Break
10:00AM	Direct Broadcast Satellites, Al Katz, K2UYH
11:00AM	VHF/UHF Operating Procedures, Bill Tynan, W3XO
12:00PM	Lunch Break
1:00PM	Binaural Diversity Reception, Rick Campbell, KK7B
1:30PM	How we put the G-line to work, Warren Weldon, W5DFU
2:00PM	Antenna Measuring in area South of Hotel Marc Thorson, WBØTEM & Al Ward, WB5LUA
7:00 - ?	Flea Market & Noise Figure measurements in North meeting rooms.
9:00PM	Board of Directors Meeting, Firenze Room
Saturday, July 29	
8:00 - Noon	Registration open
8:30AM	AMSAT, Jan King, W3GEY & Ralph Wallio, WØRPK
9:30AM	Packet Radio, Ralph Wallio, WØRPK
10:30AM	Coffee Break
10:45AM	Techniques for 1296 MHz, Al Ward, WB5LUA
12:00PM	Lunch Break
1:00PM	VUAC Report, Dick Jansen, WD4FAB
1:30PM	A Digital Antenna Positioning System, Pete Sias, WDØDRL
2:00PM	Coffee Break
2:15PM	144MHz DX-pedition, Lance Collister, WA1JXN/7
2:45PM	220MHz DX-pedition, Ed Gray, WØSD
3:15 - 3:45PM	CSVHF Society Business Meeting
6:30 - 7:30PM	Social Hour, South Banquet Rooms
7:30 -10:30PM	Banquet Dinner; speaker: Terry VanBenschoten, WØVB "Gee Dad, this is some hobby!"
Sunday, July 30	
9:30AM	K2UYH EME video tape, your slides, etc.

Family Program Schedule

Thursday, July 26

7:00 - 10:00PM	Get acquainted time, Roma Room

Friday, July 27

8:00 - 9:00AM	Get acquainted around pool; Coffee, orange drink, & donuts
9:30 - 3:30PM	Charter Bus for Amana Tour, Marlene Miller Guide; Cost - $22.50 includes lunch at Ox Yoke Inn
9:30 - 11:30AM	School Bus for Seminole Valley Park Mr. Pankey, Guide at Park; Cost - $1.00 suitable for younger children
1:00 - 5:00PM	Van to Chapman's Fun World, Cost - $7.50/ea

Package includes:

2 tkts to go-carts	1 tkt to dune buggy
2 tkts to bumper boats	1 hr. on water slide
5 min. on trampoline	2 rnds miniature golf

Happy Joe's Pizza available on premises
Recommend children under 13 be accompanied by adult. No small childrens games.

Saturday, July 28

9:00 - 10:00AM	Cake Decorating Demonstration, Firenze Room by Cherie Carnahan
10:00 - 11:00AM	Make-up Demonstration, Firenze Room by Vicki Blackledge, Mary Kay Beauty Consultant
11:00 - 12:30PM	Lunch Break
12:30 - 5:00PM	School Bus for afternoon tour, Cost - $3.00

Includes:

Brucemore Estate

Turner West Mortuary

Restoration of turn of the century building whose design was influenced by Grant Wood while he was living in the Carriage house out back.

Czech Village includes museum

6:30PM	Social Hour
7:30PM	Banquet Dinner Babysitting and Children's banquet, Verona Room

NOTE: Ladies Hospitality Room 107
Babysitting - Venezia Room
Please meet in the Lobby 15 minutes prior to scheduled tour departure times.

TABLE OF CONTENTS

* The Central States VHF Society wishs to thank the American Radio Relay League for permission to reprint the above mentioned items.

QUIET! preamp at work

by H. Paul Shuch, N6TX

ABSTRACT

For years, the standard technique employed by radio amateurs to improve receive sensitivity has been to precede their receivers by one or more stages of preamplification. Especially at VHF and UHF, conferences such as this one have encouraged the practice by conducting noise-figure and gain measuring competitions. Invariably, a preamplifier which performs well on the bench will actually degrade the actual on-the-air system sensitivity. This paper will explore the relationship between gain, noise figure, bandwidth, distortion, and sensitivity, and attempt to answer the classic preamp question: "If a little is good, is a lot better?"

SENSITIVITY

The ultimate objective of a communications receiver is to recover the modulation content of a weak signal. Sensitivity is a measure of the weakest input signal which will produce a specified output signal-to-noise ratio. We can quantify receiver performance in terms of minimum discernible signal sensitivity, which is the input level producing an output signal-to-noise ratio of unity; tangential signal sensitivity, which generally refers to the input level needed to produce an output signal-to-noise ratio of 6 dB; or threshold, frequently employed in FM systems, which refers to the input amplitude required to produce a specified level of receiver quieting. All of these sensitivity measures are a function of the receiver circuitry's internally generated noise, bandwidth, and distortion.

Of these three parameters, the receive bandwidth can be considered fixed for a given application, and would ideally be wide enough to pass all the modulation sidebands of the desired signal, yet sufficiently narrow to exclude both background noise and any adjacent-channel signals. Since the response bandwidth of modern receivers is established primarily in the IF stages, it is relatively independent of the parameters of any preamplifier employed.

Both noise and distortion, on the other hand, are very much influenced by preamplifier performance. Most radio amateurs are now aware that preamplifier gain, by itself, does not necessarily assure an improvement in receiver sensitivity. Rather, to be beneficial in a system, the preamplifier must generate an internal noise level significantly lower than that generated by the receiver it precedes. The noise relationships in a cascade are quantified by the now-familiar Friis Equation, first published in the Proceedings of the IRE for July, 1944. A well known rule of thumb, derived from the Friis Equation, is that if a preamp's gain exceeds by at least 10 dB the noise figure of the receiver it precedes, the noise performance of the preamplifier will dominate the cascade.

Yet the above relationship serves merely to confuse the amateur who measures his new preamp at a regional VHF Conference at, say, 3 dB noise figure for 15 dB gain, brings it home, installs it in front of a 10 dB noise-figure receiver, and finds his sensitivity actually degraded. What has he overlooked? Probably the effects of distortion.

DISTORTION

A linear amplifier is one whose output signal is an exact replica of the input signal, measured in either the time or frequency domains, differing only in its increased amplitude. Try as we might, we cannot build truly linear amplifiers in the real world. Any non-linearity introduced by an amplifier will manifest itself as a deviation from sinusoidal response when viewed in the time domain, or as the generation of new frequencies when measured in the frequency domain.

In a receive preamplifier, as in any non-linear device, the distortion products generated are integer multiples (harmonics) of the input frequency, plus their various sums and differences. Normally these distortion products would not degrade receiver sensitivity, as they would fall outside of the receiver's passband. Rare, however, is the receiver to which only a single input signal is applied. In our crowded spectra, we can anticipate countless signals of varying amplitudes within the passbands of our preamplifiers, only one of which (at a time) can be said to constitute "signal". All potentially interfering waveforms must, from a communications standpoint, be classified as noise.

It is these multiple input signals which give rise to both intermodulation (mixing of in-band signals) and cross-modultion (mixing of signals from in-band with out-of-band) distortion. When the harmonics of one signal mix with the harmonics of another, the resulting distortion products can fall within the receiver passband, degrading sensitivity.

DYNAMIC RANGE

Neglecting distortion effects, the weakest signal to which a receiver can respond is a function of its bandwidth and noise performance. If the multiple input signals applied to a receive system are all relatively low in amplitude, their distortion products may fall below this sensitivity limit, and be negligible. But if the input signals are of sufficient amplitude, their distortion products may appear strong enough to degrade one's reception of the desired signal. Thus, while noise figure of a receiver generally determines the weakest signal to which the receiver can respond, it is the receiver's maximum spurious free input signal, a function of its linearity, which determines the largest signal which it can tolerate. The difference between sensitivity and maximum spur-free input levels is called spurious-free dynamic range, and represents a primary limitation to receiver utility.

Dynamic range is generally degraded by the addition of a pre-amplifier in front of a receiver. This occurs because, although the low inherent circuit noise of a preamplifier may significantly improve minimum discernible signal sensitivity, any additional gain in a system amplifies the distortion products as well as the signals, diminishing the maximum spurious-free input signal level. Thus, at least with respect to preamplifier gain, the old Yankee axiom "if a little is good, a lot is better" can get us into trouble. Preamplifiers should be used only when actually necessary to improve weak-signal performance, and then only with as much gain as is actually necessary to establish the required system noise performance.

Even so, preamplifiers can result in a net degradation in system sensitivity. And some preamps are worse than others in this respect. Since as far as dynamic range is concerned, not all preamps are created equal, we need to measure and quantify their dynamic range, as well as their noise figure, in order to accurately predict their impact on system performance.

GAIN COMPRESSION

Inferences about an amplifier's dynamic range can be drawn by applying to its input a single signal of varying amplitude, and observing the amplitude present at the output. In its linear region, the amplifier will produce a one-dB change in output signal amplitude for every one-dB change in the applied signal. That is, the gain of the amplifier is independent of applied signal level. But as the upper limit of dynamic range is approached, output signal changes will be unable to keep pace with the input. That is, the gain of the amplifier compresses at the upper end of its dynamic range. The output level at which the amplifier is exhibiting one dB less gain than it was under weak-signal conditions is referred to as its output one-dB compression point, and is a fair indicator of the amplifier's immunity to intermodulation and cross-modulation distortion.

Obviously, for a given noise figure, the preamplifier with the highest compression point will offer the greatest spurious-free dynamic range. But correlating the two parameters directly is difficult, because the relationship between compression and distortion varies between active devices, and between circuit configurations.

Another indicator of dynamic range relates to the fact that, if you continue to increase the drive level to an amplifier beyond the compression point, the gain further compresses. Eventually, the amplification of the desired signal is degraded to the point that its amplitude at the output of the amplifier, and those of the intermodulation distortion products, are the same. The output level at which this occurs is called the output intercept

Point. Intercept point is more readily correlated to dynamic range than is compression point, but is difficult to measure directly.

To best quantify dynamic range limitations, it is thus necessary to test the preamplifier in its actual operating environment - that is, under multiple-signal conditions.

TWO-TONE TESTING

In the industry-prevalent method of dynamic range testing, two sinusoidal signals of equal amplitude are applied to the input of the device under test, and the resulting output spectrum monitored in the frequency domain. The two input signals, or tones, may be generated by summing the outputs of two signal generators in a power combiner, or by applying a single RF source to the LO input of a balanced mixer, a suitable audio signal generator to the mixer's IF input, and applying to the device under test the double-sideband (two-tone) signal appearing at the mixer's RF port. In either case, the two tones must be separated in frequency sufficiently to be individually resolved on the spectrum analyzer's display, yet sufficiently close in frequency to both fall within the response bandwidth of the device under test.

A typical interconnection of instruments for two-tone dynamic range analysis is shown in Figure 1, and a typical resulting spectrum is displayed in Figure 2. Note that the distortion products of greatest amplitude (in this case, the pair of signals immediately adjacent to the two applied tones) are roughly 2 divisions, or 20 dB, below the amplitude of the desired output tones. The intermodulation distortion level of this particular amplifier, measured at this particular signal level, is thus -20 dB.

If the vertical axis of the spectrum analyzer is calibrated in absolute amplitude (typically in dBm), the output power per tone, the PEP output power (6 dB above the level of each individual tone), and power of the individual distortion products can be readily determined. And from these values, with minimal number crunching, we can determine the dynamic range of the preamplifier.

DATA ANALYSIS

The mathematical relationships which we apply next are, as we say in the college texts, "beyond the scope of this course". However, I have included as Figure 3 of this paper a listing of a MICROSOFT tm BASIC program which performs the complete analysis. Although written to run under the CP/M tm operating system, the program can likely be modified to run on any of the popular home computers under their available versions of BASIC.

Figure 4 thru Figure 8 are sample executions of the IMD (for InterModulation Distortion) program, for various receiver configurations. Comparing these printouts will enable us to draw some significant conclusions with regard to the utility of preamplifiers in VHF and UHF communications systems.

MIXER DESIGN CONSIDERATIONS

As a rule, balanced mixers offer excellent dynamic range and intermodulation distortion performance, although their weak-signal sensitivity leaves something to be desired. Mixers are designed to operate at varying levels of local oscillator injection, and generally, the higher the LO level employed, the higher will be the mixer's compression level. However, raising the LO injection above perhaps 5 milliwatts tends to degrade mixer conversion efficiency and noise figure. Nontheless, as Figures 3 and 4 indicate, so-called high level mixers offer sufficiently improved dynamic range to override the considerations of slightly degraded sensitivity, in most applications.

Not shown in the computer runs, but worthy of consideration, are the so-called "starved LO" mixers. These devices augment an extremely low LO injection level with external DC bias of their mixer diodes, and excel in low-noise performance. Their dynamic range, however, is severely degraded, typically 12 to 15 dB below that of even the "low-level" balanced mixer shown in Figure 3. Thus, except in those applications where it is impractical to generate 5 mW or more of LO injection, starved LO operation should be avoided.

The same is true for harmonic mixers. These devices are extremely popular in microwave TV receive converters, and employ LO injection at half the normal frequency, with the mixer diodes serving double duty as frequency multipliers. Obviously, the more frequencies we generate within a mixer, the more spurs will be available to bite us later. I recommend multiplying in a stage separate from that doing the heterodyne conversion.

PREAMP DESIGN CONSIDERATIONS

Most receive preamplifiers operate with their active devices drawing relatively low quiescent current. This is done because high device current generates high thermal activity, which degrades the noise performance significantly. Unfortunately, biasing any active device near cutoff tends to limit its dynamic range, such that the "optimum" bias point from a noise figure standpoint often coincides with the "worst" bias point as far as dynamic range, and actual system sensitivity, are concerned. Remember, although we talk about desiring high "signal to noise ratio", what we really need for maximum sensitivity is a signal level which is high relative to the sum of noise and distortion. If, by giving up some slight ammount of noise performance, we can considerably reduce IMD interference, the overall system sensitivity has got to improve!

Joe Reisert, W1JR, probably the most prominent UHF DX'er of our time, has long advocated designing bias circuits for preamplifiers so that device quiescent current can be readily and remotely varied. This way the user can optimize noise figure when operating conditions call for it, and readily improve dynamic range, at a sacrifice in noise performance, should interference conditions dictate. Since all RF design is a series of compromises, Joe's approach seems the best of all possible worlds.

There has long been a controversy in amateur circles over the relative merits of bipolar junction transistors and MOS field effect devices as VHF preamplifiers. Bipolar advocates boast the excellent low-noise performance of these devices, while those preferring the MOS devices cite their higher gain and stable operation, which eliminates the need for neutralization. Figures 6 and 7 seem to indicate that neither device holds a clear advantage as far as overall system performance is concerned. The two representative amplifiers which I tested in preparing this manuscript exhibited identical dynamic range.

Gallium-Arsenide Field Effect Transistors, on the other hand, are the undisputed winner in all areas of VHF and UHF performance. As indicated in Figure 8, the GaAs fet offers exceptional high gain, low noise, and wide dynamic range performance. If only they didn't cost so damn much!

SUMMARY

In evaluating receiver performance, it is necessary to consider dynamic range limitations, as well as noise figure, to select the combination of devices and circuits which will yield the best overall sensitivity. Table 1 (below) summarizes the results of testing various competing mixer and preamplifier technologies. Although the tests were performed at 2 meters, we can generalize the results to other VHF and UHF bands as well.

It appears that the best receiver performance will be achieved by cascading a GaAs FET preamplifier with a high-level doubly balanced mixer. Two-tone analysis confirms that such a combination has considerable immunity to intermodulation and cross-modulation interference, while maintaining an impressively low noise figure.

FIGURE 1
TWO-TONE IMD TEST CONFIGURATION

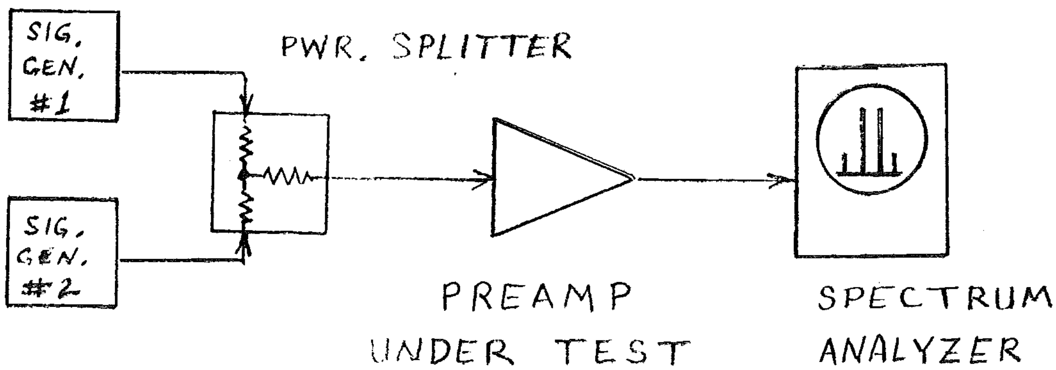


FIGURE 2
TYPICAL IMD SPECTRUM DISPLAY

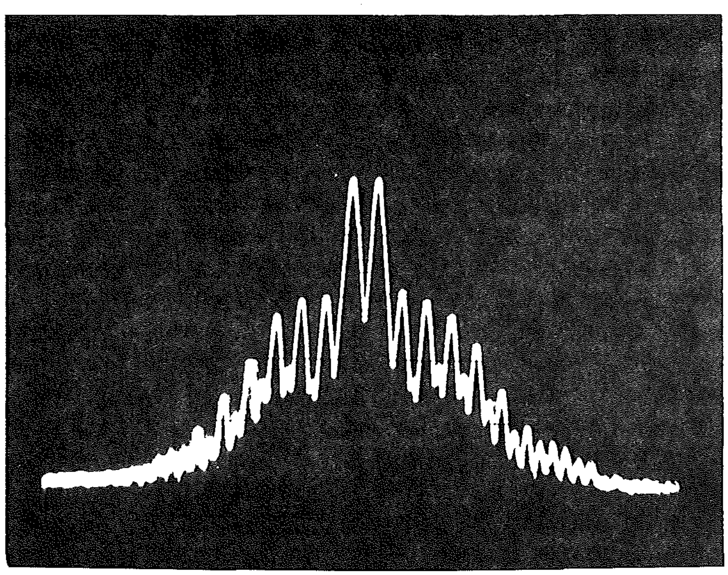


FIGURE 3
PROGRAM LISTING (SHEET 1 OF 2)

```
10 '---------> IMD.BAS <------------------------
20 '           Rev. A, 24 May '84
30 '           by N6TX
40 '  COPYRIGHT (C) 1984 MICROCOMM
50 '
60 '  Determines Spurious-Free Dynamic Range from
70 '  Spectrum Analyzer Two-Tone IMD Measurements
80 '
90 '------------------------------------------
100 CLR$ = CHR$(26) ' Defines Clear-Screen String
110 PRINT CLR$
120 PRINT "DO YOU WISH OUTPUT ROUTED TO:"
130 PRINT
140 PRINT "                      PRINTER (P)"
150 INPUT "               or     SCREEN  (S)";PR$
160 IF PR$="P" OR PR$="p" OR PR$="S" OR PR$="s" GOTO 200
170 PRINT CLR$
180 PRINT "YOU MUST RESPOND WITH 'P' OR 'S'" : PRINT
190 GOTO 120
200 '------------------------------------------
210 PRINT CLR$
220 PRINT "TONES -->           |   |"
230 PRINT "                    |   |"
240 PRINT "                    |   |"
250 PRINT "                    |   |"
260 PRINT "  IMD  -->      |   |   |   |"
270 PRINT "                |   |   |   |"
280 PRINT "              ----------------" : PRINT
290 PRINT "FOR TWO-TONE OUTPUT SPECTRUM AS INDICATED ABOVE,"
300 PRINT
310 INPUT "ENTER Two-Tone Output Amplitude, in dBm ",TONES
320 INPUT "ENTER Third-Order IMD Amplitude, in dBm ",IMD
330 INPUT "ENTER System Gain,               in dB  ",GAIN
340 INPUT "ENTER System Noise Figure,       in dB  ",NF
350 INPUT "ENTER System Bandwidth,          in kHz ",BW
360 I3=TONES + ((TONES - IMD) / 2)
370 MDS = NF - 144 + 10*(LOG(BW)/LOG(10))
380 INMAX = ((2/3)*(I3-GAIN))+(MDS/3)
390 RANGE = INMAX - MDS
400 '------------------------------------------
410 PRINT CLR$
420 PRINT "INTERMODULATION ANALYSIS BY MICROCOMM"
430 PRINT : PRINT
440 PRINT USING "####.# dBm -->          |   |   ";TONES
450 PRINT       "                        |   |   "
460 PRINT       "                        |   |   "
470 PRINT       "                        |   |   "
480 PRINT USING "####.# dBm -->      |   |   |   |";IMD
490 PRINT       "                    |   |   |   |"
500 PRINT       "                  ----------------"
```

FIGURE 3
PROGRAM LISTING (SHEET 2 OF 2)

```
510 PRINT : PRINT
520 PRINT USING "SYSTEM GAIN             = ####.# dB";GAIN
530 PRINT USING "SYSTEM NOISE FIGURE     = ####.# dB";NF
540 PRINT USING "SYSTEM BANDWIDTH        = ####.# KHz";BW
550 PRINT
560 PRINT USING "OUTPUT THIRD ORDER INTERCEPT POINT = ####.# dBm";I3
570 PRINT USING "MINIMUM DISCERNIBLE INPUT SIGNAL   = ####.# dBm";MDS
580 PRINT USING "MAXIMUM SPURIOUS-FREE INPUT SIGNAL = ####.# dBm";INMAX
590 PRINT USING "SPURIOUS-FREE DYNAMIC RANGE        = ####.# dB";RANGE
600 '-----------------------------------------
610 IF PR$="S" OR PR$="s" THEN GOTO 800
620 LPRINT "INTERMODULATION ANALYSIS BY MICROCOMM"
630 LPRINT : LPRINT
640 LPRINT USING "####.# dBm -->          |  |   "; TONES
650 LPRINT       "                        |  |   "
660 LPRINT       "                        |  |   "
670 LPRINT       "                        |  |   "
680 LPRINT USING "####.# dBm -->       |  |  |  |"; IMD
690 LPRINT       "                     |  |  |  |"
700 LPRINT       "                  ----------------"
710 LPRINT : LPRINT
720 LPRINT USING "SYSTEM GAIN            = ####.# dB";GAIN
730 LPRINT USING "SYSTEM NOISE FIGURE    = ####.# dB";NF
740 LPRINT USING "SYSTEM BANDWIDTH       = ####.# KHz";BW
750 LPRINT
760 LPRINT USING "     OUTPUT THIRD ORDER INTERCEPT POINT = ####.# dBm"; I3
770 LPRINT USING "     MINIMUM DISCERNIBLE INPUT SIGNAL   = ####.# dBm";MDS
780 LPRINT USING "     MAXIMUM SPURIOUS-FREE INPUT SIGNAL = ####.# dBm";INMAX
790 LPRINT USING "     SPURIOUS-FREE DYNAMIC RANGE        = ####.# dB";RANGE
792 LPRINT
794 LPRINT
796 LPRINT
798 LPRINT
800 '-------------------------------------------
810 PRINT : PRINT
820 INPUT "TYPE <return> TO CONTINUE, 'Q' TO QUIT ",D$
830 IF D$ = "Q" OR D$ = "q" THEN GOTO 850
840 GOTO 100
850 '
860 '-----------------------------------------------------------------
870 '
880 '         EQUATIONS EXECUTED
890 '
900 'MINIMUM DISCERNIBLE SIGNAL  =  -174 dBm/Hz  + NF (dB)  + 10 * LOG BW (Hz)
910 '
920 'OUTPUT INTERCEPT POINT      =  P (tones)  +  [ P (tones) - P (imd) ] /  2
930 '
940 'MAXIMUM INPUT SIGNAL LEVEL  =  (2/3) * (INTERCEPT - GAIN) + (M. D. S. /3)
950 '
960 'SPURIOUS FREE DYNAMIC RANGE =  MAXIMIM INPUT - MINIMUM DISCERNIBLE SIGNAL
970 '
980 '
990 '-----------------------------------------------------------------
1000 END
```

FIGURE 4
STANDARD LEVEL (+7 dBm L.O.)
DOUBLE-BALANCED MIXER

INTERMODULATION ANALYSIS BY MICROCOMM

```
  -6.0 dBm -->          |  |
                        |  |
                        |  |
                        |  |
 -26.0 dBm -->       |  |  |  |
                     |  |  |  |
                   -----------------
```

```
SYSTEM GAIN           =   -6.0 dB
SYSTEM NOISE FIGURE   =    7.0 dB
SYSTEM BANDWIDTH      =    2.4 kHz

     OUTPUT THIRD ORDER INTERCEPT POINT =    4.0 dBm
     MINIMUM DISCERNIBLE INPUT SIGNAL   = -133.2 dBm
     MAXIMUM SPURIOUS-FREE INPUT SIGNAL =  -37.7 dBm
     SPURIOUS-FREE DYNAMIC RANGE        =   95.5 dB
```

FIGURE 5
HIGH-LEVEL (+17 dBm L.O.)
DOUBLE-BALANCED MIXER
INTERMODULATION ANALYSIS BY MICROCOMM

```
  -7.0 dBm -->          |  |
                        |  |
                        |  |
                        |  |
 -65.0 dBm -->       |  |  |  |
                     |  |  |  |
                   -----------------
```

```
SYSTEM GAIN           =   -7.0 dB
SYSTEM NOISE FIGURE   =    8.0 dB
SYSTEM BANDWIDTH      =    2.4 kHz

     OUTPUT THIRD ORDER INTERCEPT POINT =   22.0 dBm
     MINIMUM DISCERNIBLE INPUT SIGNAL   = -132.2 dBm
     MAXIMUM SPURIOUS-FREE INPUT SIGNAL =  -24.7 dBm
     SPURIOUS-FREE DYNAMIC RANGE        =  107.5 dB
```

FIGURE 6
BIPOLAR JUNCTION TRANSISTOR PREAMPLIFIER

INTERMODULATION ANALYSIS BY MICROCOMM

```
 -14.0 dBm -->             |  |
                           |  |
                           |  |
                           |  |
 -25.0 dBm -->          |  |  |  |
                        |  |  |  |
                     -----------------
```

```
SYSTEM GAIN          =   12.0 dB
SYSTEM NOISE FIGURE  =    2.0 dB
SYSTEM BANDWIDTH     =    2.4 kHz

     OUTPUT THIRD ORDER INTERCEPT POINT =    -8.5 dBm
     MINIMUM DISCERNIBLE INPUT SIGNAL   = -138.2 dBm
     MAXIMUM SPURIOUS-FREE INPUT SIGNAL =  -59.7 dBm
     SPURIOUS-FREE DYNAMIC RANGE        =   78.5 dB
```

FIGURE 7
MOS FIELD EFFECT TRANSISTOR PREAMPLIFIER

INTERMODULATION ANALYSIS BY MICROCOMM

```
  -9.0 dBm -->             |  |
                           |  |
                           |  |
                           |  |
 -22.0 dBm -->          |  |  |  |
                        |  |  |  |
                     -----------------
```

```
SYSTEM GAIN          =   17.0 dB
SYSTEM NOISE FIGURE  =    3.0 dB
SYSTEM BANDWIDTH     =    2.4 kHz

     OUTPUT THIRD ORDER INTERCEPT POINT =    -2.5 dBm
     MINIMUM DISCERNIBLE INPUT SIGNAL   = -137.2 dBm
     MAXIMUM SPURIOUS-FREE INPUT SIGNAL =  -58.7 dBm
     SPURIOUS-FREE DYNAMIC RANGE        =   78.5 dB
```

FIGURE 8
GaAs FIELD EFFECT TRANSISTOR PREAMPLIFIER

INTERMODULATION ANALYSIS BY MICROCOMM

```
  -2.0 dBm -->          |  |
                        |  |
                        |  |
                        |  |
 -28.0 dBm -->       |  |  |  |
                     |  |  |  |
                   -----------------
```

```
SYSTEM GAIN            =   24.0 dB
SYSTEM NOISE FIGURE    =    1.0 dB
SYSTEM BANDWIDTH       =    2.4 kHz

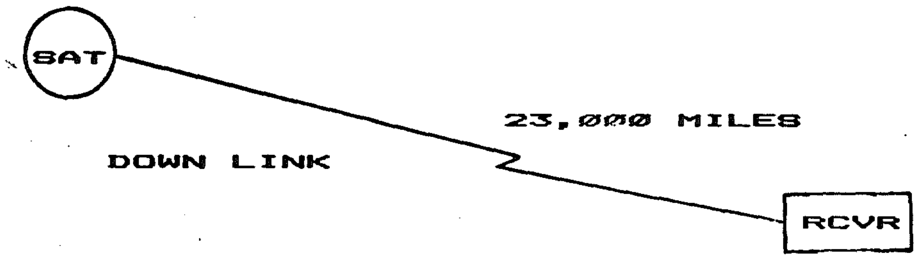
     OUTPUT THIRD ORDER INTERCEPT POINT =    11.0 dBm
     MINIMUM DISCERNIBLE INPUT SIGNAL   = -139.2 dBm
     MAXIMUM SPURIOUS-FREE INPUT SIGNAL =  -55.1 dBm
     SPURIOUS-FREE DYNAMIC RANGE        =   84.1 dB
```

N6TX TABLE 1
RECEIVER DYNAMIC RANGE COMPARISON

	STANDARD LEVEL DBM	HIGH LEVEL DBM	BIPOLAR JUNCTION TRANS	MOS FIELD EFFECT	GaAs FIELD EFFECT
Conversion Gain (dB)	-6	-7	12	17	24
Noise Figure (dB)	7	8	2	3	1
IMD Intercept (dBm)	+4	+22	-8	-2	+11
SSB Sensitivity (dBm)	-133	-132	-138	-137	-139
Maximum Input (dBm)	-38	-25	-60	-59	-55
Dynamic Range (dB)	95	107	78	78	84

NOTE: Measurements were performed at 144 MHz, with representative devices.
Results at other frequencies will vary, but comparisons will be similar.

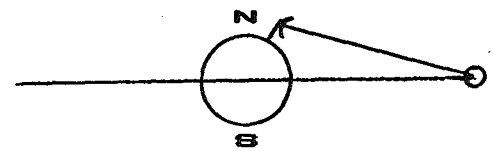
DBS
SYSTEM CONSIDERATIONS

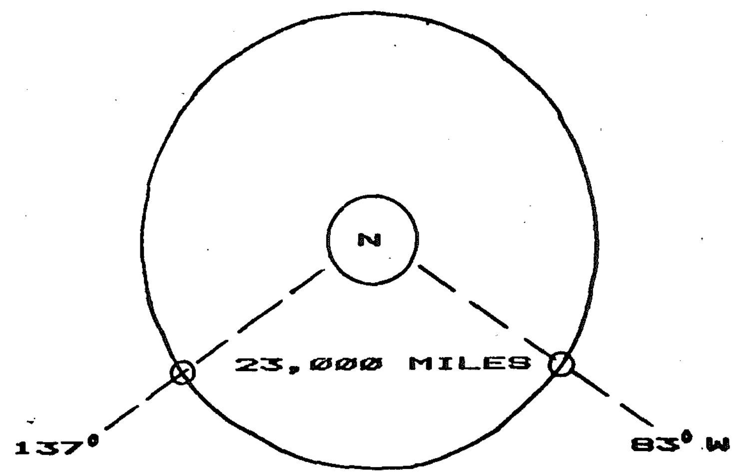


* REVIEW SOME BASIC SYSTEM THEORY.

* INVESTIGATE THE REQUIREMENTS TO SEND A 12 GHZ TV SIGNAL FROM A GEOSTATIONARY SATELLITE TO A HOME RECEIVER.

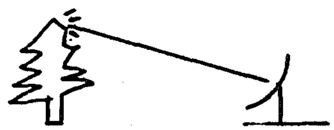
GEOSTATIONARY SATELLITES MUST BE LOCATED OVER THE EQUATOR





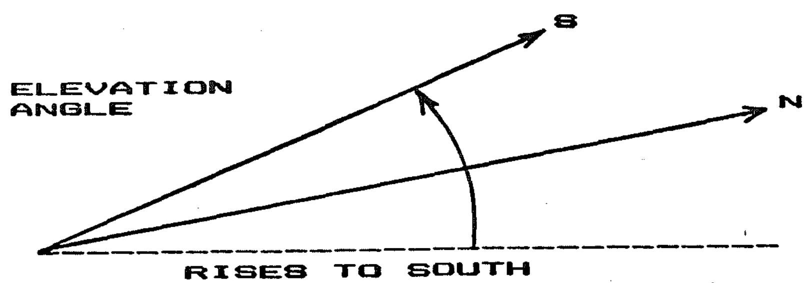
"PREFERRED LOCATIONS"

MUST SEE SAT TO RECEIVE IT!

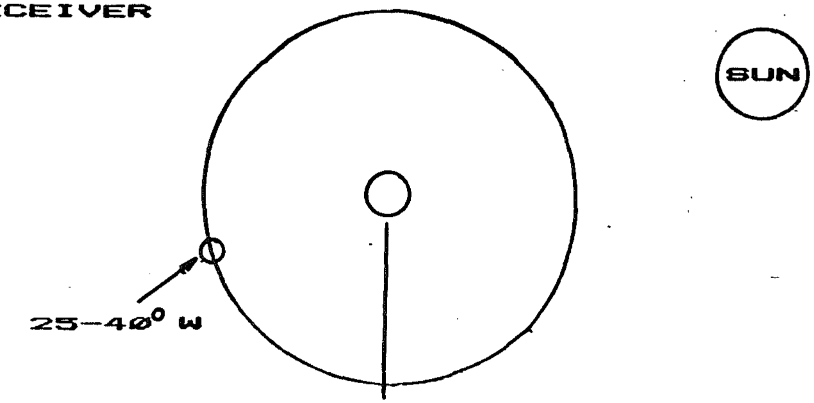


TREES ... HOUSES ... ETC. OPAQUE

EL & AZ DEPEND ON LOCATION AND SATELLITE POSITION



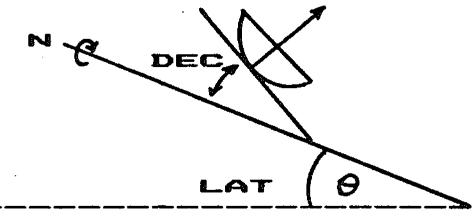
ELEVATION ANGLE DECREASES AS SAT MOVES WEST OF THE LAT OF THE RECEIVER



* WANT SAT AT LONGITUDE OF RECEIVER FOR MAXIMUM ELEVATION.
* MUST MOVE WEST TO AVOID PRIME SHUT DOWN DURING SOLAR ECLIPSE.
* 25 TO 40 DEGREES WEST OF THE TIME ZONE IS A GOOD COMPROMISE.
* 1ST DBS AT 105° (EST ENDS AT 88°) (N E MAIN 25°, NYC 35°, DETROIT 37°, SOUTH FLORIDA 52°)

TWO CLASSES OF ANT MOUNTS

POLAR



* ONE AXIS TRACKING

EL-AZ

* LESS COMPLEX   * ↓

* EASIER TO INSTALL

* ONLY ONE DBS SAT (POSITION)

* MANY SATELLITES CLUSTERED AT ONE POSITION

POWER RECEIVED =

TRANSMITTER POWER

X ANT GAIN (TX)

X PATH LOSS

X ANT GAIN (RX)

TRANSMIT POWER LIMITED BY AVAILABLE AND ALLOWABLE SATELLITE WEIGHT.

<u>25Ø WATTS OUTPUT</u>

ANTENNA GAIN DEPENDS ON ANT SIZE

$G = \eta 4 \pi A / \lambda^2$ WHERE A = AREA

η = EFFICIENCY

GAIN IS INVERSELY RELATED TO COVERAGE AREA OR BEAM WIDTH

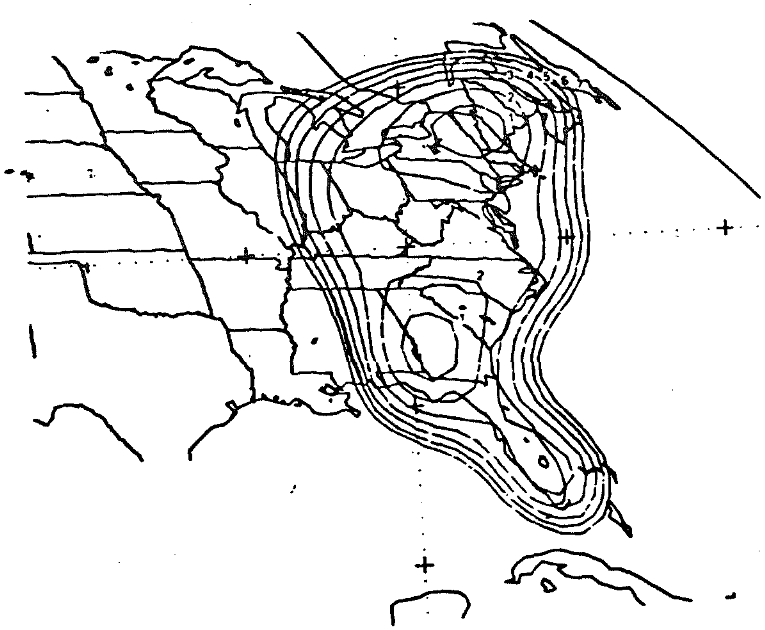
$G = 1.44 \eta \pi^2 \lambda / ANG^2$

WHERE BEAM WIDTH OR

$ANG = 1.2 \lambda / D$ (RADIANS)

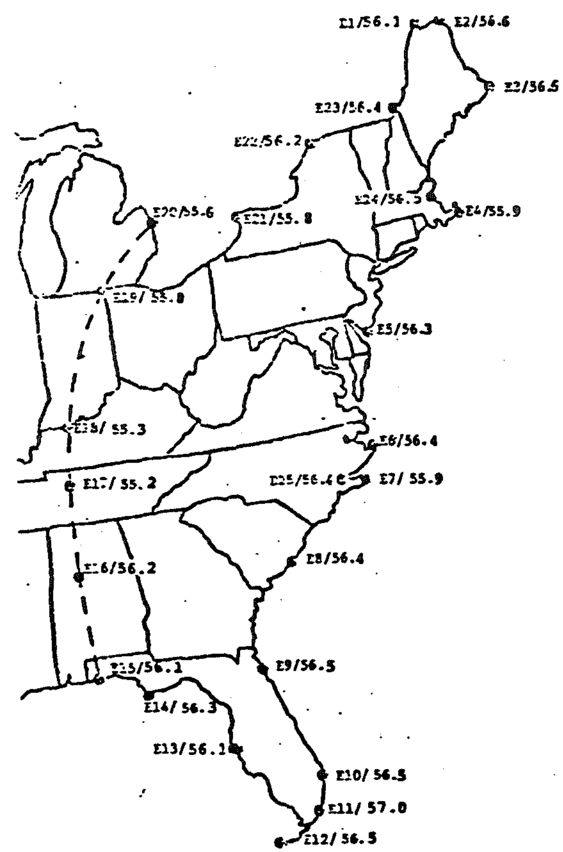
AND D = DISH DIAMETER

TO ACHIEVE HIGH ANT GAIN COVERAGE MUST BE LIMITED TO ONE TIME ZONE.



EQUIVALENT ISOTROPICALLY RADIATED POWER = EIRP

EIRP = TX POWER X ANT GAIN (IN A GIVEN DIRECTION)



PATH LOSS DEPENDS ON DISTANCE (23,000 – 26,000) AND WEATHER

IN CLEAR WEATHER:

$$P_{loss} = 10 \text{ LOG } (4.56 \times 10^3 \; F^2 \; D^2)$$

F ↑ MHZ, D ↑ MILES

$$P_{loss} = 205 \text{ DB} \quad (\Delta < 1.5 \text{ DB})$$

RAIN INCREASES PATH LOSS ----------

P < 6 DB FOR .1 % CONFIDENCE

(IN MOST AREAS OF USA)

RAIN DEGRADATION AT 12.0 GHz
SYSTEM AVAILABILITY = 99.90% (RAIN RATE EXCEEDED 0.1% OF THE TIME)
RECEIVER NOISE TEMPERATURE = 500°K

City	Elevation Angle (°)	Rain Rate (mm/hr.)	Attenuation (L_{rain}) (dB)	Δ(G/T) (dB)
SATELLITE AT 135°W				
Atlanta	25.4	21.0	5.5	1.4
Chicago	23.0	15.0	4.5	1.2
Houston	34.5	35.0	7.5	1.5
Miami	24.0	35.4	10.0	1.7
New York	14.0	15.0	7.0	1.5
Seatle	33.5	8.0	1.5	0.6
SATELLITE AT 95°W				
Atlanta	48.4	21.0	3.0	1.0
Chicago	41.3	15.0	2.3	0.8
Houston	52.4	35.0	5.5	1.4
Miami	55.5	35.4	5.3	1.3
New York	38.7	15.0	2.3	0.8
Seattle	30.0	8.0	1.6	0.6

COMMUNICATION LINK PERFORMANCE
ESTABLISHED BY
CARRIER-TO-NOISE RATIO

$$\frac{\text{CARRIER (POWER)}}{\text{NOISE}}$$

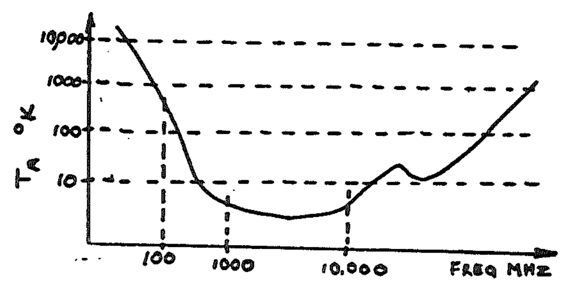
NOISE = ANTENNA NOISE
+ NOISE ADDED BY RECEIVER

NOISE USUALLY SPECIFIED IN K (TEM

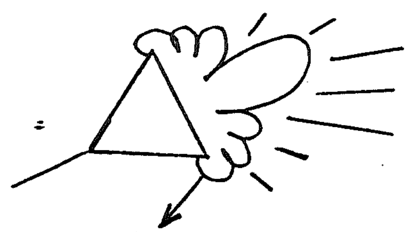
T = TEMPERATURE OF A RESISTER WHIC
GENERATES THE SAME THERMAL NOISE
POWER -------------------> N = KTB
WHERE
K = BOLTZMANN'S CONSTANT 1.38x1Ø
B = BANDWIDTH IN HZ

ANTENNA NOISE IS A FUNCTION OF
1) AREA OF SKY THE ANTENNA SEES
2) FREQUENCY
3) ANTENNA PATTERN
3) RESISTIVE LOSSES (USUALLY NEG.)

SKY TEMPERATURE IS STILL VERY LOW
AT 12 GHZ



ANTENNA INTEGRATES THE TEMPERATURE
IN ALL DIRECTIONS



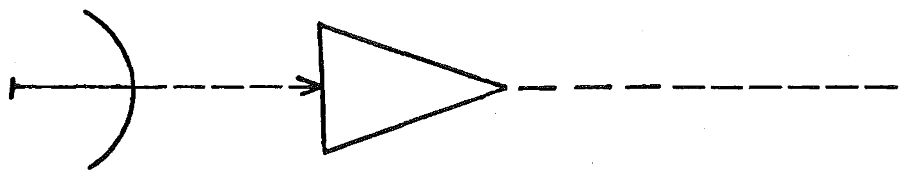
COSMIC NOISE

HOT EARTH = 293 K

$$T_A = \int_{\text{ALL DIRECTIONS}} G_A \times T \, dS$$

CONSERVATIVE HOME SYSTEM T = 6Ø° K

RECEIVER NOISE TEMPERATURE DEPENDS ON DEVICES USED IN 1ST AMPLIFIER



TRADITIONALLY DEVICES EVALUATED IN TERMS OF NOISE FIGURE (NF)

$$NF(DB) = 10 \; LOG \; (SNR_{IN} / SNR_{OUT})$$

WITH T_A = 293 K

$$= 10 \; LOG \; (1 + T_R / T_A)$$

T_A ← 293 K

OR

$$T = 293 \; (10^{(NF/10)} - 1) \; ^{\circ}K$$

T°K	NF dB	T°K	NF dB	T°K	NF dB
10	.148	175	2.056	340	3.378
15	.220	180	2.103	345	3.412
20	.291	185	2.149	350	3.446
25	.360	190	2.194	355	3.480
30	.429	195	2.239	360	3.513
35	.496	200	2.284	365	3.547
40	.563	205	2.328	370	3.580
45	.628	210	2.372	375	3.613
50	.693	215	2.415	380	3.645
55	.757	220	2.458	365	3.678
60	.819	225	2.501	390	3.710
65	.881	230	2.543	395	3.742
70	.942	235	2.584	400	3.773
75	1.002	240	2.626	405	3.805
80	1.061	245	2.666	410	3.636
85	1.120	250	2.707	415	3.867
90	1.177	255	2.747	420	3.897
95	1.234	260	2.787	425	3.928
100	1.291	265	2.826	430	3.958
105	1.346	270	2.865	435	3.988
110	1.401	275	2.904	440	4.018
115	1.455	280	2.942	445	4.048
120	1.508	285	2.980	450	4.077
125	1.561	290	3.018	455	4.107
130	1.613	295	3.055	460	4.136
135	1.665	300	3.092	465	4.165
140	1.716	305	3.129	470	4.193
145	1.766	310	3.165	475	4.222
150	1.816	315	3.201	480	4.250
155	1.865	320	3.237	485	4.278
160	1.913	325	3.273	490	4.306
165	1.962	330	3.308	495	4.334
170	2.009	335	3.343	500	4.362

THE GaAs FET IS THE ONLY PRACTICAL DEVICE

NF   COST — *

BEST DEVICES ====> ≈ 1.5 DB AT 12 GHZ

REALISTIC (3–5 DB) ==> 4 DB OR 440°K

$$TS = 60^\circ + 440^\circ = 500^\circ K$$

NOISE POWER (N = KTB)

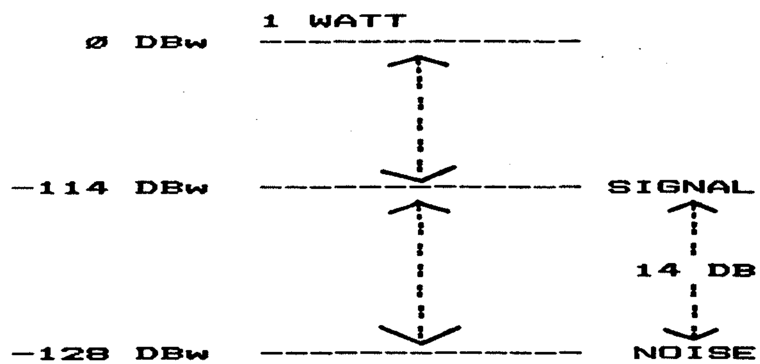
$$N = 1.38 \times 10^{-23} \times 500 \times 24 \times 10^{6} \quad **$$

$$N = 1.66 \times 10^{-13} \text{ WATTS OR } -128 \text{ DBw}$$

** 24 MHZ CHANNEL ASSUMED

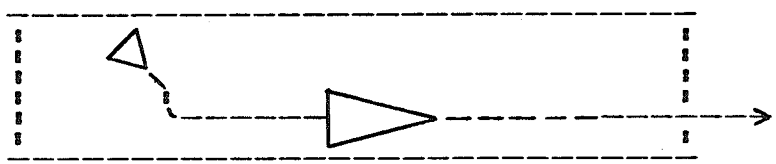
SYSTEM LEDGER

EIRP	=	56 DBw
RX ANT GAIN	=	35 DB (2 FT DISH 55%)
Ploss	=	−205 DB
Pin	=	−114 DBw
− NOISE	=	128 DBw
CNR	=	14 DB



RECEIVER ANTENNA GAIN AND SYSTEM NOISE TEMPERATURE OFTEN COMBINED TO OBTAIN A MEASURE OF RECEIVER SYSTEM QUALITY

G/T RATIO IN DB/K



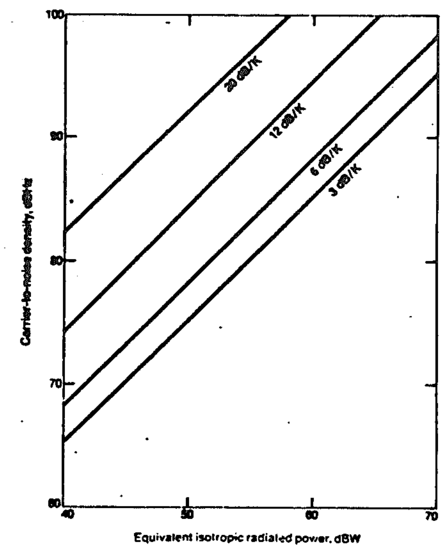
G/T = ANT GAIN (DB) − 10 LOG (T_S)

G/T = 35 − 27 = 8 DB/K

CNR CAN BE RELATED TO EIRP AND G/T

CNR = EIRP (DBw) − Ploss (DB) − G/T (DB/K) − 10 LOG(KB)

CNR = 56 − 205 − 8 − 155 = 14 DB



THIS CNR IS UNSATISFACTORY FOR AM RECEPTION

IF EVEN WITH A STANDARD 6 MHZ (NTSC) TV BANDWIDTH ....

CNR = 20 DB =====> NOISY PICTURE

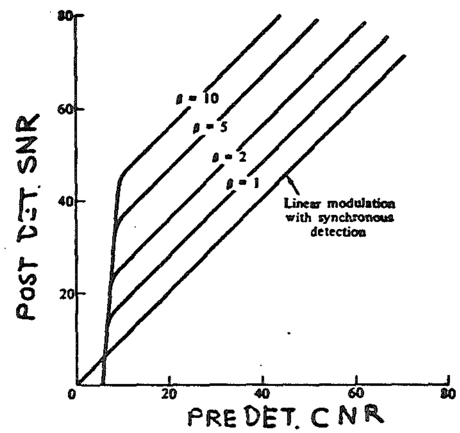
THIS IS WHY FM MUST BE USED FOR SATELLITE TV!

WITH FM:

PREDET CNR --------> [DET] --------> POST DET SNR

POST DETECTION SNR INCREASES WITH GREATER MODULATION BANDWIDTH WHEN THE PRE-DETECTION CNR IS ABOVE THRESHOLD.

AS WIDE A BANDWIDTH AS POSSIBLE WITHOUT REDUCING THE PRE-DETECTION CNR BELOW THRESHOLD IS DESIRED



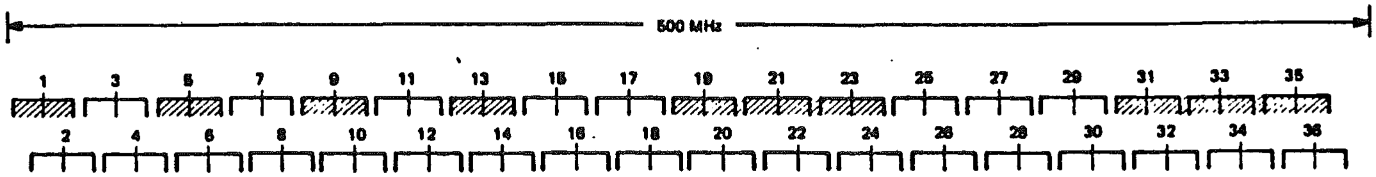
SNR > 50 DB DESIRED FOR A HIGH QUALITY PICTURE -- DBS'S MAIN SELLING POINT --

THRESHOLD CHARACTERISTIC IS A CRITICAL MEASURE OF RECEIVER PERFORMANCE.

TYPICAL THRESHOLD ABOUT 10 DB CNR.

USING THRESHOLD EXTENSION METHODS CAN BE LOWERED TO ABOUT 8 DB.

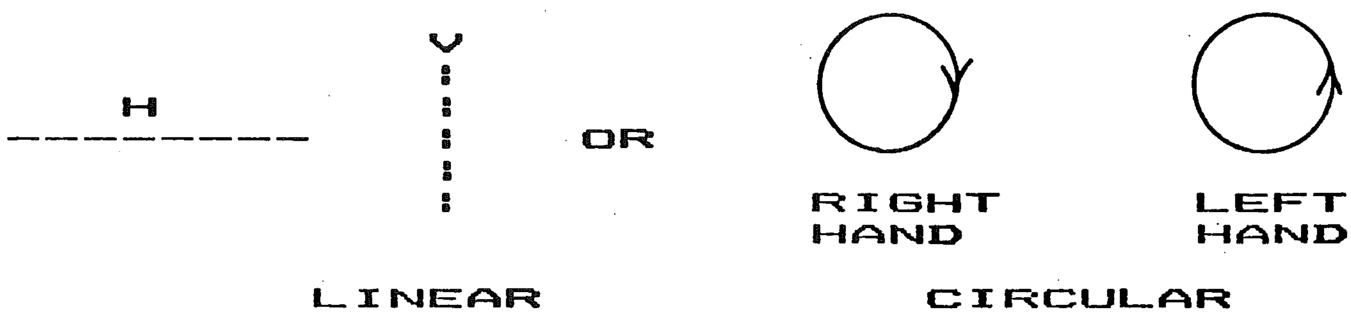
FREQUENCY PLAN ACCOMMODATES 36 24 MHZ CHANNELS



NOTES: CO-POLARIZED CHANNEL SPACING: 27 MHz
CROSS-POLARIZED CHANNEL SHIFT: 6.8 MHz
CHANNEL BANDWIDTH: 24 MHz
HIGH DEFINITION TV CHANNELS COMPRISE INTEGER NUMBER OF STANDARD CHANNELS

Direct Broadcast Satellite Frequency Plan

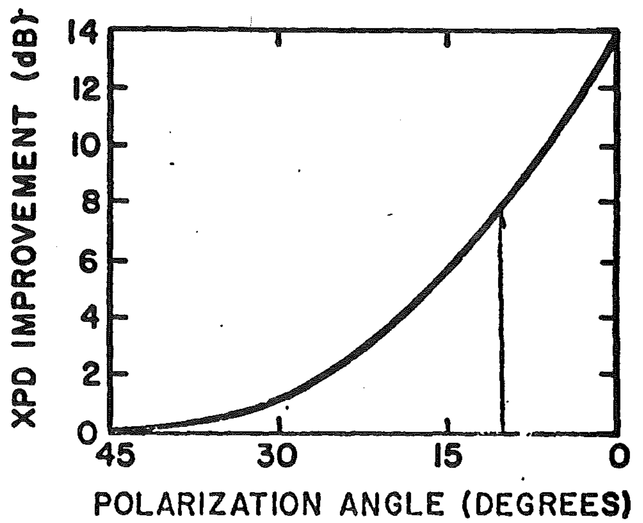
ORTHOGONAL POLARIZATION USED TO MINIMIZE CO-CHANNEL INTERFERENCE



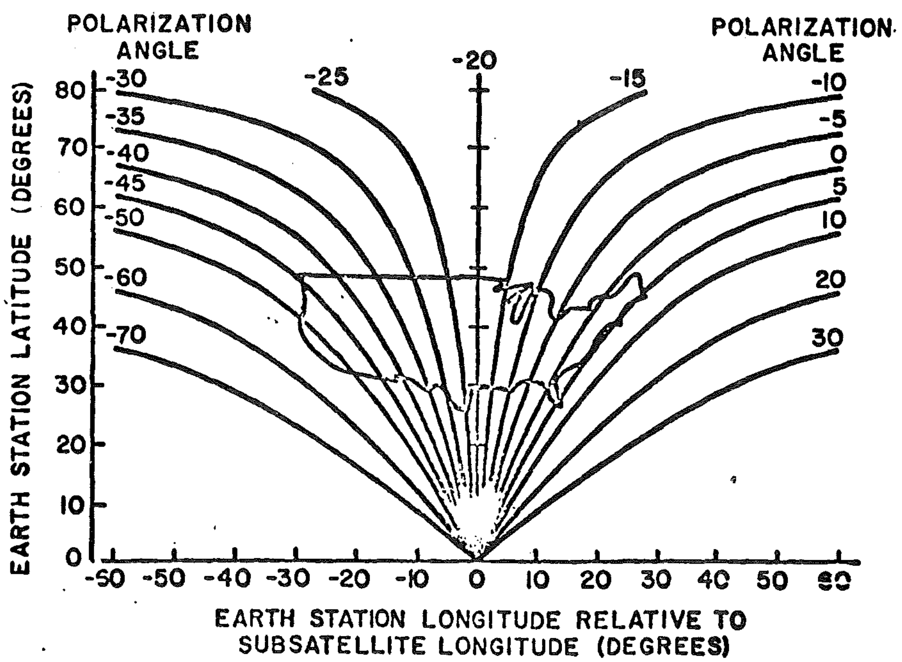
* C/I IS THE MEASURE OF CO-CHANNEL INTERFERENCE: WANT C/I > 30 DB.

* ORTHOGONAL POLARIZATION ALSO USED TO ISOLATE SIGNALS AT THE BORDER OF ADJACENT TIME ZONES.

LINEAR POLARIZATION PROVIDES SUPERIOR ISOLATION IN THE PRESENCE OF RAIN



BUT LINEAR MUST BE PRECISELY ALIGNED AT EACH LOCATION



** CIRCULAR POLARIZATION HAS BEEN CHOSEN FOR DBS APPLICATIONS **

*** SUMMARY ***

HIGH QUALITY SATELLITE TV RECEPTION CAN BE ACHIEVED WITH:

1) FM

2) 24 MHZ CHANNEL WIDTHS

3) TRANSMISSIONS LIMITED TO ONE TIME ZONE

4) 2 FT DIAMETER RECEIVE DISH

5) 4 DB NF RECEIVER

OPPOSITE SENSE CIRCULAR POLARIZATION IS USED TO ELIMINATE CO-CHANNEL INTERFERENCE AND INTERFERENCE BETWEEN ADJACENT AREAS.

DEGRADATION DUE TO HEAVY RAIN IN SOME PARTS OF THE COUNTRY CAN BE OVER COME BY USING:

1) LARGER OR MORE EFFICIENT DISHES

2) THRESHOLD EXTENSION

3) LOWER NOISE FIGURE RECEIVERS

BINAURAL PRESENTATION OF SSB AND CW SIGNALS RECEIVED ON A PAIR OF ANTENNAS

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A typical amateur receiving system consists of an antenna, a receiver to amplify and convert the RF signals to audio, and monaural headphones to present the audio to the listener. This system may be compared with a monophonic audio system consisting of a single microphone, amplifier and monaural headphones. These systems do not take advantage of human binaural hearing. Now consider a recording of a symphony orchestra from a signal-to-noise ratio standpoint. For simplicity, assume that each instrument in the orchestra contributes equal power to the total sound output, and that the cello section has one tenth of the total number of instruments in the orchestra. The output of the cello section is thus 10 dB below the total output power. A classical cellist might well consider the cello section the "signal" and all of the other instruments "noise." While listening to a good stereo recording, he is able to concentrate on and hear the cellists, even though the "signal-to-noise" ratio is -10 dB!

It is relatively simple to convert a monaural audio system to stereo--a second microphone and amplifier are added and stereo headphones are used. The same approach may be applied to a CW and SSB receiver system, as shown in figure 1. A second antenna is added, a second receiver amplifies and converts the RF signals to audio, and the outputs of the two receivers are fed to stereo headphones. There are two difficulties to overcome. According to reference 1, binaural hearing uses relative amplitude, phase, and time delay information between the two ears to determine the position of a source and allow the listener to concentrate on that particular direction. The relative amplitude requirement is satisfied by using two receivers with equal gain and no AGC. The relative phase requirement may be met by locking all of the oscillators in each receiver to a common standard, or more simply by using only one set of oscillators for both receivers. Any relative time delay is preserved along with the relative phase.

EXPERIMENTS

The first tests were conducted in 1980 using the apparatus shown in figure 2. Two LM1496 product detectors

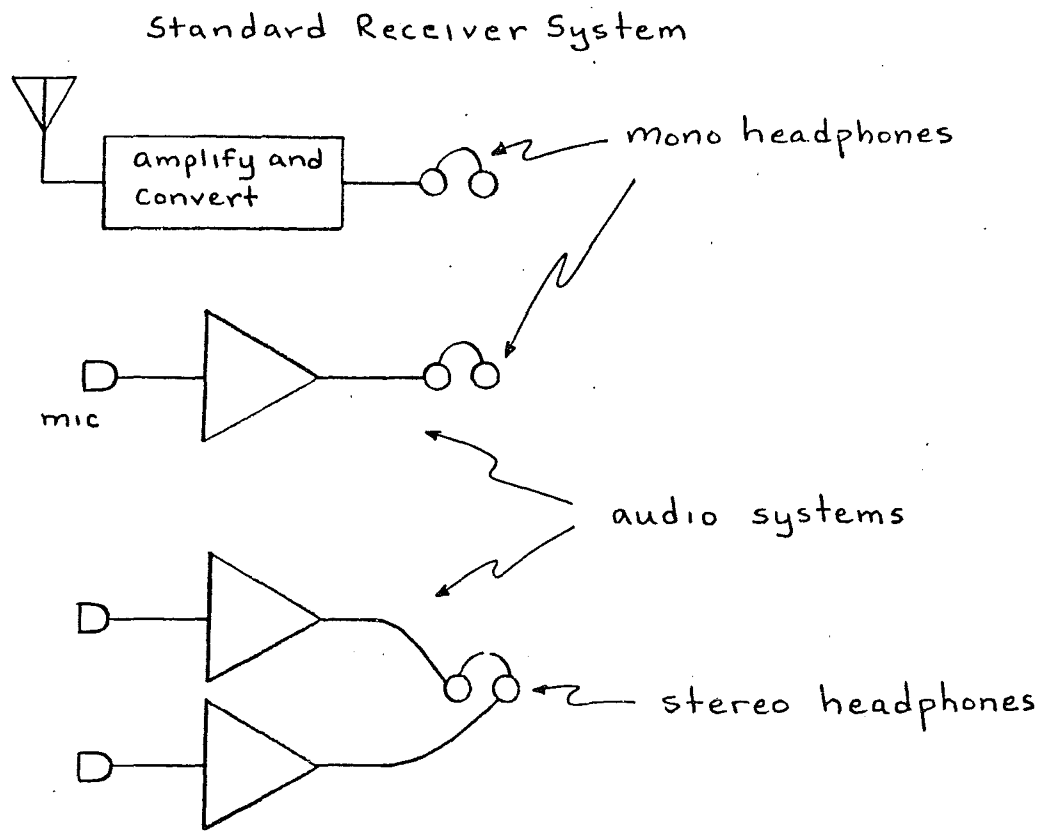


Figure 1

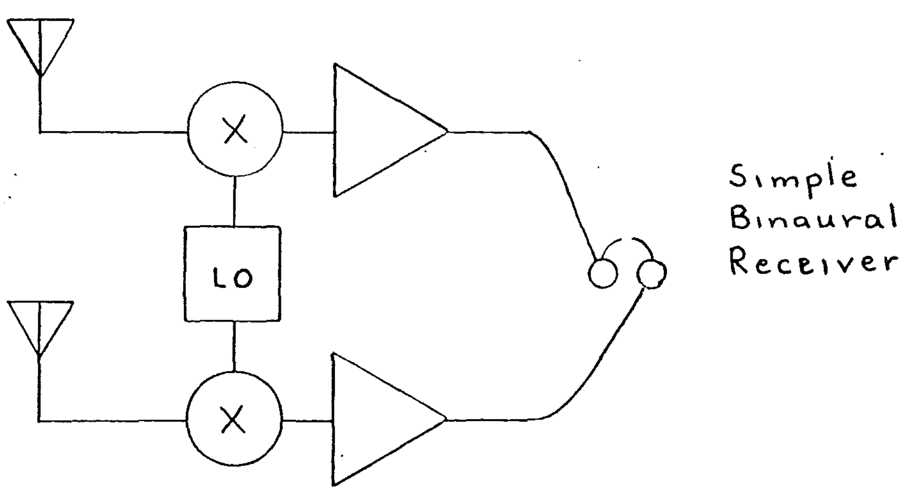


Figure 2

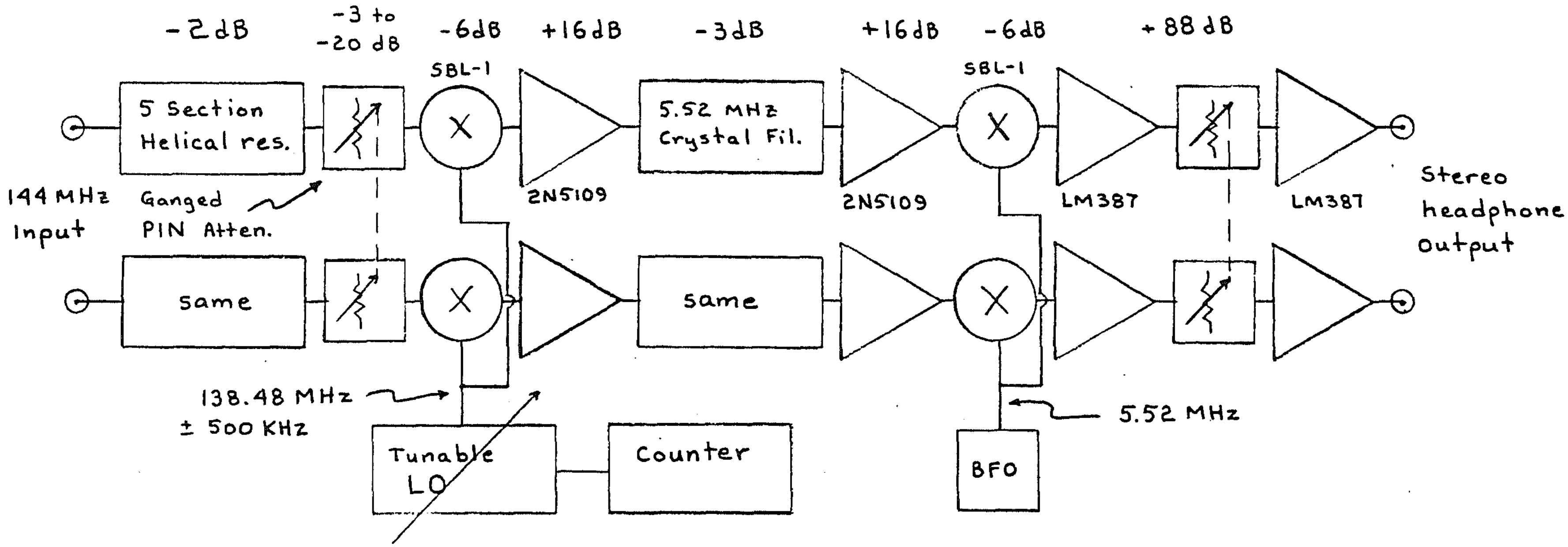
were built on a "superstrip" breadboard. The LO was a URM25 signal generator, the outputs of the two product detectors were fed to the microphone inputs of a Technics RS686 stereo cassette tape deck, and two 20 foot pieces of wire were used as antennas, connected directly to the inputs of the product detectors. The resulting binaural audio output exhibits the same qualities as a stereo audio recording, with a perceived space and each signal at a different location. The ability to concentrate on a weak signal below the noise level is greatly enhanced. It was originally supposed that the antennas would have to be widely separated to obtain a space diversity effect. With the binaural output, however, phase differences between input signals arriving from different directions provide a sense of space even when the antennas are closely spaced. Tests in 1983 on 20 m using short wire antennas indicate that the perceived binaural space is present until the antennas are closer than one tenth wavelength. To maximize the phase differences between signals arriving from different azimuth directions, a horizontal antenna spacing of about one half to one wavelength is indicated. The antenna spacing required to achieve a binaural advantage does not appear to be at all critical. Spacing may thus be optimized tor transmitting pattern or mechanical constraints without compromising binaural receiver performance.

The simple receiver system in figure 1 exhibits the several problems commonly associated with direct conversion receivers--hum, microphonics, and twice the bandwidth of an equivalent superheterodyne SSB receiver. The binaural output puts it in a class by itself, however, and after an hour of listening to 40 meters in stereo I would no more be satisfied with the best commercial HF rig currently available than with a 1958 mono "HiFi" driving a 4" unenclosed speaker.

AN IMPROVED SYSTEM

During 1981 and 1982 the 144 MHz binaural SSB-CW receiver shown in block diagram form in figure 3 was designed and constructed using modern high dynamic range techniques. Since AGC is not needed, the gain distribution is somewhat different than current practice, with most of the gain obtained at audio using LM387 low noise stereo preamplifier IC's. 144 MHz was chosen as a compromise IF for up conversion from HF, down conversion from UHF and direct use on 2 m. The noise figure of the basic receiver is about 14 dB. When used on 2 m, a matched pair of Q-bit preamplifiers with 25 dB gain reduces the system noise figure to 1.6 dB. The noise figure on the other bands depends on the converters used.

This receiver has been used during the past two years



2 m Binaural SSB-CW Receiver/IF

Figure 3

as an upconversion IF for binaural listening on all of the HF amateur bands, as part of the 2 m station at KK7B, and as a downconversion IF from 432 and 1296 with additional circuitry for coherent propagation experiments. In every instance, binaural audio output has provided improved intelligibility for weak signals. Subjectively, the ability to dig through white noise, which seems to come from all directions, and interfering signals, ignition noise and static crashes which seem to come from specific directions, adds a new dimension to weak signal work, akin to looking for crickets on a warm summer night. On 2 m, the first impression is that the noise is louder, since it seems to come from all directions. When a signal appears to come from a single direction, however, it is possible to ignore most of the noise and copy the signal. The experience at KK7B has been that if I can tell something is there (tunable noise) with the monaural system using the same pair of antennas and preamp noise figure, I can copy about 90% with the binaural system.

Figure 4 shows the present 2 m system in use at KK7B. For normal operation, where the benefits of AGC and transceive frequency control are useful, the binaural receiver is switched out of the system. When the binaural system is on, relays K1A and K1B become the transmit-receive relays, and the binaural receiver operates during receive and the conventional transceiver-amplifier operates during transmit. The antennas are 6 element yagis vertically spaced 0.75 wavelengths.

Figure 5 shows some suggested antennas for binaural operation using various amateur bands and modes. Of particular interest is the meteor scatter array, which provides an optimized receiver for each ping, once the brain is accustomed to listening for a signal arriving from a different direction each time.

SOME RELATED ACOUSTIC EXPERIMENTS

The references provide a basic source for binaural phenomena information. The text by Kryter contains an additional bibliography with 914 references on human hearing in noise. According to Kryter (p. 41), the maximum advantage obtained when a signal and interference are each of equal strength in both ears, but oppositely phased, is 16 dB relative to monaural presentation of both signals. According to reference 3, the effective signal-to-noise ratio improvement for speech in the presence of randomly phased white noise is about 2 dB. Thus the expected improvement in effective signal to noise ratio obtained by using a binaural receiver instead of just combining the outputs of the two receive antennas is expected to be somewhere between 2 and 16 dB, depending on the nature of the interfering signal.

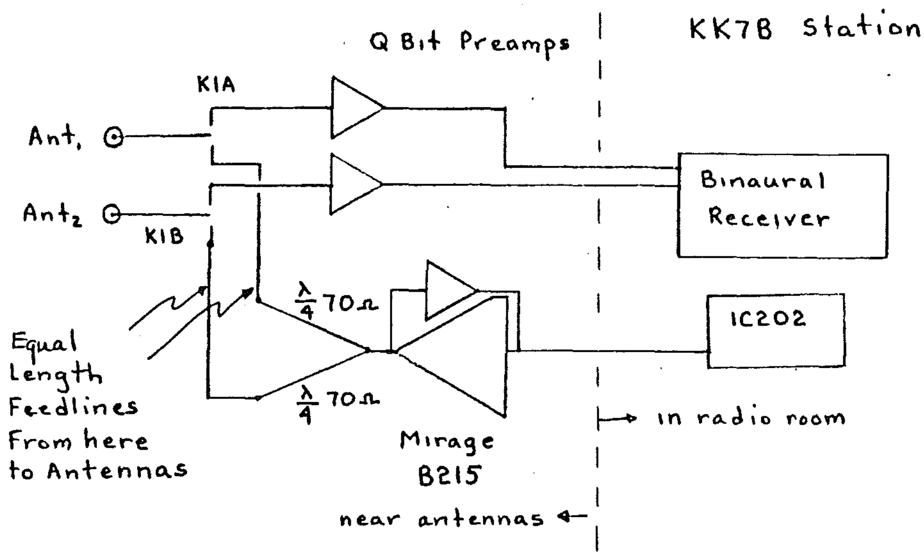


Figure 4

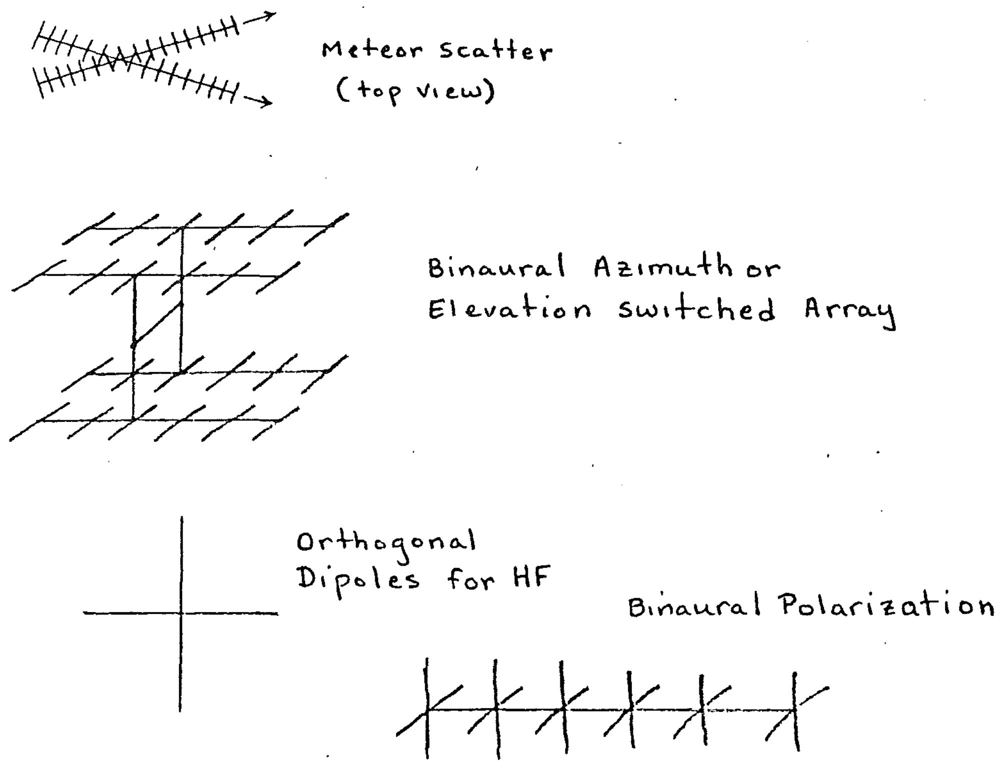


Figure 5

CONCLUSIONS

A theoretical approach to optimization of binaural communications systems (Reference 4) indicates that binaural reception provides the maximum advantage when the angle of arrival and/or polarization of the desired signal is variable, and the angle of arrival of interference is variable and unknown. These conditions apply to many of the interesting VHF-UHF propagation modes involving scatter from moving targets such as the moon, airplanes, meteors and patches of intense ionization. Particularly in the case of meteor scatter, amateurs have had to use antennas with less directivity in order to provide better "aperture to medium coupling." Another situation in which binaural reception is optimum is the early hours of a VHF contest, when multiple contacts are made in less than one beam rotation time in the presence of interference arriving from random directions.

Binaural reception allows the amateur to make better use of human hearing--the best analog weak signal processing system currently available. This is one area where amateurs may make a significant contribution, since it is uniquely suited to our peculiar communications needs and is inexpensive to implement.

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1. ITT, Reference Data for Radio Engineers 6th ed., Howard W. Sams & Co., Inc., Indianapolis, 1975 pp. 37-28 to 37-31.

2. Karl D. Kryter, The Effects of Noise on Man, Academic Press, New York, 1970 pp. 41-43, 57, 59-60, 75-76, 591-633.

3. J.C.R. Licklider, "The Influence of Interaural Phase Relations upon the Masking of Speech by White Noise," The Journal of the Acoustical Society of America, Volume 20, Number 2, March 1948.

4. R.L. Campbell, "Binaural SSB and CW Receiving System," in preparation.

5. H. Levitt and L.R. Rabiner, "Predicting Binaural Gain in Intelligibility and Release from Masking for Speech," The Journal of the Acoustical Society of America, Volume 42, Number 4, 1967.

6. Scatter Propagation Issue, Proceedings of the IRE, the Institute of Radio Engineers, Inc., Volume 43, Number 10, October 1955.

HOW WE PUT THE G-LINE TO WORK

BY

WARREN WELDON W5DFU

The Surface Wave Transmission Line, or more popularly known as G-Line, was developed around 1950 by Dr. George Goubou of the Signal Corps. Two significant articles covered the amateur applications of this unique antenna feedline system in past years. The first being an article titled "The G-Line" by Major Walter White, Jr., K2CHF appeared in the April 1953 issue of CQ magazine. The second titled "Putting the G-Line to Work" by George A. Hatherall K6LK appeared in The June 1974 issue of QST.

The system consists of a coaxial feed to a launcher, an unshielded single wire transmission line and a collector which feeds again into a coaxial line. The mechanical and electrical design of the launcher and collector are identical. If you are interested in a very detailed description of the theory, design and application of this system, I urge you to read the two excellent articles noted above.

The participants in the story that follow are Merlin Berrie W5HTZ of Wewoka, OK and Warren Weldon W5DFU of Tulsa, OK. Both have speen most of their ham careers in the pursuit of the higher frequencies and are avid home brewers of equipment to achieve better ham communications at those frequencies.

Merlin and I have been communicating with each other and experimenting with such equipment for 36 years and have had a nightly schedule for the past 8 years. The G-line has always interested us and when we got serious about the 1296 Mhz band 3 years ago, we decided the g_line was a good choice since much of the early experimental work by others had been done on that band.

G - Line   Warren Weldon W5DFU and Merlin Berrie W5HTZ

In the winter of 1981 the search for a good light weight, highly conductive amd easily solderable material for use in constructing the launcher and collector cones led us to the use of double sided 0.007 inch thick PC material. We were able to obtain this material in 3 ft x 4 ft sheets.

Each sheet provided sufficient material to fabricate 2 cones which are 21 inchs long and 13 inchs in diameter at the open end. Merlin laid out a posterboard template for the cones using a string compass. Allowance was made for a 0.750 inch overlap when the cone was rolled. After cutting, the PC material was rolled and clamped between two pieces of wood. The inside and outside of the cone were then soldered. The copper cladding on this thickness material is very thin and care must be exercised during the soldering to not over heat the copper and delaminate it from the fiberglass.

Merlin then soldered a rolled copper tube 0.375 inch ID x 3 inchs long into the apex of each cone so the tube extends slightly into the cone. A set screw was provided near the outter end of the tube to clamp another copper tube placed inside the first tube but over the shield braid of the coax feed cable. These telescoping tubes were used to match the cone to the coax feed cable.

I used a differenct method to clamp the cone to the coax feed cable tube. A 0.5 inch copper pipe coupling, 1.0 inch long, is slotted for one half its length, the resulting tabs are bent out to match the cone angle at the apex. Into the other end of the tube I soldered the male threaded end of a brass 0.375 inch tube to 0.375 inch pipe male connector compression tube fitting. I then soldered the flared tabs of the copper coupling to the apex of the cone. The compression tube fitting provides a mechanically and electrically secure method to clamp the cone apex to the coax feed cable tube. It also permits easy adjustment for matching the cone to the coax feed during tune-up.

During the period of construction, Merlin exchanged correspondence with George Hatherall K6LK (author of the QST article). George provided many helpful suggestions including this improved method of cone to coax matching.

A short length (3 ft) of Belden #8214 coax for the feedline at each cone is prepared in the following manner. The outer vinyl jacket is removed for 5 inchs at one end to form a G-Line pigtail. Push the copper braid backslightly and cut off 1 inch of the foam insulation and center conductor.

 Warren Weldon W5DFU and Merlin Berrie W5HTZ

Prepare a 5 inch long piece of 0.375 inch copper tubing by slightly flaring one end with a tubing flaring tool. On the coax, pull the braid forward over the end of the insulation so as to compress the braid into a smaller diamter bundle. Carefully feed the braid into the flared end of the copper tube keeping the braid over the foam tightly compressed. The flare on the tube should act as a funnel to aid in this operation. When the free braid emerges from the other end of the tube, clamp this braid in a bench vise to enable you to keep the braid tight. Continue to slide the tube over the braided shield until the flared end seats against the vinyl jacket. Cut off the braid 0.050 inchs beyond the unflared end of the tube and slide the remaining braid off the foam. Carefully solder the 0.050 inchs of braid to the end of the tube. Using a file, dress the solder to the same OD as the tube.

Take a 1.0 inch long piece of 0.187 inch brass or copper rod and using a #33 drill (0.113 inch), bore a hole the entire length of the rod. Being careful not to nick the center conductor, strip 0.5 inchs of foam from the pigtail and tin with solder. Tin the hole in the rod. With heat applied to the rod, press it over the center conductor. The remaining 0.5 inch will be used to attatch the actual G-Line conductor.

Thread the pigtail into the outer end of the clamping hardware you soldered to the apex of the cone. The pigtail should telescope into the cone apex support and about 32 inchs of the pigtail should now protrude from the open (13 inch diameter) end of the cone. The purpose of the pigtail is to collinate the RF to make it travel along the line and not radiate since there is no braided shield to contain it. K6LK determined the 4.5 inch length at each end is optimum.

I suggest you use a thin polyethylene disc (I use flower pot dishes) over the open end of the cone with the pigtail passing through a small hole in the center. The lower cone should be sealed with RTV. This will keep out the rain and nesting birds.

George and other early experimenters showed that the efficiency of the G-Line was highly dependant on the choice of the wire and its insulation material and thickness. During the winter of 1981-82 Merlin spent many weeks trying differenet types of wire on his test rig strung between two trees in his yard. For the majority of his tests he used a MicroWave Modules MMT 144/1296 transverter as the RF generator. The following are the results of the wire tests:

Wire/Insulation Type	Loss
1. No. 14 solid / 0.062 inchs polyethelyne	1.8 db/80 ft
2. No. 12 solid / enamel	2.7 db/80 ft
3. No. 12 solid / thermoplastic (house wire)	2.7 db/80 ft
4. 7/22 stranded mild steel / plastic cloths line	5.8 db/80 ft
5. No. 20 stranded / plastic (hookup wire)	4.5 db/80 ft
6. No. 8 stranded / 0.025 inch teflon	1.3 db/100 ft
7. No. 14 Stranded / 0.015 inch teflon	1.2 db/100 ft
8. No. 14 stranded / 0.015 inch teflon	2.8 db/200 ft
9. Cones nose to nose (pigtails only)	0.4 db

G - Line   Warren Weldon W5DFU and Merlin Berrie W5HTZ

In our systems we used the No. 14 stranded with 0.015 inchs of Teflon insulation. When both the launcher and collector cones have been prepared as described above, solder each end of your G-Line wire into the connector ords on the cone pigtails. Apply over this splice a thin layer of teflon tape, the same tape plumbers use, and spray with a clear platic it in place.

Install an N connector on each coax feed cable for connection to the equipment. Right here is an important point to remember anytime you are installing an N connector on Belden 8214. The center of the 8214 is 0.110 inchs in diameter and the inside diameter of the solder cup on the N connector is 0.090 inchs. In order to not create an impedance bump (which will "eat your lunch" at 1296 MHz), do NOT cut off strands to make the center fit the solder cup. Instead tin all strands together and with a small file dress all strnds to form a short tapered section and then dress the OD of the remainder to fit into the solder cup. Sometime make up a test section of cable using both methods and compare the results at 1296 MHz using a sensitive SWR-power meter. It will make a believer out of you!

A wedge type cable clamp sold to support power ine service drops we found at Pay n Pak that fits snugly over the coax back of the cones makes an excellent means of anchoring each end of the assembly.

String up the line assembly where ever it is fairly taut, in the clear along its entire lwngth and affords access to both cones. Apply RF power through an SWR reading power meter to one end of the coax and connect a power reading dummy load or power meter and antenna to the other end. Tune the system by moving the cones back and forth on th coax feed lines in small increments by means of the telescoping copper tubes until the lowest SWR reading at the input end and the highest power erading on load end is acheived. When optimum tuning is acheived, tighten the tube locking method used and coat the hardware junctions with RTV to weatherproof them. On my system the tuning tubes project into the apex of the cones about 2 inchs.

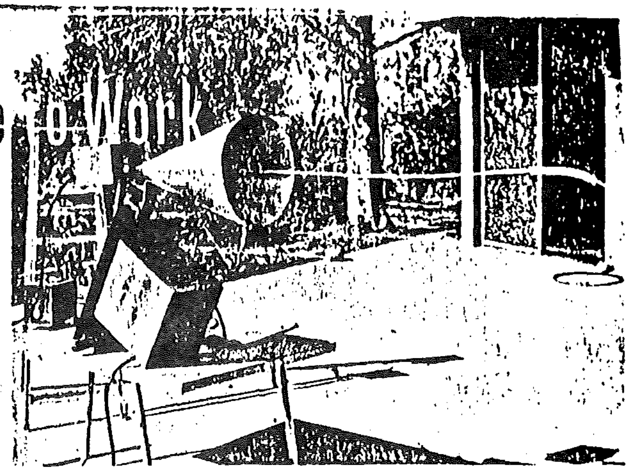
The follwoing are some notes on the performance of the G-Line:

1. Provides lower loss for equal length compared to 0.75 inch helical coax cable at a considerable cost and weight savings.
2. Very durable. Merlin's and mine have been in serivce for 2 years with winds up to 80 mph with no electrical or mechanical problems.
3. Ideal for use with telescoping and fold-over towers (which I use) where use of a stiff helical cable would present major problems.
4. Loss factor remains equally low at 2304 Mhz.
5. Best suited to straight-run feedline applications as losses rise sharply if bends are attempted.
6. The length of the coax at each end of the system should be kept very short as losses rise rapidly in this cable.
7. The area immediately surrounding (roughly 6.5 inch radius) of the G-Line and the pigtails must be kept clear of all objects.
8. Performance remains good when operated under rain and snow conditions.

Merlin is using a 7 ft dish and I am using a single 45 element loop yagi. For several months we maintained nightly communications over the 80 mile path between our locations with each of us using only 1 watt output of our Microwave Modules transverters. Merlin's best DX is W5LDV in Houston at 365 miles and mine is W9ZIH at Hickory Hills, IL at 600 miles. We are satisfied G-Line users and would like to see other ham microwave operators take advantage of this dandy feedline method.

We wish to express our gratitude to George Hatherell, K6LK for his inspirational QST article that sparked our enthusiasm to try the G-Line and for his most helpful support and suggestions during our experimentation to build a couple of highly successful working systems.

Putting the G Line to Work



A section of G line set up for measuring the loss incurred from bending and dielectric loading on the inside of the curve.

For a number of years, some amateurs interested in vhf and uhf have been curious about the use of G line. This single-wire transmission line (named after Goubau) has some interesting and unique properties, not the least of which is very low loss at uhf and lower parts of the microwave spectrum. Most experimenters were scared off by a lack of understanding of some of the drawbacks to the line. Here is a report by one (K6LK) who was not afraid to take the collectors by the horns and check out the operation.

BY GEORGE A. HATHERELL,* K6LK

THE G LINE was developed in 1950 by Goubau[1] and a practical line was constructed by this writer to test the theoretical concept. Fig. 1 shows the line and the match between theory and practice.

The system consists of a coaxial feed to a launcher, an unshielded single-wire transmission line, and a collector which feeds again into a coaxial line or to a load. When the mathematics is boiled from the concept, it appears somewhat as follows: A coaxial line supports an rf wave traveling in the dielectric between the inner conductor and the shield. This wave has both *H* (magnetic) and *E* (electrostatic) components just as does the wave radiated from an antenna. Goubau determined mathematically that a proper launcher would strip *most* of the *E* field from the wave and convert it to a form which contained the *H* component and a remaining trace of the *E* field as it traveled along a single conductor. There would be practically no radiation as the *E* component would be substantially absent. Calculation also showed Goubau several other things. There must be a dielectric surrounding the conductor as otherwise the field becomes unmanageable. A small conductor needs a heavy dielectric sleeve. As wire diameter increases, the dielectric thickness may be decreased. Also, the efficiency of the collector is proportional to the percentage of the field which it intercepts.

It has been difficult to find anyone who has worked with the line, and yet many amateurs have heard of it. W6HFR remembers seeing installations in the mid 1950s with runs from a launcher to a collector at the base of a tower, then a short coax line from the first collector to a second launcher which fed the power vertically to the top of a tower. There, a second collector fed an antenna. W6DRV did some work on the line at Northrop Aircraft some years ago but does not remember any of the details. W6QV used a 1500-foot G line for communications during the construction of the Colorado River aqueduct. The system used a 4-foot by 4-foot cone launcher and collector. This line fed signals to and from the top of a steep hill to maintain radio contact with a distant station. No audio line could be cleared of noise for the run, but the G line worked well on a frequency near 150 MHz. Use of the line is mentioned in the ARRL *VHF Manual* (First Edition), and was tried on 432 MHz with the television-kit G line then available. The loss was 2.7 dB for 100 feet of line.

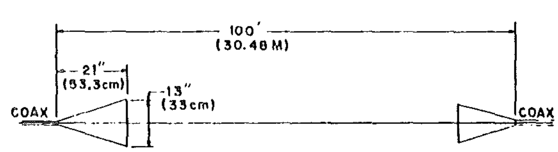


Fig. 1 — A sketch of one of the tests setup to evaluate the performance of G line at 1296 MHz. Later tests by K6LK employed a shorter length of line.

If the line is so good, why isn't it being used? There are several reasons. The line has to be fairly straight or the losses mount. It must be kept clear of metallic objects. In recent years coaxial cable has been developed with very low loss. Such cable,

[1] Goubau, *Proceedings of the IRE*, 39, 619-624 (1951); *Journal of Applied Physics*, 21, 1119-1128 (1950).

* 10160 Maude Ave., Sunland, CA 91040.

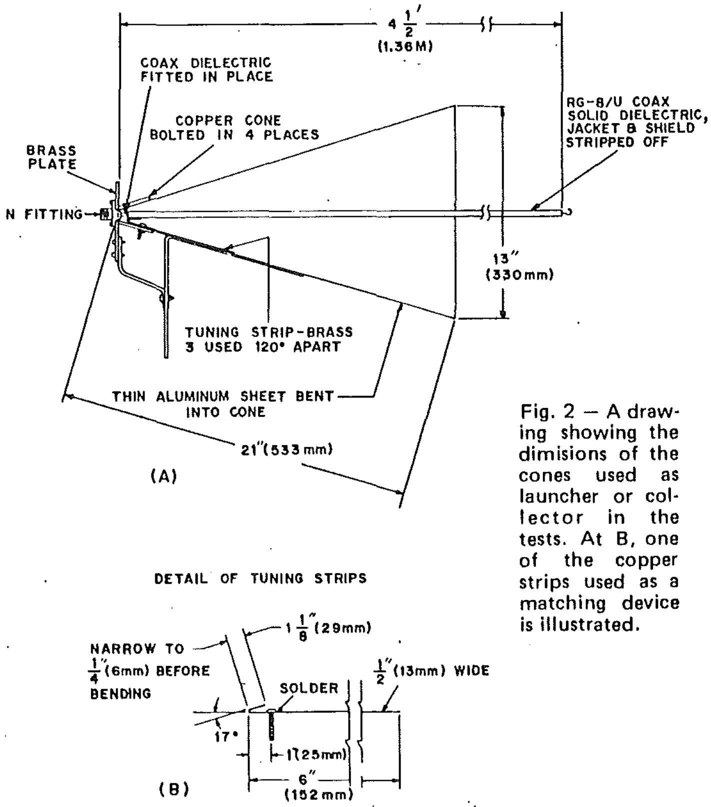


Fig. 2 — A drawing showing the dimisions of the cones used as launcher or collector in the tests. At B, one of the copper strips used as a matching device is illustrated.

however, is very expensive and is usually pressurized with dry nitrogen. Very definitely it does not fit into the average ham budget.

The G line has been under test at this location for the past two months. My dish for 1296 MHz is forty feet from the shack and I am not eager to invest in jewelry-priced coax and rent tanks of pressurized dry nitrogen. In addition, I want to run field-pattern tests which will take 87 feet of line from the shack to the radiators. Eventually, the final amplifier will be mounted at the focus of the parabola, but if all goes well with the G line the driver stage will be in the shack..

Initial Tests

The original test setup here used a 100-foot line starting with a launcher at the edge of the roof outside the shack. The launcher was fed by a 12-foot length of high quality RG-8/U foam coax. A Bird No. 43 Thruline wattmeter was coupled directly into the launcher. The 100 feet of line under test was supported by monofilament nylon fishing-line slings which were attached to four wooden frames and spaced evenly along the line. Two stretched ropes ran the 100 feet at the corners of the top horizontal frame members. This allowed additional slings to support the line from the ropes between the wood frames. The collector was clamped to the last frame and fed directly into a second wattmeter. The second wattmeter is homemade from a microwave directional coupler and is calibrated against the Bird 3.[2] Output from the second wattmeter is fed through 5 feet of coax line into a Philco 160B-300 terminating load.

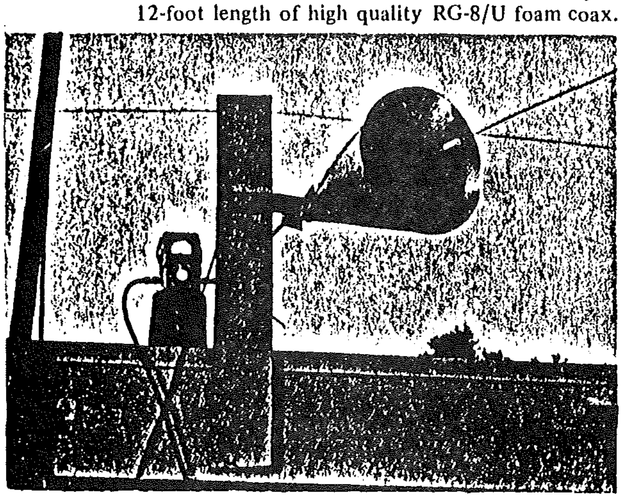
The first launch and collector horns were built approximately to the dimensions of the Goubau original experiment (Fig. 2). The horns are made of 30-gauge aluminum sheet. Since this does not accept solder readily, copper cones were formed around the small ends and bolted to the aluminum cones. Brass plates were soldered to the apex of the cones at right angles to the axis. The type-N flanged chassis fittings were bolted to the plates for easy assembly after the line conductor was soldered into the fitting.

During the first series of tests there was a little trouble with reflections back into the coax at the launcher. This problem was solved later. Forward power was set at, or close to, 10 watts on all tests. Tests at higher and lower power indicated slightly higher efficiency at the higher power, for some unexplained reason.

Test results at 1296 MHz:

100 feet No. 12 enamel coated wire	loss 3.87 dB
100 feet No. 12 enamel coated wire sleeved with Teflon	loss 2.53 dB
100 feet No. 12 plastic-insulated house wire (white)	loss 3.62 dB
100 feet No. 12 plastic-insulated house wire (black)	loss 3.87 dB

[2] Care must be taken in calibrating a bidirectional coupler for use as a wattmeter. There is always insertion loss. Calibrate power in and power out separately. To measure power out at the collector, use the POWER IN calibration. The difference can be quite surprising in close work.



A launcher. . . .

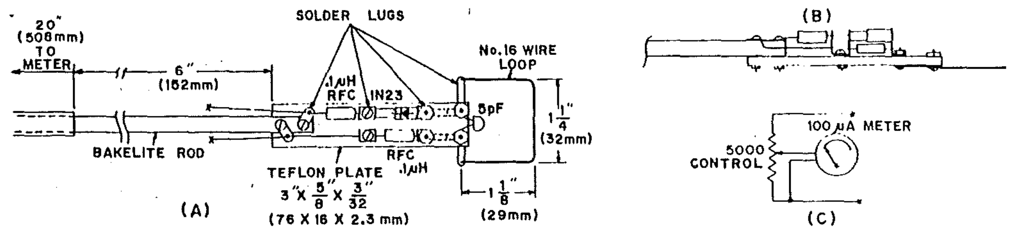


Fig. 3 — The author assembled a sensitive rf probe to investigate the rf field surrounding the transmission line.

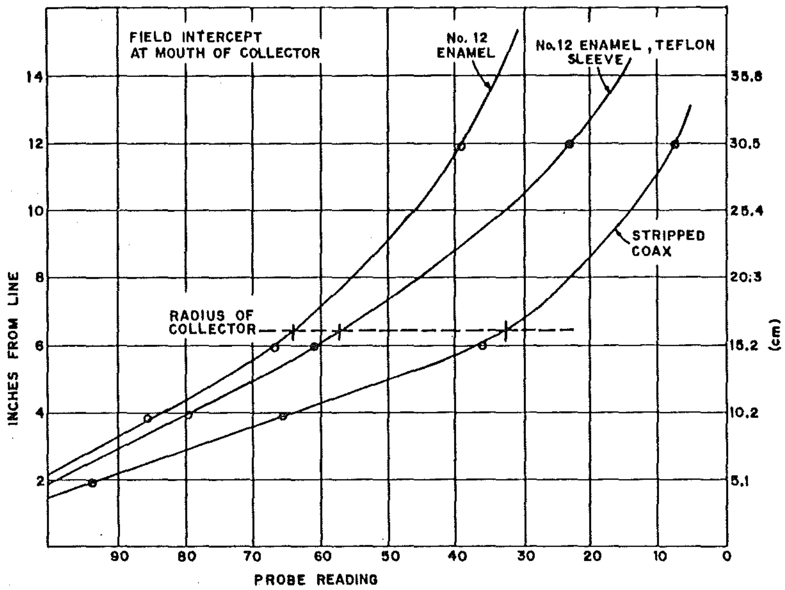


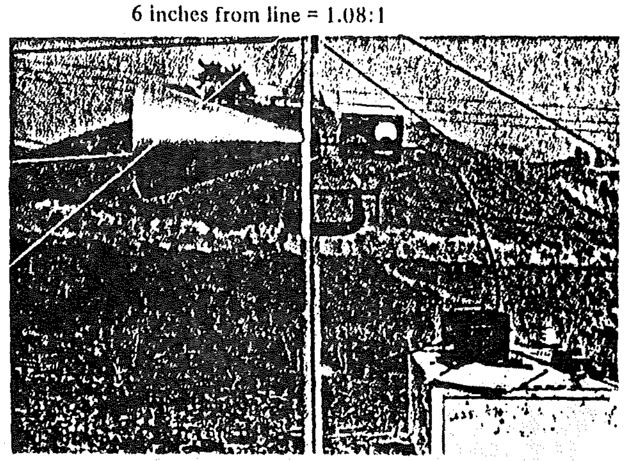
Fig. 4 — Some representative readings taken near the line, showing the effect that dielectric material has on field intensity.

Theoretical development of the G line indicated that efficiency of power transfer is dependent on the proportion of the *H* field that can be intercepted by the face opening of the collector. Field strength near the conductor is dependent on the thickness and type of dielectric surrounding the wire. A special probe was constructed to take field strength readings along the lines (Fig. 3). The same probe was used to make standing wave tests along the lines. The jacket and shield were stripped from 8 feet of RG-8/U. This section was substituted for the last 8 feet of line into the collector. Field-strength readings were taken on sections of lines consisting of the stripped RG-8/U, Teflon sleeved No. 12 enamel-coated wire and the original No. 12 enamel-coated wire. The results are shown in Fig. 4. Here the probe read 63 at the collector radius of 6-1/2 inches for the enamel coated wire and read only 27 at the same radius from the stripped RG-8/U coax. The power interception by the collector should be very greatly increased with a shift from the light-dielectric wire covering to the stripped coax, and so it is.

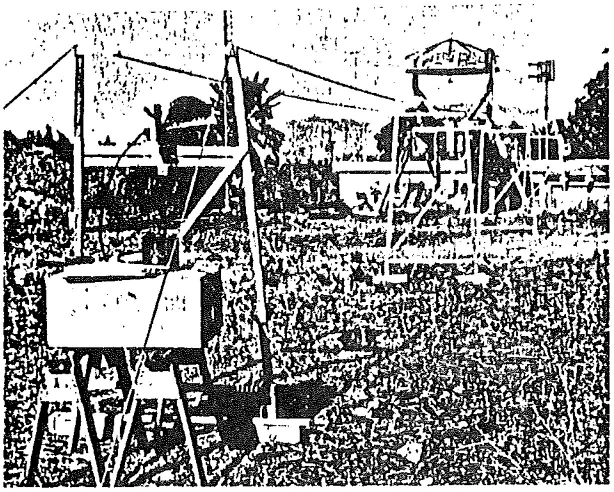
100 feet of line (92 feet Teflon sleeved No. 12 enameled wire plus 8 feet of stripped RG-8/U into collector) loss = 1.67 dB

Standing waves on the G line are a serious problem. Fortunately they are easily removed – at 1296 MHz anyway. Using the slotted-line formula for standing waves: SWR = max/min (which is probably not too accurate in a technical sense for this line), a typical group of SWR readings is:

1 inch from line = 1.05:1
2 inches from line = 1.08:1
6 inches from line = 1.08:1



. . . . and a collector



The transmission line was suspended from ropes, supported by wooden frames along the 100-foot span.

On a coax feed to an antenna this would be akin to perfection, but tests showed that it is a serious problem on the G line. It is also to be noted that these readings always showed an increase in magnitude as distance from the line was increased. The cause is probably twofold: the field is distorted by the probe being close to the line, and the magnetic field forms a pattern with the nodes on the line acting as radiating points. A collector mismatch is easily made, compared to which the above figures look good.

Separating the Losses

If all lines were 100 feet long, we wouldn't care how much of the loss takes place along the line and how much appears at the launcher and collector. The launcher and collector loss is substantially constant. If this is known, we can predict the loss in a line of any length. To separate the losses into line and terminal values, the testing was moved to a patio where 75 feet of clear area was available. A 75-foot guy wire was stretched tightly 7 feet above ground. The lines under test were suspended by monofilament fishing line, half way between the guy wire and ground. The combined launcher and collector loss was determined as follows: A piece of RG-8/U, 18.3 feet long, was stripped of jacket and shield, then mounted from N fitting to N fitting between launcher and collector. The results:

10 watts input, 8.75 watts to load, loss 0.58 dB

The line was opened near the middle and 50 feet of stripped RG-8/U coax inserted:

10-1/2 watts input, 7.5 watts to load = loss 1.46 dB
loss in 50 feet of stripped coax, 1.46-0.58 = .88 dB
loss in 100 feet of stripped coax = 1.76 dB
loss in 18.3 feet of stripped coax,
18.3/100 × 1.76 = 0.32 dB
loss in launcher plus collector 0.58-0.32 = 0.26 dB

All indications are that this loss is not divided evenly between the launcher and collector. There is freedom in the design of the launcher as long as it will load without having reflections back into the feed coax. There is no such freedom in the collector, or at least I did not find it.

The calculated loss for a 100-foot system using the stripped coax line works out to 2.02 dB. The stripped coax thus shows its value as a feed from the launcher and into the collector, but power losses in the dielectric overcome any advantages derivable from a restricted field.

A standard launch and collector system was next constructed with a 4-1/2-foot length of stripped RG-8/U which was mounted into the N fitting at the apex of each cone and brought out for connection to the lines under test. The 9 feet of stripped RG-8/U plus the launcher/collector gave a total of 0.4 dB constant loss.

A check was made with the standard launcher/collector system using the 4-1/2-foot RG-8/U stubs compared to the original 100-foot-system test using the 8 feet of stripped RG-8/U into the collector.

Fifty feet of Teflon-sleeved No. 12 enameled wire was inserted between the launcher and collector. The measured loss was 1.03 dB. For a 100-foot system this calculated to a loss of 1.56 dB. The original line with the stripped RG-8/U into the collector, but not in the launcher, showed a measured loss of 1.67 dB.

Before considering bends in the line and the losses incurred, two features of a G-line system deserve comment:

Putting sections in and taking them out between launcher and collector could have been a major nuisance if making the joints had turned out

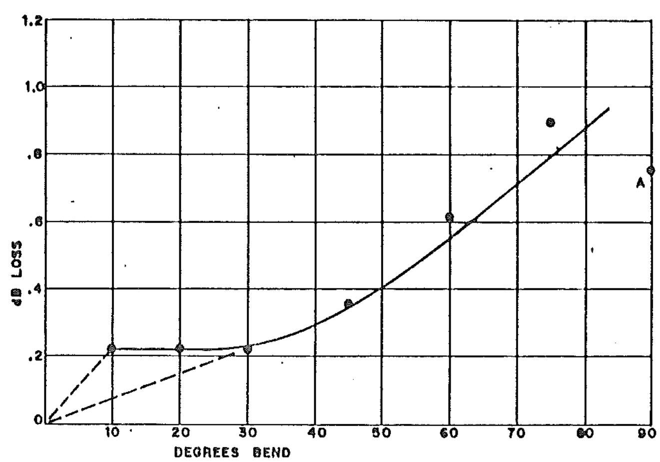
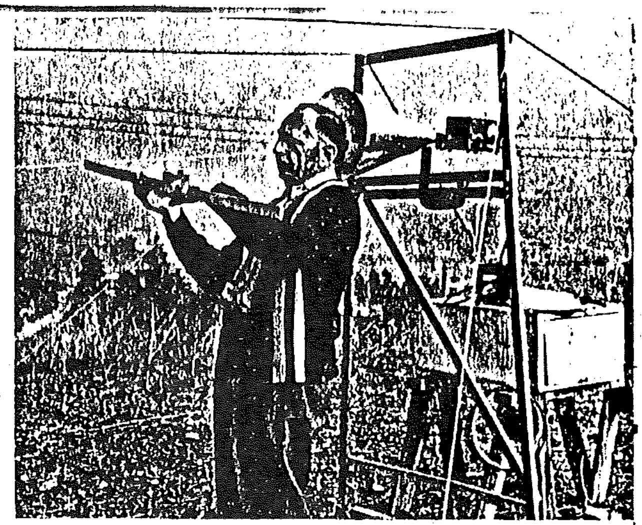


Fig. 5 — Line loss versus angle of bend. The radius was maintained at 5 feet for this test.

to be critical. When using coax at 1296 MHz there is the constant worry about reflections and losses in the connectors. There is no such problem working with the G line as it seems to be insensitive to discontinuities in the dieletric or to the type of joints used. At first the strands of the center conductor were fanned out and laid along the solid No. 12 wire and soldered. Dielectric was fitted carefully around the joints. For tests, small open-hook loops were bent into the ends of the stripped coax and used for connection (without solder). The joints were covered with dielectric in some cases and left bare in others. It made no difference in the performance of the line. A 4-inch section of Teflon-sleeved No. 12 enamel wire was put into the same spot. Again the output remained constant. Whether the joints were covered with dielectric or remained bare did not disturb the function of the line. With 10 watts in the line it is not even necessary to solder for tests of short duration.

The second feature has to do with tuning the launcher and collector. It may be possible to construct horns that will match to 50-ohm lines in and out – this didn't happen here. Possibly irregularities in the fit between the main horn and the copper shell figured in the mismatch. It is possible that the N fittings used at the apex of the horns are not the most desirable hardware for feeding and collecting power at these points. A tight metal fit right to the coax shield might be better. This would allow for a better strain relief when the line is pulled tight. However, tuning was found to be very uncomplicated. A sharp V is bent on the end of a 1/2-inch wide brass strip which is placed inside the cones. It will effect a match if adjusted properly near the apex, (Fig. 2). At the launcher, it is only necessary to watch the watt-meter and adjust for zero reflected power. At the collector, the strip is adjusted for maximum output. (There is never any reflection back into the collector if the load matches the collector coax.) At maximum output a probe will show very low standing waves on the line, or none at all.



K6BV gave the author a hand in making field-strength checks.

Bending the Line

How can we put bends in the G line? It would be ideal if we could put a simple launcher at the transmitter and use G line all the way to the antenna. Only 5 or 6 inches of clearance is needed with RG-8/U stripped line.

Two series of tests were made with the stripped RG-8/U coax. During the first series the radius was held at approximately five feet and I slowly changed the bend from 0° to 90°, (Fig. 5). In the second series I held the angle between input and output at 90° and changed the radius of the bend from 2 to 60 inches, Fig. 6. Unfortunately the results are indicative only. The stripped coax has to be suspended clear of other objects and the process of approximating the curvature is akin to orienting a length of wet spaghetti. Two hours were spent on point "A" which shows in both Fig. 5 and 6. This is a 5-foot radius with 90° between input and output. It may be considered quite accurate. The other points determined in Fig. 6 are reasonably accurate. Not until after the points were plotted did it become apparent that a real effort should

(Continued on page 152)

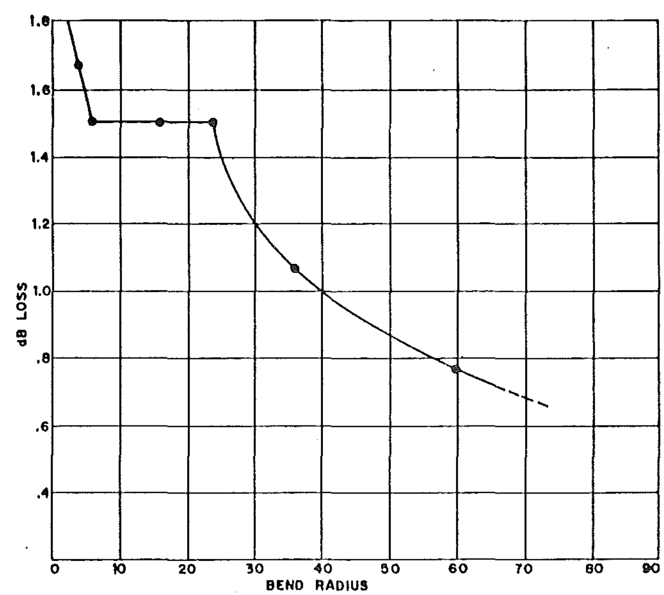


Fig. 6 – Loss incurred when the angle of the bend is held at 90° and the radius is varied.

G Line

(Continued from page 15)

have been put into making an accurate determination at a bend radius well beyond 5 feet. There is not enough information in the determined points to extrapolate much beyond the 5-foot point. The discontinuity shown at sharp bends in Fig. 6 is real and not an experimental error. It is very possible that at a bend radius of ten feet the loss may be acceptable.

Can something be done to the line to bring down the curvature loss? A number of tests were run, none of which was encouraging.

The propagation of power along the line does not take place at a velocity independent of the dielectric surrounding the wire.[3] This is easily demonstrated by setting up standing waves on the line and measuring the distance between nodes. For accuracy, twenty nodes were measured along the lines with the probe. The distance divided by ten gives the wavelength which is proportional to the propagation velocity. At 1296 MHz:

Enamel-coated line,
(free space velocity). λ = 9.1 inches

Enamel-coated line
with Teflon sleeving, λ = 9.05 inches.

Stripped coax line, λ = 8.3 inches.

Dielectric Loading

It seemed possible that loading the field with dielectric on the inside radius of a bend might reduce the loss. Bend radius was set at 12 inches and the total angle at 90°. The line was loaded with a flat strip of Teflon, 5/8 inch wide by 3/32 inch thick, on the inside of the bend. The loss increased. Loading the outside of the bend gave the same increase in loss.

A number of other tests were made around this bend. 7/8-inch coax was stripped of its jacket and shield; it was inferior to the stripped RG-8/U in all respects. RG-58/U was stripped and was found worthless in single strand, but was equal to the stripped RG-8/U if two strands were connected in parallel. The two strands were formed around the bend in the plane of the bend and perpendicular to the plane; no change was found. The strands were arranged with a varying number of twists around the bend, from test to test. There did appear to be a very slight improvement with 5 twists in the complete bend. Television 300-ohm Twin Lead was tried, placed in the bend both flat and twisted. The sleeved No. 12 enamel-coated wire was tried alone and in parallel strands and in a twisted configuration. Outside of the twisted pair of stripped RG-58/U there either was no change or there was a deterioration in efficiency around the bend. Just the same, I have a hunch that there is some way to take advantage of the velocity dependence on dielectric material to put the G line around a bend with far less loss than is presently experienced. In opposition to this, a lot of effort must have been expended in the past by a lot of people to solve this very problem, because it is the major fault of the G line. Run it straight, bend it gently and accept the loss, or forget it.

The final line arrangement here for field-pattern tests consists of 1 foot of RG-8/U foam coax plus 10 feet of copper-tubing, air-dielectric coax (loss 2.2 dB per 100 feet), plus 1-1/2 feet RG-8/U foam coax to launcher, and 75 feet of G line. Total loss in the system is 1.71 dB for the 87-1/2 feet. The G line itself can be lengthened or shortened with a Teflon sleeved No. 12 enamel wire, using a figure of 1.26 dB per 100 feet of line.

Conclusions

There is no question about the extremely low loss of the G line. It is simple to construct. There should be some commercially made wire products to take the place of the Teflon sleeved No. 12

[3] It is possible to visualize in a hazy sort of way what is happening on an antenna wire when it is radiating. It is not as easy to visualize what is happening on the G line. An *H* field appears when electrons move in a conductor; an *E* field appears when there is an unbalance of charges on a conductor; that is, the electrons appear at localized points on the wire and are not balanced by the positive ion charge on the adjacent molecules. The G line is free of charge unbalance or there would be an *E* field. The electrons are moving back and forth on the line as power flows from launcher to collector. It has to be a gentle action as if the line is really just guiding the power contained in the moving field. Taking a straight G line and slowly bending it does not disturb the input power, but bites rapidly into the output at the end of the line. The power lost must radiate at the bend, or all along the line, if standing waves are set up.

It is surprising to consider the number of approaches that suggest themselves when working on the line. Goubau felt the line would function best between 1500 and 3500 MHz. This would put 2400 MHz in a very favorable spot. Unfortunately I did not have this frequency available for the test. Those working at this frequency should give the line a try and let us know how it works. What will happen with different line sizes? Goubau took this into consideration theoretically and decided on No. 12 enamel line. Other sizes deserve a test. How much of the collector loss can be removed with a larger mouth on the horn? A horn with a wide mouth and greater included angle did not tune well here. A small horn right at the transmitter loaded as well as the bigger one, but it would not load at the end of 10 feet of 50-ohm coax. (The final amplifier here is probe coupled to the line and will match almost anything.) It was surprising how close objects could be brought to the line without reducing the output. Walk within a foot of the line, and the output dips. Place a piece of 2 × 4 dry lumber parallel to the line and it has to be closer than 6 inches to have any effect at all. The nylon slings used here were nice to use. They lessen my worry about absorption of power, but are far more elaborate than necessary. With support for the line every ten feet, dropping tension on the line put a ripple at every support point, and this showed immediately in the output reading. A tight line with a support at each end should be as good as, or better than, this multiple support system. When there are no standing waves on the line, dielectric washers and disks on the line have no readable effect on the output.

Some day, if nobody else will do it, I want to get back to bend testing of the line. Right now I want to use it. QST

enamel wire. It is a mistake to build the launcher and collector horns in a manner that forces them to pick up the line tension. The coax should be stripped of its jacket and shield for whatever extension is used from the apex of the cones to the line connection. The jacket should then be stripped from the braided shield for a distance allowing a metal-to-metal clamp right at the apex. Then the tension can be applied to the jacketed coax behind the horns. This floats the horns on the line and does away with heavy mounting brackets. The dielectric in RG-8/U is not a good weather-resistant material. In the final version here, a tight sleeve of Teflon was placed over the exposed dielectric for its entire 4-1/2 feet. This increased the diameter and interfered with tuning. Wrapping with light-gauge Teflon tape is a better approach.

Holding the line concentric with the horns is difficult though exact concentricity is not necessary. Small holes drilled at three or four places around the rim of the horn mouth allows tying the line to exact alignment with mono-filament nylon line. This is a help. Studying the G line without input and output in-line wattmeters is bound to be difficult. I think the line can be adjusted, however, with a power-reading meter at the load end. It is likely to be right when further adjustment does not improve the output.

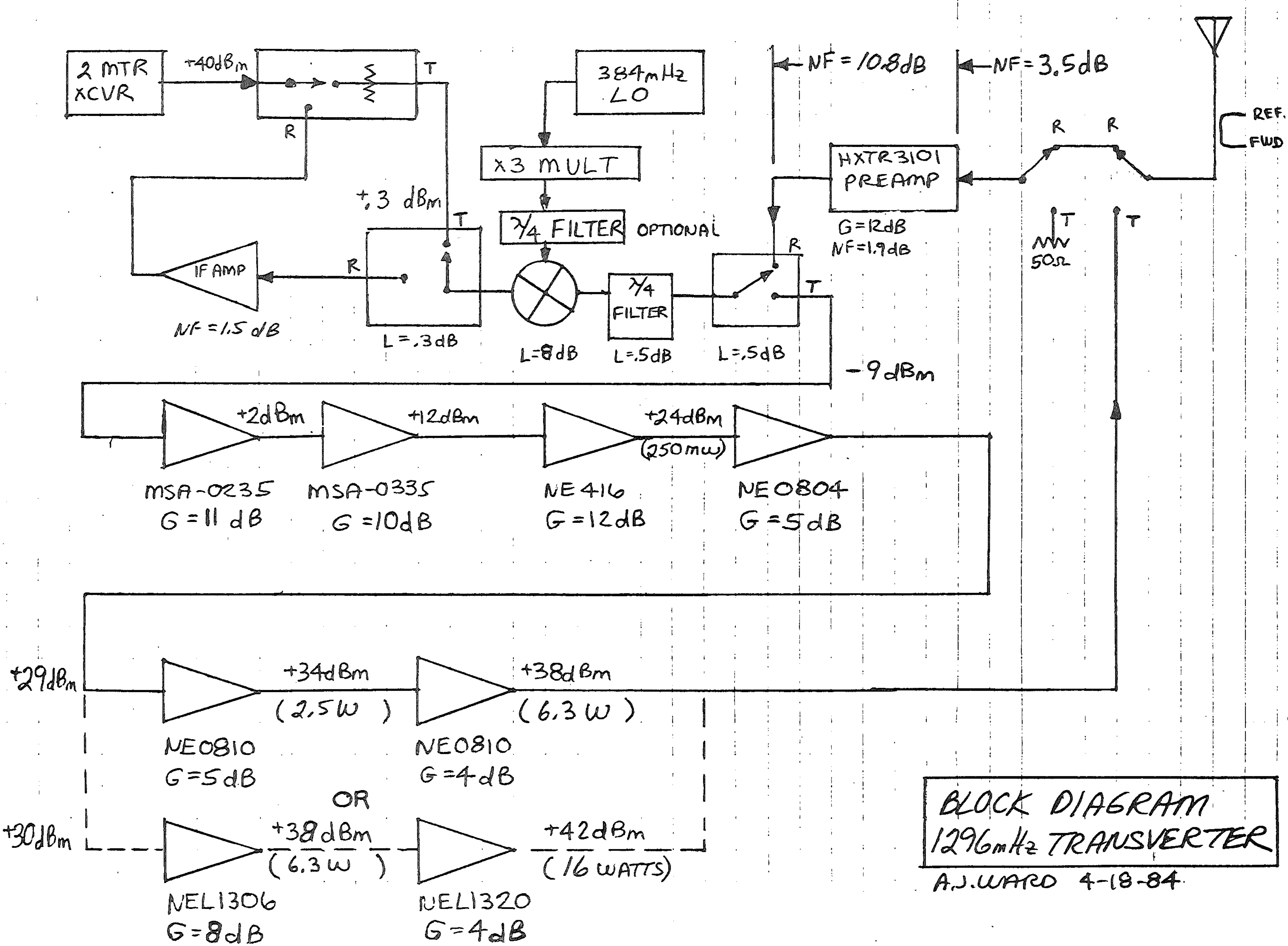
2304 LOOP YAGI UPDATE

by Kent Britain WA5VJB

The 2304 Mhz Loop Yagi was originally published in Sept 1981 QST by Bob Atkins. This article left off the element width dimension of 0.2 inchs.

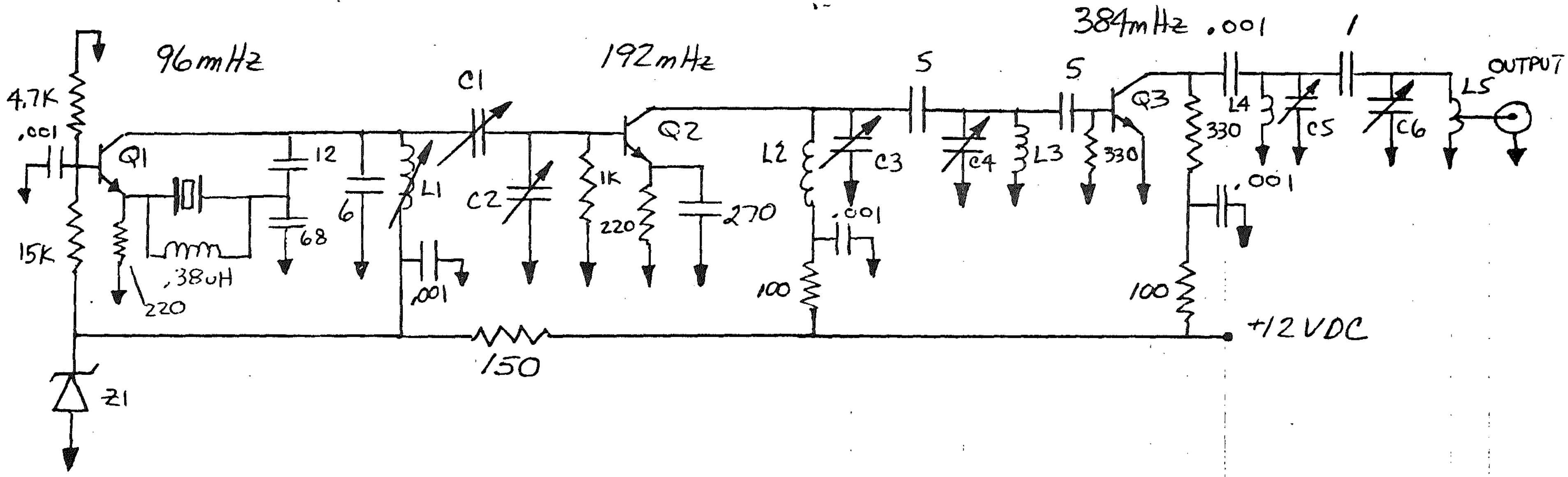
My 41 element version was assembled out of aluminum with a 2nd ring reflector replacing the screen reflector. Elements were formed by wrapping them around a D-cell flashlight battery and attatched to the boom using extremely small sheet metal screws. The driven element is brass and is directly soldered to the 0.141 inch semi-rigid coax. The finish antenna was painted with gray epoxy spray paint for corrosion resistance and low visibility.

At the 1982 CSVHF antenna contest the antenna measured 19.5 dbd gain comparing very favorably with the original copper version. For the 1983 CSVHF antenna contest I had 20,40 and 60 element versions measuring 17.5 dbi, 20dbi and 22 dbi respectively.



BLOCK DIAGRAM
1296mHz TRANSVERTER

A.J.WARD 4-18-84



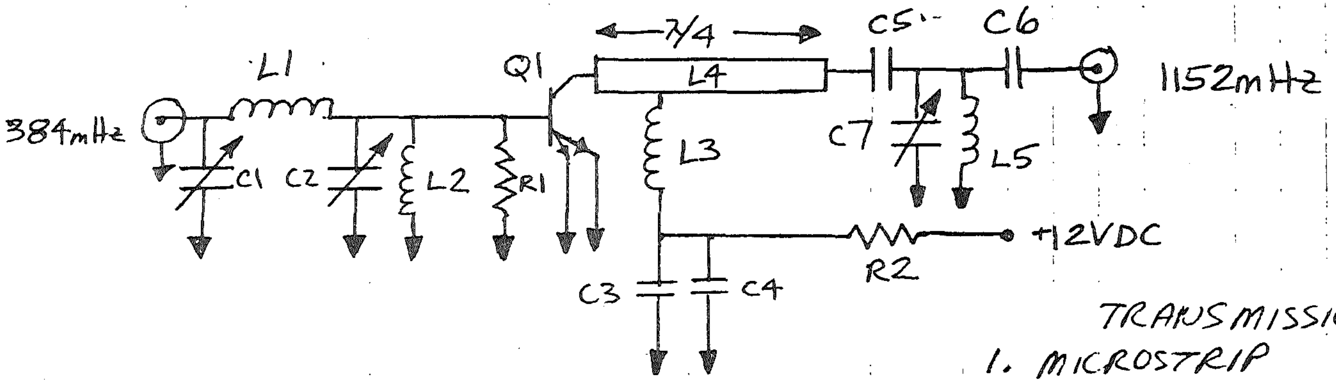
PERFORMANCE

1. 384mHz OUTPUT AT +7dBm
2. ALL UNDESIRED HARMONICS ARE -40dBC.

Q1, Q2	2N918, 2N3570, MPS3563, etc.
Q3	MRF901
Z1	1N757 9V ZENER DIODE
C1-C6	.8-10pf PISTON TRIMMER
L1	4 TURNS #24 ENAMEL WHITE CORE CLOSE SPACED
L2, L3	3 TURNS #14 .25" I.D. SPACED WIRE DIAMETER
L4	1 TURN #14 .25" I.D.
L5	1 TURN #14 .25" I.D. TAPPED ½ TURN

384mHz
LOCAL OSCILLATOR

A.J. WARD 4-18-84



TRANSMISSION LINE SUGGESTIONS

1. MICROSTRIP
   $\varepsilon_r = 2.2$
   LINE WIDTH = .050"
   Ground Plane ht = .062"
   LINE LENGTH ≈ 1.9"

2. REMOVE CENTER CONDUCTOR FROM .141" SEMI RIGID CABLE AND REPLACE WITH .010" DIA WIRE.
   CABLE LENGTH ≈ 1.7"

C1, C2, C7	.8-10pf PISTON TRIMMER
C3	.1ufd DISC CAP
C4, C5	30pf UNELCO CAP.
C6	2pf CAP
R1	820 Ω 1/8 WATT
R2	100 Ω 1/4 WATT
L1	5 TURNS #24 GUAGE .2" DIAMETER .36" LONG
L2	7 TURNS #24 GUAGE .2" DIAMETER .36" LONG
L3	3 TURNS #24 GUAGE .2" DIAMETER .6" LONG TAPPED .3" FROM Q1
L4	λ/4 100 Ω MICROSTRIP OR 100 Ω COAXIAL TRANSMISSION LINE
L5	.3" LENGTH OF #24 GUAGE WIRE FROM TOP OF C7 TO GROUND.
Q1	MRF901

P_{IN} = +4dBm

P_{OUT} = +6 to +8dBm

I_c = 24mA

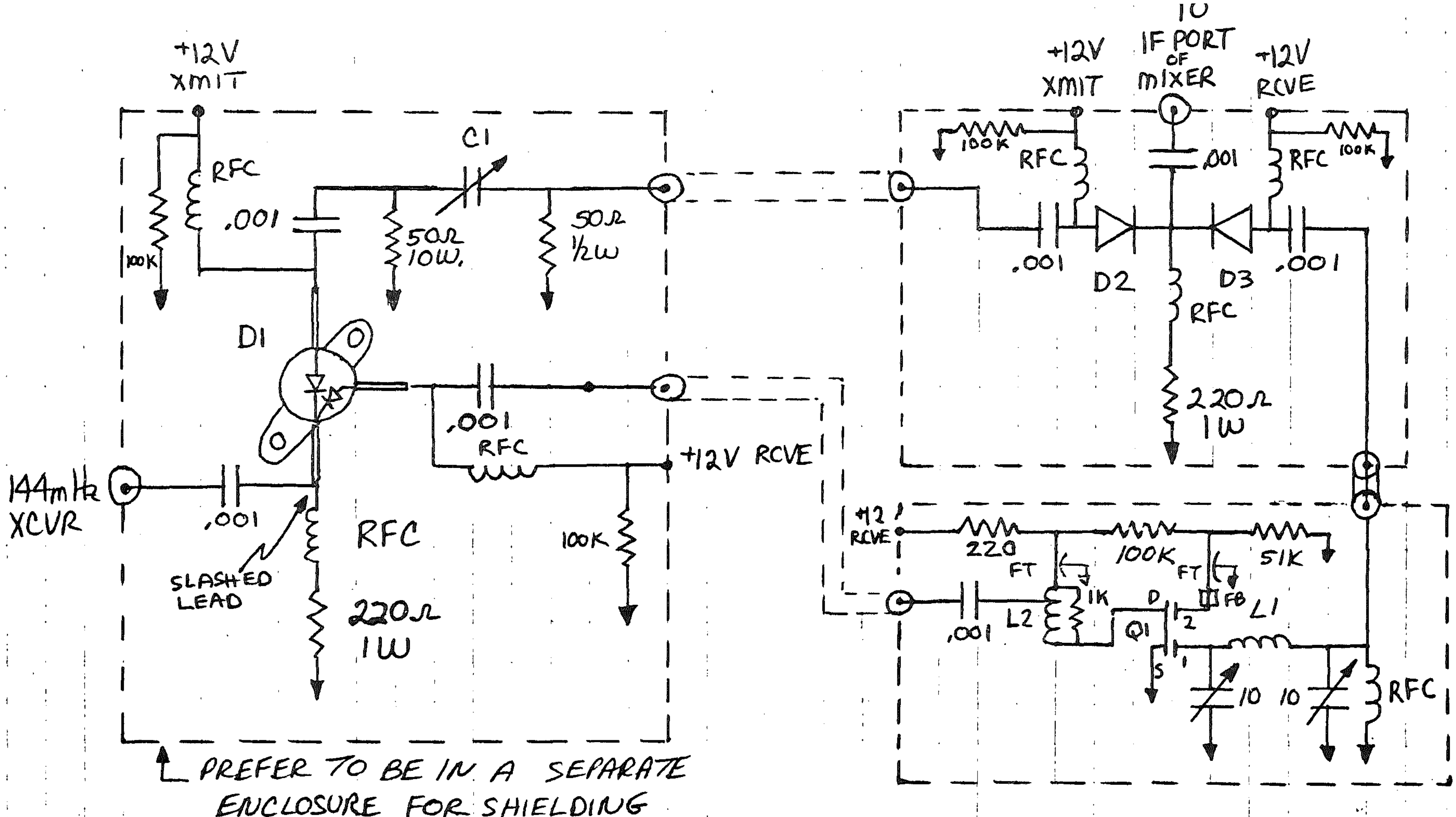
HARMONIC REJECTION

384mHz	-16dBc
768mHz	-30dBc
1536mHz	-23dBc

ORIGINAL DESIGN BY JOHN STANKUS KN5N

384 to 1152mHz MULTIPLIER

A.J.WARD 4-18-84



C1 TYPICALLY 1-2pf ADJUST FOR DESIRED DRIVE (0dBm) AT MIXER

D1 MA 8334-101 T/R SWITCH SERIES $10-$20

D2,D3 MA 47047, 47110, 47123 PIN SWITCHING DIODE ≈$2.00 OR H.P. 5082-3379 $1.60

Q1 TIS189, 3N211, 3N204, ETC.

L1 6 TURNS #18 .25" I.D. SPACED WIRE DIAMETER

L2 5 TURNS #18 .25" I.D. SPACED WIRE DIAMETER TAPPED 1 TURN UP FROM GROUND.

MA DISTRIBUTORS

- CECO COMMUNICATIONS, BROOKLYN, N.Y. (212) 646-6300
- ZEUS, PORTCHESTER, N.Y. (914) 937-7400
- ZEUS, ANAHEIM, CA (714) 632-6880

TRANSMIT/RECEIVE SWITCHING FOR 144mHz I.F.

A.J. WARD
4-22-84

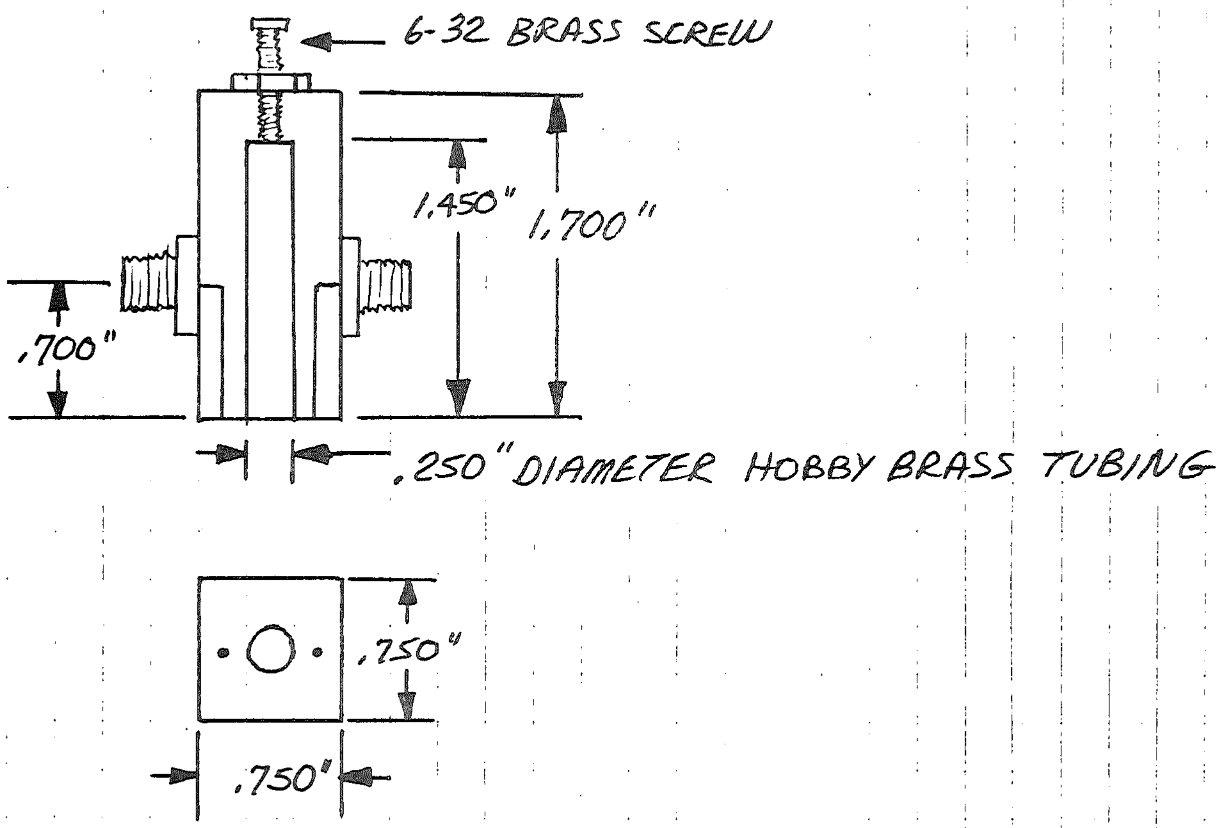
MANUFACTURER	MODEL	LO/RF mHz	IF mHz	MAX CONV. LOSS (dB)	COST	QTY
MINI-CIRCUITS	SRA-2	1-1000	5-500	8.5	$ 14.95	5-24
P.O. BOX 166	SRA-4	5-1250	5-500	8.5	16.95	5-24
BROOKLYN, N.Y.	SRA-5	5-1500	10-600	8.5	21.95	5-24
11235	SRA-12	800-1250	50-90	7.5	24.95	5-24
(212) 934-4500	SBL-1X	10-1000	5-500	9.0	5.95	1-4
VARI-L COMPANY	CM2	1200/1000	DC-1000	8.0	20.00	1-99
11101 EAST 51st Ave.						
DENVER, CO.						
80239						
(303) 371-1560						
ANZAC DIV	* MD173	5-1200	DC-1000	8.0	35.00	1-5
ADAMS RUSSELL						
80 CAMBRIDGE ST.	MD149	10-1500	DC-1500	7.5	42.00	1-5
BURLINGTON, MASS.						
01803						
(617) 273-3333						

* +17dBm LO, ALL OTHERS +7dBm

DOUBLE BALANCE MIXERS

WB5LUA
A.J. WARD
4-22-84
REV A

LOSS = 0.5dB
VSWR = 1.17:1
1dB B.W. = 30mHz
3dB B.W. = 56 mHz



FREQ.	ATTENUATION
1008mHz.	-18dB
1240mHz.	-7.5dB
1270mHz	-3.0dB
1480mHz	-20dB

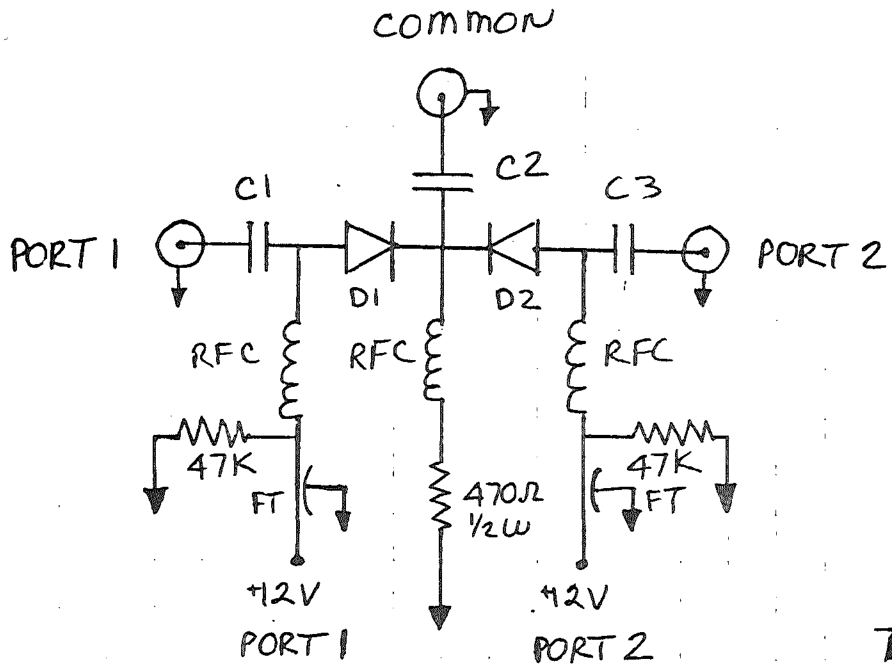
NOTES

1. COUPLING LOOPS ARE CENTERED BETWEEN RESONATOR AND CAVITY SIDE WALL AND ARE MADE OF #20 GUAGE ENAMEL WIRE
2. THE .750" DIMENSIONS ARE INSIDE DIMENSIONS OF CAVITY.
3. FOR RESONANCE AT 1296mHz THE 6-32 SCREW PROTRUDES .28" INTO THE RESONATOR.
4. CAVITY ALSO TUNES 1152mHz AND 1269 mHz.
5. USE OF CAPACITIVE PROBES WOULD ENHANCE LOW END ATTENUATION

1296mHz λ/4 CAVITY FILTER

A.J. WARD
4-17-84

SPDT RF SWITCH

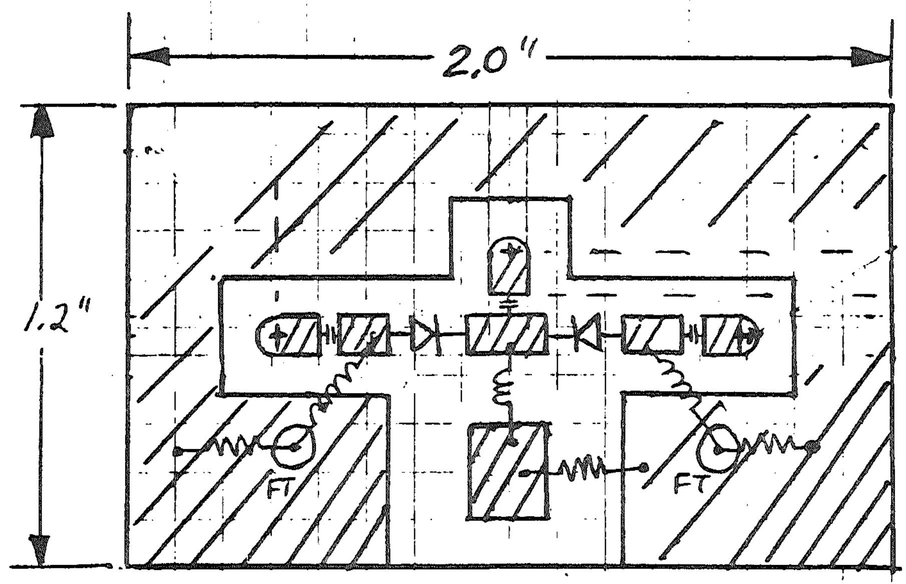


	1296mHz	2304mHz
C1, C2, C3	100pf CHIP	22pf CHIP
RFC	6T #24 1/8" I.D. CLOSEWOUND	4T #28 1/8" SPACED WIRE DIA.
D1, D2	5082-3379	5082-3379
FT	100-470pf	30pf

DIODES ARE MANUFACTURED BY HEWLETT PACKARD. COST IS $1.60 EACH.

ELECTRICAL PARAMETERS

	1296mHz	2304mHz
LOSS	.5dB	.6dB
ISOLATION	21dB	15.4dB
"ON" CURRENT	≈25mA	≈25mA

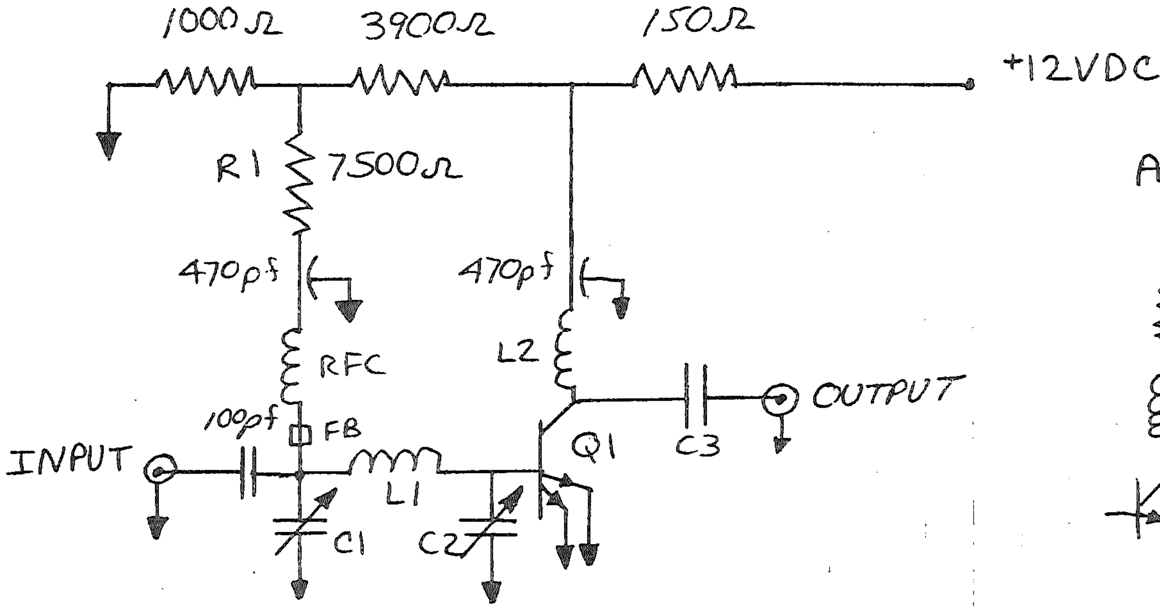


50Ω LINE WIDTHS ARE .10" WIDE
DIMENSIONS ARE 1X
DRAWING IS 2X
SLASHED AREA IS COPPER
PWB IS .062" G-10

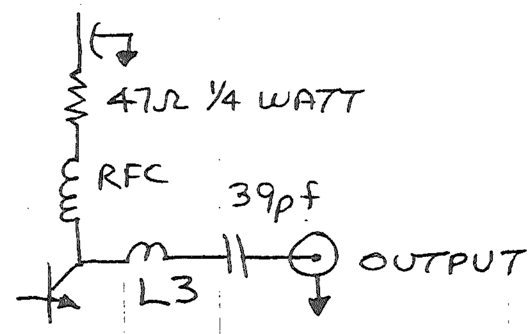
WB5LUA
A.J. WARD
4-17-84

NF = 1.9dB
G = 12dB

V_{CE} = 10V
I_C = 10mA



ALTERNATE OUTPUT CIRCUIT



RFC	6 TURNS #24 GUAGE 1/8" I.D. CLOSE SPACED
L1	.25" WIDE MICROSTRIP .2" ABOVE GROUND PLANE .5" LONG SUSPENDED BETWEEN C1 AND C2. C1 AND C2 ARE MOUNTED ON .75" CENTERS.
L2	2 TURNS #24 GUAGE 1/8" I.D. SPACED WIRE DIAMETER (≈ 9NH)
L3	1 TURN #24 GUAGE 1/8" I.D. (≈ 4NH)
C1, C2	.8-10pf PISTON TRIMMER
C3	4pf
Q1	HXTR 3101 MANUFACTURED BY HEWLETT PACKARD COST ≈ $4.00 EA.
R1	SHOULD BE VARIED TO OBTAIN OPTIMUM BIAS CONDITIONS OF Vce = 10V AND Ic = 10mA.

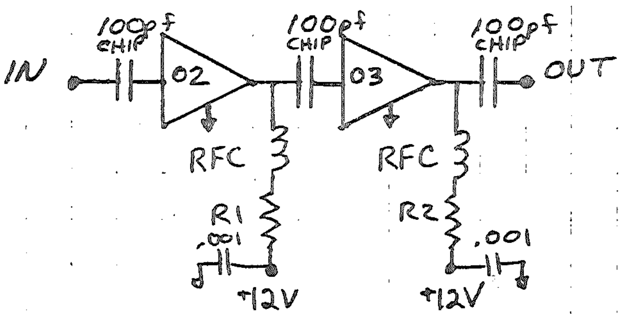
HXTR 3101 1296mHz PREAMPLIFIER

A.J. WARD
4-17-84

DEVICE	BIAS CURRENT	150mHz G	150mHz 1dBC.P.	1300mHz G	1300mHz 1dBC.P.	2300mHz G	2300mHz 1dBC.P.	3300mHz G	3300mHz 1dBC.P.
MSA-0335-22 (MSA 0304) $4 ea.	50mA	13dB	+16dBm	12dB	+12dBm	11dB	+5dBm	8dB	≈ +2dBm
MSA-0235-22 (MSA0204) $4 ea.	50mA	14dB	+14dBm	13dB	+10dBm	12dB	+6dBm	8dB	≈ +2dBm
MSA-0135-22 (MSA0104) $4 ea.	20mA	19dB	+5dBm	16dB	+1dBm	12dB	≈ -3dBm	9dB	≈ -6dBm
0135/0235/0335	120mA	46dB	+16dBm	41dB	+12dBm	35dB	+5dBm	25dB	≈ +2dBm
0235/0335	100mA	27dB	+16dBm	25dB	+12dBm	23dB	+5dBm	17dB	≈ +2dBm

(SUMMARY OF DATA SHEETS)

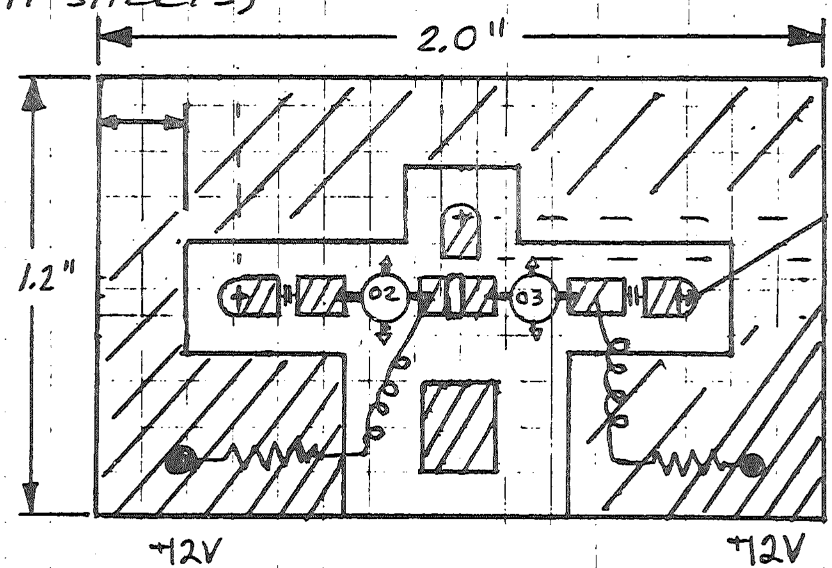
2 STAGE AMPLIFIER EXAMPLE
1300mHz DESIGN



RFC 6 TURNS #24 G. ENAMEL CLOSE WOUND 1/8" I.D.
R1 220Ω 1/2 W.
R2 150Ω 1 W.

ACTUAL PERFORMANCE

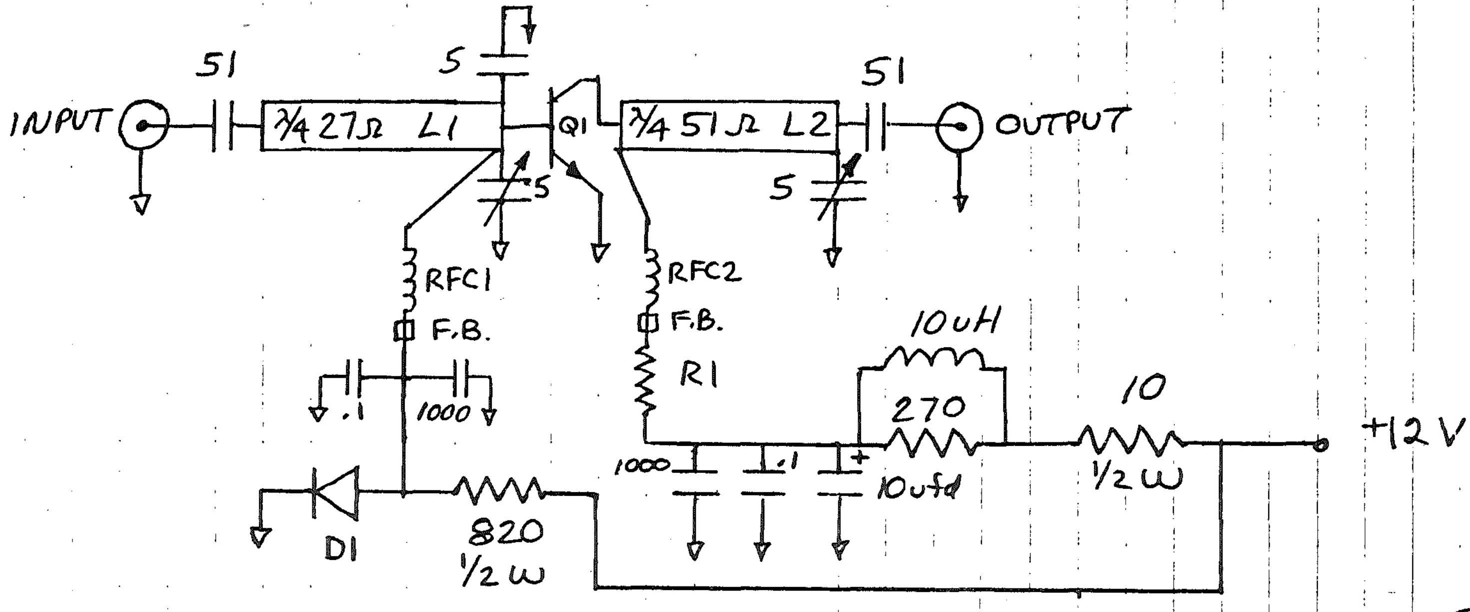
	GAIN	1dBC.P.
1300mHz	21dB	+13dBm
2300mHz	14dB	+7dBm (RFC NOT OPTIMUM)



50Ω LINE WIDTHS ARE .10" WIDE
DIMENSIONS ARE 1X
DRAWING IS 2X
SLASHED AREA IS COPPER
PWB IS .062" G-10

AVANTEK MONOLITHIC MICROWAVE INTEGRATED CIRCUITS

A.J. WARD 4-17-84 REV A



Q1 NE41620 POWER TRANSISTOR (C.E.L.)
D1 1N4001 OR 1N914
R1 22Ω 1/2 WATT
RFC1, RFC2 4 TURNS #24 GUAGE 1/8" I.D., LENGTH = .375"

I_Q = 25mA

G = 12dB

P(1dBCP) > +24dBm (250mW)

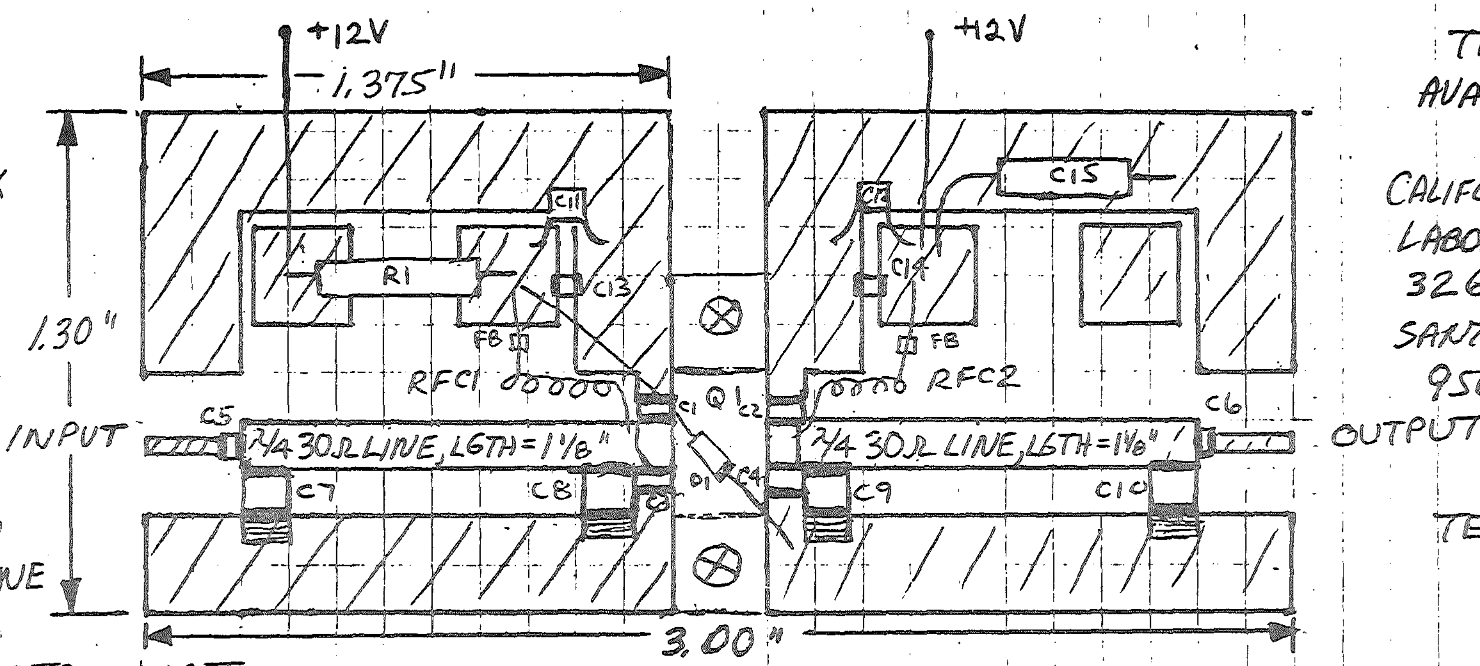
NE41620 1296mHz AMPLIFIER

WB5LUA
A.J. WARD
1-7-84

DRAWING 2X
DIM. 1X

PWB ⇒
.031" G-10

FOIL ALL
EDGES TO
GROUND PLANE



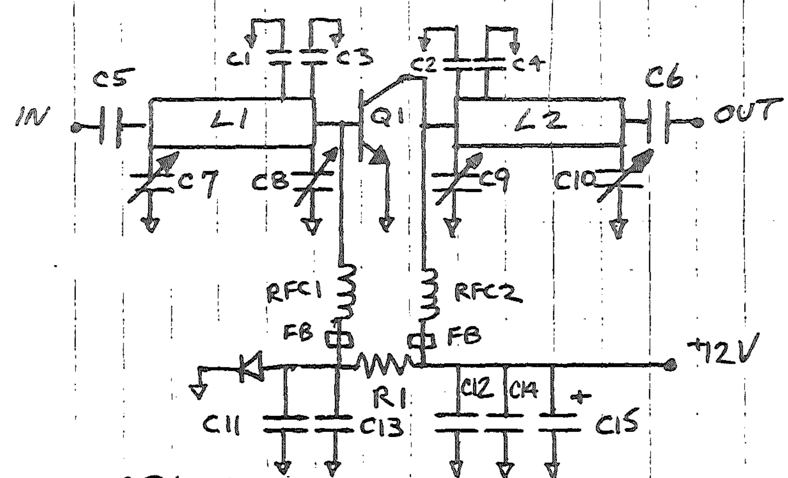
TRANSISTORS
AVAILABLE FROM:

CALIFORNIA EASTERN
LABORATORIES, INC.
3260 JAY ST.
SANTA CLARA, CA.
95050

TEL: 408-
988-3500

PARTS LIST

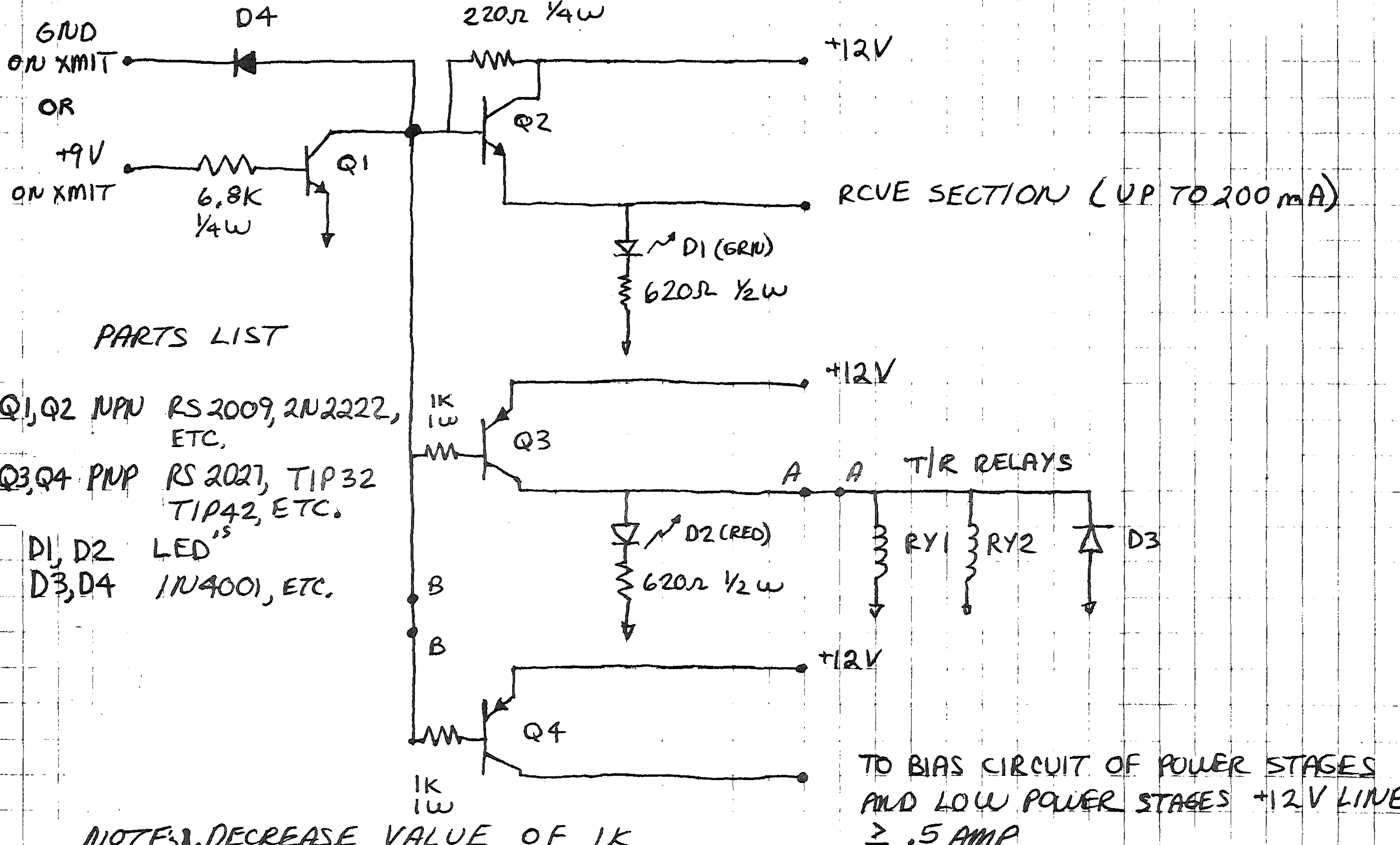
C1, C2, C3, C4	3.6-5.0pf CHIP CAP.
C5, C6, C13, C14	100pf CHIP CAP.
C7, C8, C9, C10	.8-10pf PISTON TRIMMER
C11, C12	.01ufd CAP.
C15	10ufd ELECTROLYTIC CAP.
RFC1, RFC2	4 TURNS #24 GUAGE ENAMEL WIRE CLOSE SPACED
D1	1N4001 OR EQUIV.
R1	220Ω 1W FOR NEL1306 180Ω 2W FOR NEL1320



	NEL130681-12	NEL132081-12
Pout @1dB C.P.	8 WATTS	>15 WATTS
Gain @1dB C.P.	8 dB	4.5 dB
COLLECTOR EFF.	55%	56%
IQ	30mA	150mA

NEL1306/NEL1320 1296mHz
POWER AMPLIFIER
(PRELIMINARY)

AJWARD 4-21-84 REVA



PARTS LIST

Q1, Q2	NPN	RS 2009, 2N2222, ETC.
Q3, Q4	PNP	RS 2027, TIP32 TIP42, ETC.
D1, D2		LED's
D3, D4		1N4001, ETC.

NOTES: 1. DECREASE VALUE OF 1K BASE RESISTORS TO INCREASE CURRENT CAPACITY THROUGH Q3 AND Q4

2. BREAK AT B-B TO ALLOW FOR CONTROL FROM EXTERNAL FINAL AMPLIFIER TO GIVE REQUIRED DELAY

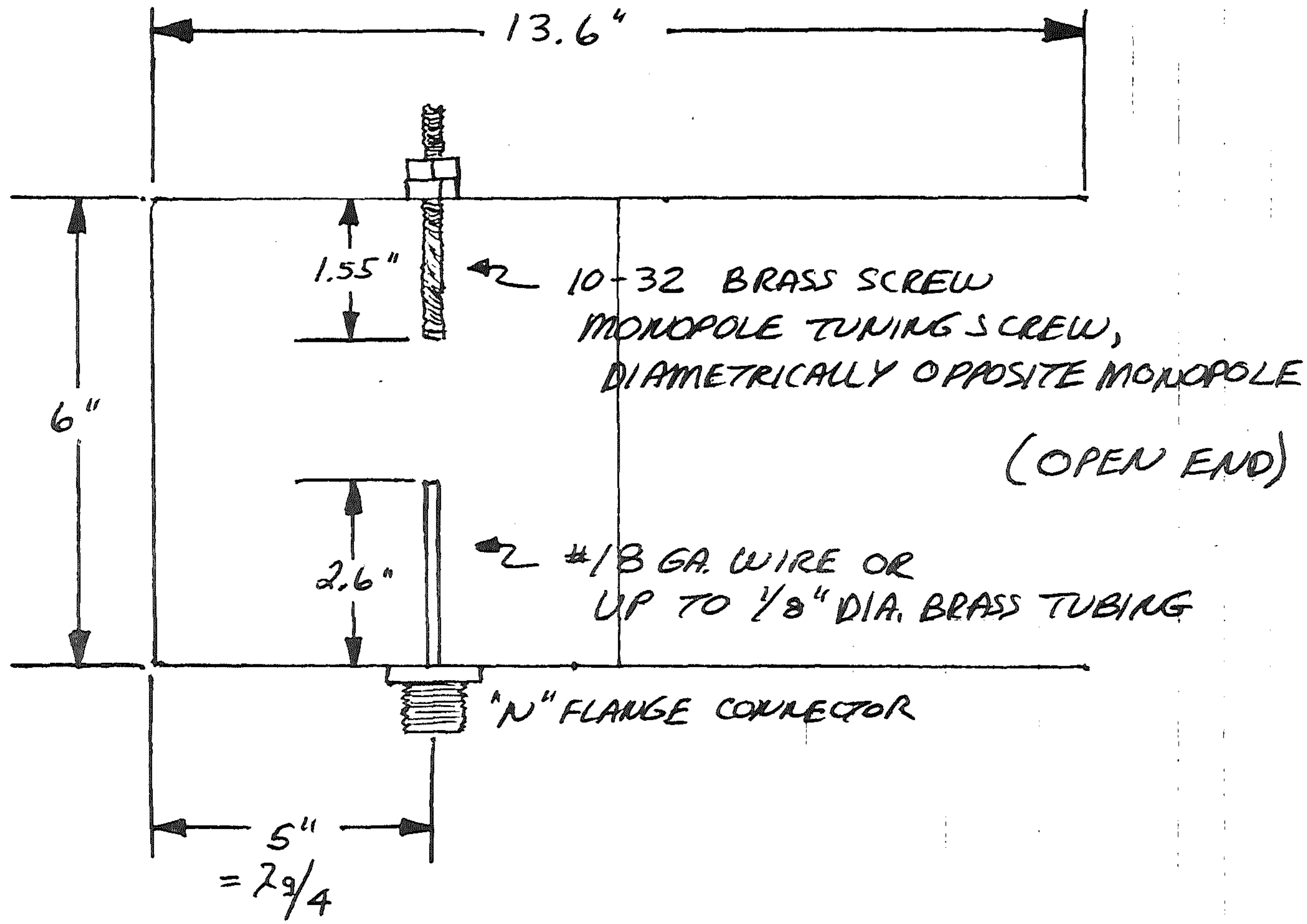
TRANSVERTER T/R SWITCHING

A.J. WARD
7-8-84

PRINTED CIRCUIT BOARDS AVAILABLE FROM NORTH TEXAS MICROWAVE SOCIETY

- SPDT SWITCH
- MONOLITHIC AMPLIFIER
- WB9SNR NE0800 SERIES AMPLIFIERS
- NEL1300 SERIES AMPLIFIERS
- NE416 AMPLIFIER
- 2304mHz BALANCED MIXER
- MRF901 1296mHz PREAMPLIFIER
- NE645 2304mHz PREAMPLIFIER

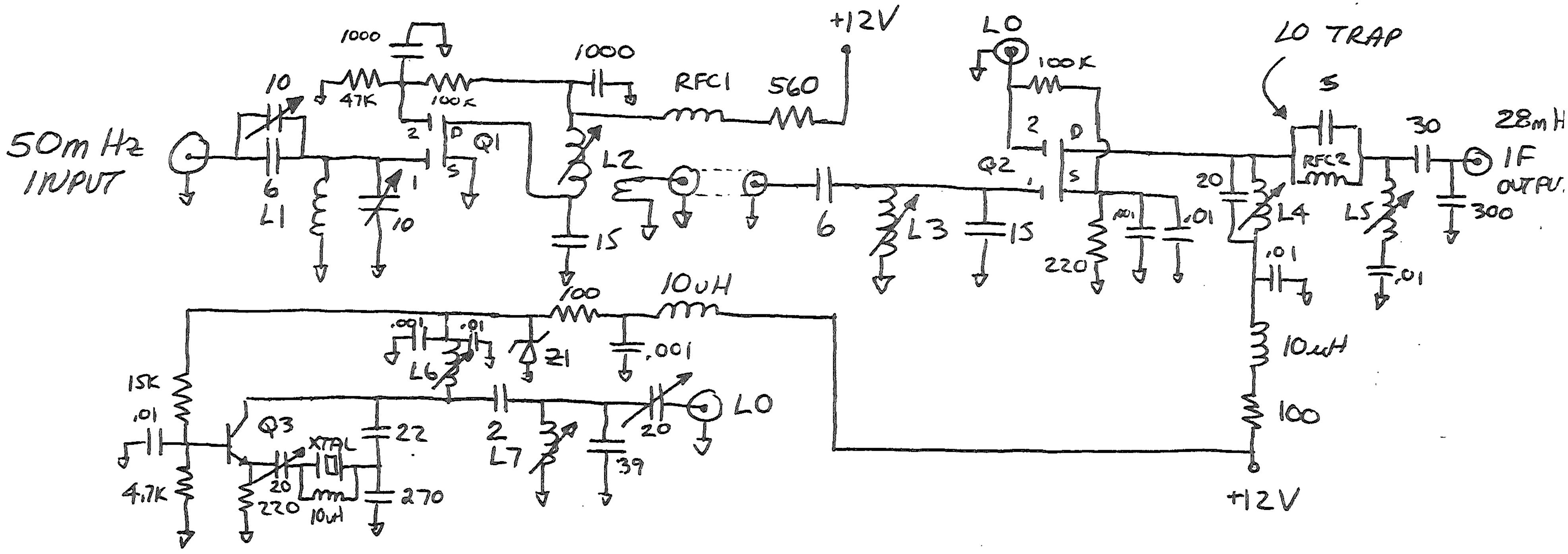
SEE WA5TKU OR WB5LUA



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



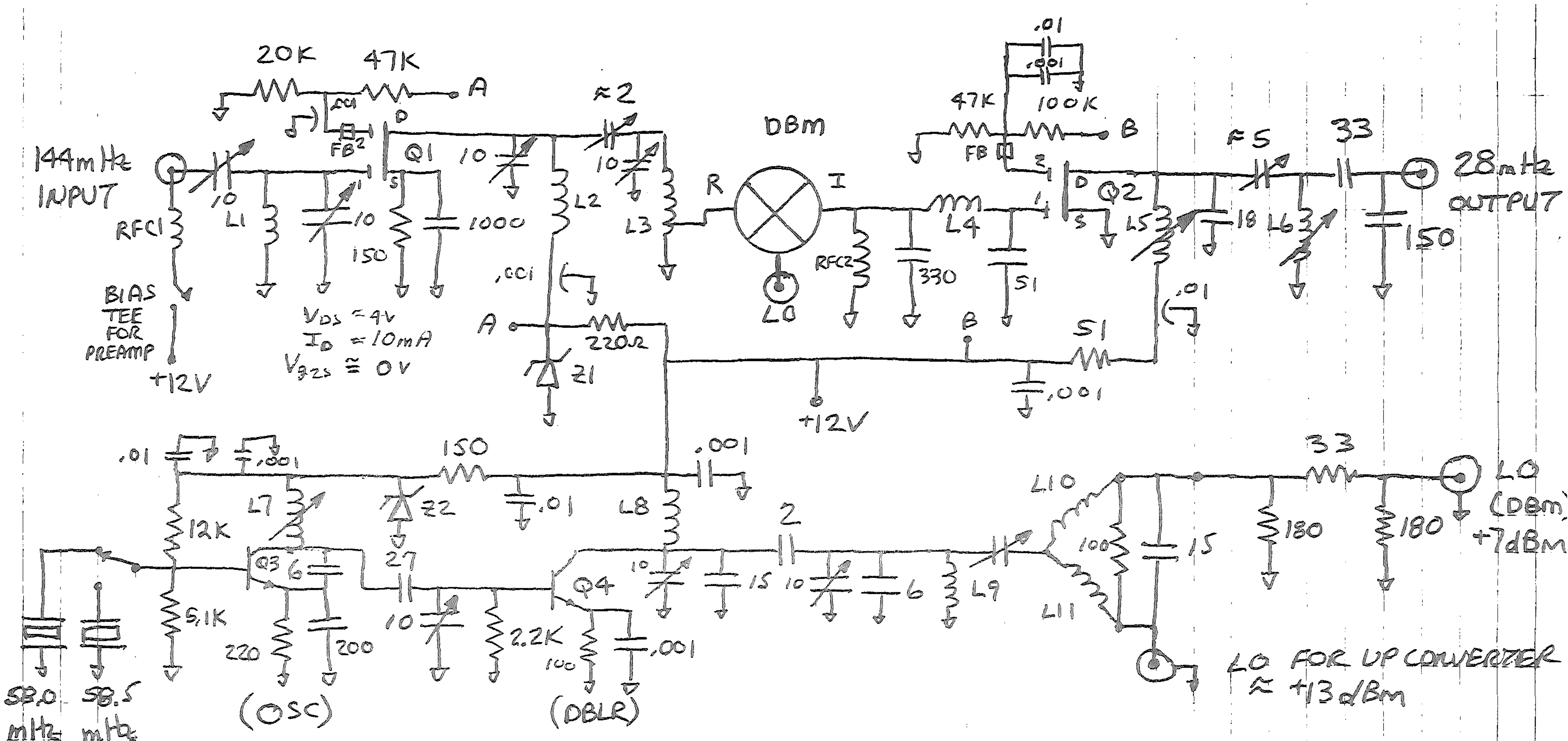
L1	8T	#16 SPACED WIRE DIA. .5" I.D.
* L2	6T	#28 SPACED WIRE DIA, WHITE CORE .25" I.D.
L3	10T	#28 CLOSE SPACED WHITE CORE SLUG .25" I.D.
L4	12T	#28 CLOSE SPACED WHITE CORE SLUG .25" I.D.
L5	12T	#28 CLOSE SPACED WHITE CORE SLUG .25" I.D.
L6	15T	#28 CLOSE SPACED GRN CORE SLUG .25" I.D.
L7	15T	#28 CLOSE SPACED GRN CORE SLUG .25" I.D.
Q1, Q2	TIS189, C3T225A, 3SK48, 3N204, 3N211	
Q3	2N918	
Z1	1N757 9V ZENER DIODE	
XTAL	22mHz	

N.F. MIXER ONLY = 6.5dB
N.F. PREAMP ≈ 1dB

50mHz CONVERTER

A. J. WARD
4-17-78

* SECONDARY IS 1 TURN HOOKUP WIRE.

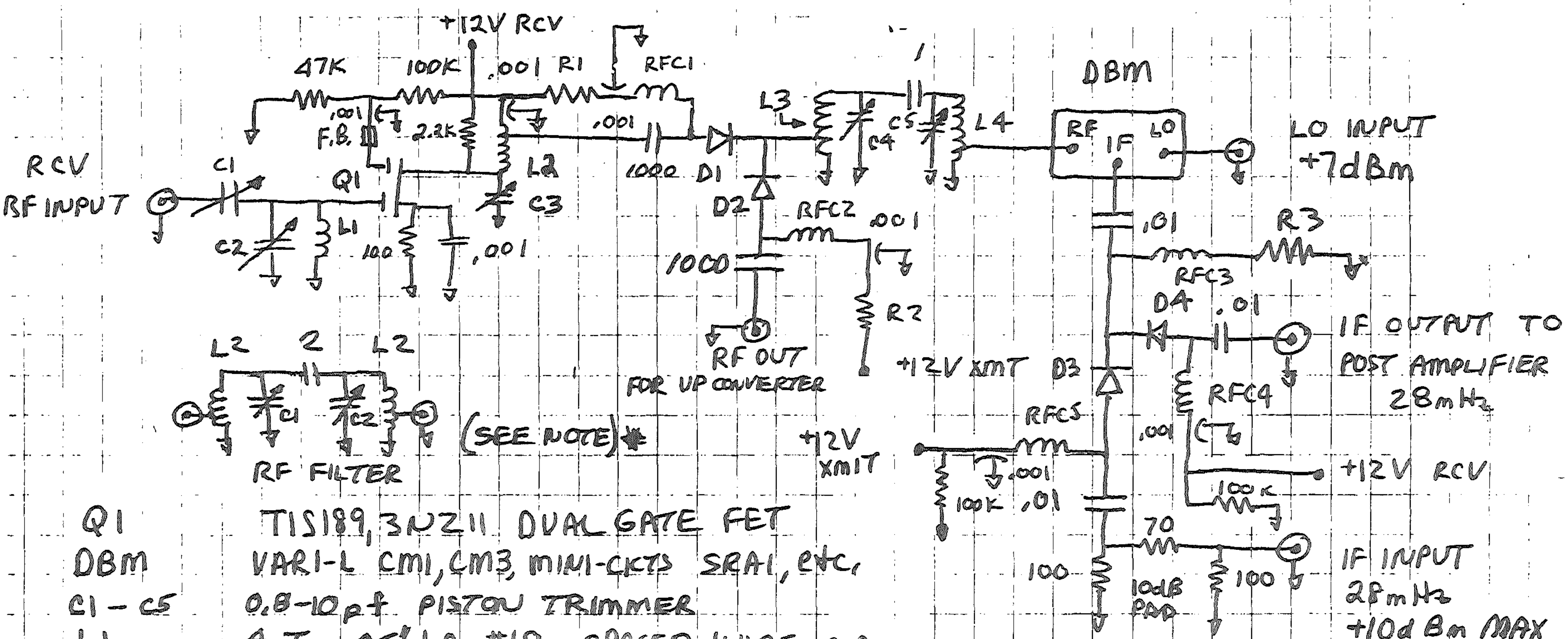


N.F. RF AMP = .5dB
N.F. CONV = .8dB

Q1	NE41137 DUAL GATE GaAs MESFET
Q2	3N211, 3N204 ETC (DUAL GATE FET)
Q3,Q4	2N2369, 2N918, 2N3570, ETC (BIPOLAR)
L1	6 TURNS #24GA .25" I.D. .5" LGTH.
L2,L3	5 TURNS #16GA .25" I.D. S.W.D. - TAP L3 1T FROM GND
L4	9.5 TURNS #28GA .25" I.D. WHITE FORM CLOSE SPACED
L5,L6	11 TURNS #28GA .25" I.D. WHITE FORM CLOSESPACED
L7	7 TURNS #28GA .25" I.D. WHITE FORM CLOSESPACED
L8,L9	7 TURNS #24GA 1/8" I.D. S.W.D.
L10,L11	4 1/2 TURNS (SAME AS L8,L9)
Z1	1N752 ZENER (5.6V)
Z2	1N757 ZENER (9.1V)
RFC1	1uH RFC
RFC2	22uH RFC
DBM	CM-1, SRA-1, ETC

144 mHz RECEIVE CONVERTER

AJWARD
7-10-84

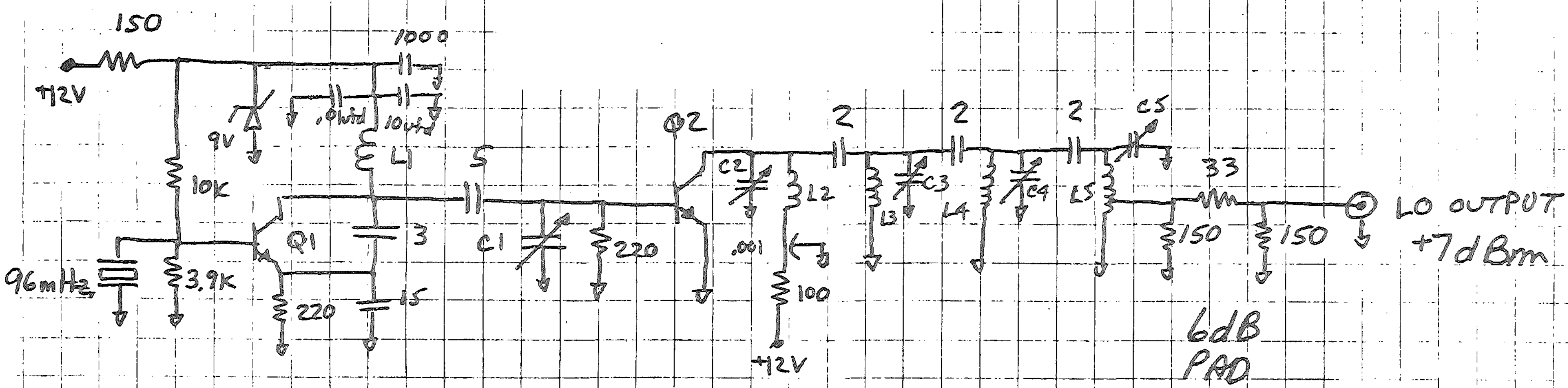


Q1	TIS189, 3NZ11 DUAL GATE FET	
DBM	VARI-L CM1, CM3, MINI-CKTS SRA1, etc.	
C1 – C5	0.8–10pf PISTON TRIMMER	
L1	4T .25" I.D. #18 SPACED WIRE DIA.	
L2, L3, L4	3T .25" I.D. #18 SPACED WIRE DIA., TAPPED 1T UP FROM GROUND	
RFC1, 2	.38 – .47uH RF CHOKE	
RFC3, 4, 5	2.7uH RF CHOKE	
D1, D2	47110 MICROWAVE ASSOCIATES VHF/UHF PIN DIODE OR EQUIV.	
D3, D4	SAME AS D1, D2 (ALSO TRY 47047, 47123) OR HP5082-3379 WITH	
R1, R2, R3	220Ω 1 WATT RESISTOR	R1, R2, R3 470Ω 1W

220mHz PREAMPLIFIER / LOW LEVEL TRANSVERTER

* RF FILTER USES COMPONENTS C1, C2, AND L2 FROM ORIGINAL LIST ABOVE. RF FILTER IS USED BETWEEN LOW LEVEL XVTR AND TRANSMIT POWER STAGES TO ENHANCE IMAGE AND LO REJECTION

A.J. WARD
12-10-83
REV A 1-3-84



Q1	2N3572, 2N918, etc
Q2	2N3866
L1	5T #18 .25" DIA. FORM - GREEN SLUG
L2, L3	4T #14 .25" AIR WOUND - SPACED WIRE DIAMETER
L4	3T same as L2, L3
L5	4T same as L2, L3, tap 1 turn from cold end.
C1-C5	0.8-10 pf PISTON TRIMMER

SPECIFICATIONS

POUT @ 192mHz = +13dBm w/o PAD

96 mHz DOWN GREATER THAN 60 dBC
288 mHz " " " 50 dBC
384 mHz " " " 45 dBC

NO OTHER SPURIOUS ~~ABOVE~~ 384mHz. LESS THAN -60dBC

192 mHz L.O.
FOR 220mHz CONV.

AJWARD
8-3-82
12-4-83 DRAWN

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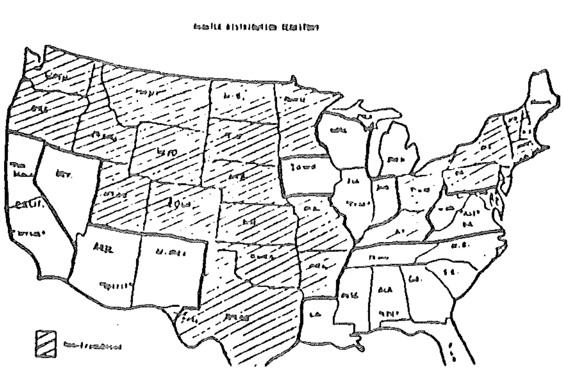

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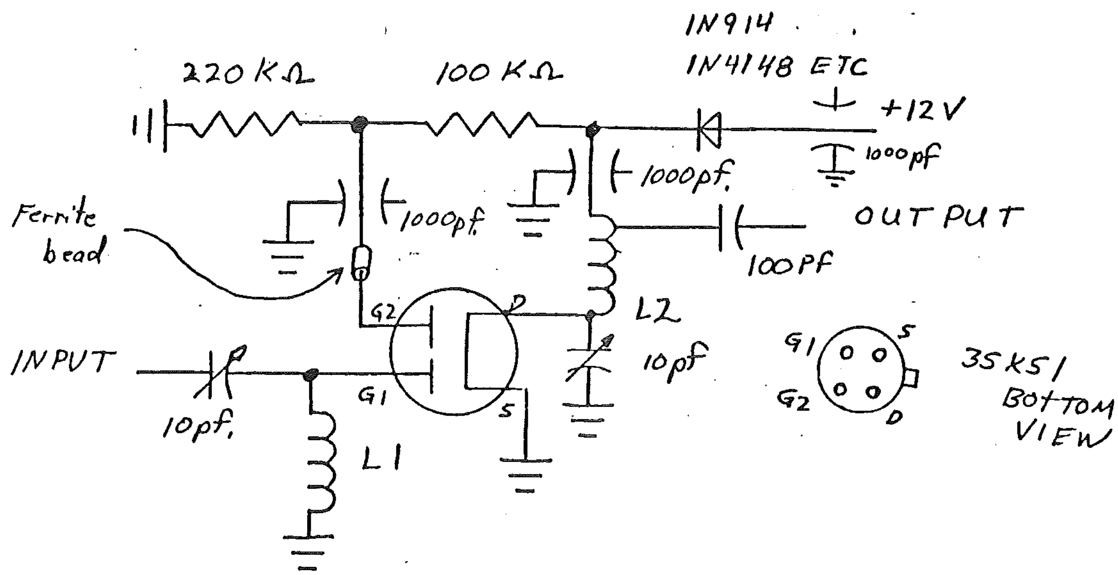
3SK51



L1 144 MHz 8 Turns
220MHz 5 Turns

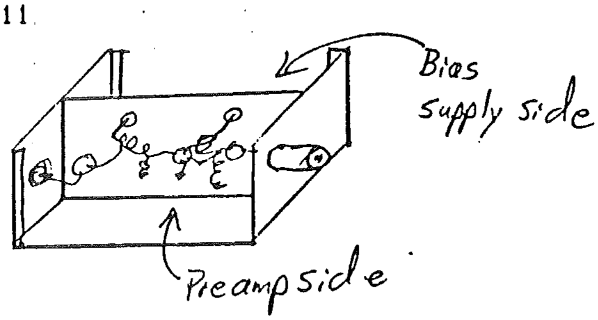
L2 144 MHz 8 Turns
Tap at 1 Turns
220 MHz 5 Turns
Tap at ½ Turn

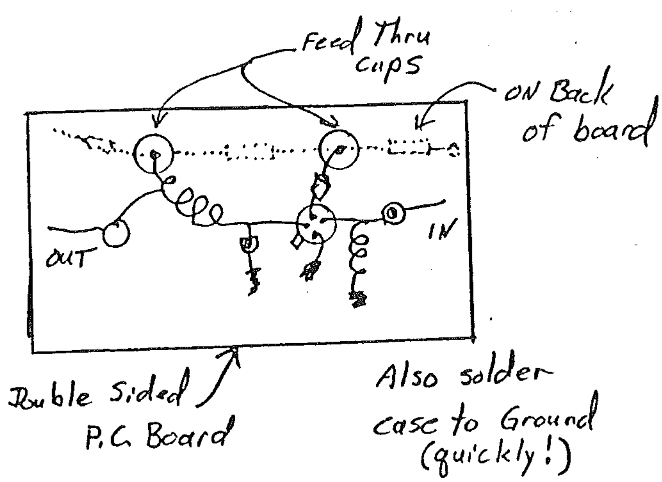
All coils 3/16" Diameter
½" length
18 guage solid
Copper Wire.

On an HP342 Noise Figure Meter these units have measured as low as 1.3 db N.F. on 144 and 1.6 db NF on 220 MHz with 1.5 and 2.0 being typical.

Devices usable in this circuit from most to least desirable.

3SK48
3SK51
3N204
3SK40
3N211

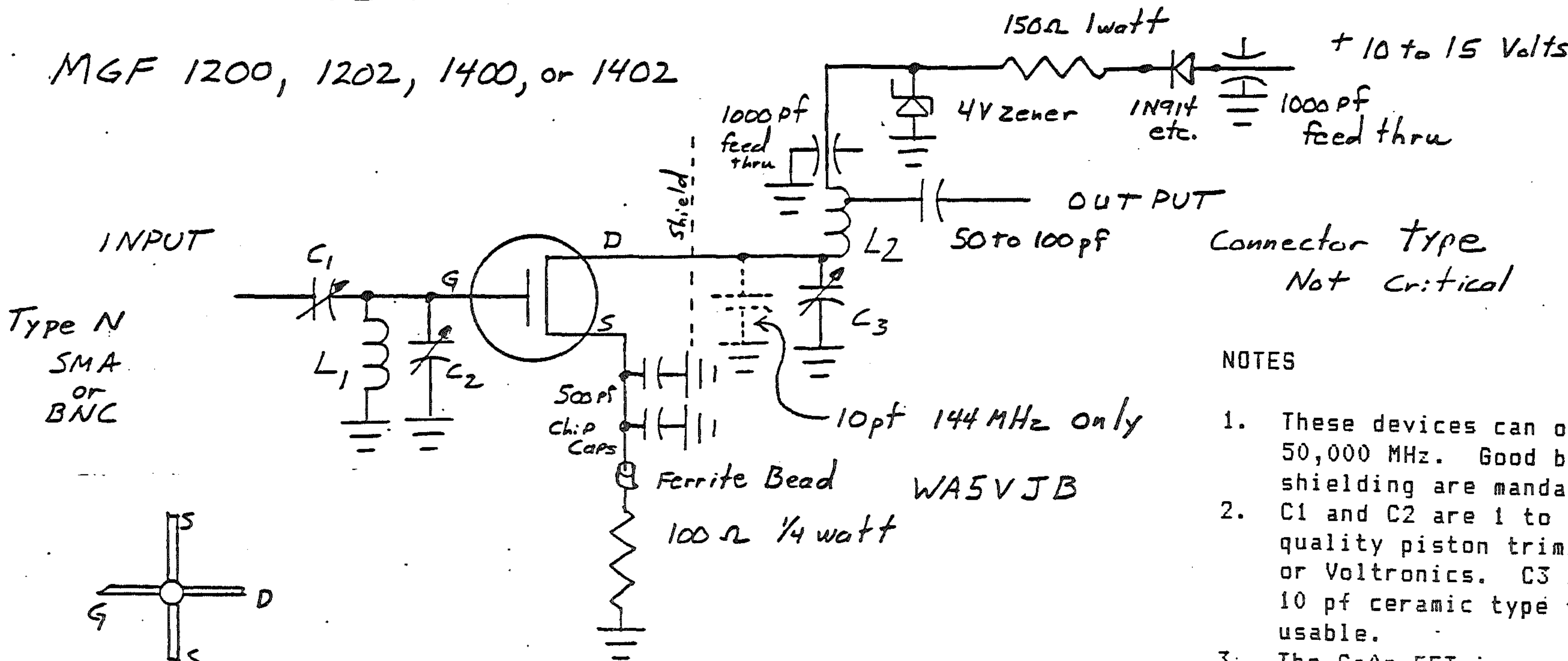


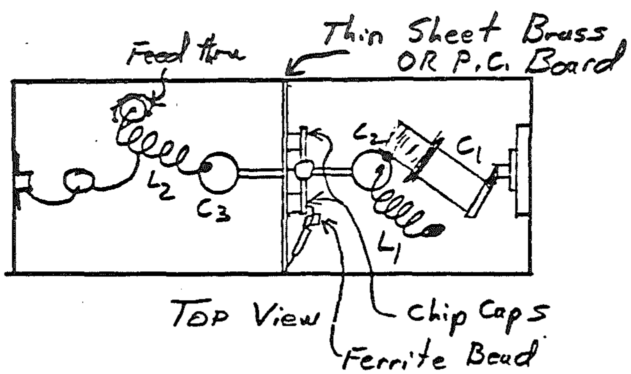


WA5VJB

Very Low Noise Pre-amp

MGF 1200, 1202, 1400, or 1402





NOTES

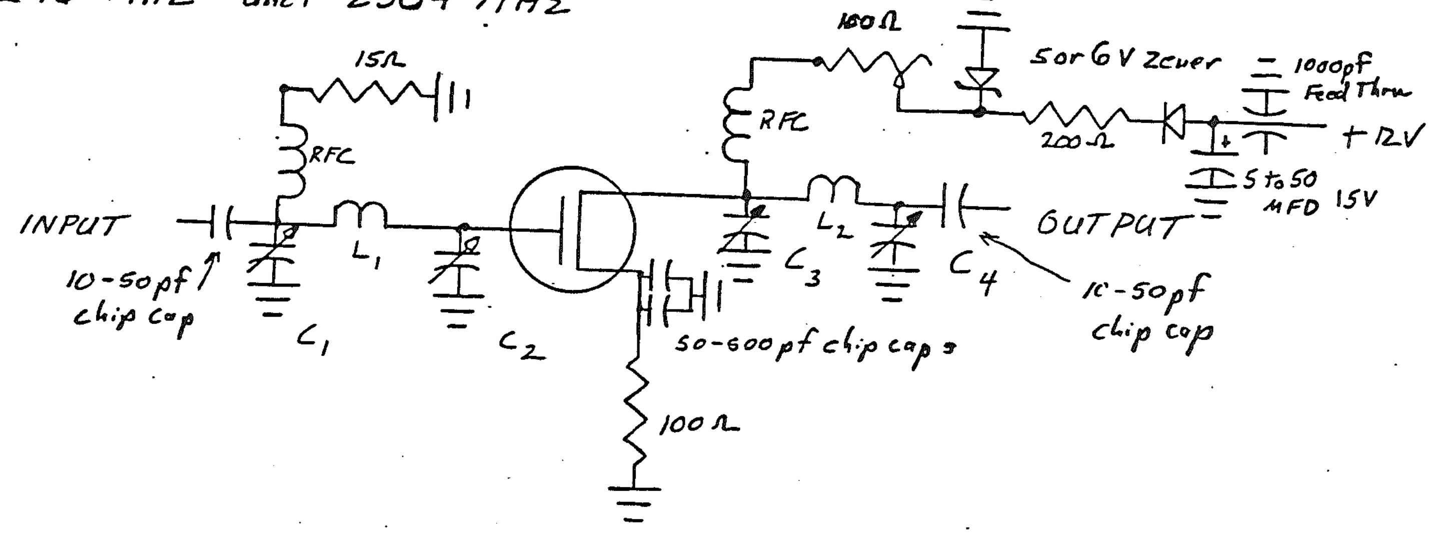
1. These devices can oscillate up to 50,000 MHz. Good bypassing and shielding are mandatory.
2. C1 and C2 are 1 to 10 pf high quality piston trimmers, Johanson or Voltronics. C3 is not critical, 10 pf ceramic type trimmers are usable.
3. The GaAs FET is mounted thru a hole in the shield , keep the chip caps close.
4. Similar Dexcel and NEC devices work well in this circuit.

	144	220	432	
L1	9T	6T	2.5T	all 3/16 DIA
L2	6T	4T	2T	all 3/16 DIA
tap at	1.5T	1T	0.5T	

18 TO 22 ga Solid Copper Wire.

WA5VJB

1296 MHz and 2304 MHz



1296 L_1 & L_2 Stripline .8" long, .25" wide, .2" above Ground

C_1 – C_4 1pf to 10pf Piston trimmers

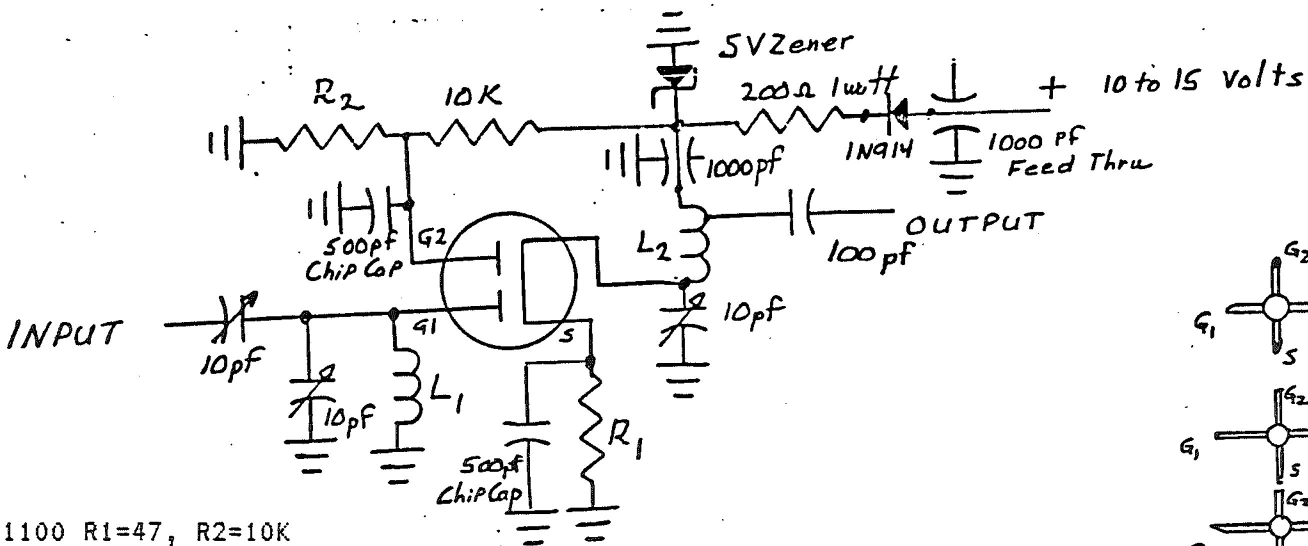
2304 L_1 & L_2 Stripline .5" long, .25" wide, .25" above ground

C_1 – C_4 .3pf to 3pf Piston trimmers

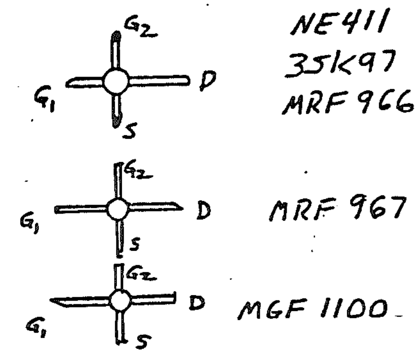
RFC's 6 turns 1/8" dia #20 wire/enameled close spaced

WA5VJB

Dual Gate:



WA5VJB



NE411, 3SK97 and MGF 1100 R1=47, R2=10K
MRF 966/967 R1=100, R2=4.7K

MGF1100 3SK97	L1	L2	L2 TAP	MRF 966 MRF 967	L1	L2	L2 TAP
144	5T	7T add 10pf accross L2	1T		12T	8T add 10 pf accross L2	2T
220	3.5T	4T	0.5T		8T	5T	1.5T
432	1.5	2T	0.5T		4T	2T	0.5T

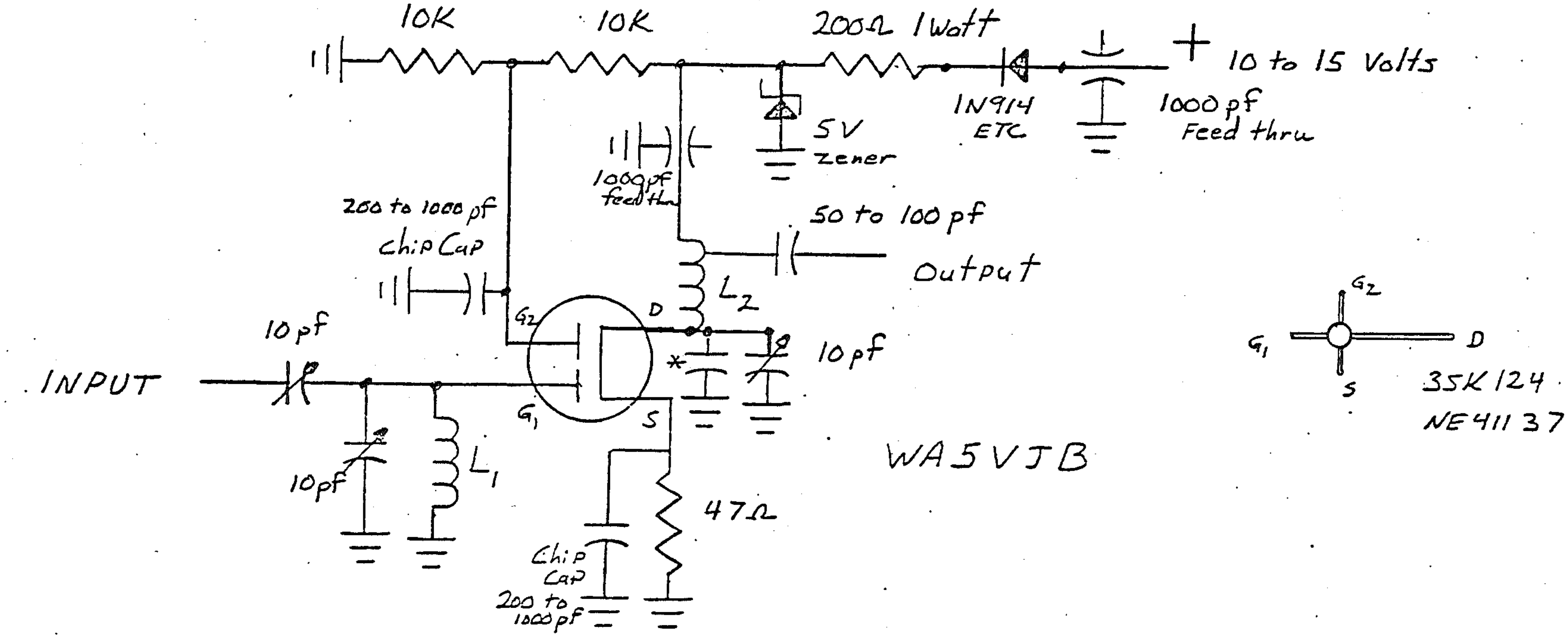
NE411/3SK124 L1.

144	7T
220	5T
432	2.5T

WA5VJB

Use 3SK97 info for L2.
All coils are 18 to 22 Ga solid Copper wire, 1/4 inch diameter.

NE 41137 / 3SK124 GaAs FET

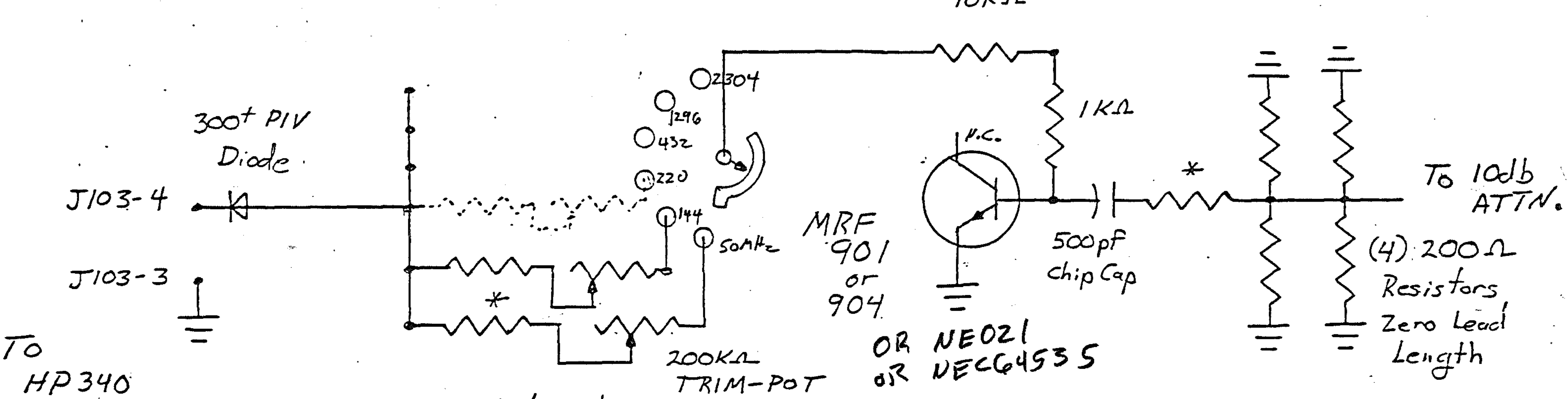


	L_1	L_2
144 MHz	7 turns	7 turns tap at 2 turns + * 10pf cap
220 MHz	5 turns	5 turns tap at 1½ turns
432 MHz	2½ turns	2 turns tap at 1 turn

WA5VJB

NOISE SOURCE

NOTE: The 1K resistor on the base of the transistor is really being used as an RF choke.



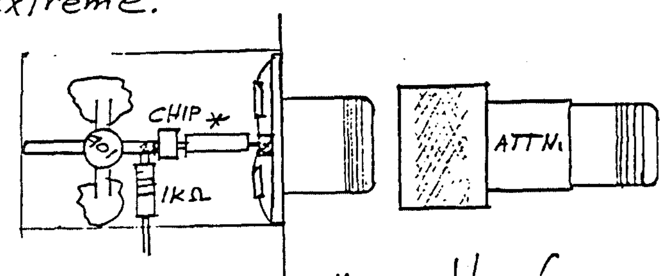
* Selected Value
0Ω to 100KΩ
should Trim-pot
reach extreme.

The current control on the NF Meter itself will have no effect.

* Selected Value depending on ATTN: Value

0Ω - 20db Pad
270Ω - 10db Pad

The 50 - 144 - 220 range can be a single positioin with less than 0.5 db error.



Max usable frequency limited by quality of the Attn. Typical 2-5 GHz..

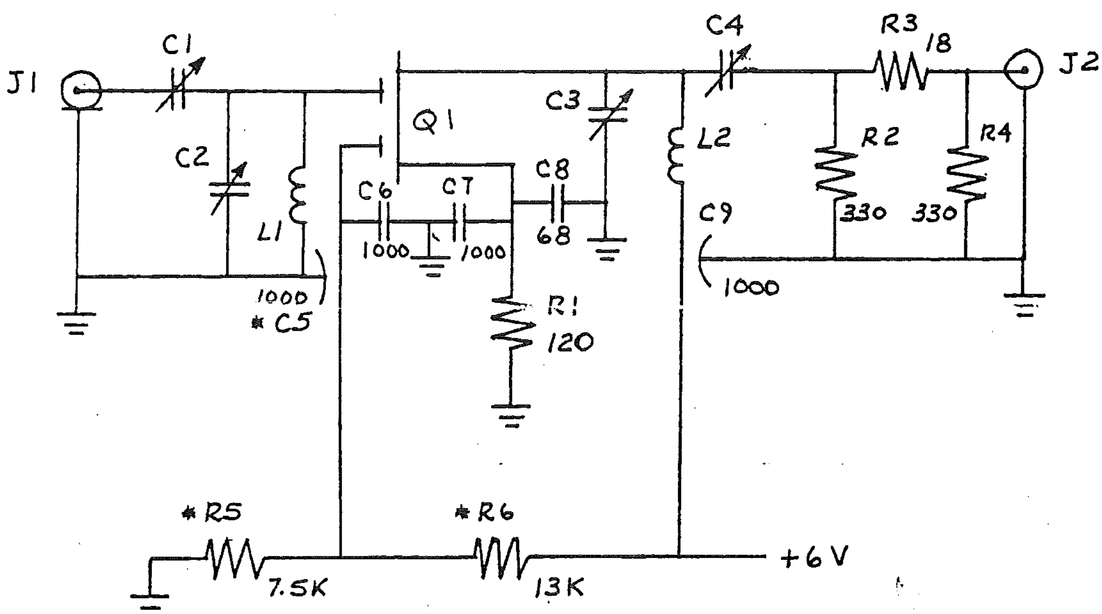
This noise source produces 25-30 bd excess noise compared to the 5.2 db for the HP noise heads, so the 20 db of attenuation is necesary.

WA5VJB

Two-Meter PREAMP
(MRF-966)

KØRL, 6/84

N.F.: less than .7 dB
Gain: greater than 20 dB



*Gate 2 maybe tied to the source and these components eliminated.

Parts list

C1	Johanson, 5201, .8 to 10 pF
C2,C3	Johanson, 5200, .8 to 10 pF
C4	Johanson, 7274, .6 to 4.5 pF
C6,C7	Ceramic chip, 1000 pF
L1,L2	5 turns, #24 AWG, 0.25 in. I.D.
Q1	Motorola MRF-966 or NEC 3SK124 (NE41137)
J1,J2	Johnson SMA

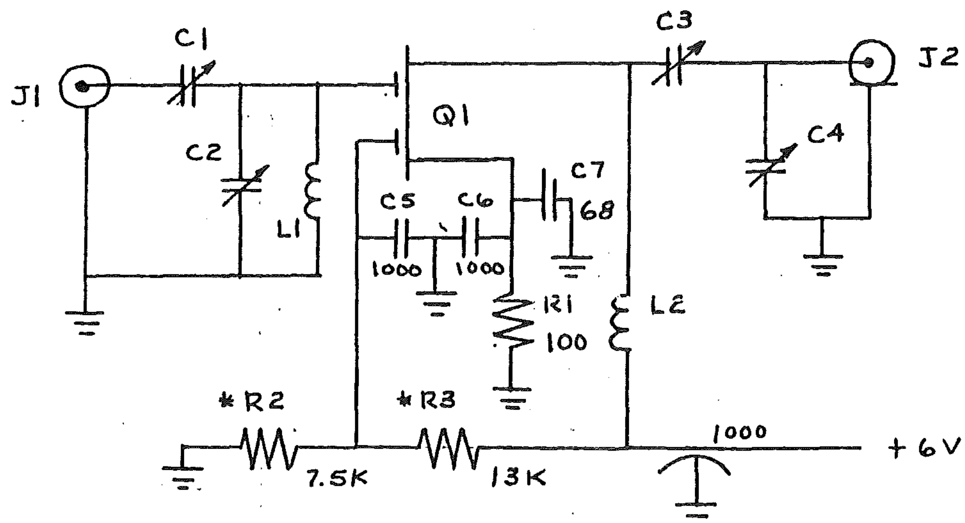
All resistors .25 w carbon comp.

KØRL

70 cm PREAMP
(MRF-966)

KØRL, 6/84

N.F.: less than 1 dB
Gain: greater than 18 dB



*Gate 2 maybe tied to the source and these components eliminated.

Parts list

C1	Johanson, 7273, .6 to 4.5 pF
C2	Johanson, 5202, .8 to 10 pF
C3	Johanson, 7293, .8 to 8 pF
C4	Johanson, 5502, 1 to 20 pF
C5,C6	Ceramic chip, 1000 pF
C7	Porcelin chip, 68 pF
L1,L2	1 turn, #20 AWG, 0.25 in. I.D.
Q1	Motorola MRF-966 or NEC 3SK124 (NE41137)
J1,J2	Johnson SMA

All resistors .25w carbon comp.

Inexpensive GaAs FET Preamplifiers for 2 meters and 70 cm

Ron Lile, KØRL

Schematic diagrams and part lists for a preamplifier for the 2 meter and 70 cm amateur bands are shown. The preamplifiers are being used for AMSAT Oscar-10. The units provide the necessary gain and noise figure for the required signal to noise ratio for good communications.

The two meter preamplifier has a Noise Figure of less than .7 dB, while the gain is greater than 20 dB at this N.F.

The 70 cm preamplifier has a Noise Figure of less than 1 dB with gain of greater than 18 dB at this N.F.

The FET's used in the amplifiers are relatively new and have single unit costs in the neighborhood of three dollars. In fact the capacitors used in the units cost more than the active device.

REFERENCES:

1) Gary Barbari,"UHF Preamplifier Centers on Budget Dual-Gate FET",Microwaves& RF, February, 1984, page 141.

2) Shigeru Sando, JH1BRY, "Very Low Noise GaAs FET Preamp for 432 MHz.", Ham Radio, April, 1978, page 22.

3) Shigeru Sando, JH1BRY, "Improved GaAs FET Preamp for 144-432 MHz.", Ham Radio, November, 1979, page 38.

KØRL

HOMEBREW

220 MHz. PRE-AMPLIFIER

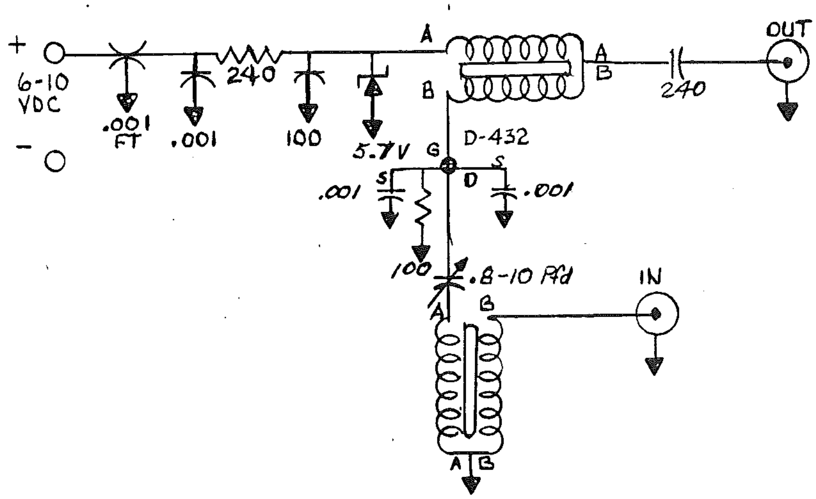
de: WA6KOU

This project was an effort to dispell some of the myths about having to use "N" or "SMA" type connectors, chip capacitors, careful shielding, and a nice die-cast box, all supposedly necessary to attain a reasonable gain and noise figure.

In 1981 when I did this crazy act, I was just recovering from several weeks of mental torture building a 432 pre-amp using a DEXCEL D432. After reading the DEXCEL APPL. NOTES, the precautionary litertaure that came with the device, and W6PO's EIMAC papers, full of horror stories as to how I could destroy the device. Anyhow, I spent about $90.00 for parts (D-432's at that time were $34.00), and I was pleased with the results, 19.6db gain and .9db N/F, not bad but not to swift by todays standards. Having done the job without blowing the GaAs FET and having purchased two of them for reasons stated, and recognizing that using this device was sort of an overkill insofar as the FET's capabilities are concerned at 220 MHz.

With FET in hand and the balance of the parts and pieces on hand via the junk box and spare parts shelf, I proceeded through several iterations of construction and design using on the air signals, sun and moon noise, and the FM handy speakie to try and get the best results that I could. I am not adverse to using some of the sophisticated highly accurate test gear but do not have same so made do!

The real moment of truth will be when Marc Thorson publishes the noise figure results. My objectives were to get 18 to 20 db gain and a N/F of .4 to .6 db, so if that comes to be, I will declare it a success and be satisfied with my $34.00 "sub-state-of-the-art" pre-amplifier.



NOTE: The .001 caps on which the source leads are mounted are leadless 1/8 x 3/16 inch ceramics (ERIE). The input and output inductors were cut out of surplus so values are not known, suggest that almost any small toroid or bead that you can get from 5 to 8 turns of 20 or 22 gauge solid copper wire on and dip out to frequency will do the job.

WA6KOU ANTENNA RACK FOR 432 MHz

The rack accomodates 4 - 14 element KLM antennas, their individual baluns, feedlines and a 4 way power divider. Construction is all non-metalic material comprising glass fiber tubing, glass fibre cloth and resin in gel form. The finish is one coat of primer and two coats of finish color (see material list for details). This project provides a non-metalic environment of strong non-corrosive materials which should enhance the performance.

CONSTRUCTION

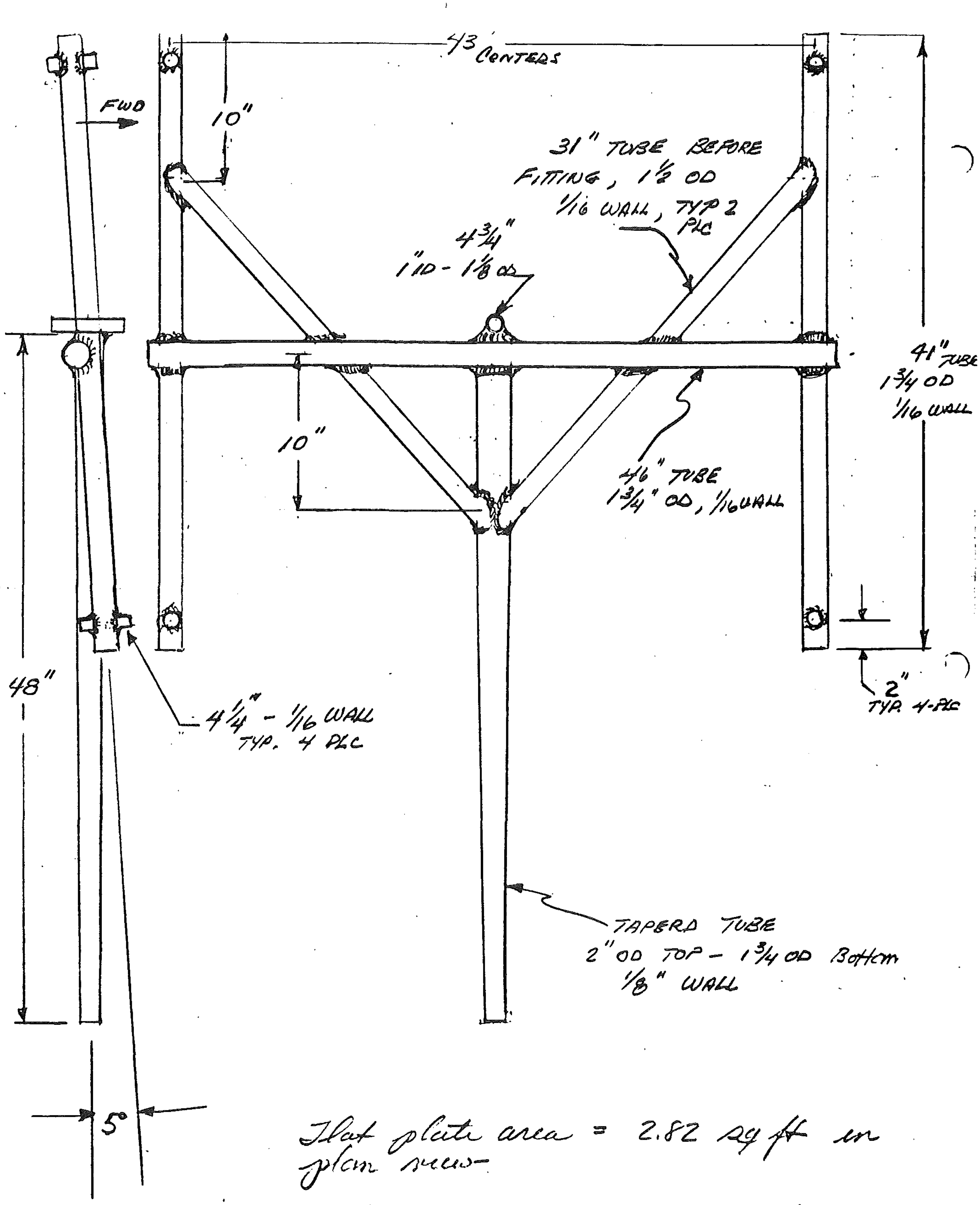
All joints are fitted to achieve at least 90% total contact of the pieces to be joined. Rubber bands linked together form an elastic cord or string used to hold the pieces in place during initial joining. This initial joining is accomplished by sweeping a very small radius fillet of resin around the contacting surfaces. Clean any residue or build up with a coarse file or sandpaper. Gel impregnated glass cloth is next applied and smoothed to achieve a pleasing appearance in the joining surfaces. Accute angles require additional cloth and work due to the added depth. Again file and sand to the disired contours and smoothness. A final coating of the gel resin is swept over the joint to fill in low areas and taper the fillet out. Final finishing is done with 400 grit wet and dry sand paper with a small amount of water and detergent used to prevent the paper from adhearing to the surface. When all surfaces have been sanded, apply a coat of primer and smooth it with 600 grit sandpaper. Finish color coats should be applied about 3 hours apart.

MATERIALS

1. Glass fiber tubing of dimensions shown in the figure.
2. One piece of glass cloth 1 ft x 2 ft, cut into 1 inch strips of lengths needed for each joint.
3. One can of "Superglass Gel" resin. The can contains a mixing container, a tube of hardner and a spreading tool to push the gel into the cloth.
4. One 12 oz can of "Indothane" enamel (440-1c-40) gray color.
5. One 13 oz can of "Krylon" enamel (1902) Baby Blue or Sky Blue color.
6. Assorted sandpaper and a pint of lacquer thinner

TOOLS AND MISC

A Black and Decker shopmate work stand has been indispensible during contruction. An assortment of coarse and fine files, a hacksaw, a 1/4 inch hand drill with a 1 inch diameter rotory file cutter. Some assorted sizes of C clamps, a 3 ft level and several pieces of 1x4 and 1x2 inch lumber for levelling and aligning prior to bonding



Flat plate area = 2.82 sq ft in plan view

Side view area = 1.045 sq ft

HISTORY OF THE CENTRAL STATES VHF SOCIETY

During the early 1960's, when serious vhf and uhf experimenters were a rare (peculiar?) breed, much of the activity was concentrated in the Northeast and along the Pacific Coast. A few hardy pioneers scattered across the "vast reaches of the interior" were active and determined. Some of these found "eyeball" QSO's with likeminded amateurs few and far between. Visits to the gatherings held each year.. notably the West Coast VHF Conference...were long and expensive. Talk arose among these people as to the possibility of some sort of yearly meeting closer to home. Those running long hours of schedules over unlikely paths needed to get together to discuss their ideas, gear, and antennas, and to make plans.

Thus, some area gatherings were held by various small groups ...one in 1965 at Sioux Falls, S.D. and another in Sand Springs, OK, in 1966. Continuing discussion on 75 meters led to a decision to establish an annual event to be called the Central States VHF Conference. The date was determined by the stars; not through astrology, but by the Perseids meteor shower. To permit handshakes among successful MS schedulers, and mutual listening to tape-recorded QSO's while memories were still fresh, the Conference was set for the August weekend following the Perseids.

With Larry Nichols, W5UGO, as General Chairman, and Sam Whitley, W5WAX (now K5SW),Don Hilliard, WØEYE (now WØPW), Dennis Main, WØYMG, and Jay Liebmann, W5ORH (now K5JL), as Committee Chairmen, the first Conference was scheduled for August 19 & 20, 1967 at the Western Hills Lodge in Sequoyah State Park 40 miles southeast of Tulsa, OK. Many were family groups on their vacation, they came by car and private and commercial aircraft...some 125 persons representing 19 States and seven call areas. The fine technical program of lectures, demonstrations, and antenna measurements was well received.

Joe Hall, K9SGD, and Glenn Smith, WØDQY, agreed to host the 1968 Conference under the continuing guidance of W5UGO as the General Chairman. So on the 16, 17, and 18 of August, at Lake O'the Ozarks, 170 miles west of St. Louis, MO., some 100 VHF'ers from 35 states plus Canada and England met in Conference. Don Hilliard, WØPW, chaired a fine technical program to which Ed Tilton, W1HDQ, contributed. At this meeting it was voted to incorporate as the CSVHF Society. The first Board of Directors was elected consisting of 14 members. This Board in turn chose the officers for 1969. The President was WØPW, the vice-President was WØMOX, the Treasurer was KØRZJ, and the Secretary was W4FJ. All present received a comprehensive computer-printed AZ/DX Directory prepared by Dick Allen, W5SXD. This was our first computer printout, for any purpose.

The third Conference was held in scenic Boulder, Colorado. Happily, many new amateurs from 6 and 7 land attended, and our members from the East Coast and Canada were again there. The technical program was excellent and was supplemented by tours to WWV and the BUSTAN antenna range. The women's program was particularly interesting. At the business meeting President Hilliard announced that the Society was now incorporated...the attorney being WØIC, a real VHF'er himself. Also that Vice-Pres. Breyfogle, WØMOX, had filed with the FCC the Society's first formal comment. This filing was to Docket 18508, and in it we supported moving the exclusive A-1 subband from 147.9 - 148.0 to 144.0 - 144.1 MHz. The FCC later so ruled. Officers elected for 1970 were K5SW, President; K5JL, Vice-President; K5WXZ, Treasurer; and W4FJ, Secretary.

In 1970, the Conference returned to its birthplace at the Western Hills lodge near Tulsa under President Whitley. Some 125 were registered. John Fox, WØLER, put together a very fine technical program which added to the developing prestige of the Society. Bill Smith, KØCER, proposed the establishment of an award to recognize and honor members who make outstanding technical contributions to the advancement of VHF-UHF communications. It was named the John T. Chambers Award to memorialize the dramatic exploits of W6NLZ in record-breaking QSO's across the Pacific on 144, 220, and 432 MHz with W2UK in Hawaii. The proposal was enthusiastically adopted. Officers elected for the following year were WØLER, President; W4FJ, Vice-President; K7NII, Sec'y; and KØMQS, Treasurer.

Since those first four years we have gained in recognition and prestige. The Society has grown without sacrificing stature for mere size. Each Conference increases in technical excellence. A summary follows:

The 1971 Conference was hosted by Bill Smith, KØCER, at Sioux Falls, SD, under the Presidency of John Fox, WØLER. The first Chambers Award was presented to Mel Wilson, W2BOC, for his patient observations and brilliant reporting of VHF propagation phenomena, especially E_s. Sam Harris, W1BU/KP4BPZ, highlighted the program with his Arecibo story.

The 1972 Conference was held at Overland Park, KS under the leadership of President Larry Nichols, W5UGO. Pres. Dannals of the ARRL was present as banquet speaker. Ed Tilton, W1HDQ, received the Chambers Award for his many years of research, and his service as editor of the QST column, "The World Above 50 MHz".

The 1973 Conference was at Minneapolis under President John Fox, WØLER and Ron Dunbar, WØMJS (now WØPN). The Chambers Award went to Tommy Thomas, W2UK, for his numerous VHF exploits, particularly with W6NLZ.

In 1974, we returned to Boulder, CO with Dick Hart, KØMQS, as President. The Chambers Award went to Dick Knadle, K2RIW, for his design of UHF amplifiers and parabolic antennas. The program emphasis was on moonbounce and its equipment requirements. The Society became a Life Member of AMSAT and affiliated with ARRL.

The 1975 Conference was again held in Western Hills Lodge, OK. Our host was Sam Whitley, K5SW, under President Charlie Calhoun, WØRRY. The Chambers Award was presented to WØLER for his dedicated study of OSCAR telemetry and other service to the amateur community.

In 1976, to wind up the first decade, the Society visited Houston, TX. Hosting this Conference was Conf. Chmn. Orville Burg, K5VWW; Joe Muscanere, WA5HNK, and Pres. Dick Allen, W5SXD. Dick Hart, KØMQS, received an ARRL Achievement Award for the first ever 2-meter WAS. The Chambers Award went to Joe Reisert, W1JR, for his many contributions to VHF and UHF.

The 1977 Conference was held in Kansas City, MO. Our hosts were Conf. Chmn. Tom Bishop, KØTLM, Rex Widmer, WBØITA and Pres. Orville Burg, K5VWW. The VHF/UHF Advisory Committee (VUAC) held its first meeting. The Chambers Award was presented to Bob Sutherland, W6PO, for his dedicated efforts in bringing moonbounce information to so many.

1978 found us in Minnesota again, this time at Rochester. Pres. Ed Fitch, WØOHU, and Treas. Terry Van Benschoten, WØVB, headed the team. The Chambers Award went to Wayne Overbeck, N6NB, primarily for his work on the Quagi antenna and his EME DXpeditions. The newly established "President's Award" found its first recipient in Ted Mathewson, W4FJ, who has been secretary of the society since its early years.

1979 was in Dallas, TX, hosted by Pres. Al Ward, WB5LUA, and Bill Duval, K5UGM, and their crew. Emily Ward led a fine ladies program. A large registration enabled an increase to $400 in our annual check to AMSAT. There was no Chambers Award. Mike Vestal, WØYZS, became the proud possessor of the first 432 Mhz WAS certificate. Bob Taylor, WB5LBT, received an individual award from Louis Anciaux, WB6NMT, for the first W/XE EME contact on 144 MHz.

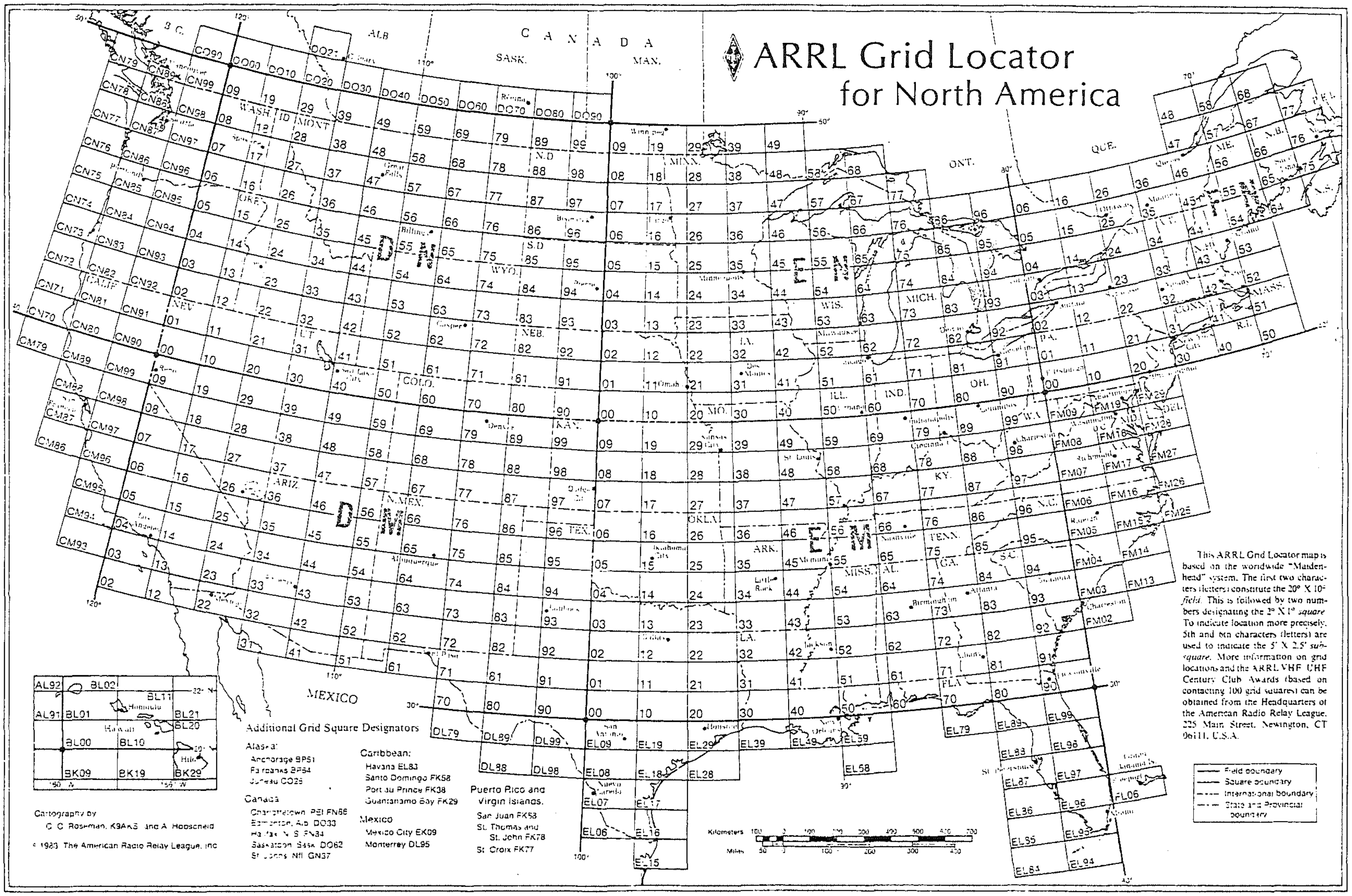
Our 14th Conference, in 1980, was back in the Rockies, at Colorado Springs, Ray Uberecken, AAØL, hosted, with Doug Moloney, WBØMHP, as Conference Chairman and Eric Ericson, KØKE, as Program Chairman. 162 VHF'ers registered, from five countries and 41 states, including Hawaii. The program had something for everyone. Speakers included familiar faces and new ones. The Chambers Award went to Jan King, W3GEY. The AMSAT contribution was increased to $500.

In 1981, we went to Sioux Falls for the second time. Ed Gray, WØSD, and his wife, Edith, WAØUFS, backed by their committees, lived up to our expectations. The broad technical program, under Chuck Hoover, KØVXM, gave us new aspects of familiar fields as well as fresh ideas on antennas, weak signal reception, computer applications, and "upward mobility". The Chambers Award first presented 10 years ago in Sioux Falls, went this year to Louis Ancioux, WB6NMT, especially for his use, promotion, and technical improvement of 220. His efforts were significant in our retaining this band. The AMSAT contribution was $400. The Committee on Society Awards Chairman, Lance Collister, WA1JXN/7, presented their recommendations, which were adopted. Three single-band certificates can be earned: one for sustained activity (100 stations worked); another for geographical diversity (100 1-degree grids worked); and the third for earning 1000 points, computed by applying a grid distance formula to all contacts made within each month of any two-month period. Five of our members are on the ARRL VHF/UHF Contest Committee.

In 1982, the 16th Conference, hosted by Bob Taylor, WB5LBT, at Baton Rouge, LA, was dedicated to the memory of our respected Mel Wilson, W2BOC. Mel was probably the world's most knowledgeable man in sporadic E propagation, both as scientist and as radio amateur. A new Society award, to be known as the Mel Wilson Award, was explained by Al Ward, WB5LUA. The first Mel Wilson Award was presented by Russ Wicker, W4WD, to Bill Tynan, W3XO, for his varied and valued services to us in The World above 50 MHz and to the Society. Mel's widow, Ellie, was with us, to our great delight, and she shared in our satisfaction at establishing this new honor. The Chambers Award was presented to Al Katz, K2UYH, for his many technical accomplishments and for his participation in many of our Conference programs. The technical program was fully up to par, which of course is high praise. New features included coverage of ATV by Warren Weldon, W5DFU, an old timer in VHF & UHF, plus late information on the new 902 MHz band, and much good material for 1296 and 2304 MHz. Our AMSAT contribution this year was $400.

1983 took the Conference to the Kansas City area for the third time, this year to Overland Park, KS. Pres. Tom Bishop, KØTLM, and V.P. Jim McKim, WØCY, hosted well, and all aspects of the conference were well received. A note of sadness again prevailed, however, because for a second consecutive year the Conference was dedicated to the memory of a Silent Key. Carl Scheideler, W2AZL, a pioneer in VHF & UHF work, died just 11 days before the Conference. He is probably best known for his development of improved converters, preamplifiers, and antennas. Carl had served on the Society Board and on the Chambers Award committee since their beginnings. Preamp testing this year was very interesting, due both to diversity of design and frequency coverage of the test items and to sophistication fo test equipment. No Chambers Award was made. The Mel Wilson Award went to Ed Fitch, WØOHU, for his 16 years of devoted service to the Society in many and varied ways as director, officer, and Conference host. The annual AMSAT donation was $400. The prize collection in 1983 was truly impressive, thanks again to Al and Emily Ward. Donors included some 30 manufacturers and dealers, 4 organizations, and several individual Society members.

Raymond L. Nichols, W5HFV
Historian, CSVHF Society



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ANTENNA GAIN MEASUREMENTS OF THE LAST SIX CONFERENCES

144 MHz

1978 Rochester, MN

N4PZ	N4PZ 14 element Yagi	+1.75 dB
WA5HNK	16 element F9FT Yagi	+1.75 dB
WØSD	14 element homebrew KLM Yagi	+0.5 dB
KØTS	10 element Hygain Yagi	+0.3 dB
K5IS	14 element KLM Yagi	0.0 dB
K9XY	11 element Cushcraft Yagi (REFERENCE)	0.0 dB
K9XY	8 element Quagi (metal)	0.0 dB
WBØBVC	8 element Hygain	-0.1 dB
WA5HNK	9 element F9FT Yagi	-0.2 dB
WBØUIP	8 element Quagi	-1.0 dB
WA9KGQ	5 element Hygain Yagi	-2.9 dB
WBØEKL	5 element Quad	-3.4 dB
W5UPR	4 element F9FT Yagi	-3.9 dB
KØTS	5 element Yagi	-4.5 dB
WØRGU	10 element Yagi	-5.2 dB
WØRLI	3 element Yagi	-5.6 dB
WØPUF	4 element KLM Yagi	-5.9 dB
KØFQA	5 element Yagi	-8.7 dB
WA9HCZ	Mini Wheel	-12.8 dB

1979 Dallas, TX

K1WHS	17 element Cushcraft, 29 ft. Boom	14.4 dB/D
K1WHS	19 element C.C. Boomer, 22 ft. Boom	14.1 dB/D
W5UPR	19 element F9FT Yagi, 22 ft. Boom	14.1 dB/D
WA5HNK	16 element F9FT Yagi, 21 ft. Boom	13.2 dB/D
K1WHS	14 element 2.2λ C.C., 15 ft. Boom	13.1 dB/D
N4PZ	14 element homebrew Yagi, 23 ft. Boom	13.0 dB/D
K4PKV	20 element C.C. Collinear	13.0 dB/D
K5GW	14 element homebrew Yagi, 17½ ft. Boom	12.2 dB/D
WB5LUA	14 element SWAN LPY, 18 ft. Boom	12.0 dB/D
W5DC	12 element Loop Yagi, homebrew	11.3 dB/D
W5DC	7 element Loop Yagi, homebrew	11.0 dB/D
WA5HNK	9 element F9FT, 11 ft. Boom	10.8 dB/D
WB5LUA	6 element NBS Yagi (REFERENCE)	10.4 dB/D
W3XO	4 element F9FT, 2.5 ft. Boom	9.2 dB/D
W5UPR	4 element F9FT, 2.5 ft. Boom	9.0 dB/D
W5LUU	5 element homebrew Yagi	7.4 dB/D

1980 Colorado Springs, CO

WBØIKJ	Experimental Cushcraft Boomer...........	14.6	dB/D
WBØIKJ	Cushcraft Boomer........................	12.3	dB/D
WB6NMT	NMT-11/144..............................	12.1	dB/D
WA8OGS	homebrew 2.2λ NBS Yagi..................	12.0	dB/D
NØAVY	homebrew 16 element collinear...........	12.0	dB/D
WBØOMN	13 element KLM LB.......................	11.9	dB/D
WA8OGS	2.2λ NBS Yagi (less triagonal Refl.)....	10.6	dB/D
WA8OGS	2.2λ NBS Yagi (with triagonal Refl.)....	9.5	dB/D
WBØSSG	2.2λ NBS Yagi (less triagonal Refl.)....	9.7	dB/D
WBØSSG	2.2λ NBS Yagi (with triagonal Refl.)....	8.6	dB/D
WBØLTV	2.2λ NBS Yagi (with triagonal Refl.)....	8.6	dB/D
W5LUU	5 element homebrew Yagi.................	7.0	dB/D

1981 Sioux Falls, SD

W1JR	8 element homebrew Yagi, 12 ft. Boom....	11.7	dB/D
KCØP	11 element Cushcraft Yagi...............	11.1	dB/D
WBØTEM	8 element Hygain Yagi (Reference).......	9.9	dB/D
KCØP	8 element Homebrew Yagi.................	9.9	dB/D
WA9HCZ	9 element homebrew Yagi.................	7.9	dB/D
KØKE	5 element Mobile........................	6.3	dB/D
KØKE	Halo....................................	-0.3	dB/D

1982 Baton Rouge, LA

KR5F	WB5JWL "PTG" 11 element Quad, 18' long..	13.5	dB
KR5F	WB5JWL "PTG" 9 element Quad, 13' long...	13.2	dB
KR5F	WB5JWL 9 element wide spaced Quad, 16'..	12.5	dB
W5UN	homebrew long Quagi, 26' long...........	12.5	dB
KR5F	WB5JWL 6 element wide spaced Quad, 10'..	11.7	dB
WA5HNK	4 element Tonna Yagi....................	6.0	dB
W5RCI	Homebrew Yagi...........................	5.0	dB

1983 Kansas City, KS

K1WHS	Cushcraft 4219 Yagi.....................	14.8	dB/D
K1WHS	Cushcraft 3219 Yagi.....................	13.1	dB/D
	Swedish CUDEE 15 element Yagi...........	12.7	dB/D
N5DL	12 element 2.2λ NBS Yagi................	12.3	dB/D
WA8OGS	12 element 2.2λ NBS Yagi................	11.9	dB/D
WD5AGO	8 element Quagi.........................	11.0	dB/D
WA8OGS	6 element 1.69λ NBS Yagi................	10.0	dB/D
WA8OGS	6 element NBS...........................	9.9	dB/D
K5IS	3 element Quad..........................	9.7	dB/D
K5IS	5 element "Ed Tilton"...................	9.1	dB/D
WA5DBY	Dipole..................................	0.4	dB/D
	REFERENCE ANTENNA.......................	9.9	dB/D

220 MHz

1981 Sioux Falls, SD

Prize	17 element Cushcraft Boomer.............	14.2	dB/D
WBØTEM	11 element Lunar, 12 ft Boom............	13.0	Ref.
WBØTEM	11 element homebrew, 12 ft Boom..........	12.8	dB/D
K9KFR	11 element homebrew, 12 ft Boom..........	11.9	dB/D
W7FN	10 element, 10 ft Boom.................	11.7	dB/D
W7FN	5 element homebrew......................	8.7	dB/D

1982 Baton Rouge, LA

WD4MHK	8 element Yagi.........................	12.7	dB/D
K9XY	8 element Quagi........................	11.7	dB/D

1983 Kansas City, KS

K1WHS	Cushcraft 220B.........................	14.2	dB/D
KB9NM	3.8λ Quagi (W5UN)......................	13.8	dB/D
WBØTEM	13 element Yagi........................	13.8	dB/D
K9LQZ	long boom NBS Yagi.....................	13.0	dB/D
K9LQZ	3.2λ NBS Yagi..........................	12.9	dB/D
WA5DBY	Dipole.................................	-0.8	dB/D
	REFERENCE ANTENNA......................	13.0	dB/D

432 MHz

1978 Rochester, MN

WB9SNR	2X 13 element Quagi....................	+5.3	dB
W5UPR	21 element F9FT Yagi...................	+5.0	dB
K2RIW	19 element RIW Yagi....................	+5.0	dB
WA9HCZ	16 element Collinear (expanded)........	+4.4	dB
WA8ULG	4X 22 element NBS Yagi.................	+2.3	dB
VE4MA	8 element Quagi........................	+0.3	dB
K9XY	8 element Quagi (REFERENCE ANT.).......	0.0	dB
WØSD	Quagi - short boom.....................	-0.5	dB
WA9KGQ	6 element KLM..........................	-4.3	dB
WØQIN	Standard reference dipole..............	-9.9	dB

1979 Dallas, TX

WA5HNK	21 element F9FT Yagi...................	14.5	dB/D
WBØYSG	19 element homebrew Yagi...............	13.9	dB/D
K5IS	8 element Quagi, homebrew..............	10.8	dB/D
WB5LUA	6 element NBS (REFERENCE ANT.).........	10.3	dB/D
K7IS/W7LUX	PATCH homebrew......................	1.3	dB/D
?	4 element field built Yagi.............	-5.3	dB/D

1980 Colorado Springs, CO

NØAVY	48 element Colinear........................	15.4	dB/D
W8TN	K2RIW Yagi..................................	14.2	dB/D
WØOHU	HB 15 element Yagi, Quagi feed...........	11.6	dB/D
K5IS	HB 15 element Quagi.......................	11.6	dB/D
WØKJY	HB 13 element Quagi feed..................	11.2	dB/D
WØKJY	HB 15 element Quagi.......................	9.2	dB/D
WØKJY	HB 17 element Yagi........................	8.9	dB/D
K9XY	HB 15 element Yagi, Quagi feed...........	8.0	dB/D
K5IS	HB F9FT....................................	7.0	dB/D
WBØCZI	HB 17 element with triagonal refl........	5.2	dB/D
WA8ULG	HB motel room special Yagi...............	-7.0	dB/D

1981 Sioux Falls, SD

W1JR	28 element HB 21 ft Boom..................	17.7	dB/D
K1WHS	24 element Cushcraft Boomer, 17 ft.......	16.4	dB/D
KL7WE	22 element HB 17 ft Boom..................	16.0	dB/D
WBØTEM	19 element HB RIW, 13 ft Boom............	15.2	REF.
WBØYSG	19 element HB RIW.........................	15.1	dB/D
KØDAS	19 element RIW............................	15.0	dB/D
WBØTEM	19 element RIW HB.........................	14.8	dB/D
K9XY	15 element Quagi..........................	14.3	dB/D
WBØYSG	16 element KLM............................	13.2	dB/D
KØDAS	19 element RIW (less front 6 elements)..	12.8	dB/D
WØPPF	8 element Quagi...........................	12.0	dB/D
W1JR	6 element NBS 1.2λ........................	10.2	dB/D
WB5LUA	6 element NBS 1.2λ........................	8.4	dB/D
WA9HCZ	39 element Log Periodic...................	8.0	dB/D

1982 Baton Rouge, LA

K5GW	24 element Cushcraft Yagi................	14.5	dB
WD4MBK	19 element HB RIW Yagi...................	13.9	dB
WD4MBK	19 element HB RIW Yagi...................	13.9	dB
WD4MBK	19 element RIW Yagi......................	13.5	dB
W3XO	16 element Yagi (G3IOR version)..........	12.0	dB
K5GW	10 element Cushcraft Yagi................	11.5	dB
K5BAR	?	8.7	dB

1983 Kansas City, KS

KL7WE	10.5 wavelength Yagi......................	18.2	dB/D
WBØDGF	21.5 ft. Yagi.............................	16.9	dB/D
WBØDGF	Copy of Cushcraft Boomer..................	16.8	dB/D
K1WHS	Cushcraft Boomer..........................	16.8	dB/D

432 MHz (continued)

1983 Kansas City, KS (cont.)

KØNG	Small Yagi................................	15.4	dB/D
WØWL	F9FT Yagi.................................	15.4	dB/D
WBØDGF	16 element KLM Yagi.......................	14.8	dB/D
K5JRH/W5UPR	12 ft. dish........................	14.2	dB/D
KØCQ	27 element KLM Yagi.......................	13.5	dB/D
KØJJA	5 element Quagi...........................	11.2	dB/D
WA8OGS	Small Yagi................................	10.5	dB/D
KØCQ	Dipole sq. ref	10.5	dB/D
WA8OGS	Dipole .165/1.1 sq. ref	10.3	dB/D
KL7WE	3 element Yagi............................	8.2	dB/D
	REFERENCE ANT.............................	14.8	dB/D

902 MHz

1983 Kansas City, KS

W5UPR/K5JRH	12 ft. dish with log periodic feed.	17.0	dBI
WB5LUA	Spectrum Int'l 23 element Yagi...........	13.0	dBI
WØPW	Ref. Dipole...............................	2.1	dBI

1296 MHz

1979 Dallas, TX

W5GVE	4 ft. dish with foil......................	+7.2	dB
W5GVE	4 ft. dish................................	+5.5	dB
VE4MA	8 element Quagi...........................	+3.7	dB
WA5HNK	32 element J	+3.4	dB
W5UPR	32 element J (modified)...................	+3.4	dB
WA5TBE	10 turn Helix.............................	+1.2	dB
WA8ULG	EIA Standard (dual dipole)................	0.0	dB
WB5LUA	Short Coffee Can..........................	-1.5	dB

1980 Colorado Springs, CO

WB5LBT	45 element loop yagi......................	18.4	dB/D
W7LUX	1 Meter dish, RSGB feed...................	15.0	dB/D

1981 Sioux Falls, SD

W1JR	4-F9FT Yagis, 23 elements each...........	22.2	dBI
K9KFR	44 element Loop Yagi, 12 ft..............	19.7	dBI
KAØY	45 element Loop Yagi, 12 ft..............	19.2	dBI
K9KFR	22 element Loop Yagi, 6 ft...............	17.3	dBI
W1JR	23 element F9FT	16.9	dBI

1296 MHz (continued)

1981 Sioux Falls, SD (cont.)

WB9SNR	26 element Loop Yagi.........................	14.6	dBI
WBØTEM	13 element (W2CQG) Yagi....................	14.6	REF
WBØNRV	25 element Loop Yagi........................	14.2	dBI
VE4MA	Quagi	12.4	dBI
VE4MA	6 element Collinear.........................	10.8	dBI
WB7EPA	22 element Loop Yagi........................	10.1	dBI
VE4MA	Corner Reflector............................	5.2	dBI
WB5LUA	2 lb. Coffee Can............................	4.4	dBI

1982 Baton Rouge, LA

W5UPR	Tonna Yagi	17.2	dB
WA5TKU	Loop Yagi	16.0	dB
KF5N	Loop Yagi	15.5	dB
W5DC	Yagi	14.5	dB
K4KJP	???	12.5	dB
W4ODW	4 X Yagis	10.0	dB
W4ODW	???	4.5	dB
W5UKQ	2 lb. coffee can dish feed for .33 f/d..	-1.5	dB

1983 Kansas City, KS

W5UPR/K5JRH	12 ft. dish with WA8OGS feed.........	23.0	dBI
W4ODW	Metal boom Quagi............................	18.4	dBI
W4ODW	Metal boom Quagi............................	18.3	dBI
KF5N	25 element Quagi............................	16.4	dBI
KF5N	16 element Quagi............................	15.1	dBI
WA5HNK	Commercial Skeleton slot	14.8	dBI
KØCQ	Spectrum Loop Yagi	17.8	dBI
WØPPF	Rhombic	14.0	dBI
WØOHU	10 element Quagi	13.8	dBI
W4ODW	Dipole and ref	10.4	dBI
WA8OGS	Untuned dipole and ref	9.8	dBI
WA8OGS	Dipole and ref	8.6	dBI
WA5VJB	Coffee Can	7.8	dBI
WB5LUA	Coffee Can	6.6	dBI
WB5LUA	Coffee Can	6.4	dBI
WA5VJB	Coffee Can	5.6	dBI
	REFERENCE ANT...............................	14.6	dBI

2304 MHz

1982 Baton Rouge, LA

WA5VJB	41 element Loop Yagi	19.5	dB
WB5LUA	1 lb. coffee can dish feed	8.0	dB
WB5LUA	Reference Dipole	0.0	dB

1983 Kansas City, KS

WA5VJB	60 element Loop Yagi	22.0	dBI
WA5VJB	40 element Loop Yagi	20.0	dBI
WA5VJB	20 element Loop Yagi	17.5	dBI
K5PJR	Std. Gain Horn	13.0	dBI
WA5VJB	Single 3 lb. coffee can	10.2	dBI
WB5LUA	1 lb. coffee can (REFERENCE ANT).........	9.0	dBI
WA5VJB	Double 3 lb. coffee can	7.0	dBI
WØPPF	Quad Rhombic	3.5	dBI

VHF/UHF Publications of Interest

NEWSLETTERS

1. 2 Meter EME Bulletin $12.00/yr. N. America $15.00/yr. Worldwide	Gene Shea, KB7Q, Editor 417 Staudaher St. Bozeman, Montana 59715
2. 432 and Above EME News	Allen Katz, K2UYH, Editor c/o Dept. of Elect. Engineering Trenton State College Trenton, N.J. 08625
3. Northeast VHF News $3.00/yr.	Northeast VHF Association 10 Marshall Terrace Wayland, Mass. 01778
4. CHEESE BITS $2.50/yr.	Mt. Airy VHF Radio Club, Inc. Harry B. Stein, W3CL, Editor 2087 Parkdale Ave. Glenside, PA 19038
5. VHF+ Trading Post $3.00/yr.	Jack C. Parker, KCØW, Editor 1420 E. Sweet Ave. Bismarck, N.D. 58501
6. 220 Notes $1.25 sample $5.00/yr.	Walter W. Altus, Jr., WD9GCR 215 Villa Rd. Streamwood, Ill. 60103
7. SIX SHOOTER $6.00 membership fee $3.00/yr. dues	The SMIRK Journal 7158 Stone Fence San Antonio, TX 78227

MAGAZINES

1. VHF/UHF and Above $8.00/6 mo. USA $15.00/yr. USA	Harold W. Landes, Jr., KAØHPK, Pub. P.O. Box 270 W. Terre Haute, Indiana 47885
2. DUBUS Published 4 times per year in Germany. Written in German and English.	USA Distributer: D. DeMaw, W1FB 4061 N. Douglas Road Luther, Michigan 49656

SIX METER BEACON LIST

Compiled by W3XO July, 1983
Additions, deletions and corrections welcome.

Freq.	Call	Mode	Location	Remarks
50.008	PY1RO	A1	Rio de Janerio Brazil	
50.008	K0GUV	A1	Park Rapids, MN	Attended
50.015	PJ2B	A1	Curacao, Neth. Antilles	
50.018	GB3SIX	A1	Wales	25 w 3 el NW
50.023	HH2PR		Haiti	
50.025	6Y5RC	F1	Jamaica	
50.029	ZS6PW		Pretoria, RSA	
50.035	ZB2VHF	A1	Gibraltar	
50.039	FY7THF	F1	French Guiana	100 w Ver.
50.040	ZS6VHF		RSA	30 w
50.045	DL3ZM/YV5	A1	Caracas, Ven.	
50.048	VE6ARC	A1	Alberta	
50.048	WA6IJZ	A1	S. California	Attended
50.050	K6FV	A1	N. California	When conditions appear good
50.050	ZS6LN		Petersburg, RSA	10 w
50.055	WA9FEF	A1	Chicago, IL	Attended
50.060	KH6EQI	A1	Pealrl Horbor, HI	
50.060	WA8ONQ	A1	Cincinatti, OH	1 w
50.060	PY2AA	A1	Sao Paulo, Brazil	25 w GP
50.062	W3VD	A1	Laurel, MD FM19	0.1 w Vert.
50.064	WB8IGY/4	A1	Florida	
50.065	W0IJR	A1	Denver, CO DM79	20 w 2 Ring Halo
50.065	WB5ZRL	A1	New Orleans, LA	2 w Horiz. Loop
50.070	KS2T	A1	New Jersey	
50.071	W0BJ	A1	Nebraska	
50.072	VE1CCP	A1	Prince Edward Island	
50.075	N5JM		New Orleans, LA EL49	2 w 2el NE
50.077	VE3DRL		Toronto, Ont.	
50.080	TI2NA	A1	Costa Rica	
50.088	VE1SIX	A1	New Brunswick	
50.090	WA6JRA	A1	S. California	
50.095	K7IHZ		Arizona	Attended
50.098	KG6JIH		Guam	Attended
50.112	JD1YAA		Minami Torishima	
50.498	5B4CY		Cyprus	
50.740	TV sound	FM	Aukland, NZ	
50.750	TV sound	FM	Kaukapunake, NZ	
50.760	TV sound	FM	Waukapunake, NZ	
50.945	ZS1SIX	FSK/FM	Piketbergh, RSA	16 w GP
51.002	ZL1BPW		Aukland, NZ	
51.740	TV sound	FM	Wagga, NSW Aus.	
51.750	TV sound	FM	Brisbane, Queensland Aus.	
51.760	TV sound	FM	Melborne, Vic. Aus.	
52.001	VK9GA		Goroka, New Guinea	
52.006	VK6VF		Perth, WA Aus.	
52.160	VK2WI		Macquarie Islands	
52.200	VK8VF		Darwin, Aus.	

Freq	Call	Mode	Location	Remarks
52.250	ZL2VHM		Palmerston North, NZ	
52.300	VK6RTV		Perth,WA Aus.	
52.350	VK6RTU		Kalogoorlie, WA Aus.	
52.400	VK7RNT		Launceston, Tas.	
52.440	VK4RTL	F1	Townsville, Queensland Aus.	
52.450	VK2WI		Sydney, NSW Aus.	
52.500	JA2IGY		Negoya, Japan	
52.900	VK6RIT		Carnovan,WA Aus.	
52.950	VK6RTW		Albany, WA Aus.	
53.000	VK5VF		Mount Lofty, SA Aus.	
53.100	VK0MA		Mawson, Antartica	
53.200	VK0GR		Casey, Antartica	

14 JULY 84

BARRY -

ENCLOSED IS A PROGRAM LISTING AND SEVERAL SAMPLE RUNS TO ILLUSTRATE ITS USE. I HAVE ALSO ENCLOSED 2 DRAWINGS WHICH EXPLAIN THE VARIABLES.

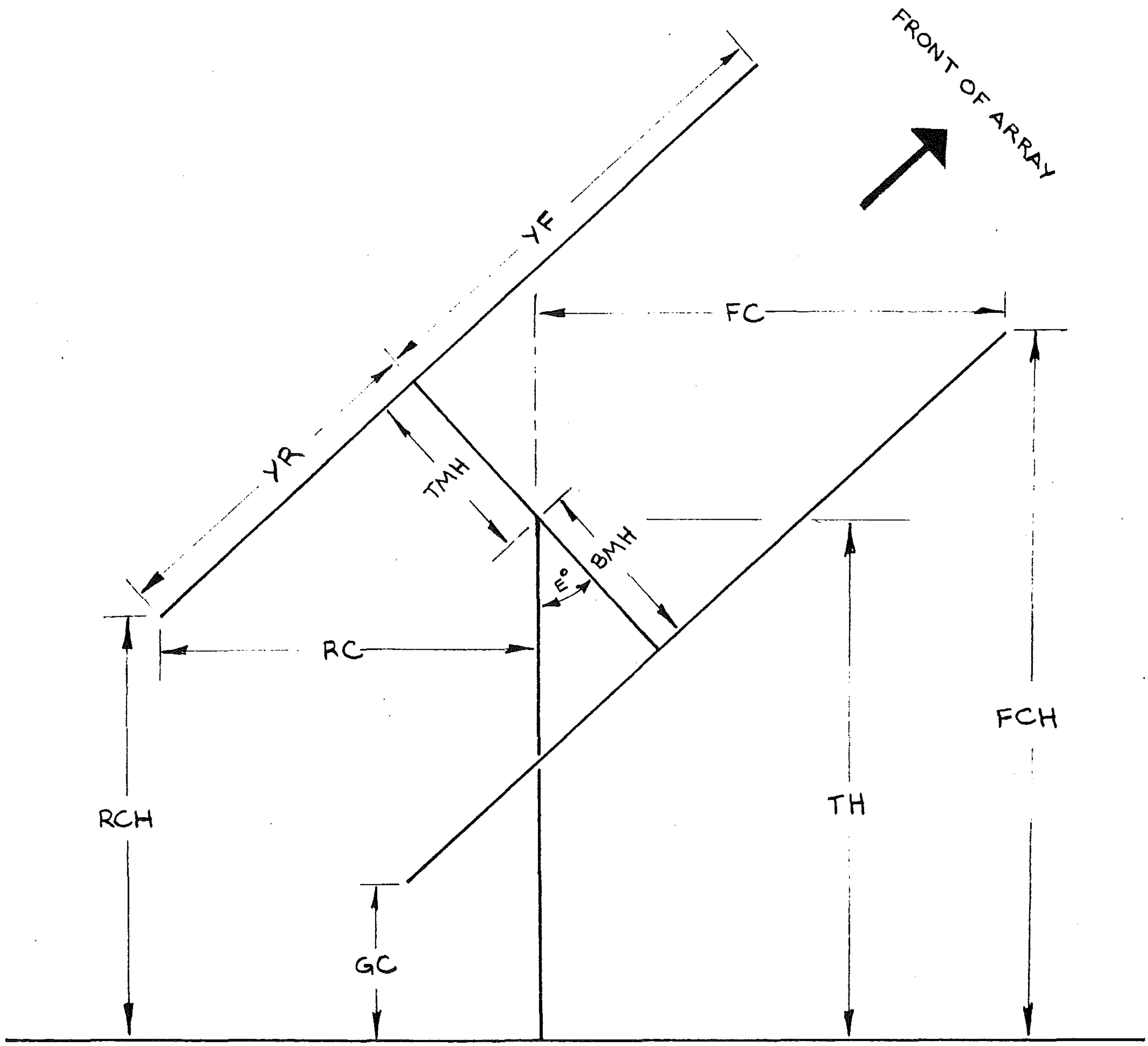
ALTHOUGH IT IS QUITE SIMPLE TO CALCULATE TURNING RADIUS FOR AN ARRAY WHICH HAS HORIZONTAL ELEMENT POLARIZATION AND IS POINTED AT THE HORIZON, THE VARIABLES OF ELEMENT POLARIZATION AND ARRAY ELEVATION RAPIDLY INCREASE THE AMOUNT OF WORK REQUIRED TO DETERMINE IF THE PROPOSED ANTENNA ARRAY WILL CLEAR TREES, CHIMNEY, GUY WIRES, ETC AT ALL ORIENTATIONS.

THE NUMBER OF TIMES I'VE HEARD PEOPLE ASKING WHETHER A GIVEN ARRAY WOULD FIT ON A TOWER ONLY SO HIGH IS EVIDENCE THAT THIS IS A COMMON PROBLEM SHARED BY MANY.

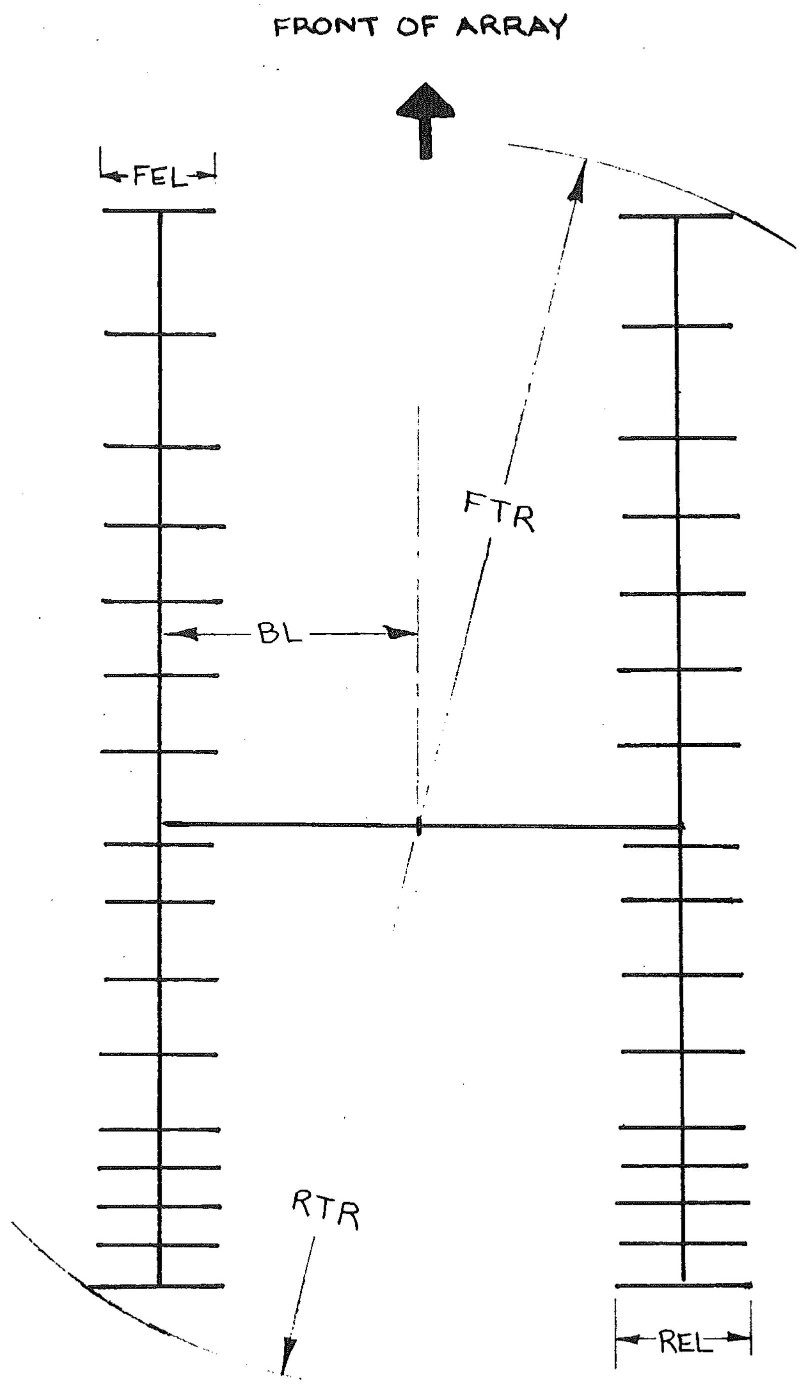
THE COMPUTER MAKES PLANNING THE SIZE OF AN ANTENNA FARM EASY, VERY QUICKLY RUNNING THROUGH CALCULATIONS THAT ARE EASY FOR US TO GET BOGGED DOWN IN IF WE TRY TO GO THROUGH THEM MANUALLY.

SEE YOU IN CEDAR RAPIDS!

73
LANCE WA1JXN



SIDE VIEW



TOP VIEW

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00010 ! PROGRAM NAME = SPACE
00020 !
00030 ! THIS PROGRAM IS DESIGNED TO PROVIDE APPROXIMATE SPATIAL CLEARANCE
00035 ! PARAMETERS AS A FUNCTION OF ELEVATION FOR ANY SYMMETRIC ANTENNA
00040 ! ARRAY OF 1 OR MORE YAGIS. DEFINITIONS OF THE VARIABLES ARE GIVEN
00045 ! THROUGHOUT THE PROGRAM, USING REMARK STATEMENTS.
00050 !
00055 ! FOR THE PURPOSE OF THIS PROGRAM, THE VERTICAL MAST(S) OF THE ARRAY
00060 ! ARE ASSUMED TO PIVOT DIRECTLY AT THE TOP OF THE TOWER.  EXACT CLEARANCE
00065 ! FIGURES WILL VARY SLIGHTLY IF THE PIVOT ASSEMBLY CHOSEN CAUSES THE
00070 ! CENTER OF THE VERTICAL MAST(S) TO MOVE DURING THE ELEVATION PROCESS.
00071 !
00072 ! CLEARANCE DIMENSIONS ARE TO THE OUTSIDE TIPS OF THE FRONT AND REAR ELEMENTS.
00073 ! IN THE CASE WHERE THE POLARITY ANDGLE IS NOT ZERO, THE FRONT CLEARANCE IS
00074 ! TAKEN TO THE LOWEST (WHICH WILL ALSO BE THE MOST FORWARD) END OF THE FRONT
00075 ! OUTSIDE ELEMENT; THE REAR CLEARANCE IS TAKEN TO THE HIGHEST (WHICH WILL ALSO
00076 ! BE THE MOST REAR) END OF THE REAR OUTSIDE ELEMENT.  THE MINIMUM GROUND
00077 ! CLEARANCE IS FROM THE LOWEST EXTENSION OF THE LOWEST REFLECTOR.
00078 !
00079 ! FOR SIMPLICITY, THE LAST DIRECTOR AND THE REFLECTOR ARE ASSUMED TO BE MOUNTED
00080 ! AT THE ENDS OF THE BOOM OF THE YAGI; DEPENDING ON THE ORIENTATION OF THE
00081 ! ELEMENTS AND THE ELEVATION ANGLE OF THE ARRAY, A SMALL ERROR IN SOME CLEARANCE
00082 ! DIMENSIONS CAN BE INTRODUCED IF THE YAGI BOOM EXTENDS APPRECIABLY PAST THE
00083 ! FRONT AND REAR ELEMENTS (THE TURNING RADIUS WILL STILL REMAIN ACCURATE IN
00084 ! MOST CASES,REGARDLESS OF THE EXACT LOACATION OF THE BOOM END).
00085 !
00086 ! LANCE COLLISTER, WA1JXN
00087 ! P.O. BOX 73
00090 ! FRENCHTOWN,MT
00095 ! USA             59834
00100 !
00110 ! JUNE 26,1984
00120 !
00200 ! ********** DATA INPUT ****************************************************
00204 DIM N$*20 !  DIMENSIONS VARIABLE N$ TO ALLOW A LENGTH OF 20 CHARACTERS
00205 DEF FNR(X)=INT(X*100+.5)/100 ! ROUNDS ARGUMENT TO THE NEAREST HUNDREDTH
00206 PRINT "WHAT IS DESCRIPTION OF ANTENNA (MAXIMUM OF 20 CHARACTERS)"
00207 INPUT N$
00210 PRINT "PLEASE ENTER ALL DATA IN THE SAME UNITS OF MEASUREMENT."
00215 PRINT
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00220 PRINT "WHAT IS THE HORIZONTAL SPACING BETWEEN CENTERS OF OUTERMOST YAGI BOOMS"
00225 INPUT S
00226 LET BL=S/2 ! "BOOM LENGTH" (DISTANCE FROM CENTER OF TOWER TO OUTERMOST YAGI CENTERLINE)
00230 PRINT "WHAT IS THE TOWER HEIGHT ABOVE GROUND (DISTANCE TO ELEVATION MOUNT PIVOT)"
00235 INPUT TH
00240 PRINT "WHAT IS THE LENGTH OF THE REAR HALF OF EACH YAGI FROM MAST TO REFLECTOR"
00245 INPUT YR
00250 PRINT "WHAT IS THE LENGTH OF THE FRONT HALF OF EACH YAGI FROM MAST TO LAST DIRECTOR"
00255 INPUT YF
00260 PRINT "WHAT IS THE VERTICAL MAST HEIGHT FROM ELEVATION PIVOT TO LOWEST YAGI"
00265 INPUT BMH
00270 PRINT "WHAT IS THE VERTICAL MAST HEIGHT FROM ELEVATION PIVOT TO HIGHEST YAGI"
00275 INPUT TMH
00276 PRINT "WHAT IS THE LENGTH OF THE LAST DIRECTOR"
00277 INPUT FEL
00278 PRINT "WHAT IS THE LENGTH OF THE REFLECTOR"
00279 INPUT REL
00280 PRINT "WHAT IS THE POLARIZATION ANGLE OF THE ELEMENTS, IN DEGREES"
00281 PRINT "(0 FOR HORIZONTAL,45 FOR CROSS-POLARIZED,90 FOR VERTICAL)"
00282 INPUT P
00285 PRINT NEWPAGE ! CLEARS SCREEN
00300 ! ********** PRINT HEADINGS ***************************************************
00305 ! THE "#255:" IN THE PRINT STATEMENTS IS TO ACTIVATE THIS COMPUTER'S PRINTER
00310 PRINT #255:
00315 PRINT #255:
00320 PRINT #255:TAB(26);"CLEARANCE CALCULATIONS FOR ARRAY OF"
00340 PRINT #255:TAB(34);N$
00350 PRINT #255:
00355 PRINT #255:
00360 PRINT #255:TAB(6);"HORIZONTAL SPACING BETWEEN";TAB(51);"TOWER HEIGHT=";FNR(TH)
00370 PRINT #255:TAB(6);"OUTERMOST YAGIS=";FNR(S)
00380 PRINT #255:TAB(51);"VERTICAL MAST HEIGHT FROM"
00390 PRINT #255:TAB(6);"LENGTH OF REAR HALF";TAB(51);"PIVOT TO LOWEST YAGI=";FNR(BMH)
00400 PRINT #255:TAB(6);"OF EACH YAGI=";FNR(YR)
00410 PRINT #255:TAB(51);"VERTICAL MAST HEIGHT FROM"
00420 PRINT #255:TAB(6);"LENGTH OF FRONT HALF";TAB(51);"PIVOT TO HIGHEST YAGI=";FNR(TMH)
00430 PRINT #255:TAB(6);"OF EACH YAGI=";FNR(YF)
00431 PRINT #255:TAB(51);"LAST DIRECTOR LENGTH=";FNR(FEL)
00432 PRINT #255:TAB(6);"POLARIZATION=";FNR(P);"DEGREES"
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00433 PRINT #255:TAB(51);"REFLECTOR LENGTH=";FNR(REL)
00450 PRINT #255:
00460 PRINT #255:
00470 PRINT #255:
00480 PRINT #255:TAB(20);"MINIMUM       FRONT         FRONT        REAR          REAR"
00485 PRINT #255:TAB(5);"ELEVATION     GROUND        CLEARANCE     TURNING      CLEARANCE     TURNING"
00490 PRINT #255:TAB(5);"IN DEGREES    CLEARANCE     HEIGHT        RADIUS       HEIGHT        RADIUS"
00495 PRINT #255:TAB(5);"==========    =========     =========     =======      =========     ======="
00500 ! ********** CALCULATIONS **************************************************
00505 LET P=P*.0174533 ! CONVERT POLARITY ANGLE TO RADIANS FOR TRIG FUNCTIONS
00510 FOR E=0 TO 90 STEP 5 ! INCREMENT ELEVATION ANGLE IN DEGREES
00520 LET R=E*.0174533 ! CONVERT ELEVATION ANGLE FROM DEGREES TO RADIANS FOR TRIG FUNCTIONS
00521 LET RV=REL*SIN(P)*COS(R)/2 ! VERTICAL COMPONENT OF REAR ELEMENT IN PLANE OF YAGI
00523 LET RH=REL*SIN(P)*SIN(R)/2 ! HORIZONTAL COMPONENT OF REAR ELEMENT IN PLANE OF YAGI
00530 LET FV=FEL*SIN(P)*COS(R)/2 ! VERTICAL COMPONENT OF FRONT ELEMENT IN PLANE OF YAGI
00532 LET FH=FEL*SIN(P)*SIN(R)/2 ! HORIZONTAL COMPONENT OF FRONT ELEMENT IN PLANE OF YAGI
00540 LET GC=TH-BMH*COS(R)-YR*SIN(R)-RV ! MINIMUM "GROUND CLEARANCE"
00550 LET FCH=TH-BMH*COS(R)+YF*SIN(R)-FV ! "FRONT CLEARANCE HEIGHT" (HEIGHT OF FRONT
00551 ! ELEMENT TIP OF THE LOWEST YAGI ABOVE THE GROUND)
00560 LET FC=BMH*SIN(R)+YF*COS(R)+FH ! "FRONT CLEARANCE" (HORIZONTAL DISTANCE FROM
00561 ! BOOM PLANE TO OUTSIDE TIP ON FRONT OF LOWEST YAGI)
00570 LET RCH=TH+TMH*COS(R)-YR*SIN(R)+RV ! "REAR CLEARANCE HEIGHT" (HEIGHT OF REAR
00571 ! ELEMENT TIP OF HIGHEST YAGI ABOVE GROUND)
00580 LET RC=TMH*SIN(R)+YR*COS(R)+RH ! "REAR CLEARANCE" (HORIZONTAL DISTANCE FROM
00581 ! BOOM PLANE TO THE OUTSIDE TIP ON REAR OF HIGHEST YAGI)
00590 LET FTR=SQR((BL+FEL*COS(P)/2)**2+FC**2) ! "FRONT TURNING RADIUS" (HORIZONTAL
00591 ! DISTANCE OF FRONT TIP OF LOWEST YAGI FROM THE CENTER OF THE TOWER)
00600 LET RTR=SQR((BL+REL*COS(P)/2)**2+RC**2) ! "REAR TURNING RADIUS" (HORIZONTAL
00601 ! DISTANCE OF REAR TIP OF HIGHEST YAGI FROM THE CENTER OF THE TOWER)
00700 ! ********** DATA PRINTOUT *************************************************
00710 PRINT #255,USING 720:E,FNR(GC),FNR(FCH),FNR(FTR),FNR(RCH),FNR(RTR)
00720 FORM POS 9,PIC(Z#),POS 21,PIC(Z#.##),POS 36,PIC(Z#.##),POS 49,PIC(Z#.##),POS 62,PIC(Z#.##),

      POS 75,PIC(Z#.##)
00730 NEXT E
00900 ! ********** PROGRAM CONCLUSION *******************************************
00910 PRINT NEWPAGE ! CLEARS SCREEN
00920 PRINT #255:NEWPAGE ! ADVANCES PAPER ONE PAGE
00930 PRINT "DO YOU WANT TO RUN AGAIN"
00940 INPUT A$
00945 PRINT NEWPAGE ! CLEARS SCREEN
00950 IF A$="YES" OR A$="Y" THEN 200
01000 END
```

CLEARANCE CALCULATIONS FOR ARRAY OF
4 KLM LBX 2M YAGIS

HORIZONTAL SPACING BETWEEN
OUTERMOST YAGIS= 13.5

LENGTH OF REAR HALF
OF EACH YAGI= 12.08

LENGTH OF FRONT HALF
OF EACH YAGI= 16

POLARIZATION= 45 DEGREES

TOWER HEIGHT= 17

VERTICAL MAST HEIGHT FROM
PIVOT TO LOWEST YAGI= 6.25

VERTICAL MAST HEIGHT FROM
PIVOT TO HIGHEST YAGI= 6.25

LAST DIRECTOR LENGTH= 3

REFLECTOR LENGTH= 3.5

ELEVATION IN DEGREES	MINIMUM GROUND CLEARANCE	FRONT CLEARANCE HEIGHT	FRONT TURNING RADIUS	REAR CLEARANCE HEIGHT	REAR TURNING RADIUS
0	9.51	9.69	17.80	24.49	14.48
5	8.49	11.11	18.32	23.41	14.99
10	7.53	12.58	18.73	22.28	15.43
15	6.64	14.08	19.02	21.11	15.78
20	5.83	15.60	19.20	19.90	16.04
25	5.11	17.14	19.25	18.68	16.22
30	4.48	18.67	19.17	17.44	16.30
35	3.94	20.19	18.98	16.20	16.28
40	3.50	21.68	18.67	14.97	16.18
45	3.16	23.14	18.24	13.75	15.98
50	2.93	24.56	17.70	12.56	15.69
55	2.81	25.91	17.06	11.40	15.31
60	2.79	27.20	16.32	10.28	14.85
65	2.89	28.41	15.50	9.22	14.32
70	3.09	29.53	14.61	8.21	13.73
75	3.39	30.56	13.66	7.27	13.08
80	3.80	31.49	12.67	6.40	12.39
85	4.31	32.30	11.67	5.62	11.67
90	4.92	33.00	10.70	4.92	10.95

CLEARANCE CALCULATIONS FOR ARRAY OF
4 KLM LBX 2M YAGIS

HORIZONTAL SPACING BETWEEN
OUTERMOST YAGIS= 12.5

LENGTH OF REAR HALF
OF EACH YAGI= 12.08

LENGTH OF FRONT HALF
OF EACH YAGI= 16

POLARIZATION= 90 DEGREES

TOWER HEIGHT= 17

VERTICAL MAST HEIGHT FROM
PIVOT TO LOWEST YAGI= 6.75

VERTICAL MAST HEIGHT FROM
PIVOT TO HIGHEST YAGI= 6.75

LAST DIRECTOR LENGTH= 3

REFLECTOR LENGTH= 3.5

ELEVATION IN DEGREES	MINIMUM GROUND CLEARANCE	FRONT CLEARANCE HEIGHT	FRONT TURNING RADIUS	REAR CLEARANCE HEIGHT	REAR TURNIN RADIUS
0	8.50	8.75	17.18	25.50	13.60
5	7.48	10.18	17.79	24.41	14.22
10	6.53	11.65	18.29	23.27	14.76
15	5.66	13.17	18.67	22.08	15.21
20	4.88	14.72	18.92	20.86	15.57
25	4.19	16.28	19.04	19.60	15.83
30	3.60	17.86	19.04	18.32	15.98
35	3.11	19.42	18.90	17.03	16.04
40	2.72	20.96	18.64	15.75	15.99
45	2.45	22.48	18.25	14.47	15.84
50	2.28	23.95	17.74	13.21	15.58
55	2.23	25.37	17.12	11.98	15.23
60	2.29	26.73	16.38	10.79	14.79
65	2.46	28.01	15.55	9.64	14.25
70	2.74	29.21	14.63	8.56	13.64
75	3.13	30.32	13.63	7.53	12.95
80	3.63	31.32	12.57	6.58	12.19
85	4.23	32.22	11.47	5.71	11.39
90	4.92	33.00	10.35	4.92	10.55

CLEARANCE CALCULATIONS FOR ARRAY OF
16 KLM LBX 2M YAGIS

HORIZONTAL SPACING BETWEEN OUTERMOST YAGIS= 40.5

LENGTH OF REAR HALF OF EACH YAGI= 12.08

LENGTH OF FRONT HALF OF EACH YAGI= 16

POLARIZATION= 0 DEGREES

TOWER HEIGHT= 27

VERTICAL MAST HEIGHT FROM PIVOT TO LOWEST YAGI= 18.75

VERTICAL MAST HEIGHT FROM PIVOT TO HIGHEST YAGI= 18.75

LAST DIRECTOR LENGTH= 3

REFLECTOR LENGTH= 3.5

ELEVATION IN DEGREES	MINIMUM GROUND CLEARANCE	FRONT CLEARANCE HEIGHT	FRONT TURNING RADIUS	REAR CLEARANCE HEIGHT	REAR TURNING RADIUS
0	8.25	8.25	27.00	45.75	25.10
5	7.27	9.72	27.96	44.63	25.90
10	6.44	11.31	28.89	43.37	26.71
15	5.76	13.03	29.76	41.98	27.51
20	5.25	14.85	30.55	40.49	28.28
25	4.90	16.77	31.24	38.89	28.99
30	4.72	18.76	31.82	37.20	29.62
35	4.71	20.82	32.29	35.43	30.17
40	4.87	22.92	32.62	33.60	30.63
45	5.20	25.06	32.82	31.72	30.97
50	5.69	27.20	32.87	29.80	31.20
55	6.35	29.35	32.79	27.86	31.32
60	7.16	31.48	32.57	25.91	31.31
65	8.13	33.58	32.21	23.98	31.18
70	9.24	35.62	31.72	22.06	30.94
75	10.48	37.60	31.12	20.18	30.58
80	11.85	39.50	30.40	18.36	30.11
85	13.33	41.30	29.60	16.60	29.55
90	14.92	43.00	28.72	14.92	28.91

CLEARANCE CALCULATIONS FOR ARRAY OF
4 KLM LBX 2M YAGIS

HORIZONTAL SPACING BETWEEN OUTERMOST YAGIS= 13.5

LENGTH OF REAR HALF OF EACH YAGI= 12.08

LENGTH OF FRONT HALF OF EACH YAGI= 16

POLARIZATION= 0 DEGREES

TOWER HEIGHT= 17

VERTICAL MAST HEIGHT FROM PIVOT TO LOWEST YAGI= 6.25

VERTICAL MAST HEIGHT FROM PIVOT TO HIGHEST YAGI= 6.25

LAST DIRECTOR LENGTH= 3

REFLECTOR LENGTH= 3.5

ELEVATION IN DEGREES	MINIMUM GROUND CLEARANCE	FRONT CLEARANCE HEIGHT	FRONT TURNING RADIUS	REAR CLEARANCE HEIGHT	REAR TURNING RADIUS
0	10.75	10.75	18.00	23.25	14.77
5	9.72	12.17	18.43	22.17	15.18
10	8.75	13.62	18.75	21.06	15.52
15	7.84	15.10	18.96	19.91	15.77
20	7.00	16.60	19.05	18.74	15.94
25	6.23	18.10	19.02	17.56	16.03
30	5.55	19.59	18.88	16.37	16.03
35	4.95	21.06	18.62	15.19	15.94
40	4.45	22.50	18.25	14.02	15.76
45	4.04	23.89	17.76	12.88	15.50
50	3.73	25.24	17.18	11.76	15.16
55	3.52	26.52	16.51	10.69	14.75
60	3.41	27.73	15.75	9.66	14.26
65	3.41	28.86	14.92	8.69	13.72
70	3.51	29.90	14.03	7.79	13.13
75	3.71	30.84	13.10	6.95	12.50
80	4.02	31.67	12.16	6.19	11.85
85	4.42	32.39	11.23	5.51	11.19
90	4.92	33.00	10.35	4.92	10.55