

# CHEESE BITS



**W3CCX**

CLUB MEMORIAL CALL



ARRL  
Affiliated  
Club

SCANNED TO PDF BY BERT, K3JUV, 2013

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Number 3

## THE PREZ SEZ

Spring is not far away. In fact, spring may already be here from the looks of the lawn and trees. Time to plan those antenna projects and get done much needed maintenance and repairs. Remember help is just a phone call away. Don't wait until next January to get things done.

The February meeting was the annual Crying Towel meeting with much weeping and wailing and gnashing of teeth. It was an interesting meeting as always, but there *did* seem to be a theme that ran through nearly all the speakers presentations: **Procrastination**. If you really think back about most of the stories, the woes were really brought about by extreme, world class procrastination. Maybe the Crying Towel meeting is a meeting topic whose time has come and gone. The origin of the crying towel meeting came about in the days of home brew equipment that was often something less than extremely reliable. Those were the days when your power supply transformer was probably salvaged from an old TV or radio and the tubes in your transmitter often glowed red from over-current and blue from gas. Things ran hot and cute little muffin fans weren't around because computers had not been invented yet. Those were the days of stories not of procrastination, but of often dramatic and sudden equipment failures. Tubes just finally gave up in the middle of a QSO, hot enough to burn the finger prints off your finger tips. Power transformers over heated and smelled of burning tar, and filter capacitors often exploded like the crack of a 30-06, showering bits of paper and other debris all over the shack! Transistors just whimper like hungry, prophetic little puppies. No grand and glorious pyrotechnic displays that left little doubt that - "Houston, we have a problem". Those were the sights and sounds that brought grown men and women to tears. Those were the days when a crying towel had some meaning.

This months meeting is the annual Home Brew night. Don't be bashful, bring along anything that you have built over the last year or so. It doesn't have to be pretty and it even doesn't have to work. The point of this meeting is to show that hams do still build some of their own equipment. This is an information exchange meeting. This is when we all get to "network" with others who share the thrill of building something and maybe even actually having it work! There actually even seems to be gentle, but observable, drift back toward building. After a long day of generating characters on a computer screen, many find that the pleasure derived from actually doing something that has weight and takes up space, is more rewarding than just thinking about it.

Speaking of thinking, time to start thinking about the June contest. The club is once again going to Camelback mountain to operate the ARRL June QSO party. Al, N3ITT, is the chairman this year and would be more than happy for a few volunteers. Not too many now, we don't want to overwhelm the rookie.

73, Ron, W3RJW

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## MEETINGS

Third Thursday each month at 8:00 PM  
Southampton Free Library  
947 E. Street Road  
Southampton, PA 18966

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**PACKRAT 222 MHz REPEATER - W3CCX/R**

222.98/224.58 MHz, Churchville, PA FN20LE

**OFFICERS: 1997-1998**

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	AA3GN	(2 Yrs) Joe Landis, <a href="mailto:landis@nad.com">landis@nad.com</a>
	N3ITT	(1 YR) Al Sheppard
	N3EXA	(1 YR) Brian Taylor

**MONDAY NIGHT NETS**

<u>TIME</u>	<u>FREQ.</u>	<u>NET CONTROL</u>
7:30 PM	50.150 MHz	K3EOD/WA3EHD
8:00 PM	144.150 MHz	N3ITT
8:30 PM	222.125 MHz	W2SJ/N3EXA
8:30 PM	224.58R MHz	W3GXB
9:00 PM	432.110 MHz	W3RJW
9:30 PM	1296.100 MHz	WA3NUP/AA2UK
10:00 PM	903.100 MHz	N3AOG

**COMMITTEE CHAIRMEN**

LADIES' NIGHT:	N3AOG	215-443-9965
JUNE CONTEST:	N3ITT	610-847-5490
HAMARAMA:	N3EXA	215-257-6303
VHF CONFERENCE:	KB3XG	610-584-2489

**PACK RAT BEACONS - W3CCX/B FM29JW**

50.080 144.284 222.065 432.295 903.072 1296.251 MHz  
2304.037 3456.220 5760.200 10,368.200 MHz



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## CALENDAR OF COMING EVENTS - MARCH 1998

- 7 **Shore Points ARC Springfest 98** at Holy Spirit High School, Rte 9, 1/2 mile S. of Rte 30 in Absecon, NJ. TI on 146.385/985. For information, contact John Barbari, KB2HZU at 609-653-1987.
- 7-8 **ARRL International DX Contest** (phone). See page 102 of the Dec.97 Issue of QST for rules.
- 7-8 **European EME Contest**, 432 and 2304 MHz and up portion sponsored by DUBUS. See March QST, page 101 for rules.
- 12 Packrat **Board of Directors Meeting** at the QTH of Brian Taylor, N3EXA, in Perkasie, PA. All interested parties welcome. Starts at 8:00 P.M. Call 215-257-6303 for directions.
- 15 **York Springfest** at the York County V0-Tech School, East Berlin, PA. <http://members.aol.com/yorkfest>. VE exams.
- 17 **St. Patrick's Day**
- 19 March meeting of the Mt. Airy VHF Radio Club at 8:00 P.M. at the Southampton Free Library on Street Rd. The program will be the annual **HOME BREW Night**. Bring your successes, failures and works in process to share with all. You do not have to be a member to enter. All interested VHFers and microwave enthusiasts are welcome. Prizes will be awarded in several categories.
- 26 **LEAP INTO THE MICROWAVES** with the Packrats! 903 and above. Every 4th Thursday of the month operate from 8 to 10 PM local time on any band 903 MHz and above. For coordination on those difficult long haul contacts 144.260 MHz is the suggested liaison frequency. So here's your chance to fix what broke in the contest and work all those stations you missed.
- 28-29 Timonium Md, **ARRL Maryland State Convention and Greater Baltimore Hamboree** and Computerfest at the Maryland State Fairgrounds. VE exams given. Call 1-800-HAM-FEST. TI on 146.67- and 224.24-.

### TID BITS

**2304 Antenna**. FYI the 2304 Mhz beacon antenna was replaced today at 1230 Hrs with the new and improved model. The beacon is still running about 300 mW at the antenna. Please send your reports regarding the improvement, no change, or degraded performance of this antenna vs. the original to myself or Ron W3RJW. Tnx, Jack Kanker N3DQZ

**Preliminary January Contest Results**: Mt. Airy VHF Radio Club: 2,810,913 points, 56 entries, North East Weak Signal Group, 1,579,1011 points, Rochester VHF Group: 1.5-M with 38 logs.

**FN22 Nets**: At 7:00pm local time (00:00 utc) there is a 6 meter net from FN22 on 50.230. At 8:00pm local time (01:00 utc) the net goes to 2 meters from FN22 on 144.230. These are both Tuesday nite local or Wednesday UTC. Net control is KB2ZVP and his usual range is 350-400 miles for all that are interested. The net is informal and for the purpose of reporting band conditions, hunting grid squares or just saying hi! Come one, come all and check-in. It has been quiet up here in N.Y. Especially looking for stations from FN04-05. Thanks 73 Jim KB2YWU

**New Work phone numbers** are: W3KM, 215-323-2166. Fax: 215-323-2507, WA3NUF, 215-323-2176, Fax: 215-323-2507, WA2OMY 215-323-2275.

**6 Meter Folks here in FN12**. Some of us 6 Meter Folks here in FN12 have started a 6 meter SSB net on 50.150 at 01:00 UTC (9:00 PM local). All are invited. see you there. 73, Carl, KB2SGX.

**New Address** As of Wednesday, February 11, my new address and phone number is: 1352 W. Chestnut Avenue, Vineland, NJ 08360. FM29LL, K3EOD, Allen Bobbit.

### New Web Page Additions: [www.ij.net/packrats](http://www.ij.net/packrats)

Ron J. Whitsel, W3RJW

I have finally screwed up enough courage to take over the Pack Rat web page. Our original web author is standing by in case I get myself in real trouble. As the saying goes "A little bit of knowledge is dangerous". There have been some recent changes and updates. If you haven't looked in the last couple of days there are some new things. If you have an idea of what might be added let me know. Cheesebits will continue to get first dibs at anything new. I will ascertain any old articles that are in electronic format. Pure text files with no embedded graphics and separate GIF figures make life easier.

**Mt. Airy VHF Radio Club, Inc.**  
**'The Pack Rats'**  
**January 1998 VHF Sweepstakes Contest**

Total Logs: 56

Total Club Score: 2,610,913

Call	Contacts and Grids per band										Grids	Total Score
	80 MHz	144 MHz	222 MHz	432 MHz	903 MHz	1.3 GHz	2.3 GHz	3.4 GHz	5.7 GHz	+Contacts		
AA2UK	146 36	309 43	93 26	115 30	38 13	54 15	19 5	13 2	19 6	806	176	289,872
W3RJW	139 30	226 24	104 16	125 15	44 9	66 11	26 4	14 2	19 5	763	116	201,260
WC2K	208 50	279 42	87 22	115 24	33 8	44 10				766	156	187,044
WA3NUF	131 29	233 23	77 11	113 17	30 4	48 9	17 4	8 2	12 3	669	102	137,904
WB3KRW	115 29	253 36	89 21	119 23	23 6	41 9				640	124	128,960
WB3JYO	128 22	186 26	83 15	92 17	35 9	46 8	16 4	5 2		591	103	119,068
N3ENA	176 29	248 20	94 16	118 17	31 5	43 5	3 2			723	94	117,312
K2TNB		467 46	50 2	126 29		67 16			5 3	715	96	108,192
N5DQZ	164 33	224 23	76 15	111 16	35 6	37 6				647	99	103,950
W2UR	101 18	178 26	46 2	81 19	37 8	43 7	17 4	5 2	8 4	516	90	98,370
N3NGE	138 25	166 25	51 13	93 18	33 8	42 8	7 3			530	100	94,800
W2SI	86 12	121 12	74 11	91 10	39 4	46 5	17 2	12 2		486	58	64,322
W2SK	65 9	147 19	54 8	72 11	27 5	33 5	13 2	8 2	7 2	426	63	58,464
W3KJM	80 14	176 17	69 10	73 13	20 3	35 4	8 3	1 1		462	63	52,416
AASGN	122 23	178 25	34 2	75 10	25 3	29 2				463	63	46,242
WA3DRC	52 5	198 22	40 2	116 19	39 7					445	55	39,490
K3XNG	47 5	67 6	43 5	56 6	25 2	37 3	13 2	11 2	12 5	311	36	30,528
K3MFI	94 13	143 9	64 8	99 9	10 2	20 2	1 1			431	44	30,404
NK8Q	108 22	137 20	37 5	78 11		8 1				368	59	29,913
K3JBB	64 20	75 13	42 8	50 7	17 3	24 4	1 1			73	56	27,720
KUST	40 6	174 23		107 14		37 4				358	47	27,072
W3KKN	110 18	101 10	39 4	53 5	21 2	31 3	1 1			356	43	26,273
N3AOG	50 6	77 8	48 5	49 5	22 2	28 2	10 2	6 2	8 4	298	36	25,668
WA3AQA	84 11	109 8	71 10	51 6	24 3	23 2				362	40	25,000
WA3EHD	80 18	143 18	64 7	18 2		23 2				328	47	22,513
K3IUV	66 8	119 11	71 7	79 10		17 2				352	38	21,014
K3DMA	88 11	131 9	67 5	61 4		25 2				372	31	17,825
W3HT	80 12	97 11	45 6	51 9					1 1	274	39	14,703
W3GXB	42 10	71 11	23 6	29 5	14 2	17 2				196	36	12,276
K2FK	33 3	31 5	48 5	36 5	17 2	20 3	10 2			195	25	11,500
K3EDZ	74 12	0 8	39 2	66 6						259	28	10,192
N3EMY		145 14	27 2	87 10						259	26	9,698
WA3RLT	68 8	88 11		49 8		11 4				216	31	9,238
WA3U	49 7	75 13	29 7	36 8						189	33	8,890
K1DSR	27 3	104 7	35 3	19 2	13 2	19 2			2	217	21	7,707
N3EVR	6 1	111 8	7 1	5 7	3 2	16 2			2	198	23	7,291
WA3YUE	18 3	51 8	13 2	17 3	10 2	10 2	5 2			124	22	5,478
WB3VLA	35 14	47 10	18 2	20 3	4 2					124	31	5,394
W3DFM	17 6	26 7	13 5	17 5	8 3	5 3				86	29	4,495
WA3IAC		72 3	33 2	44 6	4 2					153	13	3,146
W3ILY	24 5	28 5	21 4	17 3	3 2					169	10	2,450
W3HMC	62 15	16 2	11 2							89	19	1,900
K3BPP			22 2	39 6	16 2					77	10	1,860
N2DEQ		112 11	10 2							122	13	1,716
K3BA	11 4	50 7	15 2	5 1						81	14	1,414
K2UT		70 9		1 1						71	10	720
N3DG		14 2		2 1						16	3	54

Call	50 MHz	144 MHz	222 MHz	432 MHz	903 MHz	1.3 GHz	2.3 GHz	3.4 GHz	5.7 GHz+Contacts	Grids	Score
N3NID		12 1		7 1					19	2	52
W3HK		16 2							16	2	32

Multi-Ops											Contacts and Grids per band		Total
Call	50 MHz	144 MHz	222 MHz	432 MHz	903 MHz	1.3 GHz	2.3 GHz	3.4 GHz	5.7 GHz+	Contacts	Grids	Score	
W0RSJ	342 39	350 34	87 21	107 21	24 7	33 8	5 2	2 2		950	134	182,776	
w/W0RSJ W1PV KD2IX WR2ONA & NET													
K3EOD	239 35	492 33	101 13	128 17	14 3	20 3	6 2	1 1		1001	107	147,767	
w/K3EOD N3DG K1DS WA3TAC WF3W													
W3OR	190 52	171 36	66 21	92 25						519	134	90,718	
w/W3OR W3CCO													
N3ITT	145 18	231 26	52 7	93 12	24 4	31 2				576	69	61,134	
w/N3ITT N3OZO WU3C													
WA2OMY	81 14	117 20	42 3	61 12	18 3	22 3	9 2	5 2	3 2	358	61	42,700	
w/WA2OMY WA3YLE													
W3GAD	113 16	188 18	56 5	95 13						452	52	31,356	
w/W3GAD N3YOK & NET													

### Hank Hamarman, N3NID, Silent Key

Bill Gorodetzer, K3MFI

Fellow Packrats, Here's a copy of a message I sent to Warminster Amateur Radio Club members. If you wish to express your sympathy to Hank's widow and family, please see the information below

I want to take this opportunity to give an update on the observance of the death of club Vice President Hank Hamarman, N3NID, on Tuesday, Feb. 10. Approximately 15 Hams (many of them WARC members) were among those who attended Hank's funeral service on Friday, Feb. 13. We had an opportunity to hear those who eulogized him mention, among Hank's major interests, his strong connection towards amateur radio. Hank's widow Nina, their children (Sandra and Jorge) and family have asked me to pass along their appreciation for the many expressions of sympathy they have already received from Hank's amateur radio friends. This is indeed a sad time for all of us who knew Hank.

### Subject: Weak Signal Banquet

By: Tom Whitted, WA8WZG

To All VHF Weak Signal Operators .....The VHF WEAK SIGNAL GROUP that Meets Monday nights at 0200 UTC on 3.843 MHz, would like to invite everyone that is coming to Dayton Hamvention to our annual banquet...We have reserved a room, that will seat 125, on Friday Night May 15th. from 6:30 PM. until 11:00 PM at the Holiday Inn North, Waggoner Ford Road, Dayton, Ohio. There will be a cash bar as well as plenty of seating to allow you to mix and mingle with other VHF'ERS from all over the country and the world. There will be over 50 prizes with two grand prizes worth over 300 dollars being drawn starting at 9:00 PM. Also, there will be a guest speaker, Joel Harrison, W5ZN, who will provide a short talk on VHF activity. There will also be a noise figure measuring table so bring your preamps to tweak.

The cost of a ticket to attend this function which includes a 2 entree banquet dinner, is only \$30 dollars per person, and they are limited to 125. You may order your tickets by sending \$30.00 plus an SASE to either Tony Emanuelic, WA8RF, 7156 Kory Court, Concord Township, Ohio 44077 or Tom Whitted, WA8WZG, 4641 Port Clinton East Rd., Port Clinton, Ohio 43452. Website info is WWW.WA8WZG.COM. This one of the largest gathering of Weak Signal enthusiasts in the U.S., so get your tickets early and join us for an enjoyable evening at the Dayton Hamvention!

### CHEESEBITS SUBSCRIPTIONS

Cheesebits subscriptions are available to everyone interested in activities and information from the VHF through the microwave frequencies. Subscriptions are for 1 year of 12 issues. For a subscription, send the following information:

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Subscription Rate: \$10.00 per year (USA), \$12.00 (Canada), \$15.00 (Worldwide)

March 1998 Send to: SUBSCRIPTION/ADVERTISING MANAGER:

Bob Fischer, W2SJ, 7358 Walnut Avenue, Pennsauken, NJ 08110

## PACKRATS OFFER FREE VACATION

By Al, N3IIT

OK - Think back... What was your last vacation like? Hours in the car, fighting traffic, nagging wife, screaming kids? Or dealing with surly hotel staff? Bet it costs **BIG BUCKS** too! Well, if this isn't your idea of getting away from it all and having fun, read on.

Once again, the Mt. Airy VHF Radio Club is offering a **FREE** 4 day, 3 night getaway to beautiful Camelback Mountain in the Poconos, home of several world class resorts! Package includes **ALL MEALS** and 3 nights lodging in our beautiful open air Mountaintop Lodge (you provide the shelter).

WOW, Al, sounds GREAT - What's the catch??

Well, unless you consider helping to set up a top class VHF contest station, and operating from one of the best sites on the east coast a chore---There isn't any! Simply contact me ASAP to reserve your spot now - Please call soon as reservations are unlimited.

The group will be departing from the QTH of Bob Fox, W3GXB, on Friday, June 12 and returning on Monday, June 15. If you can only stay for part of the time, let me know when you plan to be up!

So, sign up now and be part of the Packrats as we again operate the June VHF Contest from Camelback Mountain.

Hope to hear from **YOU** soon!

Current list of Pack Rats on the 'Packrats-Members' reflector.

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WU3C	jkedzior@AEL.COM	N3NGE	n3nge@IX.NETCOM.COM
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N3DG	n3dg@JUNO.COM	W3OR	erevan@HOME.DMV.COM
K3DMA		N3OZO	dschwarzkopf@NEWPORT.COM
taylor_john%pax5a@MR.NAWCAD.NAVY.MIL		N3OZO	casper@VOICENET.COM
N3DQZ	jkauker@VOICENET.COM	WR3P	ralexander@GI.COM
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WA3EHD	antonacc@PACS.PHA.PA.US	W3RJW	w3rjw@aol.com
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W3GAD	docw@VOICENET.COM	W2SK	pcwt@VOICENET.COM
AA3GN	landisj@NAD.COM	KU3T	keer@VOICENET.COM
K3GNC	jbyrdk3gnc@WORLDNET.ATT.NET	K2TXB	k2txb@DXCC.COM
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N3GSA	ssellers@GI.COM	AA2UK	aa2uk@BELLATLANTIC.NET
WA3IAC	wa3iac@JUNO.COM	W2UR	w2ur@BELLATLANTIC.NET
KB3IB	kb3ib@GENESGATE	K2UT	bob@WATERW.COM
W3IIT	hbrown@VOICENET.COM	WB2VLA	dpower@VOICENET.COM
W3IIT	harry.h.brown@LMCO.COM	KB3XG	JohnKB3XG@aol.com
K3JPM	Ss1seed@aol.com	WA1YHO	gdallas@HPANVY.AN.HP.COM
K3JUV	soltoff@USCOM.COM	WA3YUE	bruce.joss@UNISYS.COM

## 11.644 GHz BRANCH HYBRID

dc: John Sortor, KB3XG & Paul Drexler, WB3JYO

### INTRODUCTION:

When Paul and I started this 24 GHz job we divided up the tasks. Paul tackled the mm wave circuits and I did the easy low frequency things like the 12 GHz 90 degree hybrid. Notice I used the word easy in this sentence. As with any other RF project I have worked on, there is always something that is unexpected that turns into a learning experience.

### DESIGN ITERATIONS:

The design of the hybrid started with a faxed copy of a textbook describing the circuit topology. (See Figure 1.) I calculated the line widths and lengths using an old DOS based K2UYH program. Within minutes I had all of the mechanical dimensions for the micro strip lines and I thought I was done with the design.

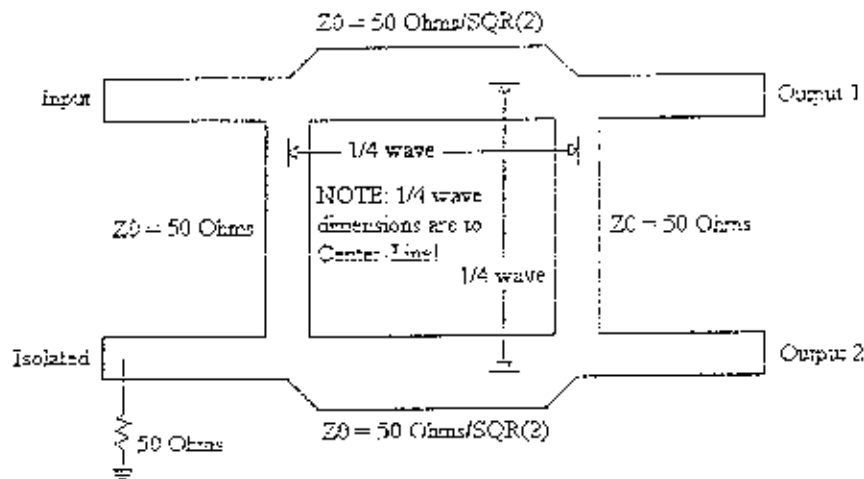


FIGURE 1: Geometry of Branch Line Hybrid

$$\text{LO freq} = (24.192 \text{ GHz} - 903 \text{ MHz}) / 2 = 11644.5 \text{ MHz}$$

PC board  $\epsilon_r = 2.17$

PC board thick = 0.010"

shunt arm 50 Ohm = 0.030"

velocity =  $1/\text{SQR}(2.17) = 0.679$

copper thick = 0.00035"

series arm  $50 \text{ Ohm} / \text{SQR}(2) = 35.36 \text{ Ohm} = 0.050"$

$$1/4\text{wave @} 11.6 \text{ GHz} = 300/11644.5\text{MHz} \times 39.37\text{in/m} \times 0.679 \times 0.25 \text{ wave} = 0.172"$$

I had access to a copy of Touchstone and just for grins I entered the mechanical dimensions into a program file. I told the computer to optimize the hybrid at the desired frequency. The machine churned away for a minute or so and came up with micro strip lines that were 12 mils longer than I had calculated. To make things more confusing, the computer said that the 50 Ohm line was slightly longer than the 35 Ohm line. What's going on here? Is the text book wrong? Did the computer make a mistake? The difference wasn't that great but at this frequency I felt that it was important to make sure things were as accurate as possible.

### ! 11.644 GHz 90 deg Branch Line Hybrid

DIM

FREQ GHz

RES OH

IND NH

CAP PF

LNG MIL

VAR

L1#100 183.12740 200 ! length of 35 Ohm line

L2#100 186.05200 200 ! length of 50 Ohm line

```

CKT
MSUB ER=2.17 H=10 T=0.7 RHO=0.8 RGH=0
MLIN 1 2 W=50 L=L1 ! series arm
MLIN 1 4 W=50 L=L2 ! input shunt arm
RES 4 0 R=50 ! isolation load
MLIN 2 3 W=30 L=L2 ! output shunt arm
MLIN 3 4 W=50 L=L1 ! series arm
DEFSP 1 2 3 HYB

OUT
HYB DB[S21] GR1 ! port 1
HYB DB[S31] GR2 ! port 1
HYB DB[S11] GR2 ! input match

FREQ
SWEEP 11.144 12.144 0.1

GRID
RANGE 11 12 0.1
GR1 -3 3 0.1
GR2 -30 0 5

OPT
RANGE 11.634 11.654
HYB DB[S21]=-3
HYB DB[S31]=-3
HYB DB[S11]<-40
*** Bottom of File ***

```

**11.644 GHz 90 deg Branch Line Hybrid**

FREQ	DB[S <sub>21</sub> ]	DB[S <sub>31</sub> ]	DB[S <sub>11</sub> ]
GHz	HYB	HYB	HYB
11.144	-3.098	-3.128	-21.835
11.244	-3.057	-3.129	-23.741
11.344	-3.024	-3.130	-26.156
11.444	-3.001	-3.131	-29.435
11.544	-2.986	-3.132	-34.345
11.644	-2.981	-3.132	-39.750
11.744	-2.984	-3.132	-34.531
11.844	-2.997	-3.132	-29.556
11.944	-3.019	-3.132	-26.244
12.044	-3.050	-3.132	-23.810
12.144	-3.090	-3.132	-21.893

**EFFECTIVE DIELECTRIC CONSTANT:**

I called Paul to ask about this discrepancy. Paul's first question was "Did you consider the effective dielectric constant?" The effective what? I had never heard of this term. It turns out that the ratio of the width of the line to the thickness of the board effectively changes the dielectric constant. The change in dielectric constant alters the width of the line but more importantly alters the length. Paul faxed me several pages of a MathCad file with lots of ugly equations.

Example of ugly equations:

$$\text{Effective Dielectric Constant } \epsilon_{\text{eff}_0} = \frac{\epsilon_r - 1}{2} + \frac{\epsilon_r - 1}{2} * \frac{1}{\left[ \text{SQRT} \left( 1 + \left[ 12.166 / \left\{ \frac{w}{h} \right\} \right] \right) \right]} + 0.0508 * \left( \frac{w}{h} \right)^{-2} * e^{0.22 * \left\{ \frac{w}{h} \right\} * \epsilon_r}$$

Frequency Effects:  $\epsilon_{\text{eff\_freq}} = \epsilon_{\text{eff}_0} * \frac{(1 - f_c)^2}{1 + (\epsilon_{\text{eff}_0} / \epsilon_r) * f_c^2}$

where operating frequency = f (GHz) and f<sub>c</sub> = (0.00895 \* h \* f) / Z<sub>line</sub>



$$\text{Characteristic Impedance: } Z_0 = \frac{60}{\text{SQR}(e\text{-eff}_f)} * \ln \frac{(0.989 * \{w/h\} - 1.769) * (0.994 * \{w/h\} + 5.8)}{\{w/h\} * (\{w/h\} + 1.269)}$$

The equation causes the dielectric constant to be less than the advertised number in the catalog. Table 1 lists 5 examples at 2304 MHz which show how the effective dielectric constant changes with a variation in width to height ratio. Table 2 shows calculated line width results from 4 different sources for my application at 11.6 GHz. This includes a calculation that ignores the copper thickness and effective dielectric constant.

**TABLE 1: EFFECTIVE  $\epsilon_r$  vs w/h VARIATION**  
material: Rogers Duroid, thickness = 0.031",  $\epsilon_r = 2.55$

Freq GHz	eff $\epsilon_r$	$Z_0$ Ohm	W mils	1/4wave mils	remarks
2.304	1.94	120	15.5	918.8	w/h = 0.5
2.304	2.00	89.5	31.0	905.9	w/h = 1.0
2.304	2.08	61.8	62.0	887.9	w/h = 2.0
2.304	2.14	47.8	93.0	875.8	w/h = 3.0
2.304	2.18	39.1	124	867.0	w/h = 4.0

**TABLE 2: MICRO STRIP LINE LENGTH CALCULATIONS**  
material: Taconic TLY, thickness = 0.010",  $\epsilon_r = 2.17$

Freq GHz	eff $\epsilon_r$	$Z_0$ Ohm	W mils	1/4wave mils	remarks
11.644	???	50.0	30.08	172.2	ignore cu & effective $\epsilon_r$
11.644	???	50.0	30.37	186.3	K2UYH
11.644	1.87	50.0	31.10	185.4	AppCad
11.644	???	50.0	30.00	186.1	TouchStone
11.644	???	35.36	50.61	172.2	ignore cu & effective $\epsilon_r$
11.644	???	35.36	49.86	183.7	K2UYH
11.644	1.93	35.36	50.64	182.6	AppCad
11.644	???	35.36	50.00	183.1	TouchStone

Tables of popular line impedances, widths, and board thickness. Notice that the effective dielectric constant increases slightly with frequency. The frequency term in the equation is insignificant at 3456 MHz and below, but at 5760 MHz and above the fringing effects around the edges of the line causes a slight increase in dielectric constant, line width, and line length. This rate of increase is more prevalent on PC board material that has a higher initial dielectric constant such as FR-4 or  $\epsilon = 10$ .

material: Taconic TLY  
thickness = 0.010"  
 $\epsilon_r = 2.17$   
 $Z_0 = 50.0$  Ohms

material: Rogers Duroid  
thickness = 0.031"  
 $\epsilon_r = 2.55$   
 $Z_0 = 50.0$  Ohms

material: G-10 / FR-4  
thickness = 0.062"  
 $\epsilon_r = 4.80$   
 $Z_0 = 50.0$  Ohms

Freq GHz	eff $\epsilon_r$	W mils	1/4wave mils
0.222	1.86	31.10	9744
0.903	1.86	31.10	2396
1.296	1.86	31.10	1669
2.304	1.86	31.10	938.7
3.456	1.86	31.10	625.7
5.760	1.86	31.10	375.3
10.368	1.87	31.10	208.5
24.192	1.88	31.23	88.9

Freq GHz	eff $\epsilon_r$	W mils	1/4wave mils
0.222	2.12	86.87	9120
0.903	2.12	86.87	2242
1.296	2.12	86.87	1562
2.304	2.13	86.87	878.0
3.456	2.13	86.87	584.6
5.760	2.14	87.02	350.0
10.368	2.17	87.82	193.5
24.192	2.26	94.02	81.1

Freq GHz	eff $\epsilon_r$	W mils	1/4wave mils
0.222	3.58	111.0	7020
0.903	3.60	111.0	1723
1.296	3.61	111.0	1199
2.304	3.64	111.1	671.5
3.456	3.68	111.6	445.3
5.760	3.77	113.8	263.9
10.368	3.98	122.2	142.7
24.192	4.43	153.4	81.1

material: 3M e 10  
 thickness = 0.031"  
 $\epsilon_r = 9.90$   
 $Z_0 = 50.0$  Ohms

Freq GHz	eff $\epsilon_r$	W mils	1/4wave mils
0.222	6.62	29.80	5164
0.903	6.64	29.79	1268
1.296	6.65	29.78	883.0
2.304	6.68	29.76	495.4
3.456	6.73	29.78	329.0
5.760	6.85	29.96	195.7
10.368	7.13	31.00	106.6
24.192	8.11	38.40	42.8

material: G-10 / FR-4  
 thickness = 0.062"  
 $\epsilon_r = 4.80$   
 $Z_0 = 25.0$  Ohms

Freq GHz	eff $\epsilon_r$	W mils	1/4wave mils
0.222	3.95	307.7	6688
0.903	3.97	307.7	1640
1.296	3.98	307.7	1141
2.304	4.03	308.4	637.8
3.456	4.09	310.1	422.2
5.760	4.20	316.1	249.8
10.368	4.40	334.0	135.6
24.192	4.66	378.0	56.5

material: Rogers Duroid  
 thickness = 0.031"  
 $\epsilon_r = 2.55$   
 $Z_0 = 100$  Ohms

Freq GHz	eff $\epsilon_r$	W mils	1/4wave mils
0.222	1.97	24.26	9456
0.903	1.97	24.26	2326
1.296	1.97	24.26	1620
2.304	1.98	24.26	911.1
3.456	1.98	24.26	607.1
5.760	1.98	24.30	363.7
10.368	2.00	24.56	201.3
24.192	2.06	27.09	84.9

material: Taconic TLY  
 thickness = 0.010"  
 $\epsilon_r = 2.17$   
 $Z_0 = 25.0$  Ohms

Freq GHz	eff $\epsilon_r$	W mils	1/4wave mils
0.222	1.97	78.90	9472
0.903	1.97	78.90	2330
1.296	1.97	78.90	1624
2.304	1.97	78.90	913.2
3.456	1.97	78.91	608.7
5.760	1.97	78.93	365.0
10.368	1.98	79.01	202.5
24.192	2.00	79.55	86.3

material: 3M e 10  
 thickness = 0.031"  
 $\epsilon_r = 9.90$   
 $Z_0 = 25.0$  Ohms

Freq GHz	eff $\epsilon_r$	W mils	1/4wave mils
0.222	7.46	96.20	4868
0.903	7.49	96.20	1194
1.296	7.51	96.20	830.7
2.304	7.58	96.20	465.1
3.456	7.67	96.20	308.3
5.760	7.86	96.90	182.7
10.368	8.24	99.80	99.10
24.192	9.09	114.1	40.5

material: G-10 / FR-4  
 thickness = 0.062"  
 $\epsilon_r = 4.80$   
 $Z_0 = 100$  Ohms

Freq GHz	eff $\epsilon_r$	W mils	1/4wave mils
0.903	3.26	24.55	1809
1.296	3.27	24.55	1259
2.304	3.28	24.57	706.9
3.456	3.30	24.69	469.8
5.760	3.35	25.27	279.8
10.368	3.52	28.15	152.3
24.192	4.03	48.22	60.8

material: Rogers Duroid  
 thickness = 0.031"  
 $\epsilon_r = 2.55$   
 $Z_0 = 25.0$  Ohms

Freq GHz	eff $\epsilon_r$	W mils	1/4wave mils
0.222	2.26	223.4	8832
0.903	2.27	223.4	2170
1.296	2.27	223.4	1512
2.304	2.27	223.5	849.5
3.456	2.28	223.7	565.4
5.760	2.30	224.3	338.1
10.368	2.33	226.8	186.5
24.192	2.42	239.7	78.5

material: Taconic TLY  
 thickness = 0.010"  
 $\epsilon_r = 2.17$   
 $Z_0 = 100$  Ohms

Freq GHz	eff $\epsilon_r$	W mils	1/4wave mils
0.222	1.75	9.04	10048
0.903	1.75	9.04	2473
1.296	1.75	9.04	1723
2.304	1.75	9.04	969.1
3.456	1.75	9.04	646.0
5.760	1.75	9.04	387.5
10.368	1.75	9.04	215.2
24.192	1.76	9.08	92.0

material: 3M e 10  
 thickness = 0.031"  
 $\epsilon_r = 9.90$   
 $Z_0 = 100$  Ohms

Freq GHz	eff $\epsilon_r$	W mils	1/4wave mils
0.222	6.03	4.13	5384
0.903	6.03	4.13	1331
1.296	6.04	4.13	926.7
2.304	6.05	4.13	520.6
3.456	6.07	4.13	346.5
5.760	6.13	4.15	207.0
10.368	6.27	4.32	113.7
24.192	6.94	6.46	46.3

**CONCLUSION:**

I thought that the concept of effective dielectric constant would only be significant at 24 GHz. I realize now that it should be part of your calculations regardless of frequency. This was made clear by my branch hybrid design example where the length of the 50 Ohm shunt arms were slightly longer than the 35 Ohm series arms.

As a side note I did go back and play with K2UYH's basic program. It is not obvious to the user, but Al did include the effective dielectric constant into his calculations. To obtain the dimensions of the micro strip you must include the thickness of the copper and the frequency of interest. The copper thickness is 0.0007" per side for 1 oz. copper and 0.0014" per side for 2 oz. copper. The length of the micro strip line is calculated as a full wavelength. I'm not sure if Al's basic programs are still in the public domain. If not, I would be happy to email a copy to anyone that is interested. Paul has also offered to email his MathCad file to any engineering weenies out there who would like a copy.

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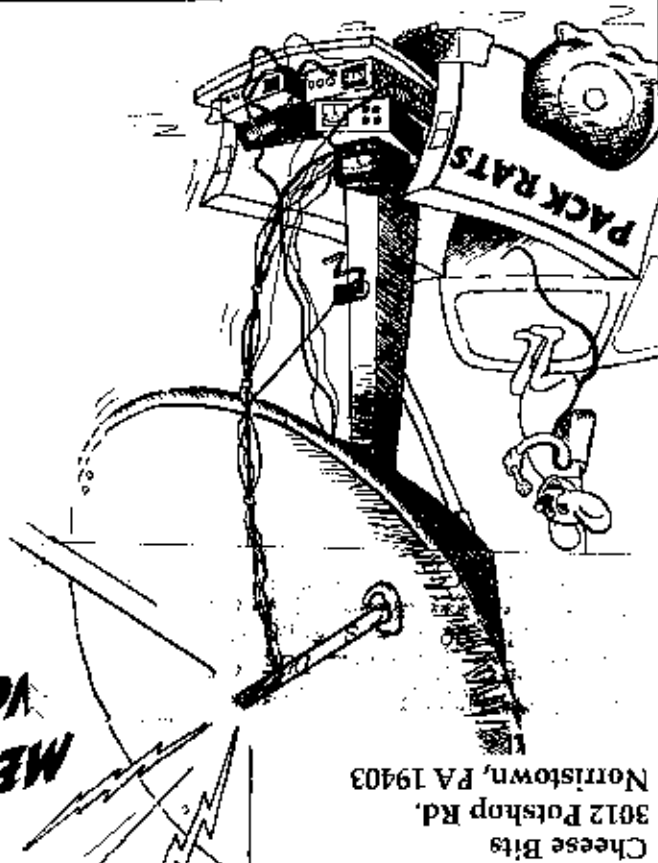
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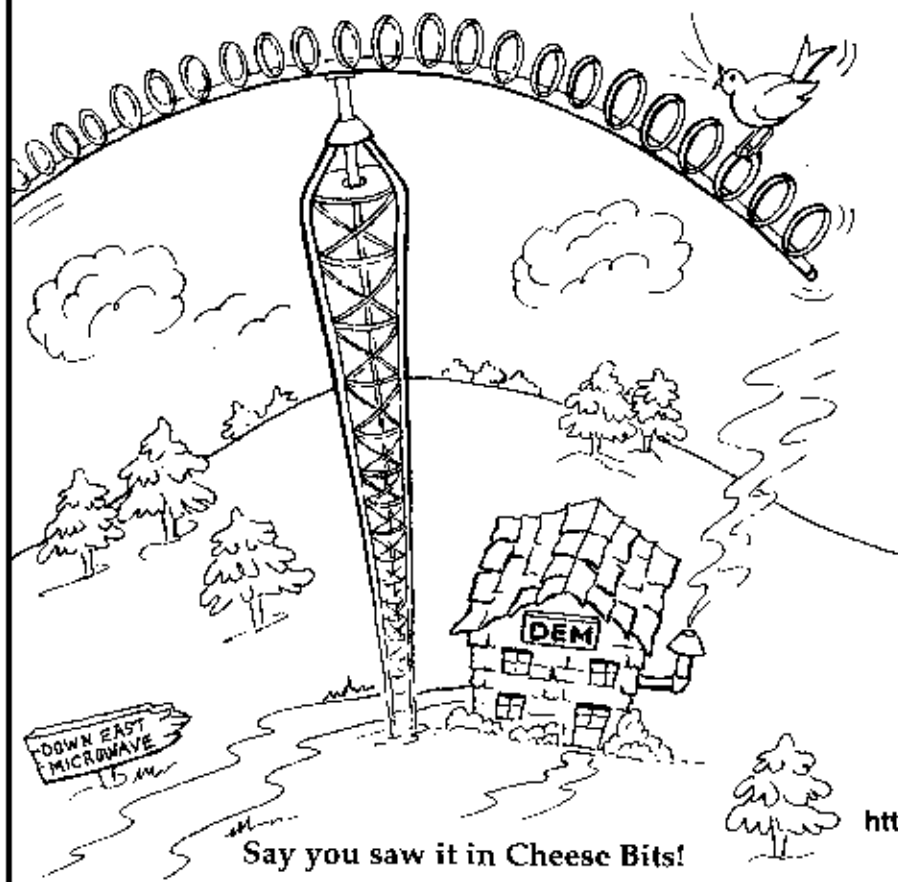
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